INSTITUTE OF ORGANIZATION
AND MANAGEMENT IN INDUSTRY
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ITESM
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Doctoral Dissertation
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Title:
AN INTEGRATED MODEL FOR OPERATIONS MANAGEMENT IN THE SMALL AND MEDIUM SIZE MEXICAN COMPANIES

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Warsaw, Poland - San Luis Potosí, México
July 1997

INTRODUCTION

An approach is developed to reinforce the *value chain* of the manufacturing companies, where typically one of its links fail, and as a consequence, both customer satisfaction and success of the supplier business are affected. Several approaches are found on the Operations Management and Industrial Engineering discipline, but they offer just local improvements for one or two links of the value chain. Other approaches as *Total Quality, Systems Thinking and Management* are very general and it's very difficult to put them in to practice with good results in the short run. Those philosophies are good promoting a holistic approach, but this is not enough for the small and medium sized manufacturing companies.

Through this work I have developed the model named *"An Integrated Model for Operations Management in the Small and Medium Sized Mexican Companies"* (IMOM). Its purpose is to integrate and coordinate the following areas of the value chain: (1) *Order Processing,* (2) *Production Planning and Scheduling, (3) finished goods storing and shipping (Warehousing), (3)Production, (4) Purchasing and (5) storing and supplying of raw materials.* I considered those areas because they are involved from the beginning of the process till the delivery of the goods to the customer.
Manufacturing systems look to reach a competitive advantage and to operate as a productivity machine at the same time, but most of the times the complexity of the system restrains its performance, so with the IMOM model a new integrated way to manage the production and operation is presented.

I designed the model considering several elements that in literature are treated individually, but in the real world they have to work together. Also, my experience as an employee and consultant in manufacturing companies has provided me with a background that has let me add particular characteristics to the model.

The model was validated through an implementation of the model in a medium size Mexican manufacturing company, and findings led the model to align four operational elements to the customer expectations and needs. The four technical elements of the model are: Hybrid Production System, Integrated Process between departments, Inventory Replenishment Policy and Information System. Three soft elements of the model were found to be protagonists for the success of the operational elements. The social elements are: *Leadership, Organizational Culture and Team Work.* Social elements aim to support the success of technical elements in order to allow manufacturing companies being more competitive and productive in domestic and international markets.

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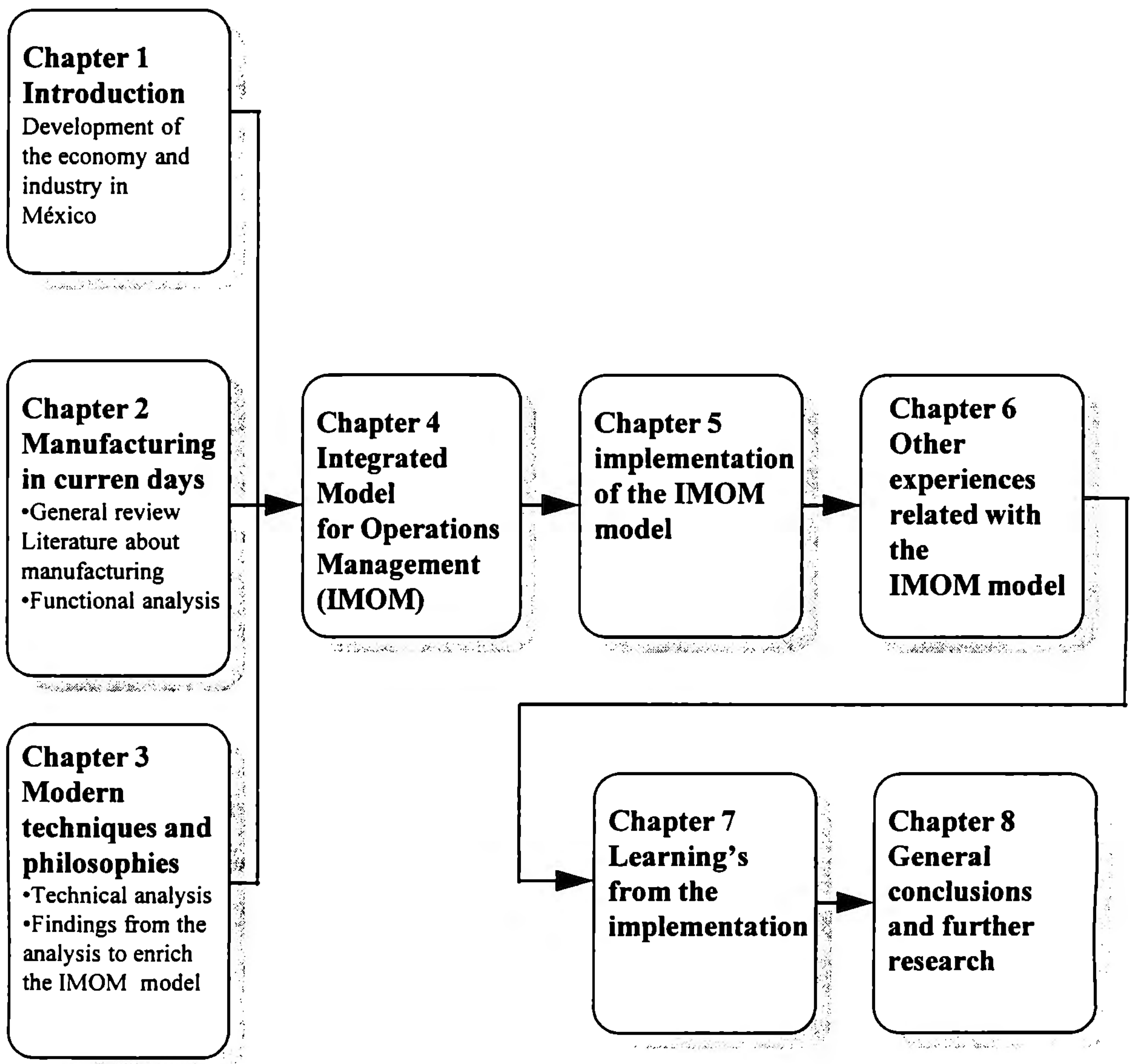
EXECUTIVE SUMMARY OF THE THESIS (graphical representation of the thesis)



DESCRIPTION AND JUSTIFICATION OF EACH CHAPTER

CHAPTER 1. DEVELOPMENT OF THE MEXICAN ECONOMY AND INDUSTRY

This chapter aims to clarify the real situation of the Mexican economy and the current situation that Mexican companies are affronting. Real problems and challenges also are covered in order to have an integrated vision to present a effective solution for the small and medium sized Mexican companies.

CHAPTER 2. MANUFACTURING IN CURRENT DAYS

Due to the relation of the study with the operation management world, it is important to know the different approaches, and new research. Some analyzed areas are: process management, team work, Systems Approach, manufacturing and quality. I could mention strengths and weaknesses on these themes for example lack of a global vision of the business, great difficult to work as a team, lack of integration, poor definition of the tasks, and functional approaches.

CHAPTER 3. ANALYSIS OF THE MODERN TECHNIQUES AND MANAGEMENT PHILOSOPHIES

The difference between this chapter and chapter 2 is basically that in chapter 2 publications related to several big areas of Production and Operations Management are analyzed in order to found opportunity areas for research. In chapter 3 the current techniques and philosophies are put altogether in a matrix comparing them with several activities of the IMOM model. With this chapter we would be able to answer questions such as "How" and "what" found in chapter 2.

CHAPTER 4. THE INTEGRATED MODEL FOR OPERATIONS MANAGEMENT (IMOM)

After the developing of the last three chapters I would be able to build a model that really integrate the different functional areas, that most of the times work with local objectives (poor integration). At the end of the chapter a model (IMOM) and its performance measures are ready to be implemented in a manufacturing business.

CHAPTER 5. VERIFICATION AND IMPLEMENTATION

This chapter shows an explain an implementation of the IMOM model using a real case of a small sized Mexican manufacturing company. Some good or not so good results came up. An implementation and the follow up of any project for improvement need something else than a good model.

CHAPTER 6. OTHER EXPERIENCES

In order to provide more feedback to this thesis, this chapter presents others experiences from companies that implemented some elements related with the model developed in this dissertation.

CHAPTER 7. LEARNING'S FROM THE IMPLEMENTATION

Some times is not easy to prove a technique or model, and when it is possible, most of the times the feed back helps to improve what we have researched. In this case I will explain what happened during the implementation and what needed to be modified or added to the IMOM model. Also is explained different actions taken for the improvement of the companies examined. Once the feed back is well handled, a methodology for the implementation of the IMOM model is suggested to warranty a good success during its implementation.

CHAPTER 8. CONCLUSIONS AND FURTHER RESEARCH

KEY WORDS

- HYBRID PRODUCTION SYSTEM. Production strategy combining a Kanban system, using the advantages of MRP II and the excellent concepts of the Theory of Constraints
- IMOM. Integrated Model for Operation Management
- INPRO. Integrated Process based on a map using data flow diagrams
- JUST IN TIME (JIT). A management philosophy based on a Pull Production System
- MRP II. Computer support system for Manufacturing Resources Planning and control
- THEORY OF CONSTRAINTS (TOC). A management philosophy based on bottleneck management
- GROUP TECHNOLOGY(GT). An engineering and manufacturing philosophy that identifies the physical similarity of parts (common routing) and establishes their effective production.
- VALUE ADDED. In current manufacturing terms, is the actual increase of utility from the customer point of view during the transformation process of raw materials until the finished good is delivered.
- CYCLE TIME. It refers to the length of time to produce an article from the raw material acquisition until the finished good is delivered in customer's dock.
- DRUM-BUFFER-ROPE: The generalized technique used to manage resources to maximize throughput. The drum is the rate or pace of production set by the system's constraint. The buffers establish the protection against uncertainty so that the system can maximize throughput. The rope is a communication process from the constraint to the gating operation that checks or limits material released into the system to support the constraint.

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1. INDUSTRIAL AND ECONOMIC DEVELOPMENT IN MEXICO

1.1 Introduction

The purpose of this chapter is to provide an understanding of how the current situation of the Mexican enterprises is. Will be presented in section 1.2 the development of the Mexican economy and some explanations about the reasons of our current situation, which explain its close relationship with current manufacturing company's situation. In section 1.3 the current situation of the Mexican enterprises is described and the barriers for its development. Those barriers are the challenges that companies need to confront sooner or later. Section 1.4 is going to present the need to develop a new way of operations management strategy, that is, promoting actions based on the global situation of the manufacturing companies instead of thinking locally.

1.2 Development of the Mexican economy

"1995 will be a year of adjustment ..." Ernesto Zedillo Ponce de León President of Mexico. This declaration is a tacit admission that 1995 will be characterized by contractions in economic growth, rising inflation and null access to credit. In business terms, this means a decline in profit margins, acute unemployment, bankruptcies all across the private sector, low stock market performance, and higher debt servicing costs. The financial crisis brought about by the currency collapse in December 1994 has not diminished by the wake of strong emergency initiatives to neutralize a nervous market, including the availability of extensive credit lines. This implies a severe contraction of credit. In a word, the challenge in 1995 is: survive (Salinas León, 1995).

At the beginning of 1993 only 15 % of the small and medium sized Mexican companies had taken care of productivity and competition issues in the last four years(El Norte, 1993). That means that currently there are many companies missing the tools and technology for being competitively and productive. Actually, the entrepreneur community talks about strong competence, because most of the companies have serious problems due to lack of cash, decreasing markets, high operational cost, war prices, etc., but really a few of them have taken care of up dating their management and operational systems with new technologies in order to reduce their problems, or at least to know how to be competitive and productive with these constraints (Flores, 1997).

On the other hand there are a lot of options for tools and management philosophies to improve the companies (Goldratt[1], 1991), but these options are confusing to the directors and managers of the enterprises. That's why some of them say "it didn't work", "I don't think this will help my company" or "I don't want to change my enterprise, it is making money". The way it is that most business men don't really know how to implement new technologies, what they really need to change, to what to change and they don't realize that they can make three times more money than now. These arguments are talk about the requirements for a new **business culture**.

Through several years our economic activity has been transformed, and we are now considered a great alternative in the manufacturing area, even when we don't have advanced technologies. In regard to the service enterprises, we are being invaded by our NAFTA partners, lecturing how to perform a quality service.

The arrival of products from the Asiatic tigers, is bringing chaos in to the Mexican producers. Their prices are so low, even though we say "our labor is not expensive". Some these imported products have very low quality, but any way the Mexican market is altered.

[1] Goldtatt's book "The Race" explains how the business world has been invaded with too many tools which promise better results for manufacturing companies, but they finally confuse managers.

The current economical situation of México requires strong companies. These companies should be able to compete in the local and international markets.

The only way to do this is by having a productive and competitive companies from the international point of view, this means, world class companies. Also the strategies must be considered in the short, medium and large periods.

The rules of the game have been changing, and to be more productive and competitive now and in the future, it is necessary to identify the current situation in Mexican enterprises , and take actions according to this local and international situation. Figure 1.1 presents how the economy and the industrialization have been changing through the times.

Tomorrow	**?**	**?**	**?**
1990	• •New laws •Nothing happening	•Fast deliveries •Quality service •Flexible production	•Personal quality
1980	•Poor management	•MRP II •Information technology and NC machines	•Quality service
1970	•Reforms	•Just In Time •The quality phenomenon (TQM)	•More companies
1950	•New technology	•Production lines •Mass production	
1900	•The labor was focused on the agricultural issue	•The industrial revolution begins •Perfection of the industry	
	AGRICULTURE	INDUSTRY	SERVICES

Figure 1.1 Transformation of the economical activities in México (Flores, 1997)

Figure 1.1 shows the big importance of being aware of how the industry is changing, and what are the new rules for competitiveness. This knowledge will allow the enterprises focus on the right direction.
In 1982, Mexico was one of the most protected economies of the world; today, it is one of the most open economies. This means that companies which have survived competition have the flexibility to adapt to difficult situations such as those presented for 1995. In 1982, 78% of exports were derived from only one product: oil. Today, manufacturing goods represent 82% of all sales abroad.

The management of production resources is critical to our productivity growth and competitiveness as a nation. As president Zedillo mentioned (Time, 1995), productivity is one of the priorities for achieving a successful National Development Plan for the next five years and realizing a higher growth.

1.3 Current situation of the Mexican enterprises. Barriers for their development

"The objective of the industrial development is to meet permanently rising social needs under the least possible expenditures of human labor and work spent on that development". This phrase presented by Grudzewski and Roslanowska (1981), could be followed by managers and leaders in the industrial sector. I would like to take in to account for the development of this chapter, the next statement of what is understood by industrial development:

> *"The industrial development ought to be meant as the effect of human actions oriented toward the accomplishment of a system of goals selected by a certain social system, and realized by appropriate strategies in the living conditions of the community which would allow to use in the most effective way the capabilities, capacities as well as material and human labor resources being at the disposal of this community."* Grudzewski and Roslanowska. (1981)

Human actions, accomplishment of system's goals and the community are going to be considered as an essential part of this thesis.
The development of this thesis will be focused on the small and medium sized companies installed in Mexico. The micro, small and medium sized Mexican companies represent a very important part of the Mexican economy, 99 % of the enterprises. They also provide 78 % of the employment (INEGI, 1994).

Small and medium sized companies have similar characteristics regarding the way they are managed, so some features about them are important. A small business is characterized (Bernett and Macness, 1983) by:

- A lack of specialist services to advice management
- Usually only one or two people involved in significant decision making
- A lack of senior firm for the senior men to think about the development of the firm
- It has relatively a small share of its market
- It is managed by its owners or part owners in a personalized way

Even this classification is made in the UK, those characteristics are similar to the Mexican small firms. I would like to include some characteristics to well define the Mexican small companies: (1) Little empowerment, (2) Non export oriented, and (3) Low technology level. In regard to the medium sized business, they have similar characteristics as the small ones, but differ from the structure. Some of their characteristics are: (1) it has a formal organizational structure, (2) It has a regular market share, (3) Moderate costs, and (4) Regular or good quality (INEGI, 1994; Aggarwal, 1997).
For purpose of this thesis, I will consider the classification size of companies as Professors Grudzewski and Hejduk purposed for the Polish companies[2]. This classification is shown in

[2]In the National Institute of Statistics, Geography and Information (INEGI) in Mexico the classification for the small and medium sized enterprises is mainly represented by less employees compares with the Polish Classification, but for research purpose is more reasonable to consider the Grudzewski and Hejduk's (1997) approach.

table 1.1, and it only represents part of her paper published. I will Describe the small and medium companies in the industrial sector as follow:

Industry sector	**Class division by number of employees**
Small	from 49
Medium	50 - 499
Large	500 and more

Table 1.1 Classification of business size by number of employees

The Mexican government is working hard in order to support the small and medium size companies (Salinas León, 1995). Several institutions were opened to provide financial support, information about exports and consulting. Unfortunately these services don't have the quality and the speed that companies would like to have. Other private institutions like business associations or chambers are providing similar support services as the government institutions, but both private and government institutions, most of the times, are focus in problem solving of external productivity factors (see section 2.2 of chapter 2 for details). Internal productivity factors (Santarek, 1996), most of the times, are ignored or considered to have little importance to the government, the private chambers and business men, and these internal factors are essential to increase competitiveness and productivity in the companies. To explain this lets consider three similar companies that compete with the same product and they have the same equipment and machinery. Two of the companies are local ones, and the third is a foreign company. The company with the biggest market share is the one that master effectively the operations and production (internal factors), taking in to account external factors.

Several tools have been developed in last years as Total Quality, Just In Time, Theory of Constraints, continuos Improvement and more, but unfortunately the expected results have been dispersed, and they go from great successes to great cracks. This doesn't mean that

some tools work and other don't. The necessities of the Mexican enterprises have required several modifications in the application of these tools, and sometimes they disturbed their core objectives.
Another common problem in Mexican companies is the paradigms and inertia of the past which blocks the actualization to the real and current business world. For instance, companies force their people to get high volumes of production in order to be more "productive", this is correct if the market is demanding it, but if not high inventories will be obtained.

A great part of nation's economy, is based on its level of production. We may say that Mexico could be a strong country, but it will need a great amount of investments that pulls the productive development, as a consequence, a big production level. The current enterprises are affording new challenges, because in the past the words productivity and competitiveness were out of our dictionary. Now a days they are still confused for some managers.

The globalization of markets and the economical crisis of 1995 are affecting the Mexican companies as follow:

1. Most of the companies are being forced to consider that competitiveness and productivity are essential to stay in the business
2. Unemployment
3. Low technology level in enterprises
4. The domestic markets are constrained (low earnings by Mexican citizens)
5. The operational conditions are not in equity compares with other countries, because the interest rates for loans are high, taxes, etc.
6. The Mexican enterprise is searching new markets. That's it, they are forced to become export companies.

In the other hand, the internal problems of the Mexican enterprises are also affecting their development. Some of the typical problems found in the Mexican companies are as follow (Flores Castro, 1995a):

⇨ The decision making process in concentrated in the owner or director a the companies. Poor empowerment
⇨ Resistance to chance (in all levels of the organizations)
⇨ Lack of a global vision by the employees of the organizations
⇨ Lack of integration
⇨ Management by crisis (a lack of global vision makes everything important)
⇨ Little strategic planning
⇨ Passive focus on customer
⇨ Lack of continuity in the improvement projects implemented

Taking in account the internal problematic of enterprises, I will describe the some challenges (Flores Castro, 1995b) for the Mexican manufacturing companies:

⇨ Fast changes in the business culture. (commitment in continuos improvements process)
⇨ Take advantage of the Mexican creativity by leading it in the right way
⇨ A real focus on customer satisfaction
⇨ Effective use of technology
⇨ Continuos seeking of integration and communication between employees
⇨ Share a global vision with all the employees of the company

As we can observe, the industry in Mexico is having new challenges, the only way to be in the game is by increasing productivity and competitiveness. There a lot of ways to achieve it, one is by receiving help from the government, and the other is by improving internally. The second choice is the hands of the business men. The goal should be searching profit now and in the future, and to reach that goal is in function of the customer satisfaction, and to get the customer satisfaction, requires that the companies work adding value to customer by providing quality products, price, service and fast deliveries.

1.4 The need of developing a new strategy for operation management (local vision vs. Global)

One of the main internal problems that has most of the companies is the short vision of the organization. This has to be changed by having a global vision of the company. Solutions are now considering global impacts. In chapter 2 this is going to be explained in more detail. In order to manage effectively the operations a new vision of the company has to be adopted as presented in figure 1.2.

Strategic vision of a world class manufacturing company

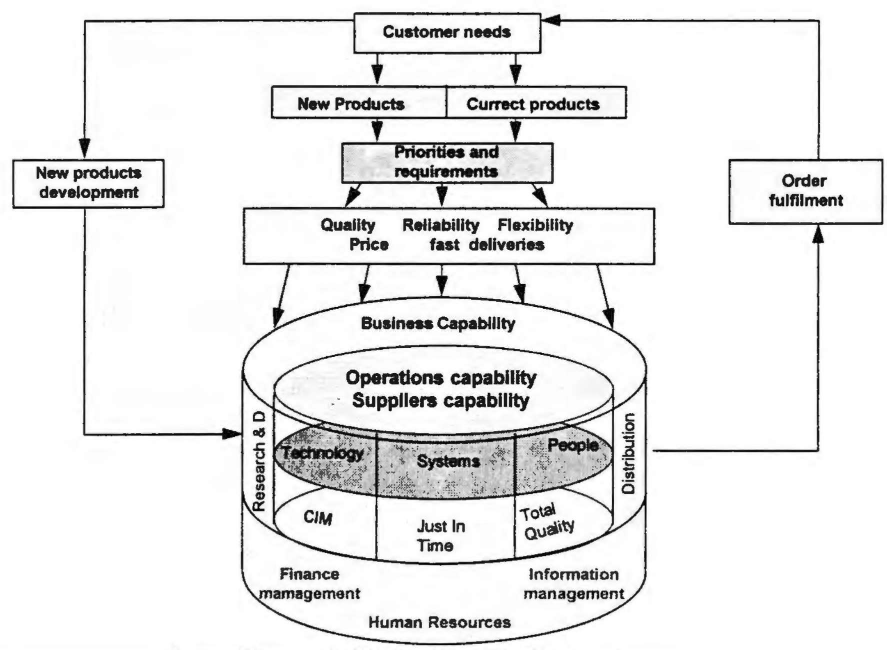

Figure 1.2 A new manufacturing strategic vision (Chased and Aquilano 1995)

Figure 1.2 shows the priorities linking into an enterprise capabilities "barrel" since operations cannot satisfy customer needs without the involvement of Research & Development and Distribution and without direct or indirect support of financial management, human resource management, and information management. Given its performance requirements, an operations division uses its capabilities (as well as those of its suppliers) to achieve those requirements, that is, to win orders. This capabilities include technology, systems, and people. IS (Information Systems) like MRP II(Manufacturing resource Planning), JIT (Just In Time) or TOC (Theory of Constraints), and TQM (Total Quality Management) represent fundamental tools and concepts used in each of the three areas. A good operations strategy is that it sees capabilities as supporting what Hayes and Pisano term the intended direction of the firm, not just its current situation (Hayes and Pisano, 1994).

Every organization is complex human system, with its own characteristics, culture, and with a system of values which determinate the information systems and the work procedures. All this set of variables have to be continuously observed, analyzed and improved in order to achieve productivity by sharing with all the people in a company the global vision (holistic systems approach).

CONCLUSION OF THIS CHAPTER

It is very important that Mexico has to be capable to export quality products and also learn to think in strategic terms (competitive). But we have to reflect, more than everything else, in productivity and competitiveness. The necessary competitiveness implies an orientation of the future behavior. The generation of innovate ideas that add competitive advantages need openness, freedom, incorporation of sciences and technology; involves and demand dynamic enterprises and innovated processes. Finally, the economic policy from the government needs to be combined at the same time with the industrial and technology policies to provide an autonomous development of the Mexican economy that provides good response welfare demanded by the society.

The next two Chapters (2 and 3), will cover the literature about operations management and the new management tools that in combination with chapter 1 will allow me to generate the model purposed in this thesis (chapter 4).

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2. MANUFACTURING IN CURRENT DAYS

2.1 Introduction

In chapter 1 the real industrial and economic situation of Mexico was presented as an evidence of how we are and what we need to improve. Also, we cover the typical development barriers for the small and medium sized Mexican companies. Finally, the need of a global vision instead a local one was presented as a strategy to manage the production and operations of manufacturing companies.

Through this chapter, I will describe in section 2.2 that Production and Operations Management are the core driver for this dissertation, and the issues of competitiveness and productivity are the final targets that have to be impacted with the output of this thesis. In section 2.3 a literature review will cover aspects like manufacturing and its implications in production, quality, operations management and business strategies. What I have learned through my experience as a professional, is that we have to take in to account all elements related with manufacturing organizations when we are performing a task. At the end of this section (see 2.3.1), I will conclude with the short comings of the literature. Section 2.4 will develop a functional analysis between the Sales, Production and Materials Supplying activities, demonstrating how they usually seek local objectives. The functional analysis together with the shortcomings from section 2.3.1 will lead to the hypothesis of this thesis shown in figure 2.6. This chapter and the next one will be linked to drive the output of chapter 4.

2.2 Production and Operations Management (POM)

When I came up with the idea of developing the theme of this thesis, I hadn't realized how big was the relation with the POM discipline, so now I realize that I am going into this field. The next subsections will describe what is understood about POM and then an analysis about competitiveness and productivity will be developed. Even competitiveness and productivity are affected by both internal and external factors, I will focus on the internal ones as an attempt to at first improve the interior of the organization. Obviously, the external factors have to be taken in account when I talk about a holistic approach.

2.2.1 Understanding POM

The history of Production and Operation Management discipline has been integrated from Taylor's approach to management till the current wave of Total Quality Management. I consider that the work of this thesis is very related to the Operations Management (OM) area because it covers most of its components. OM can be defined as the design, operation, and improvement of the production system that creates the firm's primary products or services (Chase & Aquilano[1], 1995). OM is also defined as the leader of the transformation process, which convert the inputs (land, assets, labor and management) in the desired outputs as goods or services (Adam & Ebert, 1991). OM is frequently confused with operations research, management science and industrial engineering. Operations Management provides a systemic way of looking at the organizational processes (the firm as a whole).

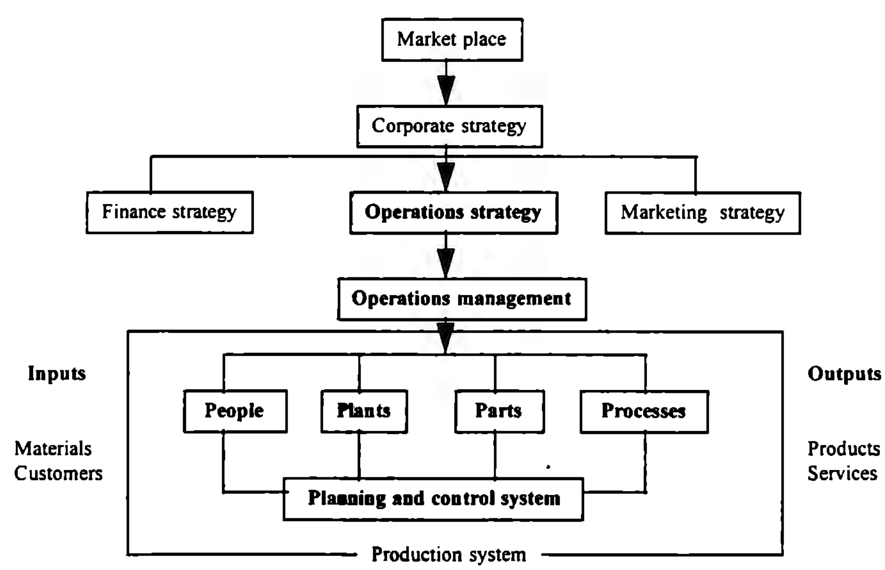

Figure 2.1 Operations Management as a function (Chase & Aquilano, 1995)

[1] Chase and Aquilo's book " Production and Operations Management", 1995, is considered one of the most complete issue about Operations Management Discipline.

The heart of OM is the management of the production systems. A production system uses operations resources to transform inputs into some desired output. An input may be a raw material, a customer order, or a finished product from another system. Figure 2.1 show how Operations Management is considered inside a organization (Chase & Aquilano, 1995). Operations resources consist of the five P's of operations management: People, plants, parts, processes, and planning and control systems.

2.2.2 Competitiveness and productivity

This section will describe two important elements for the success of manufacturing companies: productivity and competitiveness. It's important that they get to be impacted upon with the implementation of the model developed in this thesis.

At first I would like to talk about the drivers for improvement in most manufacturing enterprises. There are four strategic indicators (Johansson and Pendlebury, 1993) for a manufacturing and service enterprises: the quality of the product, service, cost and delivery time.

For the purpose of this thesis ***Quality*** refers to the physical quality of the product. ***Service*** refers to the attention provided to the customer that includes the order fulfillment process, receiving the product in good conditions, and service needed after the sale (technical support, warranty, etc.). ***Cost*** refers to normal operational expenditures as design, engineering, distribution, inventory, materials, quality assurance, etc. That is anything that can reduce customer's cost. The last one, ***Cycle Time,*** that is the time required to fill an order since the customer asks for the product until he receives it. The cycle time or lead time is normally accounted by the following steps: (1) Time for processing an order, (2) Time to produce the order (if the product is not on hand), and (3) Time to deliver the product from the warehouse to the customer dock.
These indicators, as shown in figure 2.2, are strategic weapons in the current business situation and can improve productivity and competitiveness, even more, with the opening

of global markets. We also need to consider that each company should have its own market share defined. Unfortunately, in Mexico, we are only addressing two of these indicators: Quality and Cost (REFORMA, 1994). Regarding service and delivery time we are behind, compared to international standards. There are few Mexican companies that successfully handle these four indicators (Flores Castro, 1995).

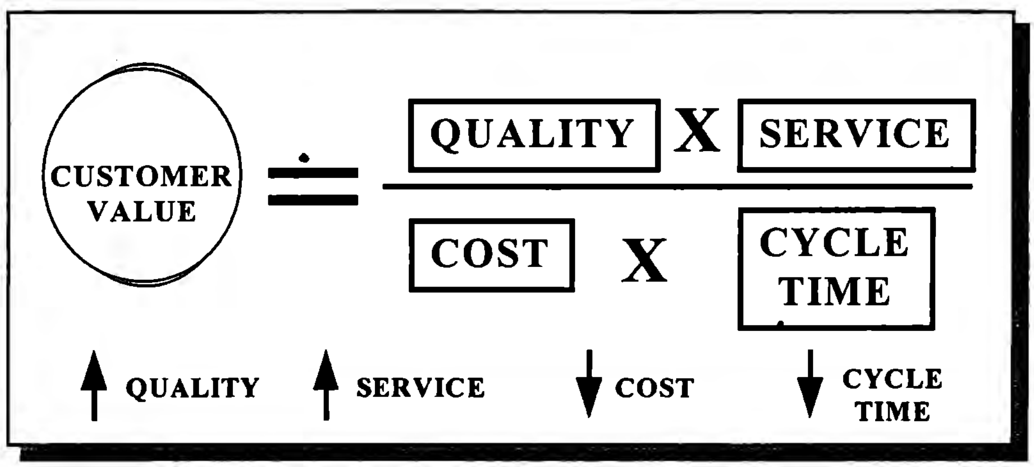

Figure 2.2 The criteria equation for customer value (Johansson and Pendlebury, 1993)

Adding customer value is to talk about Competitiveness, but I consider important to analyze and understand what is behind this concept. Competitiveness is a term that is often used but rarely defined. Managers talk about discovering and strengthening competitive advantages, Mexico bemoans its lack of competitiveness in world markets.

Competitiveness is about winning. Firms within a given industry compete with one another for market share. Nations also compete with one another for shares in the global markets. In 1985, the president's council on Industrial Competitiveness (Chase and Aquilano, 1996) offered this definition of international competition:

Competitiveness for a nation is the degree to which it can, under free and fair market conditions, produce goods and services that meet the test of international markets while simultaneously maintaining and expanding the real incomes of its citizens.

An other approach more related with manufacturing companies (Stoner, 1996), considers some elements used by the customer in order to evaluate competitiveness:

- *Quality (Q)*. Meet the quality standards of the product and customer expectations
- *Opportunity (O)*. Deliveries on time and shortest lead times as possible
- *Price (P)*. Universal measure
- *After sale service (AS)*. Warranties
- *Technology (T)*. Support for the processes
- *Ecology (E)*. Nature caring

In the other hand, Schmenner (1993) says that competitive demands that can be placed on manufacturing, can also be classified in three different groups: (1) product-related concerns, (2) delivery-related concerns, and (3) cost concerns. Which of these competitive demands takes priority, at company, they depend on several forces: the economy of the industry, particular competitive pressures, government regulations and incentives, the company's own resources, and the company's culture and attitudes. What is important to recognize is that operations can be subject to different, and changing, competitive demands. According to Porter (1982 and 1996), competitiveness is a differential advantage from one company to another, it means, that the essence of a competitive strategy is choosing to perform activities differently than rivals do. In my opinion, it depends more on the company's culture and attitudes. The above arguments from Stoner, Schmenner and Porter will be taken in to account for the development of the model in this thesis.

Productivity is often discussed along with competitiveness. Productivity is the relationship between products produced and sold (system output), and factors used in production (system inputs).
This is represented as follow:

$$productiviy = \frac{outputs}{inputs}$$

In my opinion the above measure of productivity is not useful enough for operational purposes, so for the purpose of this thesis I will consider the follow definition of productivity:

PRODUCTIVITY- the key of business profitability-is the result of how we manage the process for producing goods and services and is driven by implementing innovations in both products and their customer delivery process. (Gregory Watson)

Productivity measures the return on investment. Productivity measures both efficiency and effectiveness, and can result from downsizing (eliminating jobs), upsizing (adding workers, jobs, etc.), doing different things (new products or services), or doing things differently (new or changed business or work process)

There are several factors that affect the productivity of an enterprise. These factors can be classified as internal or external. Through the history of the Mexican enterprises the external factors have affected too many companies, but no special attention is paid to the internal ones, so they can be managed and controlled by the company itself, Even External factors affect competitiveness. Figure 2.3 represents the enterprise's productivity factors. For the purpose of this thesis and regarding operations management, I will consider only the internal factors, that is, hard and soft factors.

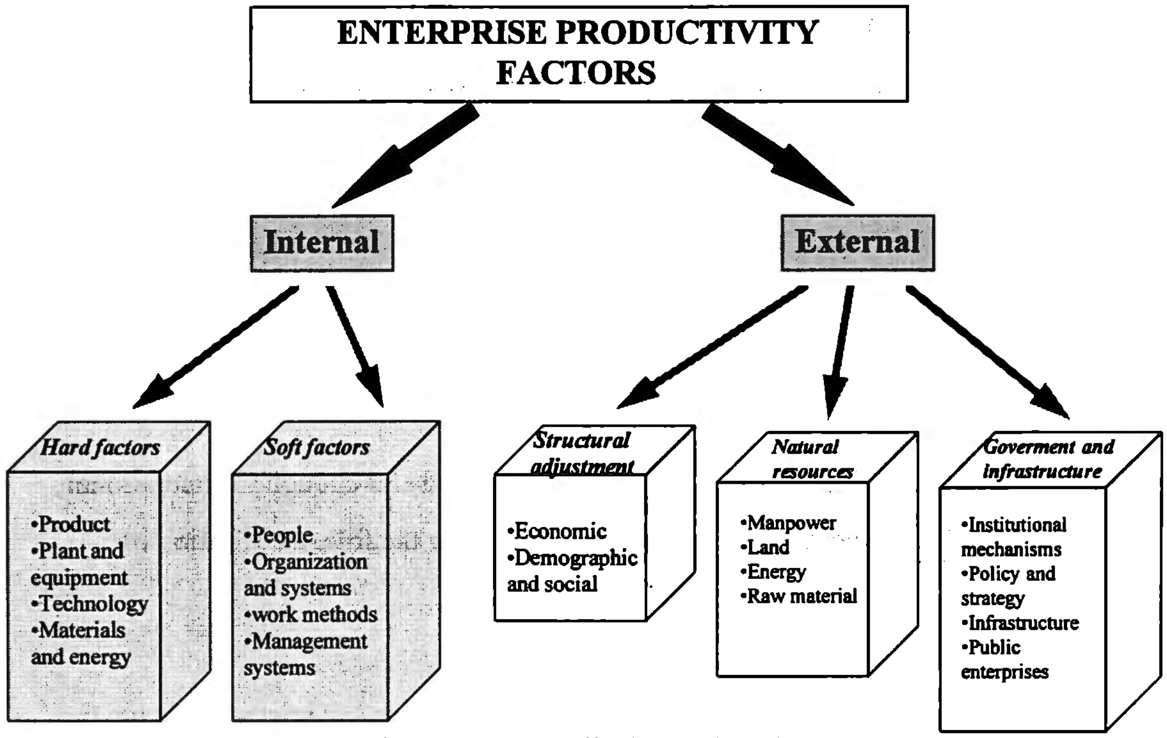

Figure 2.3 Factors affecting productivity
Adapted from Krzysztof Santarek, Productivity Improvement Programs, 1996
(source: Prokopenko J., Productivity Management, Geneva 1987)

Mexico is not as competitive as we would want. According to the Economic World Congress celebrated every year in Davos, Switzerland, Mexico was in the 26th place as a competitive country around the world in 1994, (REFORMA, 14 of October 1994). In 1996 Mexico drops till de 42nd place, and in 1997 is in 40th place (REFORMA, 26 of March 1997). Of course more global indicators are needed to verify that position. Delivery time and services are not the best weapons that Mexican companies have, and most of the times, they represent key activities to accomplish a sale.

2.3 Manufacturing based on literature

Literature research about manufacturing is a broad field almost impossible to cover in a few pages, but I would like to point out some topics related to the manufacturing value [2]chain; business strategies; Systems Approach to Management [1]; production planning, control and

[2] The Systems Thinking approach is not necessarily an area strongly related with manufacturing, but its importance in current business problematic command its analysis (Flood and Jackson, 1991)

scheduling; and Total Quality Management. I am not trying to make a classification of the manufacturing approaches, I just want to put this section in a easy way for better reading comprehension.

Some of these topics will be covered in combination with others in this section (2.3), and some as: JIT, TOC, TQM, BPR and MRP II will be covered and analyzed individually in chapter 3. We would find some of these topics in this section because of their relationship with the literature analyzed. The reason to separate the chapters about literature (chapter 2 and 3), is because the model developed in this thesis is going to be enriched with a technical review of some specific techniques (chapter 3), and the opinion of authors about literature related with this work (chapter 2).

MANUFACTURING VALUE CHAIN (LOGISTICS)

Senior-level materials managers notice consistently that their firms' critical strategic objectives require greater co-operation among the different value-added functions (Stanley & Stanley, 1995), so fulfilling the customer service requirements occurs as the firm creates customer value, which is best done by bridging functional barriers and managing firm resources as a series of interrelated flows and process.

The materials management functions of purchasing, operations and logistics are then considered and the four decision areas - infrastructure, materials, technology and people - that are common of these functional areas. This should be the way to see the chain by each of the functional areas, but in reality this is not happening (Goldratt, 1994).

Three reasons why companies struggle in their quest to fulfill customer expectations are: they possess a myopic vision of customer service; the fail to make the link between utility creation and customer value; and they organize functionally, creating barriers to the development of strategic capabilities (Hicks, 1996; Stanley & Stanley, 1995).

Meeting customer's real needs has been identified as the key to competitive success. Unfortunately, few companies excel at achieving high levels of customer service. In fact, the concept of customer service is frequently misunderstood and often poorly defined at even leading companies.

Stanley (1995) has develop three classifications about customer satisfaction:

- customer service (meeting the establish performance standards. Internal measures)
- customer satisfaction (eliminating the gap between internal and external measures)
- customer success (the knowledge of downstream requirements is used to provide a "better" produce/service mix - a mix that will lead to enhanced competitiveness for the customer). As one CEO notes,

"We turn our customers into winners. Their success is cash in our bank".

The role of the strategy is to direct the firm's use of resources so that the most important objectives are achieved. This role is meant to reduce the physical and psychological distance that separates the firm and its customer.

The main challenge in the strategy selection and management processes is to ensure that a consistency of purpose is achieved throughout the firm so that all the activities, regardless of their functional positioning, work together to accomplish the targeted goals. That is the role of the value-added functions as Purchasing, Operations and Logistics in meeting customer's needs (Stock and Lambert, 1987; Ballou, 1985).

BUSINESS STRATEGIES

According to Hayes and Pisano (1994), companies have different strengths and weaknesses and can choose to differentiate themselves from their competitors. Similarly, different production systems, the composition of decisions in a number of key areas, have different operating characteristics; and therefore rather than adopting an industry-standard production system. They argue that the "task" for a company's manufacturing organization is to configure a production system, that, through a series of interrelated and internally consistent choices, reflects the priorities and trade-offs implicit in its competitive situation and strategy. The trends on strategic planning consider as a very important element the Vision of a company, because the organization needs to be pulled by something. Collins and

Porras (1996), say that a well-conceived vision consists of two major components: *core ideology* and *envisioned future*. The core ideology provides the glue that holds an organization together through time. Core ideology consists of *core values* and *core purpose*. Core values are the essential enduring tenets of an organization., and core purpose is the organization's reason for being. Collins and Porras (1996) also say that a way to discover the core ideology is by looking inside. It has to be authentic. Envisioned future consists of two parts: a 10-to-30 years audacious goal plus vivid descriptions of what it will be like to achieve the goal.

Peter Senge (1990) with his approach in the learning organizations issue, describes the new roles, skills and tools for leaders who wish to develop learning organizations. It is based on his published book The Fifth Discipline: The Art and Practice of the Learning Organization. The prevailing view of learning organizations emphasizes increased adaptability. According to Fortune magazine "the most successful corporation of the 1990's, will be something called a learning organization, a consummately adaptive enterprise".
Leadership is another aspect considered as a very important element by Senge (1990). He argue that the traditional view of leaders-as a special people who set the direction, make the key decisions, and energize the troops-is deeply rooted in an individualistic and ***nonsystemic*** worldview. Leadership in learning organizations centers on subtler and ultimately more important work. In learning organizations, leaders are designers, teachers, and stewards. Leadership in a learning organization starts with the principle of creative tension. Creative tension means moving the current reality toward the company's vision. Senge also says that new leadership roles require new leadership skills, and this skills can only be developed through a lifelong commitment.

As a summary Senge identifies the essences as:

⇨ system thinking: holism and interconnectedness (the Fifth Discipline)

⇨ personal mastery: being, generativeness and connectedness

⇨ mental models: love of the truth and openness

⇨ building shared visions: commonality of purpose and partnership

⇨ team learning: collective intelligence and alignment

SYSTEMS APPROACH TO MANAGEMENT

The systems thinking is a wide range discipline with several approaches[3] in the field. The reason to point out this approach, is because it is a serious and well supported discipline of management sciences. The system thinking approach covers a series of areas like:

Hard System Thinking, Cybernetics, Systems Dynamics, Soft System Thinking, Emancipatory Systems Thinking and Critical Systems Thinking. When I refer to Systems Thinking it is about thinking with Holons. The Holon word is an abstract idea of a whole having emergent properties (Checkland and Scholes, 1990).

Systems Thinking takes a holistic rather that a partial for good management (Jackson, 1991 and 1995). In my opinion the argument about holisims is one of the major contributions to management sciences, so I am trying to says that this is the only contribution that we can take in account.

PROCESSES MANAGEMENT

According to an early survey (Majchrzak and Wang, 1996), I found that in order to promote collective responsibility from the employees is necessary something more than reorganizing a company. Departments can reduce cycle times by redesigning jobs with overlapping responsibilities. In the other hand, managers who aren't ready to promote collaborative culture maybe better off leaving their functional departments intact. Many managers do away with functions but fail to change their own positions. They continue to act like functional chiefs even though the functions no longer formally exist. People who

[3] For more details about the different approaches of the Systems Thinking see Lane and Jackson (1995), and Jackson M. C. (1991)

feel collectively responsible are willing to work especially hard to avoid letting the team down (Majchrzak and Wang, 1996).

If companies are not ready to take the steps required to change their culture, they may be better off leaving their functional departments intact. After all, coordination on functions can be greatly improve without reorganizing around complete processes.

Majchrzak and Wang (1996) suggest that to cultivate collective responsibility is necessarily to consider the next points:

Make responsibilities overlap. Designing jobs so that employees can at least partially perform most of the functions assigned to the departments helps create a shared sense of responsibility because people understand one other's work and thus share common language and similar constraints and objectives. More important, if a complete-process department does not make responsibilities overlap, it will end up with a set of specialized jobs.

Base rewards on unit performance. This allows to have better company results than individual rewards. A unit reward can be as follow:

- X percentage to customer satisfaction
- Y percentage to plant performance
- Z percentage to others important issues as quality, individual performance, creativity, etc.

It needs measurement and tightly monitor processes by the departments. The measures need to be done every day in order to show team performance.

Change the physical layout. The layout of a work site can either inhibit or promote collective responsibility. According to this study, complete-process departments with layouts that permitted people to see other's work had cycle times 4.4 times faster than those with layouts that didn't.

Redesign work procedures. When managers redesign their organizations, they should ask their employees what they need in order to work well together (Hammer and Champy, 1993; Johansson & Pendlebury, 1993). It means:

- shared ideas for improvement with people in other discipline
- involving everyone who would be affected by a decision
- helping others do their work

There is no single cookie-cutter design for achieving a collective sense of responsibility, so the designed processes need to be customized.

Business Processes Reengineering (BPR), that is now considered as an important POM tool (Chase & Aquilano, 1995), is changing the way business are manage. The BPR approach, attempts to change radically and fundamentally the *business processes* in order to achieve short lead times, low cost, improve service and quality (Hammer & Champy, 1993), (Johansson & Pendlebury, 1993). See chapter 3 to further details.

PRODUCTION PLANNING, CONTROL AND SCHEDULING

Is very important to review what is behind the concept of Lean Manufacturing. According to Oliver, Delbridge and Lowe (1996), Inside the factory, lean producers are characterized by just-in-time production, small lot sizes and minimal inventories. Operators on the shop floor are organized into small groups and these small groups take in many of the responsibilities that have traditionally been the prerogative of specialist support functions in mass-production factories. They explain how the Supply Chain is a manifested by tightly integrated material flows between firms, with frequent deliveries of small batches and minimum inventories, active information exchange between firms, permitting activities such as joint cost reductions, and “shared destiny” relations between firms.

A study of many plants reveals that the common factor across the world-class plants appeared to be a *process discipline and control* (Oliver, Delbridge and Lowe, 1996).

About inventories, it’s said they are a key measure of leanness, and are affected by the simplicity of productions flows, and the uncertainty of both demand and supply. Inventories may be used to protect one stage of the process from problems elsewhere.

The use of production teams in the factory is an important component of the lean production model. A second element of the lean production model involves the pushing of responsibility on the front line operators.
Visual Control covers features such as Andon lights above production lines, which are activated by operators in order to indicate a problem with the production process, and by visual and public displays of volume and quality performance.

In specific areas of POM, Thomas M. (1997) says that the traditional scheduling, satisfies a limited group of industries well. Make to stock producers apply Just In Time to continuous and discrete production lines increasing efficiency. Kanban and Zero Inventories work in a computer motherboard assembly. But JIT philosophy has severely limited the role in the one of a kind job shop. In the other hand, Linear programming (LP), the great optimizer, grants stunning success to high volume, continuous producers. LP selects the manufacturing alternative that is economically optimal or near optimal. Sometimes planners apply LP simulation to more limited exercises such as figuring the least cost combination of raw materials for a given output of the optimal transportation schedule. LP determines the best changes to make when rough-cut capacity planning detects an unfeasible master production schedule.
Finally Thomas (1997) says that success and survival in industry demands realistic, feasible manufacturing schedules .

The real scenario when applying Materials Requirement Planning systems(MRP) is that it produces production schedules based on an infinity capacity producing big conflicts in the shop floor (Leibert, 1997). Most executives in these industries claim awareness of MRP, but they have never used or investigated it further. Manufacturing Resources Planning (MRP II) has been promising a good alternative to integrate functional areas based on information systems, but experience has shown that is too complicated to implement it, putting the investments on software, hardware and training in danger.

The response time experienced by a customer is consider one the strategic weapon for competitiveness (Loveloy and Whang, 1995). It typically has several components: the time to process an order (typically handled by the sales or marketing department) , the time to produce the request item (an operations function), and the time to deliver the item (distribution).

The production system is likewise characterized by a series of production steps that must be performed in sequence, and no product is complete until it completes all steps in the process. The production lead time is the time it takes for a product to complete all of these steps, and reductions in this lead time are presumed available via improved production and control activities.

The total delay experienced by the customer is the interval between the time a sales representative takes an order from customer, and the time the order is shipped form production. It is this total delay, the result of an integrated order processing/production activity, that is penalized via the delay costs in the model proposed by Lovejoy and Whang (Loveloy and Whang, 1995).

An integrated order-processing/production system objectively minimizes the average cost per period incurred. One feature of this model is that there is a statistical correlation between orders entering the information system and the demand that will eventually be downloaded to production (which will those orders be that clear the ordering processing). Consequently, there is an information benefit (to production) for long information lead times, but an attendant cost to the firm for delaying customer's orders.

Leibert (1997) argues that in the enterprises there are two kinds of systems approaches, management focus on accountability based decisions and operations with an approach to quick actions. Unfortunately in the real world both systems have poor communication and

lack of integration. The Manufacturing Execution Systems (MES) is offering a good alternative to integrate management and shop floor operations. MES is a system based on the production flow and can be integrated with the current management systems.
MRP II and ERP (Enterprise Resource Planning) Systems were installed to help in management challenges (Gumaer, 1996). In most cases these systems address only materials management. Manufacturers today want these systems to do more. For manufacturers with big investments in MRP II and ERP systems, the competition with agile manufacturers is difficult and the solution is reengineering the corporation.

Software tools evolution: the first manufacturing applications were limited generally to inventory control and purchasing, one of these examples is MRP and MRP II packages. ERP systems represents the application of newer information technology to the MRP II model (relational database management systems, graphical user interface, open systems and client/server architecture).

Assumptions of the MRP model: MRP II systems focus primarily on material requirements using an infinite capacity planning model and these causes that MRP II can't meet the need to plan, execute, and redirect manufacturing processes in real time. All these root causes are the basis for creation of Finite capacity Scheduling and Manufacturing Execution Systems. Synchronized manufacturing integrate dynamic finite capacity scheduling with MES and obtains a real-based scheduling approach. Logistics planning have emerged into Supply Chain Management (Leibert, 1997).

The next generation solution: Supply Chain Synchronization (SCS) is a process that combines the real time execution approach of MES with advanced planning technologies. SCS is complementary to ERP and Supply Chain Management. Supply Chain Synchronization closes the loop between supply and demand. The real feedback time loop is one of the most important elements of the systems design.

Synchronization relates to MRP II or ERP : when applied together, Optimized Planning and Synchronized Manufacturing can add the following capacities to MRP II and ERP systems: a graphical modeling tool for precise a definition of the business processes, a learning-enabled optimization and simulation engine, a distributable and scaleable approach to simulation and optimization, dynamic finite scheduling and continuos rescheduling of all resources, materials management integration, continuous performance measurement for real time decision support. The result of applying a complete Supply Chain Synchronization solution is the coordination of all direct and indirect activities.

TOTAL QUALITY MANAGEMENT

According to the world class standards presented by Basu and Wright (Basu and Wrigth 1996), Total Manufacturing concerns with the complete manufacturing business that includes interactions between the conversion process of the factory with all other business processes (functions). Total manufacturing consist of several pillars and foundation stones as follow:

- Marketing and innovation: understanding market and competition, production and process innovation
- Supply chain management: manufacturing planning & work with suppliers, distribution management & working with customers, supply chain performance
- Environment & safety: product safety, industrial safety, environmental protection
- Manufacturing facilities: sourcing strategy, appropriate manufacturing technology, flexible manufacturing systems
- Procedures: quality management, financial management, information technology
- People: manufacturing skills organization, flexible working practices, continuous learning

Deming's approach to TQM (Feigenbuam, 1983; Evans and Lindsay, 1993) is based in his 14 points and I would like to remark the follow ones because they are strongly related with this thesis:

- Adopting a new philosophy
- Improving constantly and forever the system of production and service
- Institute training
- Institute Leadership
- Breaking down barriers between staff areas

An other important approach from Deming's philosophy is his focus on the system and not in individual parts. Deming also mentions in one of his points that numerical quotes need to be eliminated, so I consider that this point needs to be included in a company during the organizational process (most of the cases of Mexican companies).

2.3.1 Shortcomings and contributions of the literature

Most of current literature recommends to be aware of the value chain of an organization. Driven by competition and increased technological developments, the logistics processes of enterprises dealing with the production and distribution of end-customer goods are growing on a closer integration to form logistic chains (Slats, 1995). But it doesn't explain how to improve the value chain or how to manage it in detail. Some of the articles that came up with the aim to integrate different functional departments, that is, to focus on the business processes instead the functional areas. But again they miss on showing how to do it, even worse they don't include essential elements as leadership, processes mapping, and how to integrate and coordinate across horizontal and vertical levels.

Another problem, that I found, is that some literature goes with very general recommendations and they are not able to go down to the production shop floor and put into practice the strategies recommended.

The systemic approach has been considered as an important issue in the continuous improvement process in manufacturing firms. The contemporary English movement of the System Thinking promoted by its expertise, Mike Jackson (Jackson, 1991), is questioning the way to see an organization (the system) and the way to solve complex problems by managers. This Systemic movement has been promoting the organization holistic approach, it is, to think in terms of the whole system. Unfortunately the systems methodologies are depth in philosophy (systems thinking), that do not invite the managers to use it, even though the Systems Methodologies are well tested by the community of management sciences.

Production and Operations Management (POM) may try to incorporate the Systems Thinking, to this discipline, promising good results.
The POM from a manufacturing perspective, provides a wide range of well know tools, but is short in approaches to help effectively the small and medium sized manufacturing business.

Real time systems are racing to utilize workshop scheduling and dispatching to improve manufacturing efficiency and reliability in flexible manufacturing. Bottlenecks in the process train frustrate MRP. Constraint management sprang up in the 1980s to confront this impediment. The idea of constraint management spreads the concept of the bottleneck. Constraints may be caused by a timing problem, resource, market demand, raw material, or management policy (Goldratt & Fox, 1985; Dettmer, 1997).

The Theory of Constraints (TOC) approach is good for the bottlenecks management. TOC's primary objective is to establish a rhythm of manufacturing set by the constraint. This is referred to as the drum beat. Like Just In Time (JIT), it sets the rate of production for the entire line process or train. But JIT's drum beat is established by the demand rate, not constraint rate. Linear programming (LP) techniques may be applied to optimized product mix at the bottle neck.

The theme of This thesis can be considered as part of Deming's approach of TQM, but unfortunately he never showed us how to apply it in the real world. Short explanations, short results. Still about TQM approach, its traditional concepts and techniques are limited to large manufacturing companies (Ehresman, 1995), so the concepts and techniques are the same for any business, but the way to applied TQM depends on the business situation and conditions.

The lack of a single methodology for BPR has been producing different approaches and results when it is applied. Unfortunately less than 45% of the BPR implementations are successful (Majchrzak and Wang, 1996). It comes out that something is missing when BPR is applied. Process management and improvement need to adopt other important elements as cited in this thesis. However, BPR has changed the way to manage an organization, to focus on business processes instead of the functional areas.

Information's Systems, are now considered the lost link (Goldratt, 1990) and one of the things in today's manufacturing is that needs to be Reengineered (Stein, 1996). Stein (1996) says that the infrastructure of manufacturing information systems should be reengineered to the public domain for integrated manufacturing decision support and the shop floor and scheduling systems.

As a general conclusion of the literature reviewed in this chapter, regarding both shortcomings and contributions, I want to point out the following statements:

⇨ **Is necessary to integrate different concepts and techniques in order to provide better results for the business**
⇨ **The fads (TQM, JIT, MRP II, TOC, Senge's approach, etc.) tend to recommend solutions which they believe hold in all situations**

- ⇨ **The necessity to take in account the value chain of manufacturing systems is clear in the logistics discipline, but not in others areas as TQM and Production, it is not explained how to do the improvements**
- ⇨ **Business management must consider a holistic approach**
- ⇨ **Leadership and organizational culture are essential elements for the success of concepts and techniques for manufacturing systems. Normally those issues are analyzed independently**
- ⇨ **The production flow must be synchronized, instead of balancing the production lines. Here is where bottle neck management may help**
- ⇨ **Team working is a mandatory culture in today's operations management.**
- ⇨ **Information Systems are essential to support production activities as well as the value chain, so they are not well designed for the decision support, shop floor and scheduling.**

2.4 Functional analysis and hypothesis

In order to develop a functional analysis I will take in to account only three big activities of a company that have the greatest impact on competitiveness and productivity. Chapter 4 will justify why only these activities are considered. These activities are:

i. SALES
ii. PRODUCTION
iii. THE SUPPLYING OF RAW MATERIAL

Normally these three activities are not well coordinated to provide a fast delivery time and service for the customer (Goldratt, 1985, 1992 1994; Lovejoy & Wang, 1995). The lack of coordination seems to be due to the following symptoms: lack of raw material, frequent schedule changes, unbalanced goods inventory, slow order processing, high cycle times, high inventories, etc. (Fisher, 1997)

The question now is, *What is the relationship between productivity and competitiveness with the activities of Sales, Production and the Supply of raw materials?* Table 2.1 shows the relationships as they should work.

As we can see in table 2.1 productivity and competitiveness are impacted simultaneously, most of times, by the three activities.

	PRODUCTIVITY	COMPETITIVENESS
SALES	• Finished goods inventory levels policy	• Marketing strategies • Customer service • Promises according to the lead time of the factory
PRODUCTION	• Inventory levels policy (raw material and finished goods) • Setup reduction • Schedules according to the market needs and the operational cost of the company	• Delivery time • Schedules according to the market needs and the operational cost of the company
MATERIALS SUPPLYING	• Raw materials inventory levels policy • Suppliers development	• Raw materials inventory levels policy • Suppliers development

Table 2.1 Relationship between the three main activities (S, P, MS) and, productivity and competitiveness

A hierarchical structure of any manufacturing organization with at least these three main activities described above, is represented in the figure 2.4. The historical reason for the division of the activities is because a company needs to separate its efforts in order to achieve its objectives. But unfortunately each department became accustomed to working with local goals instead global goals(Goldratt & Fox, 1985). The sales department normally tries to provide the goods as soon as the customer needs them, but forgets that the production process has a certain capacity level and it can't respond immediately without upsetting the flow process.

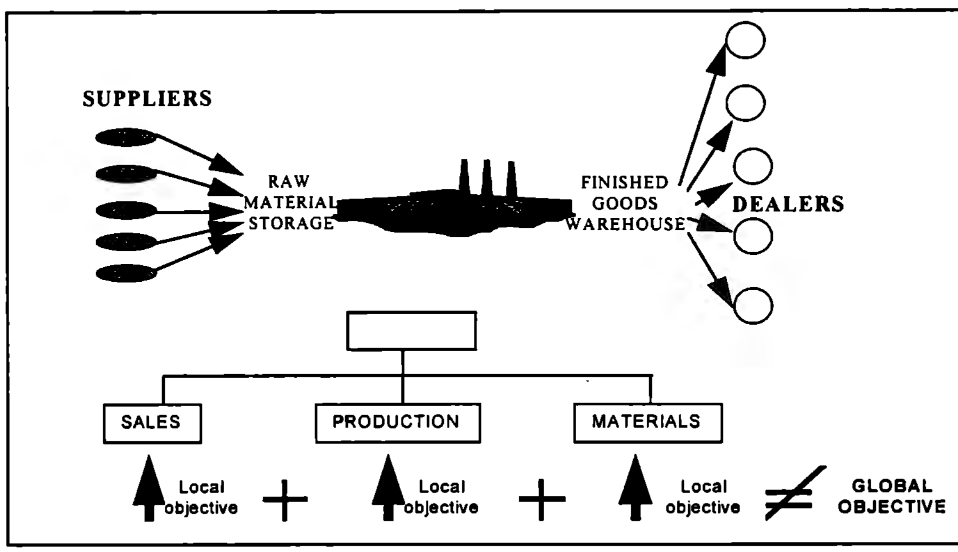

Figure 2.4. Hierarchical structure of the three main activities of a company and its individual objectives

On the other hand the production department has a utopian goal of producing as much as they can, and not taking into account whether the product will be sold. With this situation an over production happens, and the company will probably run out of cash flow. If the production department needs some urgent raw material due to an "urgency" in the sales department, the request will be refused by the purchasing department, because they will argue that the suppliers have a specific lead time and they can't respond right away. As we can see, each department has been seeking its own success, in other words, they have local goals.

The above paragraph is related to my experience working in manufacturing companies (ITESM, 1995). Part of this problem is represented with a current reality tree developed by Dr. Goldratt (see figure 2.5)

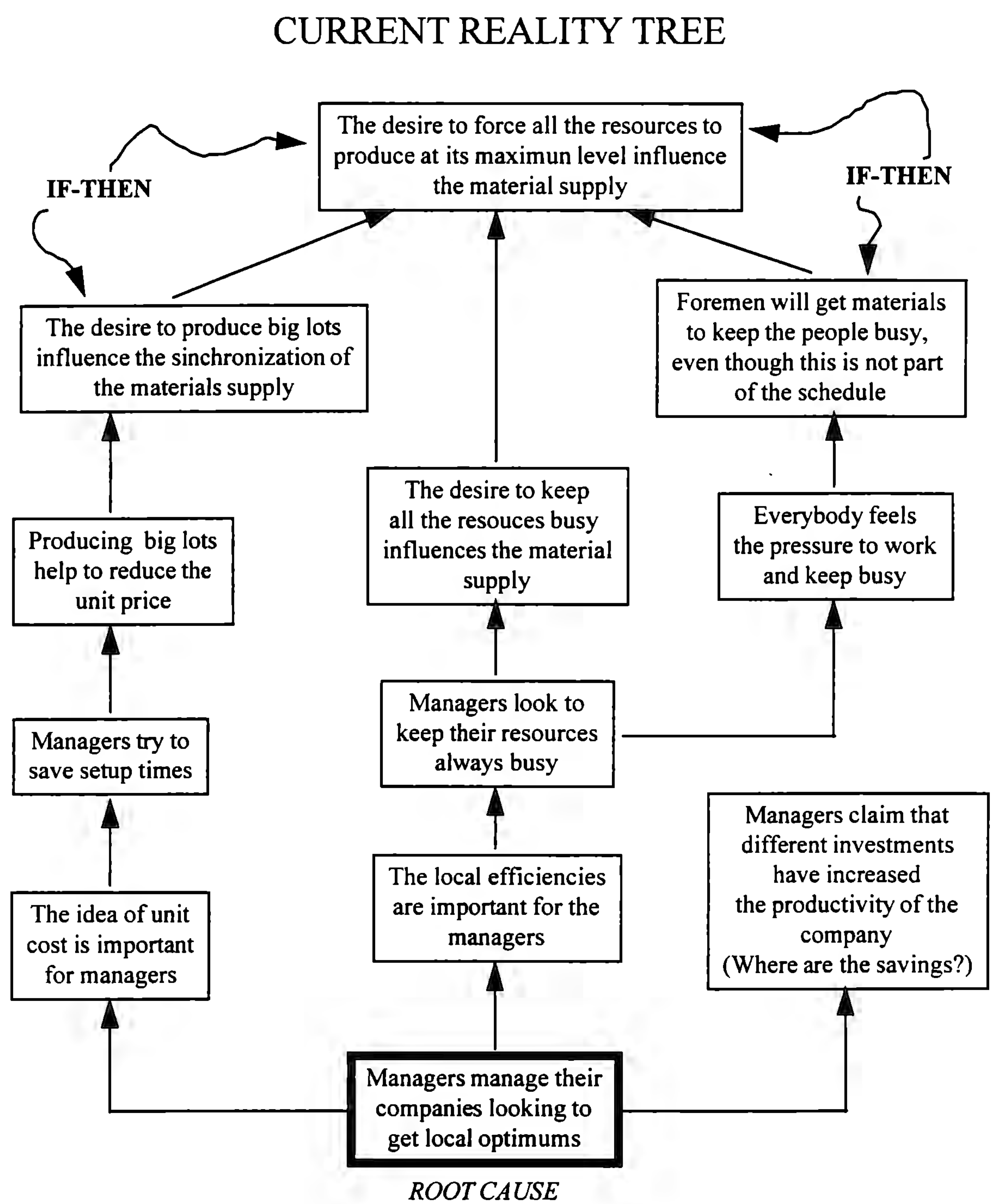

Figure 2.5. Current reality tree (EFFECT-CAUSE-EFFECT) of the lack of coordination in the Sales - Production - Materials activities (Goldratt, 1993)

The lack of integration of these three activities will cause a failure in the response to the customer's lead time and services. As a coordinator of a Reengineering research project[4] in one of the most popular Mexican companies, I found the truth about the situation, and I still find it in every intervention as a consultant (ITESM, 1995).

Putting those statements together, and in combination with the shortcomings from section 2.3.1, the hypothesis of this thesis is now stated as the necessity to create a *model that effectively integrate the Sales, Production and Materials supplying activities. (see figure 2.6)*

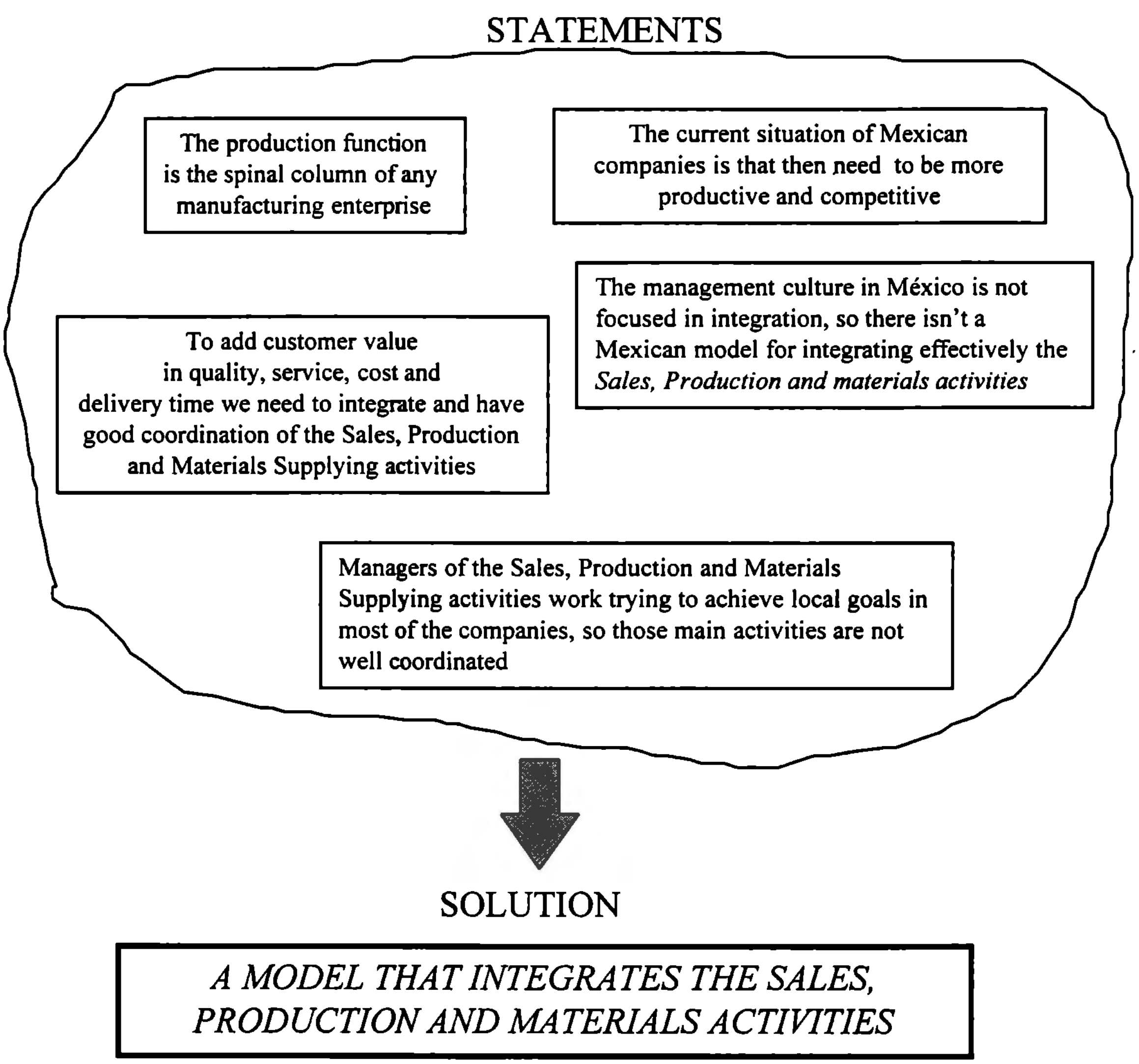

Figure 2.6. A schematic hypothesis approach

[4] Reengineering project for the Sales- Production-Purchasing Process in Canel's Co., (ITESM Campus San Luis, 1995)

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3. ANALYSIS OF THE MODERN TECHNIQUES AND MANAGEMENT PHILOSOPHIES

3.1 Introduction

In chapter 2 we went in through the literature made by authors in several disciplines as Value Chain (logistics), Business Strategies, Process Management, Production and Scheduling, and TQM. This analysis allows me to answer the question about "What to research". In the section of this chapter I will develop a description of what is behind the following techniques and management philosophies: (1) Manufacturing Resource Planning (MRP II), (2) Business Process Reengineering (BPR), (3) Total Quality Management (TQM), (4) Just In Time (JIT), (5) Theory Of Constraints (TOC), (6) Group Technology (GT), and (7) ISO 9000. The reason to consider only these tools is because they are the highly related with the conclusion from the shortcomings and contributions of the literature in chapter 2, and they are well know as vanguardist techniques used in world class manufacturing companies (Chase and Aquilano, 1995). Also in my opinion, they are the tools that need to be integrated and will contribute more in the development of the model in this thesis. In section 3.3 I will be develop a matrix that aims to relate the above tools with the possible issues contained in the model of this thesis, and then, the findings from the analysis of the matrix will be presented as the "How" of the "What" found in chapter 2. With the conclusion of this chapter, chapters 1 and 2, and I will be able to start developing the model in chapter 4. The details about the content of the model shall be described on chapter 4.

3.2 Description of the modern techniques and management philosophies related to Production and Operations Management in Manufacturing

MRP II (Manufacturing Resource Planning)

BASIS :

The concept of MRP II is "getting the right materials to the right place at the right time". (Chase & Aquilano, 1996).

The objectives of inventory management under an MRP system are the same as under any inventory management system: to improve customer service, minimize inventory investment, and maximize production operating efficiency.

The philosophy of materials requirement planning is that materials should be expedited when their lack, if so would a delay or the overall production scheduled and de-expediting when the scheduled falls behind and postpones their need.
Feedback on MRP pretends to have information about lots of production all the time.
MRP II philosophy is based on Materials Requirements Planning and adding financial functions allows executives to get data such as cash flow, cash to purchase materials and others, also it's allows several uses.
MRP implementation requires expensive software and almost 2 years to show results(Wallace, 1990).

Now the hybrid software (MRP-JIT) is the objective, but this may not be reachable because of the differences between MRP and JIT like their basis, objectives, process type, data requirements and operation.
There are three principal disadvantages of an MRP System : lack of top management commitment, failure to recognize that MRP is only software, a tool that needs to be used correctly, and the integration of MRP to JIT (Brooks, 1985).

REENGINEERING :

BASIS :

Reengineering is an improvement tool developed by Dr. Michael Hammer that has been revolutionizing the business world. Business Process Reengineering is defined as the *fundamental* rethinking and *radical* redesign of business *processes* to achieve *dramatic* improvements in critical, contemporary measures of performance, such as cost, quality, service and speed (Hammer & Champy, 1993).

In other improvement methodologies the changes are gradual, Reengineering is totally different, this may cause a great change in organization and that is the reason of executive's fear. Only it's name, Reenginnering, causes fear therefore it is important to change to other descriptions like Redesign or others.

Now days, a lot of Reengineering methodologies are being created because Dr. Hammer didn't make a methodology. Rapid Re is a good methodology of Reengineering because it shows ways to implement and gives a set of tools that may increase good results.

Why BPR ? because in this times, organizations should be flexible, lead the market, be innovative and act like winners, all this characteristics are just dreams, our organizations are rigid, give poor quality, focus in other things that not are the client, then, BPR is the motor that takes organizations into the real world. The objective of BPR is to make a flexible organization that can react to client's expectations (Cornejo, 1996).

Information Technologies play an important roll in this changes, IT promotes process integration in the organizations, results, an information for the organization that not only is automated.

Some techniques and tools used in BPR are (Rozenberg, 1996):

1. Inductive thinking

2. Flow diagrams
3. Creative process redesign
4. Benchmarking
5. Simulation
6. Specialized Software like Texas Instruments Business Design Facility and goal Software's Design/IDEF are expensive and an evaluation should be made to decide before buying.

Implementation can take 6 months to 2 years and consists of the next steps (Rozenberg, 1996):
- Making a work team with the necessary people.
- Analyzing priorities in the process to fulfill the customer satisfaction.
- Redesign of process, blank paper is common used.
- New Design Implementation

** Note : It's important to suggest fast improvement, to prevent lost of interest.

Finally, Reenginnering generally involves a System Information's change that is generated by great advantages in Electronic and Computer Machines. Paradigms are broken with this methodologies and it allows the development in the work process.

The main reasons of reengineering implementation are (Soldevilla, 1996) :
1. Inappropriate strategy
2. Assigning the best people
3. Underestimating change reaction, in this point would be considerate three actions :
- Reaction
- Communication
- Deal with opposition
4. The Team only makes the Design but does not Implement it.

TOTAL QUALITY MANAGEMENT (TQM)

BASIS :

TQM is an administration philosophy that allows improvement work methods, increase of productivity, reworks reduction, rejects and scrap reduction through continuos improvement (Feigenbaum, 1989).

Quality born in Japan (after Second World War), Dr. Deming showed Japanese a set of statistical methods (Statistical Control) that allow process control. Japanese now leads TQM, all procedures and philosophies their creation helps industry (country) development, some people like Dr. Taguchi, Crosby, Joseph Juran and others have created different philosophies but everyone tries to get a better product, process, etc..

Different points of view of TQM like process, product and last focusing on the customer (suppliers, personnel and client), show quality evolution and necessary implementation of Japanese methods in the industry around the world.

Now Quality involves a set of tools like statistical methods, 7M, 7H, Statistical Control, Sampler, QFD and others that cause the empowerment in personnel (Spitzer, 1993).

TQM is focused on the prevention of failures through the production process, that is, certifying quality of raw material, work in process and finished goods.

The idea of a total quality environment including vendors and customers as well as all personnel and operations in the firm itself will probably not be a competitive weapon, it will be a requirement!, a TQM environment with defect-free production will be an entry credential even to begin to play the competitive game(Chase & Aquilano, 1996).

JUST IN TIME

BASIS :

" I need it now, not yesterday or tomorrow " this is the principal lemma of JIT·philosophy (Hay, 1989). JIT was created by Taiichi Ohno (Toyota's Vice-president): JIT is just a combination of Administration philosophy and Production control politics (Pull Production System).

The basic principles of JIT are (Hay, 1989):

- Cut size lots and increase order frequency
- Decrease security inventory
- Reduce Purchase costs
- Better materials handling
- Try to obtain Zero Inventory
- Search reliability and better supplier

Japanese productivity focuses in waste elimination and respect for people (Gettsman, 1991). Waste is everything beyond a minimum of necessary equipment, materials, parts or workers that are necessary for production. Elimination of waste causes bottleneck and problem exposition, but then the organization will be able to solve them.

Pull Production system is the group of manufacturing policies in JIT, production works with KANBANS (cards) that contain data such coding, description, location and other, principles of this systems are the result of Benchmarking with Japanese industries an the American supermarket. There are two kinds of KANBAN, production and reposition.

A new contribution in the Japanese world of quality and production's systems that works with JIT Systems is SMED It was created by SHIGEO SHINGO (Shingo, 1985).

SMED is a set of policies that work in the reduction of setup times. Setup time is the interval of time between product A ending stage and the first acceptable B product

Recommended methodologies use the following steps :

a. Seeking warm up objective
b. Analysis of actual setup processes. Using tools like video, time studies or others.
c. Identifying extern and intern activities, intern activities are the ones made when the machines are down and extern activities are those done when the machine is working.
d. Objective : changes all internal time in external ones.
e. Reducing internal and external times
f. Practicing and Train setup processes

There are 7 elements of JIT (DeLuzio, 1993):

- Specialized Industry
- Group Technology
- JIDOKA , if something is bad stop production
- Zero Inventories
- Production balance
- KANBAN (Production Control System)
- Setup time's Minimization

Social elements of JIT are :

- Work security
- Company Union (employees)
- Employees Empowerment
- Automatization
- Group Administration
- Outsourcing
- Quality circles

¿ What are the causes of lost time ? Overproduction, waiting time, process time, inventories, materials translation and defect product.

¿ How to implement JIT ? it's necessary to design process flows in JIT layouts, TQM, to become production program stable, Kanban System, Suppliers Development, Inventory reduction and Product Design. All this things are done through an improvement in continuos system.

Some of the principals boundaries of JIT are :

1. JIT is limited to repetitive manufacturing
2. Requires a stable production level (usually about a month long)
3. It does not allow very much flexibility in the products produced. (Products must be similar with a limited number of options).
4. It still requires to work in the process using with kanban so that is "something to pull" This means that completed work must be stored on the downstream side of each workstation to be pulled by the next workstation
5. Vendors need to be located nearby because the system depends on smaller, more frequent deliveries.

THEORY OF CONSTRAINS (TOC)

BASIS :

TOC was created by Eliyahu Moshe Goldratt and this philosophy spread in his book " The Goal" involves a general aim for a business : "Make money now and in the future" (Goldratt & Fox, 1985).

TOC is considered a management philosophy that seeks "to maximize long-term profit" through the proper management of organizational constraints (i.e. bottlenecks such as machine capacity limitations and management policy restrictions).

TOC proposes the drum-buffer-rope production programming systems with 2 types of lots : transference and process. The drum is the master schedule based on the constraint, the Buffer is inventory placed before constraint, and the rope are the rules to supply materials according to the constraint capacity.

There are 3 types of Buffers : Constraint buffer, Shipment's buffer and buffer with no constrains resources placed after Constrain(Goldratt, 1990).

TOC is implemented through "five iterative steps of continuos improvement" (Goldratt & Fox, 1985):

1. Identifying the system's constraints.
2. Deciding how to exploit the constraint.
3. Subordinating everything else to the above decision.
4. Elevating the system's constraint.
5. If in the previous steps a constraint has been broken, go back to Step 1, but do not allow inertia to cause a system constraint.

The above steps are used "to focus a manager's attention on the constraining resource - the factors inhibiting growth and profits". By following this simple procedure, identification of the limiting constraint can lead to money making, the common goal of all profit-seeking organizations. Through the delicate balance of three global operational measurements, product mix decisions can be done to maximize profits. These measurements are: Throughput, Inventory, and Operating Expense. Throughput is the rate at which the system generates money through sales (i.e. sales minus raw materials and energy). Inventory is defined as all the money the system invests in purchasing things the system intends to sell. Operating Expense is all the money the system spends in turning Inventory into Throughput. Any change in one of these factors will result in a proportional change in one or both of the other two.

Goldratt says that, "with this three-dimensional dynamic underlying the system's operation, ongoing improvement require efforts to increase Throughput, decrease Inventory, and decrease Operating Expenses"(Ruhl, 1995). Though historically the emphasis of management has been placed on the reduction of operating expenses, Goldratt focuses on a different order of importance. "According to Goldratt, the largest gains are to be gotten by, first increasing Throughput and then by reducing Inventory. Operating Expense reduction should be the third priority. The rationale behind this philosophy "involves the law of diminishing returns: both Operating Expenses and Inventory have a theoretical lower limit of zero (and a practical limit considerably higher), but theoretically there is no upper limit to the increase of Throughput". As potential sales seem infinite, the focus should be on this area.

The theory of constraints involves three global operational measurements found within its seven basic assumptions (Lambreath, 1989):

1. The goal is to make money now and in the future.
2. Throughput is defined as revenue minus the variable cost of materials and energy.
3. There is at least one or a few constraints on in business which limits the firm's revenue.
4. There are three types of resources: scarce bottleneck resources, nonbottleneck resources, and capacity constraint resources (CCR).
5. Most manufacturing operations have only a few CCRs, and they are easy to control.
6. There are dependent events result of interactions between resources and products. Within every manufacturing environment, statistical fluctuations and random events occur.
7. The optimized production technology system is implicitly stable - at any given time bottlenecks are identified, and the order mix is stable with respect to given resources.

A process-improvement focus, TOC can be useful in identifying waste, called non-value-added activities under ABC. By identifying waste activities of constraint resources and effectively eliminating them, these constraints can be improved.

TOC is specially useful in: pricing decisions, establishing bids for new contract opportunities, and in product emphasis decisions. Also, TOC focuses towards the output of the entire system, rather than a compartmentalized look at certain components which may have little or no positive effect on the overall performance of the system.

GROUP TECHNOLOGY

BASIS :

Technology Group was created in Soviet Union for Dr. Mitrofanov and consist of grouping different machines in cells that produce distinct products with similar forms and process requirements. This philosophy is used in assembly plants, chip manufacturing and joints in complement of JIT policies and production systems (Bednarek, 1996). It is considered a manufacturing system that requires testing structural changes in order to implement it.

Benefits of GT are (Hyer, 1984):

- Better relationships between employees
- Increasing in Learning Curves
- Reducing inventories and better inventory management
- Setup costs reduction

The sequence to implement GT is :

- Identifying a classification and codification of products
- Grouping products in families based in process requirements and ruts to make cells.

At the moment there are software's that do the classification and form family processes with a little data. Some of this software like MAPICS (IBM MRP II version) could have a high cost though benefits are in saved time.

Shifting form process layout to a GT cellular layout entails three steps :

1. Grouping parts into families that follow a common sequence of steps. This step requires developing and maintaining a computerized parts classification and coding system. This is often a major expense on such systems, although many companies have developed short-cut procedures for identifying part families.
2. Identifying dominant flow patterns of part families as the basis to locate or relocate the processes.
3. Physically grouping machines and process to in cells. Often there will be parts that cannot be associated with family and specialized machinery that cannot be placed with in any one cell because of its general use. These unattached parts and machinery are placed in a "remainder cell"

ISO 9000

BASIS :

Through history man has been trying to standardize all his production process and write it down Multiple systems of quality have been developed. The International Standard Organization works on the normalization of technical and no technical processes like measure units, part specification, materials, tools, test methods, machines and others. ISO 9000 is not a product standard, it's a Quality System standard.

If an organization wants to get a place in the international market this would be in a ISO 9000 wagon (Morrow, 1994).

The International Standards Organization was found in Switzerland (1946) and over its years of operation have worked in establishing a set of standards over the world. Over

75000 companies in 100 countries are participating in this organization today(Mooradian, 1995).

The work of ISO has create specifications for 8000 different kinds of products like film velocity, paper's sheet sizes and others.

ISO 9000 is the best product of this organization, this norms can guide an organization get customer recognition around the world. In Europe more than 500,000 companies adopted ISO 9000 (Pfeiffer, 1996).

ISO 9000 has 5 series of norms, 9000 and 9004 series are basic rules for organizations and 9001,9002, 9003 are guides for design-manufacturing-service, production-service, and final inspection respectively.

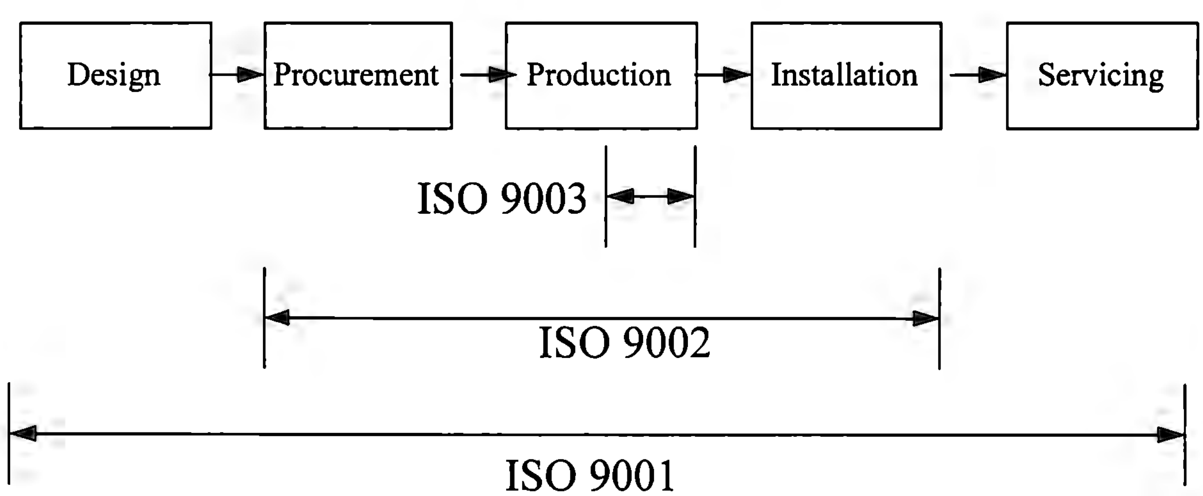

Figure 3.1. ISO 9000 Boundaries

There are three forms of certification like a ISO 9000 company ,

1. Self auditing the company in ISO 9000 standards
2. A client audits a supplier
3. A national or international certified agency audits the company

The third type of audit is the most effective because the certificate that the organization get is valid around the world.

The 20 elements to be addressed in a ISO 900 Quality System (Rothery, 1994):

1. Management responsibility
2. Quality system
3. Contract review
4. Design control
5. Document control
6. Purchasing
7. Customer supplied material
8. Product identification and traceability
9. Process control
10. Inspection and testing
11. Inspection, measurement, and test equipment
12. Inspection and test status
13. Control of nonconforming product
14. Corrective action
15. Handling, storage
16. Quality records
17. Internal quality audits
18. Training
19. Servicing
20. Statistical techniques

ISO 9000 has provided standards to get a certification and to get into the foreign markets. It develops language and confidence to deal with suppliers and customers around the world (Zuckerman, 1995).

3.3 Findings from the analysis

Next, I will develop a relationship matrix including the techniques described above and 21 activities or areas related with the output of this thesis, the IMOM model. The short comings of section 2.4 from chapter 2 state the necessity to integrate several concepts and techniques in order to get a superior value from them. Also, as stated by systemic people, like Mike Jackson (1995), the fads or the techniques described above are presented as a solution for any case in each of its disciplines, and this is not necessarily true. The IMOM model proposed in this dissertation aims to provide better results regarding competitiveness and productivity for the small and medium sized manufacturing companies (mainly in shop floor and assembly lines processes), so for this cases a special approach has to be developed. The IMOM model is purpose is to integrate and coordinate the following areas of the value chain: (1) *Order Processing,* (2) *Production Planning and Scheduling, (3) finished goods storing and shipping (Warehousing), (4)Production, (5) Purchasing and (6) storing and supplying of raw materials.* So the 21 activities or areas in next matrix are related with the above six areas. The criteria to provide the weight in relationship to the next matrix is related to the findings in section 2.4 and to the experience learned during the consulting projects (ITESM, 1193, 1995a, 1995b and 1997)

RELATIONSHIPS MATRIX

	Activity	Theory of Constrains	Just in Time	Reengeniering	Total Quality Management	MRP II	ISO 9000	Group Technology
1	Focus on Customer	2	4	4	4	4	4	
2	Impact on Improvement	4	2	4	2	2	2	4
3	Maximize production operation efficiency	4	4	4	1	2		4
4	Work with Suppliers	2	4	2	4	2	4	
5	Changes in Cultural Organization	2	2	4	4	2	2	1
6	Team Work Oriented	2	4	4	4		2	1
7	Use other tools (combination)		2	4	4	1	4	
8	Bussiness Strategy oriented	4	1	2	4	1	2	
9	Break of paradigms	4	1	4	4			
10	Information Systems Rol	2	2	4		4		1
11	Processes improvement	2	1	4	2	1	2	1
12	Empowerment	2	2	4	2		2	
13	Management philosophy	4	4		4			
14	Shop Floor Control	4	4			2		2
15	Automatization	1	4			2		4
16	Inventory Management	4	4			2		1
17	Production Planning and Scheduling	4	2			4		1
18	Setup cost reduction	2	4					2
19	Software oriented	2	1			4		1
20	Bottlenecks Management	4						
21	Production Flow Synchronization	4						

Relationship	
None	
Low	
Medium	
Strong	

Table 3.1 Relationships Matrix

CONCLUSION:

In the relationship matrix we could see that the dark zones represent the techniques with more impact in the activities listed. In the other hand, the white zones represent a low impact. With this in mind I would conclude the following:

- ☑ TOC and JIT look strong in Production Control and scheduling as well as shop floor control
- ☑ Reengineering is strong in Process Management and improvement
- ☑ TQM looks very strong in cultural changes and is team work oriented
- ☑ MRP II in the matrix is the only formal information system
- ☑ The only important issue about ISO 9000 in this analysis is its customer orientation and suppliers development. As we can observe ISO 9000 is a standard and not a technique.
- ☑ Group Technology seeks for help to make more efficient the production process, based on cellular layouts.

Other important conclusions are:

- All tools focus on the customer and try to maximize production operation efficiency.
- Most of the tools provide changes in the culture of the organization
- The change is slow (continuous improvement) but some tools maximize results with a quantum change (Reengineering and TOC), but the best way is to combine both approaches.
- Most of the techniques involve multidisciplinarie team work for better performance.
- MRP II is directly related to the use of information systems as a support for the decision making process, but it doesn't mean that is the best alternative.

According to the above statements, it can be considered proper to improve the current situation in Mexican companies (see chapter 1). Also it will be taken into account as drivers of the model developed in this thesis.

The human side in the philosophies and techniques previously analyzed is the basis for the better implementation. It is necessary to state Mission and objectives, there are the company's motor to continuous improvement.

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4. THE INTEGRATED MODEL FOR OPERATIONS MANAGEMENT (IMOM)

4.1 Introduction

The objective of this chapter is to generate a model to effectively integrate the production and operation of manufacturing companies in order to be more competitiveness and improve productivity. The model is " An Integrated Model for Operation Management" (IMOM) which represents a great integration of several strategies and operational elements of the value chain in manufacturing systems. The model is going to be developed taking into account the current situation of Mexican manufacturing enterprises (chapters 1), the strengths and weaknesses of the literature (chapter 2), and with the findings from the analysis in chapter 3. Section 4.2 presents the research methodology (action research) used in this thesis. In section 4.3 the general assumption on the IMOM model is described according to the hypothesis of this thesis which states the need to create a model that effectively integrates the Sales, Production and Materials Supplying activities. The purpose of the IMOM model once the integration is set up, to improve the productivity and competitiveness of a manufacturing company (small or medium sized based on assembly lines and/or shop floor production processes. Section 4.4 represents the content of the IMOM model, which describes each of its elements and how they are integrated, and finally in section 4.5 presents the measured performance of the IMOM model. Note that The figures shown in the sections 4.3 and 4.4 were elaborated from my our approach and are part of the output of my thesis's research.

4.2 Research methodology

ACTION RESEARCH

This research method has been chosen for the development of the thesis. Action research is a form of self-reflective inquiry undertaken by participants in a social or enterprise situation in order to improve the performance of their own social or enterprise practices, their understanding of those practices and the situations in which the practices are carried out (Blaxter, Hughes and Tight, 1996; Eden and Huxman, 1996).

Action-research might be defined as 'the study of a social or enterprise situation with a view to improving the quality of action within it' (Blaxter, Hughes and Tight, 1996).

Criteria distinguishing action research

1. Is educational
2. Deals with individuals as members of social groups
3. Is problem-focused, context-specific and future-oriented
4. Aims improvement and involvement
5. Involves a cyclic process in which research, action and evaluation are interlinked
6. Involves a change intervention
7. Is focused on a research relationship in which those involved are participants in the change process

In the other hand Phillips and Pugh (1995) mentioned different types of research as follow:

1. ***Exploratory research***. This type of research that is involved in tackling a new problem, issue, topic about which little is known, so the idea cannot at the beginning be formulated.
2. ***Testing-out research***. This type of research tries to find the limits of previously proposed generalizations.
3. ***Problem-solving research***. This type of research starts from a particular problem in the real world, and bring together all the intellectual resources that can be brought to bear its solution. The problem has to be defined and the method of solution has to be discovered. This will involve a variety of theories and methods, often ranging across more than one

discipline since real-world problems are likely to be messy and not soluble within the narrow confines of an academic discipline.

The Problem-solving research (type number 3) is pretty similar to the Action Research method described above. For the purpose of this thesis Action Research is going to be considered as the research method to be followed, including what was defined as a Problem-solving research type 3. So, I am going to be part of the implementation of the model developed in this thesis, that is, I am going to play the role of an observer and as a consultant.

The research sequence followed during the thesis is shown in the figure 4.1

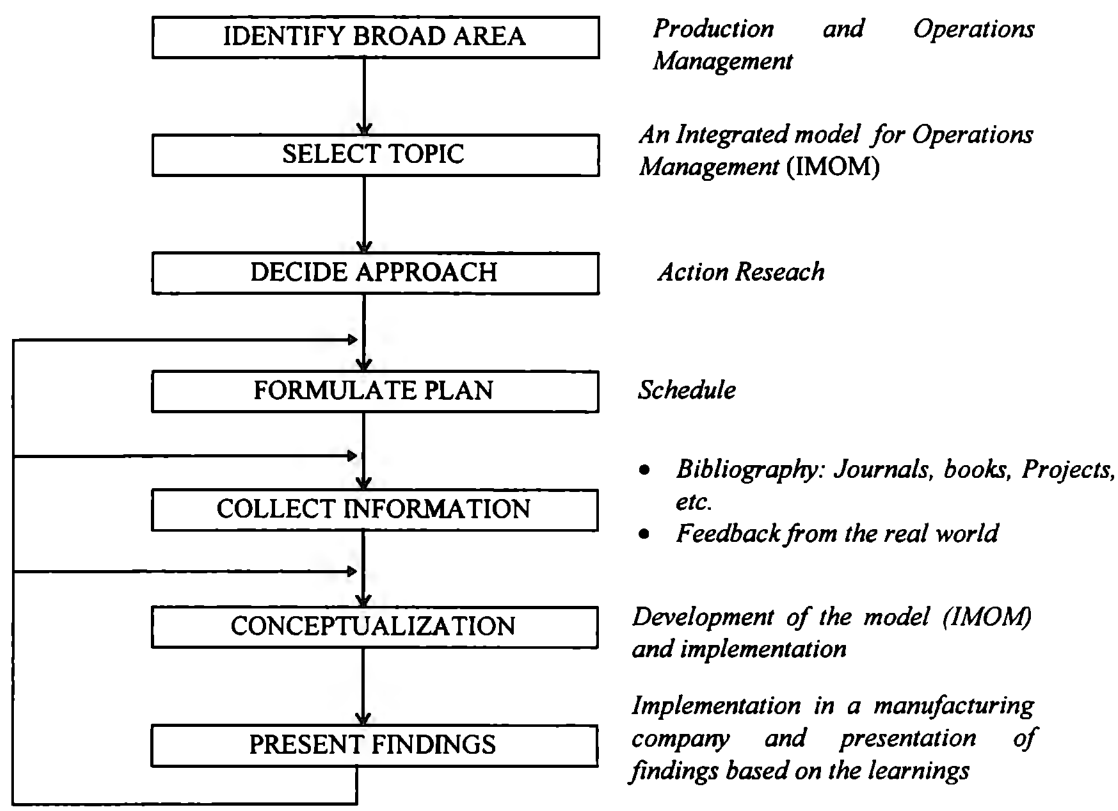

Figure 4.1 Research process used (adapted from Gill and Johnson, 1991)

Also, as a complementary test, I considered very important to develop a series of questions to evaluate the reliability of the research. For this purpose, nine questions were used to evaluate the research:

1. What is the Integrated Model for Operations Management (IMOM)?

2. How should it be defined?
3. What are the expected results?
4. What would the contribution be used?
5. What are measurements to evaluate the results?
6. What functional areas are to be considered?
7. How is the IMOM going to be built?
8. What are the necessary conditions in order to allow the model to work?
9. What the research methodology will be used?

These questions are going to be used during the development of the model in the next sections of this chapter. Even when they wont be specifically answered in the next sections and chapters, the content of the thesis will answer them.

A operationalization process was used during the research and four concepts were included. It is shown in figure 4.2.

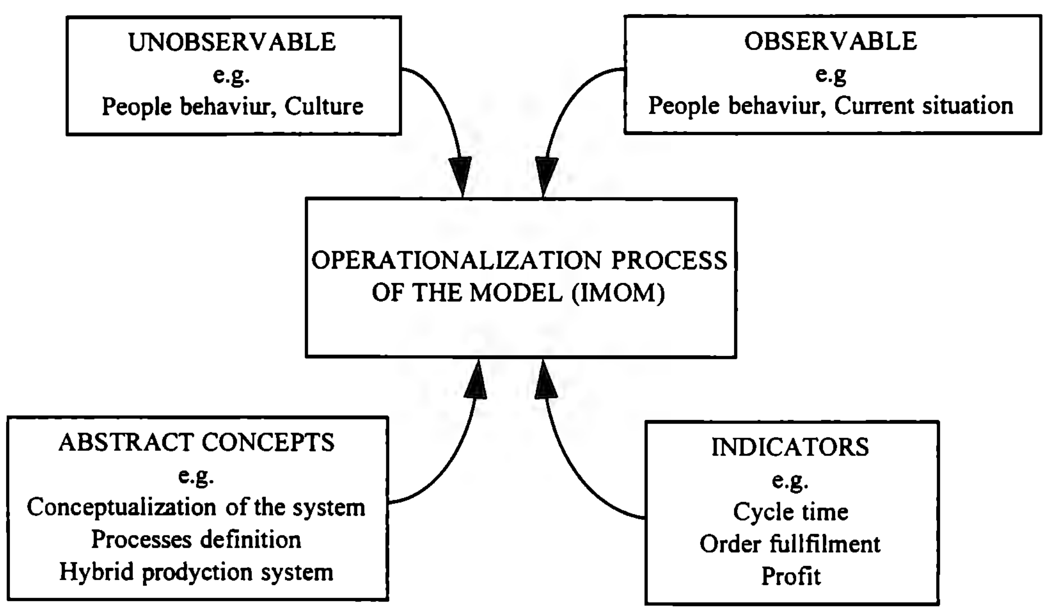

Figure 4.2 Operationalization process for the research (adapted from Gill and Johnson, 1991)

4.3 General assumption of the model

During the development of chapters one, two and three, an idea had been coinceived; a model that allows manufacturing companies to become more productive and competitive.

Obviously, this model needs to be scaled for research purposes and applied in a real Mexican enterprise to proved its reliability in the Production and Operations Management world.

Chapter one described the real situation of the Mexican manufacturing companies and its challenges in the current world expectations. World class productivity and competitiveness are considered essential elements to be shaped by manufacturing companies. Achieving these elements is a hard task because several activities inside and outside a company, and some necessary conditions need to be linked and well performed.

Chapter two shows the opinions and shortcomings in t literature about operations management, and I can conclude that there are different approaches, not well integrated that provide support to the Mexican manufacturing companies to achieve world class productivity and competitiveness.

Chapter three analyzed the most advanced techniques and philosophies applied in manufacturing companies around the world. In table 3.1 from chapter 3, we can find the relationship between these advanced techniques and the activities realted with areas of the value chain considered in this model. As I did with the tools in chapter 3, the IMOM model may present some weaknesses for companies not included in the manufacturing sector, and even in the same sector little adjustments may be done to reach the objectives of the model in a few cases.

It is very important to say that a big part of my inspiration to build this model, was because during my experience as logistic manager in Goodyear tire and Rubber Co., and as a consultant in two projects in manufacturing companies (ITESM, 1994 and 1995) about Business Process Reengineering in the logistic value chain, I found a big necessity to integrated effectively the departments related in those processes, and with the use of the proper advanced techniques obtain the results expected for the companies about competitiveness and productivity.

Lets considered a systemic view of the manufacturing company represented in a model that includes the minimal requirements (activities) for the business operational success. In figure 4.3 we can see that the relationships between activities and how the external elements are involved in the company. Some activities or entities in figure 4.3 look obvious, but in a lot of cases an elemental activity is not well performed or just not performed.

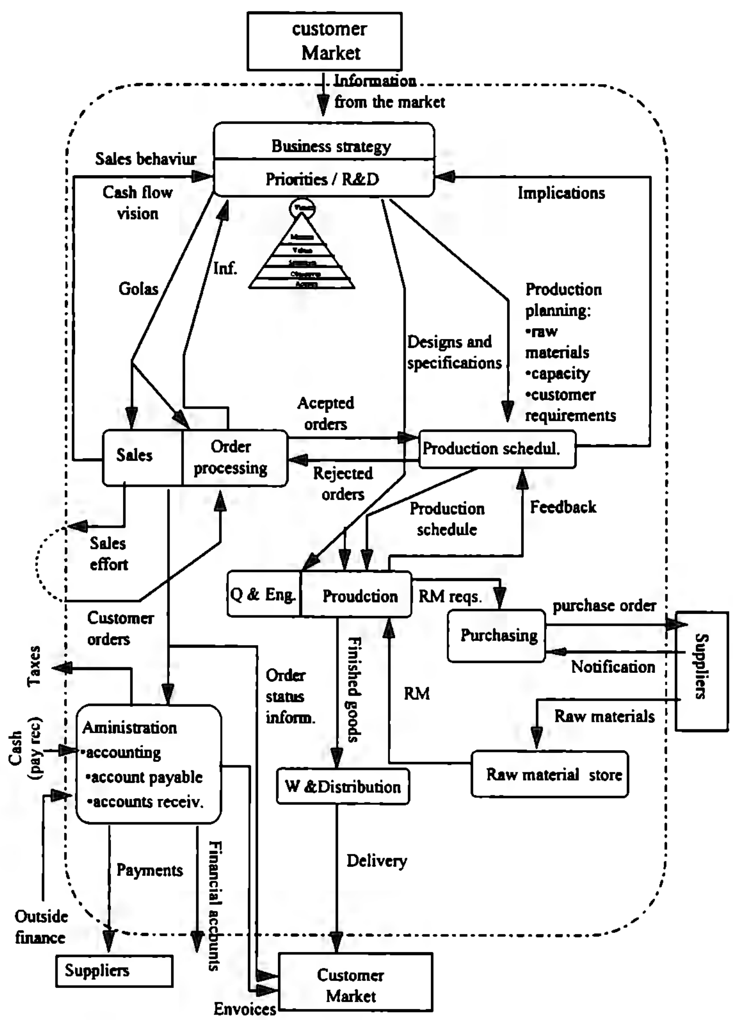

Figure 4.3 model of a manufacturing firm

In chapter 2, I have registered an interest to solve the problem of integration between departments, and in my professional experience as an employee and consultant I have found a natural tendency to reach local goals instead of global ones. Figure 2.4 represents this lack of integration in three typical departments or areas: Sales, Production and material supplying.

I would like to analyze in more detail what has being happening in the organization within the functional departments. This concern to integrate what is non integrate from the research point of view, for connivance is necessary to select the activities with the most impact in productivity and competitiveness in order to develop an alternative to get a real integration. It needs an analysis of the whole system and a selection of those activities that are the most problematic and impact the system the most. A conceptual model from the operational point of view of the most typical functional areas of a manufacturing company is represented in figure 4.3. Sales & marketing, production, research & development, material supplying, finance & accounting and human resources are normally found in small and medium size companies. These functional activities can also be considered as a key to business processes. The current reality system in figure 4.4 shows how communication between three activities is normally i affected by a disturbed information, encoded or filtered information

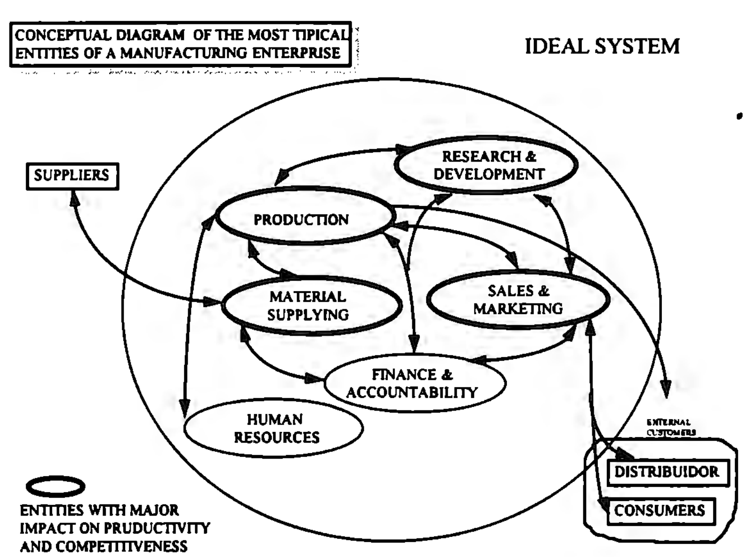

Figure 4.4 Conceptual model of the typical manufacturing activities

As shown in figure 4.4 and 4.5, Sales, production and the material supplying activities represent those with the major impact in productivity and competitiveness and also present a day by day lack of communication and integration.

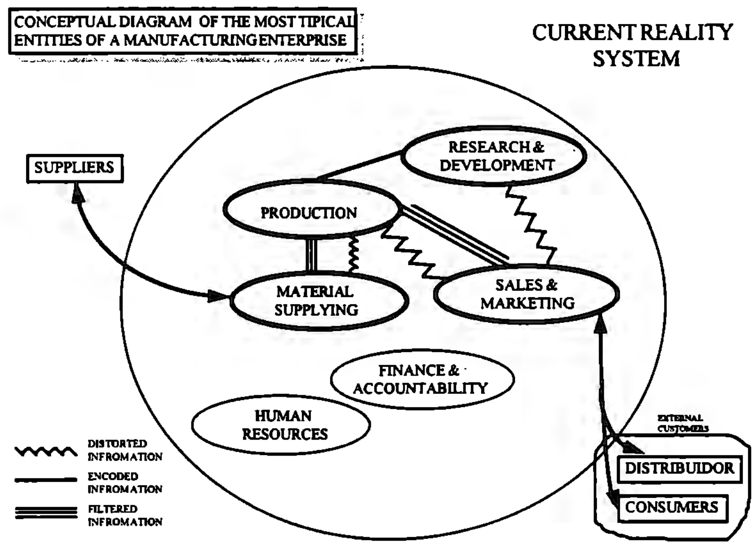

Figure 4.5 Current reality of the three activities of the system

Table in section 2.2 represents how these activities can help the success of the firm. According to my experiences related with the activities of Sales, Production and Material Supplying (both as an employee and consultant) they often show illness in regard with communication and integration that affects the business performance in cycle time, fast deliveries, inventory levels, customer service, etc.

For the purpose of this thesis I will consider only the activities or processes related with the functional areas of Sales, Production and Material Supplying. Even R&D is also considered as an important area which can help increase competitiveness the scope of this thesis will include the above functional areas. They are composed of several activities or processes. It is very important to scale the activities involved in the three main areas of a business. Looking again at the whole system we can identify (figure 4.6) those processes related with the three main functional areas. As figure 4.7 shows the processes selected for the research they are: order processing, production, warehouse and distribution, purchasing and raw material storing.

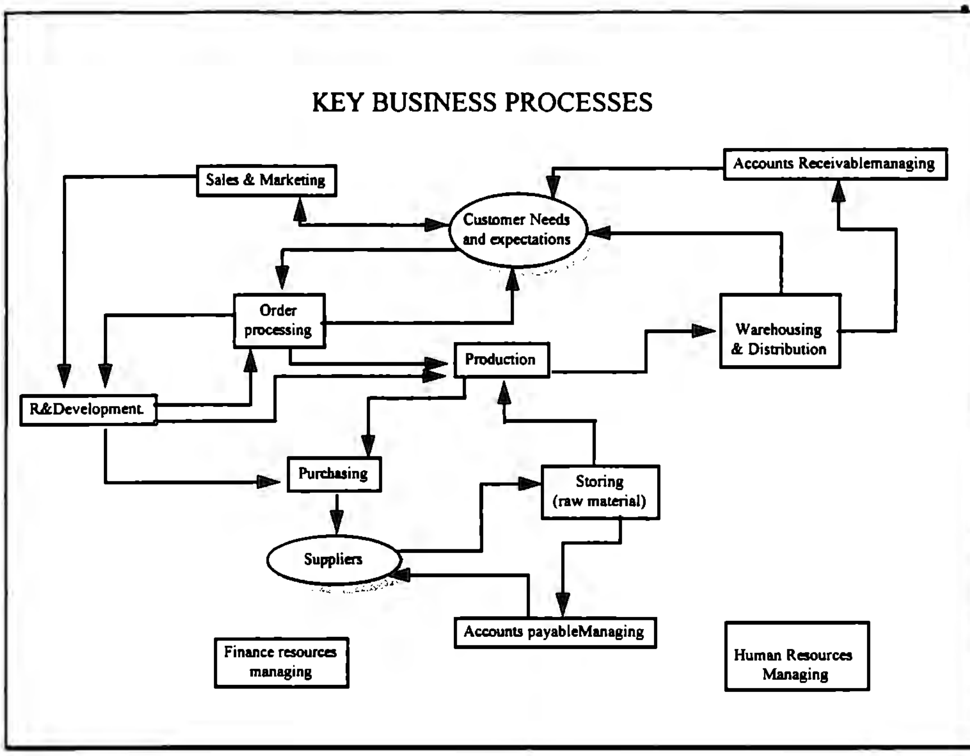

Figure 4.6 Key business processes

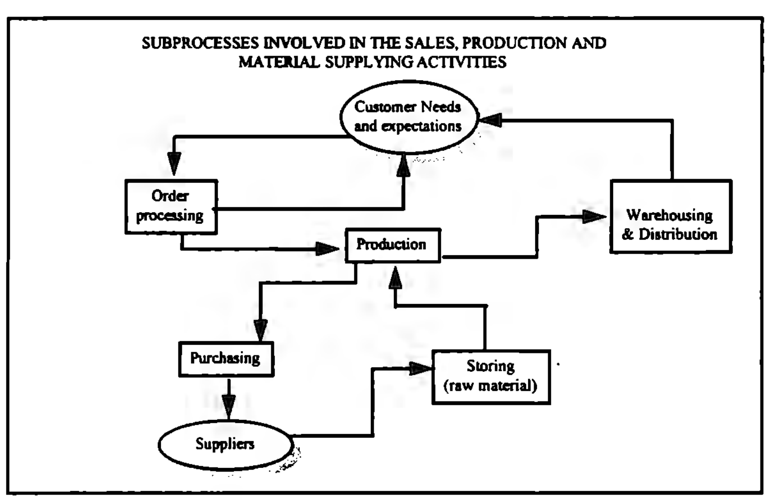

Figure 4.7 Processes selected for the research

Now, the problem is how to get these processes to work together and seek the same goal? This is the first step of interest in order to build an integrated model for operations management.

I want to describe what is understood for each of the processes selected:

☑ *Order processing*. This process consist of the collection and processing of all the customer's orders

☑ *Production*. The steps needed for the transformation of a product

☑ *Warehousing distribution*. Finished goods' control and shipping

☑ *Purchasing*. Purchase order placement according to the requirements

☑ *Raw material storing*. Storing and control of inventories

These processes or main activities are going to be integrated in a model with the purpose represented in figure 4.8. As shown in that figure the IMOM model represents only a part of what should be stated in the Vison and Mission. The base of a manufacturing company are their operations which can become the enterprises competitive and productive (Chase and Aquilano, 1995)

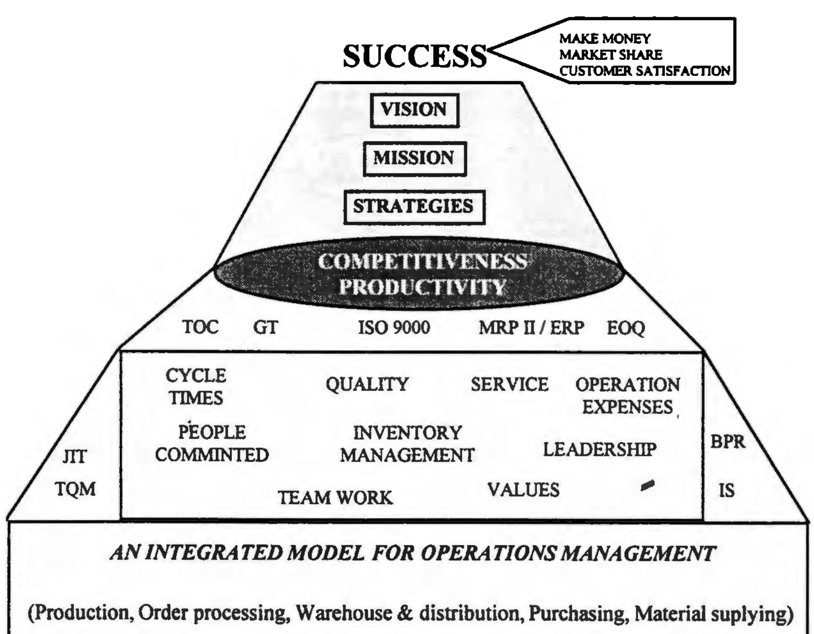

Figure 4.8 Vision of the final result of the model

The general assumption of the model is represented in figure 4.8. This is a first draft of how the people involved in the activities should see and think about the processes. What we can observe in the figure 4.9, is the relationship with the information processes with the shop floor process and its points of inventory control. The production function refers to a productivity view or thinking of the operation performance. I can say, about this draft, that it is a different way to see a model trying to integrate the administrative processes with the operational activities. Most of the times efforts are focus only in one of those, loosing the linking strategy. Figure 4.9 is showing how the technical elements will work in the IMOM model approach. At this moment only a social elements as team work is considered.

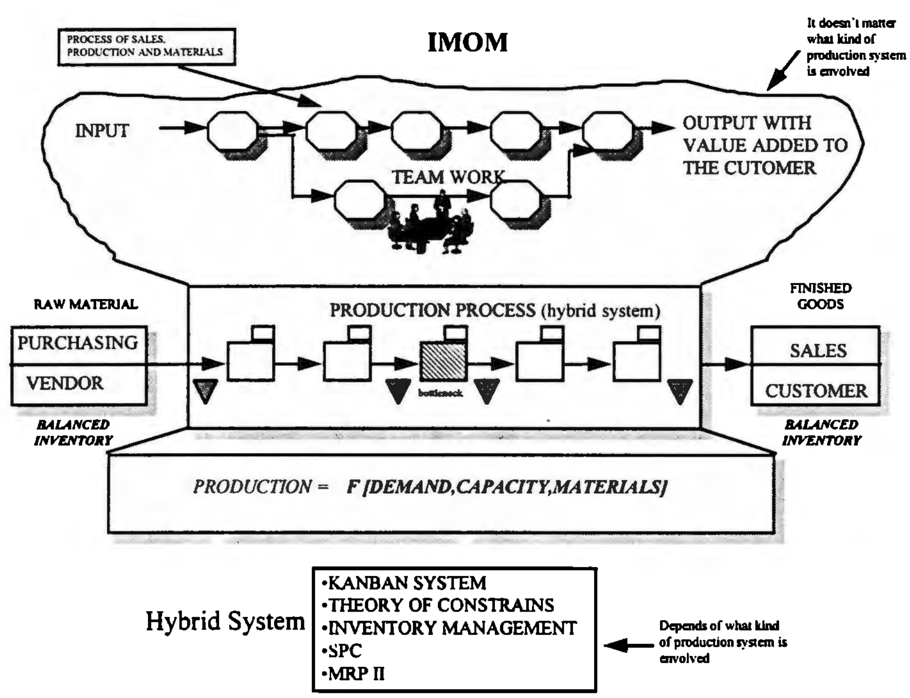

Figure 4.9 General assumption of the model

4.4 Content of the IMOM model

INTEGRATED MODEL FOR OPERATIONS MANAGEMENT (IMOM)

The IMOM model is composed of seven strategic elements; these elements were analyzed and considered as a very important ones for the business success (figure 4.7). The reason to consider only those seven elements came from the literature shortcomings of chapter 2 and the findings from chapter 3. What I want to do with the IMOM model is to prove how to effectively integrate the activities in the processes selected in figure 4.6. These processes need to be properly linked and well communicated, one of the best strategies is changing from functional approaches to PROCESS ORIENTED. In the other hand, the production process is to produce the right goods that the market and customer need, and delivered on time. Chapter 2 and 3 suggest the use of both JIT and TOC to make the production shop floor more effective and productive. Non of literature in chapter 2 show the strong relationship between the administrative processes and the production shop floor, so this is what I want to purpose. To enable the above arguments to work properly in reality to I, included to the model some intangible elements as leadership, the organizational culture and team work. Next, as shown in figure 4.7, those seven elements are described as follow:

1. **INTEGRATED PROCESS OF SALES, PRODUCTION, PURCHASING, WAREHOUSING AND STORING**

- representation of the activities and information flows in two (level 1 and level 2)
- computer support system
- performance measures

2. **INVENTORY POLICIES FOR RAW MATERIALS, FINISHED GOODS AND WORK IN PROCESS**

- maximum, minimum, safety stock and reorder point for raw materials and finished good
- buffer inventory to work in process managed with a kanban system

3. **DEFINITION OF A PRODUCTION FUNCTION**

- production = f(capacity, demand forecast, customer orders, inventories)

4. SYNCHRONIZED PRODUCTION PROCESS

- a hybrid system. Shop floor management based on the principals of the Theory of Constraints and Just in Time

5. TEAM WORK

- integration of the functional areas (see processes)
- Sharing performance measurement
- shared leadership

6. ORGANIZATIONAL CULTURE

- analysis of the organizational moment
- shared VISION and MISSION of the company
- employees commitment
- closing the gap between the company's VISION and employees beliefs
- change management.

7. LEADERSHIP

- leadership performance by the managers

8. INFORMATION SYSTEM

- Utilization of an Information System and not a Data Collector System

The objective of this model is to get a real integration of the activities involved in the IMOM model in order to become a manufacturing organization competitive and productive by satisfying the customer expectations and needs. The figure 4.10 represents part of this objective.

A conceptual representation of the IMOM model is including the elements as shown in the figure 4.10. Next I am going to describe each element in order to present my point o view about them.

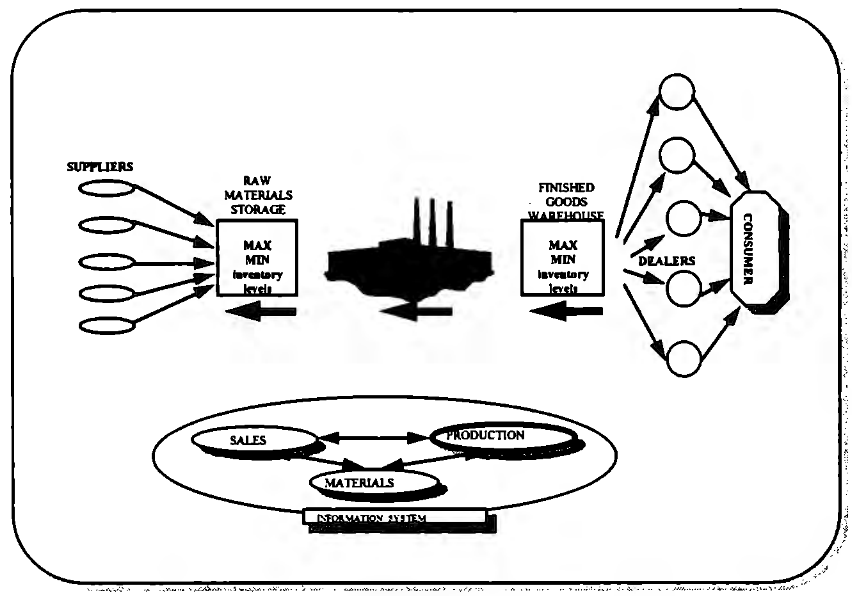

Figure 4.10 The general purpose on the IMOM: integration of the logistic chain based on the activities of Sales, Production and materials supplying

1. INTEGRATED PROCESS OF ORDER PROCESSING (SALES MANAGEMENT), PRODUCTION, PURCHASING, WAREHOUSING AND STORING

This is a representation of the activities, their sponsors and information flows as processes in a high level map (general level). This process is going to be called INPRO in the rest of thesis. The representation is by mapping the processes using the Data flow Diagramming (DFD) technique (see figure 4.11). With this map, the team is able to share the whole picture of the process avoiding isolated tasks that normally are performed.

Porter (1982) explains that the competitive value of individual activities cannot be separated from the whole. There are several important characteristics in this process map that need to be explained. The customer is inside the process. The customer is frequently lost in the process, or only the subprocess like the Order Processing knows who they are and what he wants. This is in the best case that the Order Processing activity exist.

Sometimes is not present. It is not enough to know that the customer is in the process, what every people in the process needs to know are the requirements from the customer in terms of quantity, delivery date, service, and quality specifications.

The supplier also appears in the process. He needs to know well, what are the process requirements of the enterprise. A previous meeting and negotiation is needed to share each other their expectations.

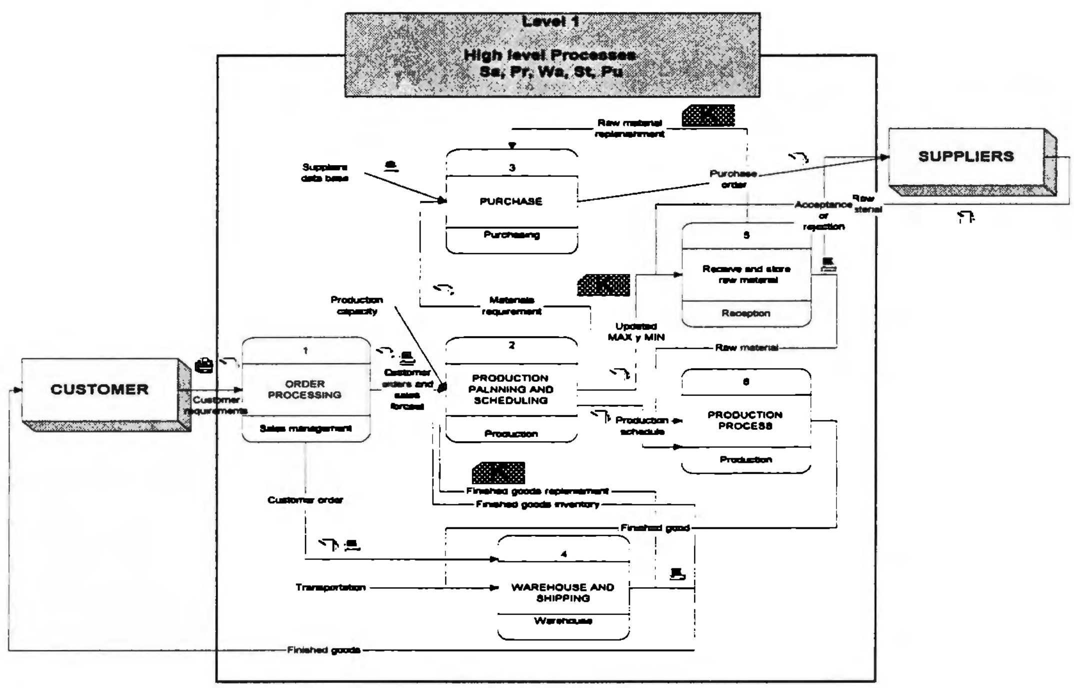

Figure 4.11 First level Process mapping

The information requirements (inputs and outputs) for each subprocess also appears in the map. As I said before, this is a first level process mapping, so only general information is provided. A second level map detail information can be found (case study chapter 5). The first level map shows general information (inputs and outputs), it is critical to have good process performance, because people know what is the purpose of the activity and what needs to be provided to the next partner or to the customer if it is the output of the whole process.

A kanban system is also included to replenish raw material or finished goods based on maximum and minimum inventory policies (see inventory policies).

2. INVENTORY POLICIES FOR RAW MATERIALS, FINISHED GOODS AND WORK IN PROCESS

According to traditional inventory methods like the Economic Order Quantity (EOQ), they suggest to calculate the optimum lot size based on costs like: setup cost or order cost, holding cost, cost of materials and in some cases the backorder cost. The holding cost and the cost of materials are easy to calculate, but the setup cost and the backorder cost include intangibles factors that make these cost be an approximation, as a consequence the "optimized lot size" is not precise. These assumptions make the EOQ impractical. In the other hand, the setup cost sometimes is an utopia if it is related to a nonconstraint in the production chain.

An alternate and easy inventory policy called MAFC [6], was developed to put it in practice without deep knowledge of math's [Flores Adrian, dissertation thesis for master degree, 1993] . In figure 4.12 the MAFC inventory method is shown.

If we see how it is calculated the MAX = 1.5 (MIN), the 1.5 was obtained from a survey with the materials managers in Monterrey, Mexico 1993 and also was based on experimentation [Flores Adrian, 1993]. In appendix 5 a simulation is shown using ARENA and to demostrate how the MAFC model works with the parameters set for the calculation.This is what makes different this inventory model from others.

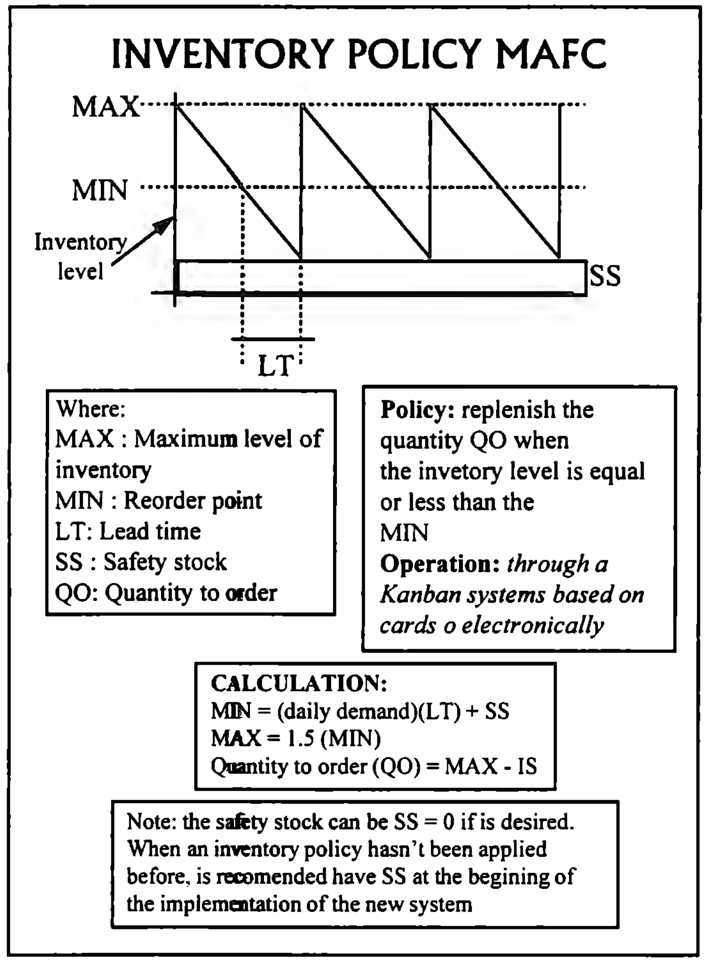

Figure 4.12 Inventory policy MAFC based in maximums and Minimums
(Model developed by M. Adrián Flores Castro, 1993)

3. DEFINITION OF A PRODUCTION FUNCTION

Most of the production functions are developed focusing in a microeconomics perspective, but there are variables like meeting customer needs (delivery lead time, quantities specified by customer, and committed delivery dates) that make almost impossible to achieve these functions. The production function developed here tries to address the operational expectation from the customer point of view.

In order to define what is the production to be achieved in manufacturing companies it most of the times depends on the following variables:

- Customer demand (quantity, delivery time and frequent lots)
- Capacity (machines and labor)
- Inventory available of goods and raw materials
- Demand forested
- production cost

According to this variables the production output is represented as follow:

Production = f(capacity, demand forecast, customer orders, inventories)

This expression is valid for a specific period of time, for instance, a month.
Next there is a description of the variables involved in the production function:

Capacity

The production capacity is based on the current bottle neck of the process. Most of the times the capacity of a plant is based on a past bottle neck of its process and this produce a wrong production lead time expected. The capacity of a current bottle neck can be calculated on the follow situations:

☑ speed of a machine

☑ size of the labor (number of people involved on that process)

☑ combination of both

Demand forecast

This is an important element in order to calculate the inventory policies. A three months period of sales estimation by product is a good data that can be used to exploit the bill of materials and determinate the materials required for the period. The size of the sales period of time to be considered and the forecasting tool depends of what kind of product is going to be analyzed. The shortest the period of the forecast is, the most accurate it is. If the behavior of the market is almost estimable, one month period as a horizon of forecast is very recommendable. This variable could be consider or not depending of the type of product (s) to be analyzed. There are companies that work only with customer orders, and in this case a sales forecast is necessary.

Customer order

This variable has fallen apart from the demand forecast, because this kind of orders have priority from the orders for replenishment. A customer order needs to have specific data like: type of product, quantity, date committed, and frequency of the shipments (lots). These date may modify production function of a manufacturing company.

Inventories

This data has to be considered as an important variable, because the finished goods inventory tells what is the net amount of products to be produced and then scheduled. Once the production of finished goods is known, the work in process and the raw material inventory is also analyzed to determinate if there are materials to complete the orders, if not the materials are required and production output is adjusted while the materials arrive.

4. SYNCHRONIZED PRODUCTION PROCESS

This element is the links the INPRO process of the activities or processes involved in the IMOM model with production management in the shop floor. Once the INPRO process is well performed, accurate information will be received in the shop. There are three possible ways (see table 4.1) to control the production process, one is using a MRP II system, using a Just in Time (JIT) system, using the Theory of Constraints (TOC) approach, or combining the best of each. In my opinion, the last choice is the best option, because normally bottlenecks are found in manufacturing enterprises, and then are ignored by JIT and MRP II. In the other hand, the Kanban system (JIT) is an easy way to control the production system. Combining JIT and TOC we would have a powerful tool to manage properly the production process. Managing the shop floor with JIT and TOC, MRP II is recommendedto be used without the production module, it means, to have working modules of inventories (raw material and finished goods), accounting, sales management, etc. The combination of the three tools are a ***Hybrid Production System***. This makes sense, because JIT was initially developed as a Kanban System by Taichi Onho (Monden,1993), (Duncan,1988) and the Theory of Constraints was originally applied as a bottleneck management tool (OPT). A study between these tools is necessary to be done in order to see the simulations and differences. Table 4.1 how this information.

Situation	JIT	MRP	TOC
System	pull-system	push-system	Push-system downstream from constraint, and pull-system upstream the constraint
Capacity scheduling	-----	·infinite	finite
Environment assumptions	stable	-----	stable
Reaction on changes	very sensitive	quick reaction because of infinite scheduling	sensitive
Transfer batch	focus in on a batch size of 1	set to the process batch size	optimized to maximize throughput
Improvement	Continuous improvement. Set up improvement everywhere	Changes the scheduling	Continuous improvement based on the constraints. Set up time change when throughput can be improved
Focus on	Quality	Customer services and due dates	Bottlenecks
Inventory status	Reducing inventory till ZERO	Inventory is no problem, but less is better	Inventory is before the bottlenecks and when the throughput would affected
Production pace	Set by master production schedule	Set by master production schedule	Set by the beat of the Drum Buffer Rope system

Table 4.1 Study of JIT, MRP and TOC (http://www.iaech.nl/users/drshofm/kene/TB/jitord.htm)

JIT, TOC and MRP were originally developed for a specific purpose, and after their success, the authors were continuously adding elements till the transformation of JIT and TOC in a management philosophy and MRP II in a integrated information system that promise to solve everything. This argument justifies the only use of the key elements that compose these tools.

A JIT pull system based on the Kanban system works as follow:

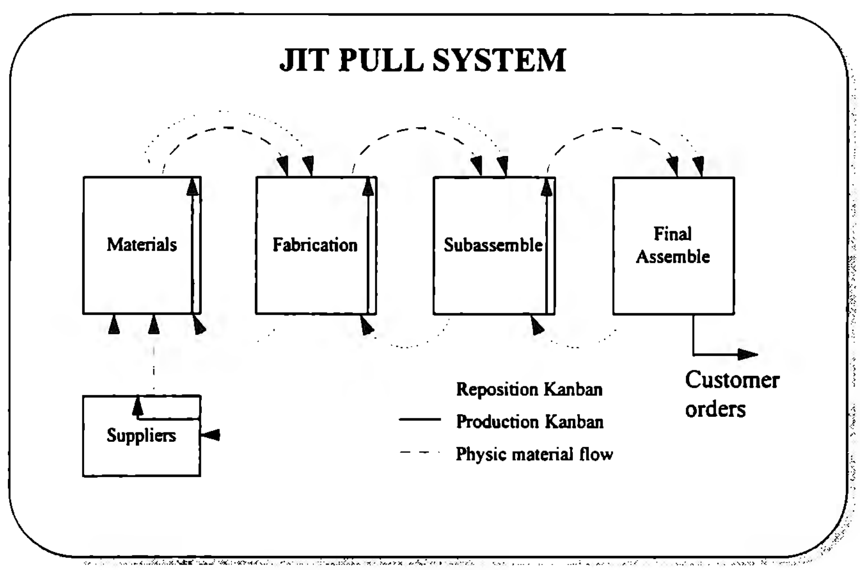

Figure 4. 13 JIT pull system [3]

In the other hand, the TOC approach works by managing the bottleneck in the process. Figure 4.14 represent the Drum - Buffer - Rope (DBR) System for production management.

The DBR system works as follow:

☑ The ***drum*** is to carry on the rhythm of the bottleneck in the production process. This rhythm of the drum (master schedule) indicates the rate at which the previous process will be working. Not working more than the constraint allows.

☑ The ***Buffer*** indicates the time used to protect the constraint. In other words an inventory is placed before the bottleneck in terms of time.

☑ The ***Rope*** will help supply the materials for the non-bottlenecks in the amount specified by the rhythm of the bottleneck. The reason is because when a resource is idle and it has raw materials available to work, the people in production will put this resource to work and the production flow will be disturbed and inventories will grow up.

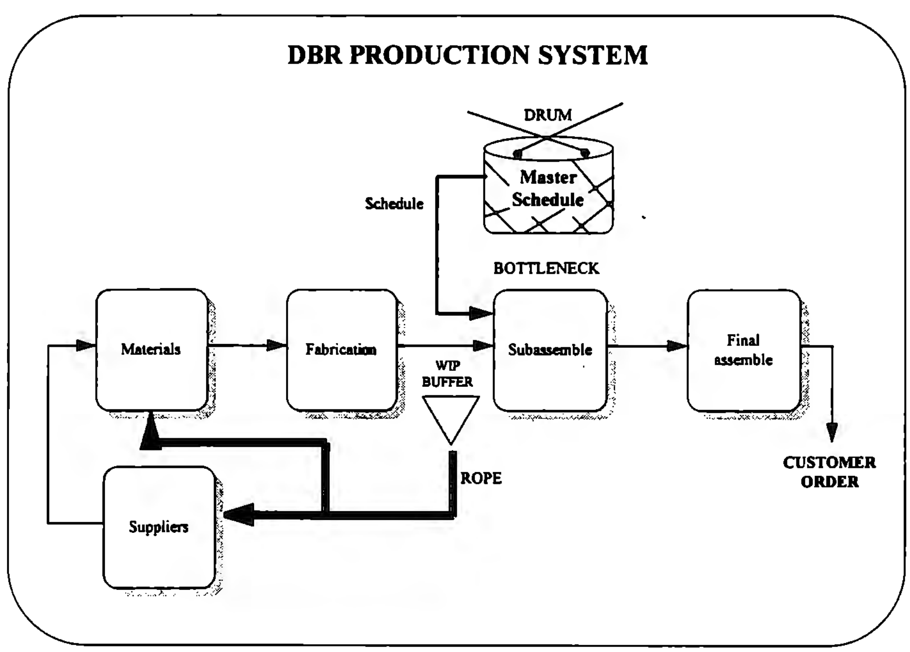

Figure 4.14 Drum - Buffer - Rope system for production (TOC)

Taking into account the advantages of JIT and TOC and MRP II, a hybrid system for production management is developed in the figure 4.15.

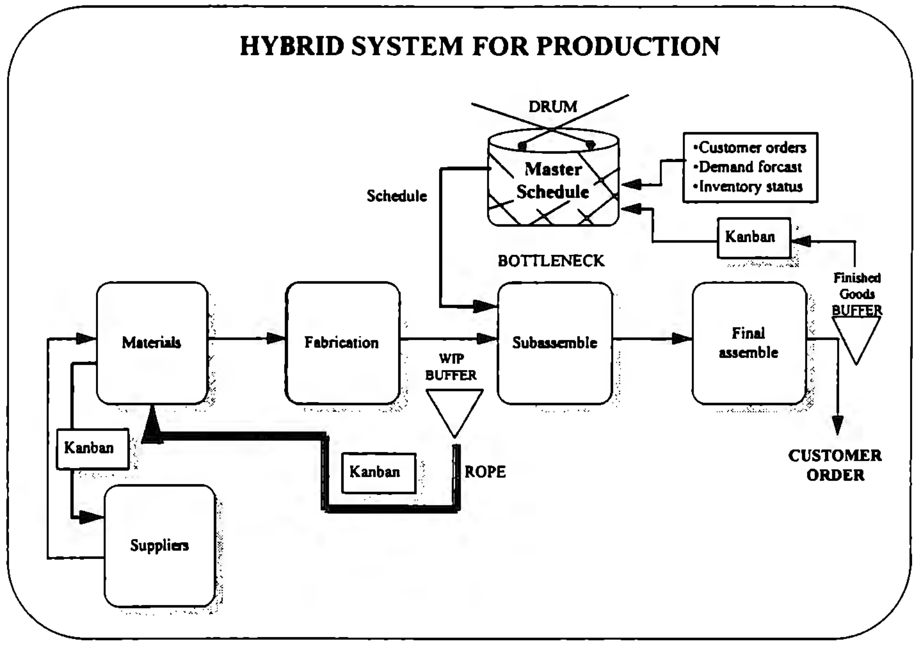

Figure 4.15 The Hybrid System for Synchronous Manufacturing

We can observe that the two buffers, one before the bottleneck and the other as a finished goods buffer, are replenished by the Kanban System approach. in this case the drum will be the Master Schedule, and it would be provided by a MRP II system, or made by hand. The Kanban System, is used to replenish the buffers and to help the replenishment of raw material.

5. TEAM WORK

Even though there are several theories about team work, team focus on processes are essential to achieve the desired output of the IMOM model.

The characteristics of the team work considered in this thesis are as follow:

☑ Shared vision of the process by the people involved

☑ Clear responsibilities for each person focus on the process

☑ Collective responsibility through overlapping responsibilities

☑ Rewards based on team performance

☑ Enable a physical layout for team work

☑ Sharing performance measures

☑ Shared leadership

In the Mexican manufacturing companies, team work in not exactly the best way to improved widely in the long run, but now is very important for achieving the world class manufacturing standards. During the Reengineering projects where I have been practicing (ITESM Campus San Luis, 1995), the start up always takes at least one month to begin developing a real team work.

Integrating the functional areas.

As is shown in the process mapped in figure 4.11, this clear vision and responsibilities, start to produce good result for team working, but it has to continuously be developed to avoid a relaxation in the team because of lack of synergy

Sharing performance measurement

Rewarding based on unit performance or team work is important to keep collective interest in the process's performance (Maychrzak&Wing, 1996).

Three criteria's for rewarding process's team are as follow:

- **X** percentage to customer satisfaction
- **Y** percentage to profit generation
- **Z** percentage to others important issues as quality, individual performance, commitment, etc.

Shared leadership

Shared leadership is a concept practice by geese fly. They share the leadership when the one on the front gets tired. Another one takes the leadership to keep the geese together. They fly faster compares with flying alone. A synergy inside the team needs to be keep to shared the leadership in order to meet the desired output of the IMOM model.

6. ORGANIZATIONAL CULTURE

A transformation needs to occur in the organization if it wants to become a competitive enterprise. The transition through the current state to the desired state of the company, has to be taken as a serious issue to be analyzed.

Six steps are recommended to move the cultural organization to a quality based approach:

1. analysis of the organizational moment
2. shared VISION and MISSION of the company
3. employees commitment
4. closing the gap between the company's VISION and employees beliefs
5. implement the IMOM model
6. change management.

Miller that describing the cycle life of a company (organizational moment), it can enable and drive the cultural change to a clear vision fixed by the enterprise.

A **basic condition** to move the cultural change in favor of the IMOM, is the generation of the VISION and the MISSION of a manufacturing company. once the VISION and MISSION are declared, the employees will be moving to the purpose reason of existence of the company.

7. LEADERSHIP

The challenge of developing or reestablishing a clear strategy is often primarily an organizational one and depends on LEADERSHIP (Porter, 1996). Experience has shown that once a project has been launched in a company, it normally ends with regular results because of the lack of commitment by the directors or top managers of the company.

The first person that need to be convinced about the real advantage of applying the IMOM model is the head of the organization, called General Manager, General Director, or CEO.

After that, the head of the organization has been declared the leadership implement the IMOM model. A survey for small manufacturing business shows that the leadership (one of the main points evaluated) of the top management is poor in most of the cases. This fact opens a space to be analyzed in the human resource discipline. That's why the manger role has to change, instead being expediting and signing papers the manager or director must be seeking to reach the Vision of the company through the Mission, both already established, and developing action implementing the IMOM model. At the beginning of the implementation of the IMOM model the leader has to be calling his colleagues (employees) to meeting, perform basic operations conditions and sinerigyzing the team work. After about two or four month the leader would reduce his participation (not aborting the project), once the team is already empowered.

8. COMPUTER SUPPORT SYSTEM

In the figure 4.8 the information system appears as an element of the IMOM model, and it is considered as an intrinsic element, it means, that the information system is very important, but it may not be a key element for the success of the IMOM. The challenge to become an enterprise competitive, is by changing the way we perform our job, focus on processes.

A good performance of a process of the IMOM, needs a computer information system. The MRP II can be a good alternative if it is combined properly with a hybrid module of production. Now a days the ERP's (Enterprise Resource Planning) are offering a better performance as production module compares the one offered in the MRP II systems. At the begging of the implementation of the IMOM model, is very recommended to put it in practice manually, without the information system. The first obstacle for a successful implementation of an information system, is the current job culture, so starting with minimum use of the information system trying to achieve the new work culture, then the information system is enable to be successful.

4.5 Measures of performance

It is very important to develop and follow the measures to know if we are reaching the desired objective of the IMOM. Two questions need to be answered: Is the process able to satisfy customer requirements? Is the process improving? Is the process providing profit to the company?

The follow indicators are considered to be part of the IMOM:

- ⇨ Profit of the organization
- ⇨ Customer satisfaction. It envelopes meet the quantity committed, the delivery date committed, service, and customer complains
- ⇨ Cycle time. From receiving the customer order till it is delivery to the customer
- ⇨ Inventory turns and holding cost
- ⇨ Market share

These performance measures will be fully described in the next chapter.
In figure 4.16 we can observe the impact of the permance measures in terms of quality, customer satifaction and profit (Ehresman, 1995). It is very important to undestand what is the benefit of measuring the evolution of a process, and if we are really achieving its objective.

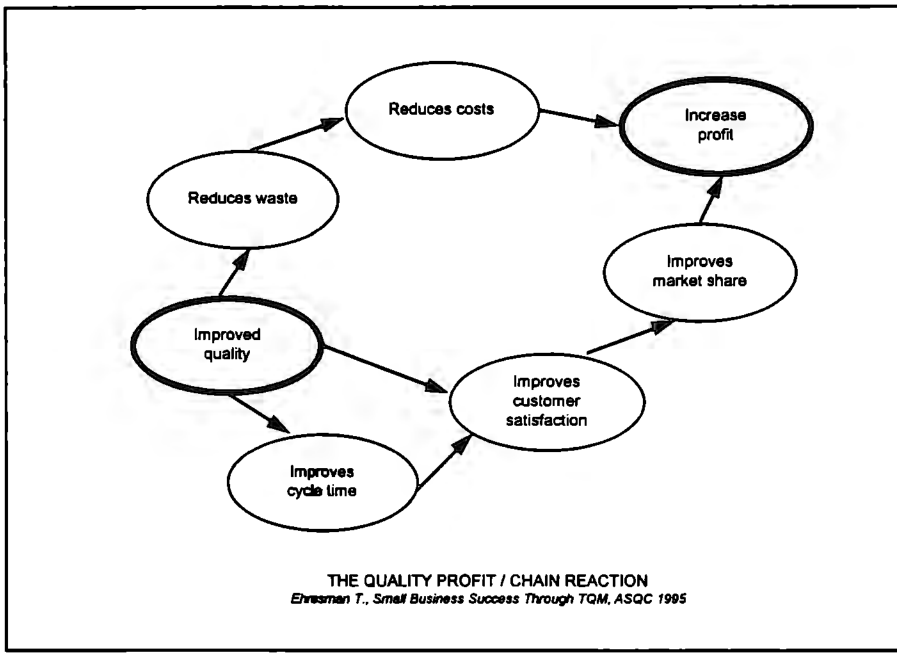

Figure 4.16 Impact of the performance measures to Quality and Profit

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5. IMPLEMENTATION OF THE IMOM MODEL (Case study)

5.1 Introduction

This chapter aims to put in practice what is presented the IMOM model from chapter 4, so as a case study, a medium sized manufacturing company was selected . First, I am going to describe in section 5.2 the antecedents background its strengths and weakness. Section 5.4 will developed the implementation of the IMOM model covering the experiences in each of its elements. Section 5.5 is going to be validated the implementation through a survey and the experience that I found as participant, and finally section 5.6 will developed others experiences related to the IMOM model. These experiences provide a feed back due the validation of some elements of the IMOM model. I think that it can enrich a lot the conclusion of the thesis, even a partial validation was made.

5.2 Introduction and antecedents of the company

According to the research methodology proposed, in chapter 4, the IMOM model has to be applied in a real situation in order to test the theoretical conceptualization of the IMOM model.

As described before, this thesis is focused in the small and medium sized Mexican manufacturing companies based on job shop or assembly lines systems. Fortunately the enterprise ***BH Excercycle*** opened its doors to apply the IMOM model. It is important to describe at first the characteristics of the enterprise and the situation found at the beginning of the implementation.

BH Excercycle is a medium sized manufacturing company located in the industrial zone of San Luis Potosí México that owns to a corporate of several enterprises. It has 120 employees. Products produced are fitness equipment for home, like gyms, trotters, bikes (see figure 5.1). There are 30 different products. The monthly sales are presented in appendix 1.

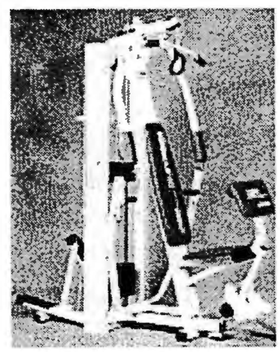

Figure 5.1 A representation of a BH Excercycle product (GYM)

The raw material is composed by structural metal (almost 70 % of the finished product), buffers, screws, sits, small parts, electronic indicators, etc. 250 components integrate the products.

90 % of the current market is domestic and the remaining is to export to south America (Brazil, Venezuela and Uruguay). The company is five years old, and there was a joint venture with BH fitness from Spain, now it is almost domain by Mexican assets. The Spanish company provides the technology required for the production process and consulting in some management areas.

BH faced several problems due to lack of organization in the whole company. Next I am going to present the strengths and weakness in order to diagnose the current situation of BH:

STRENGTHS

- ✓ High potential to grow in the domestic market
- ✓ Good opportunities to increase export products to south America
- ✓ Most of the people are willing to improve the company
- ✓ The BH's products are competitive in quality and price

WEAKNESS

- ✓ The BH's Vision and Mission are not defined
- ✓ Strategic and operational planning are not performed
- ✓ Unbalanced raw material inventories. Some parts with high levels of inventory and other with short levels that produce shortages in the shop floor.
- ✓ Poor accuracy of inventories (50%)
- ✓ Lack of integration between sales, production and purchasing areas
- ✓ There isn't a Quality policy for the company
- ✓ High levels of obsolete finished goods
- ✓ Finished goods inventory unknown
- ✓ Lack of training in all levels of the organization
- ✓ There isn't feedback from the market (customers)
- ✓ High Process batches
- ✓ Poor use of the "Information Systems" (MRP II)
- ✓ Continuous shortages of parts in production
- ✓ Lack of actualization of the Bill of Materials (BOM)
- ✓ There is not a formal Product development department

The above diagnostic shows the BH's current problem represents a Complex Manufacturing System (Gupta, 1997). This kind of systems is pretty common in the small and medium sized Mexican companies. This is one of the reasons to develop this thesis. The production process is performed by a combination of job shop and assembly lines layout. The first two stations are based on a job shop process, and after the painting area the remaining process is of assembly lines. Figure 5.2 represents the layout plant.

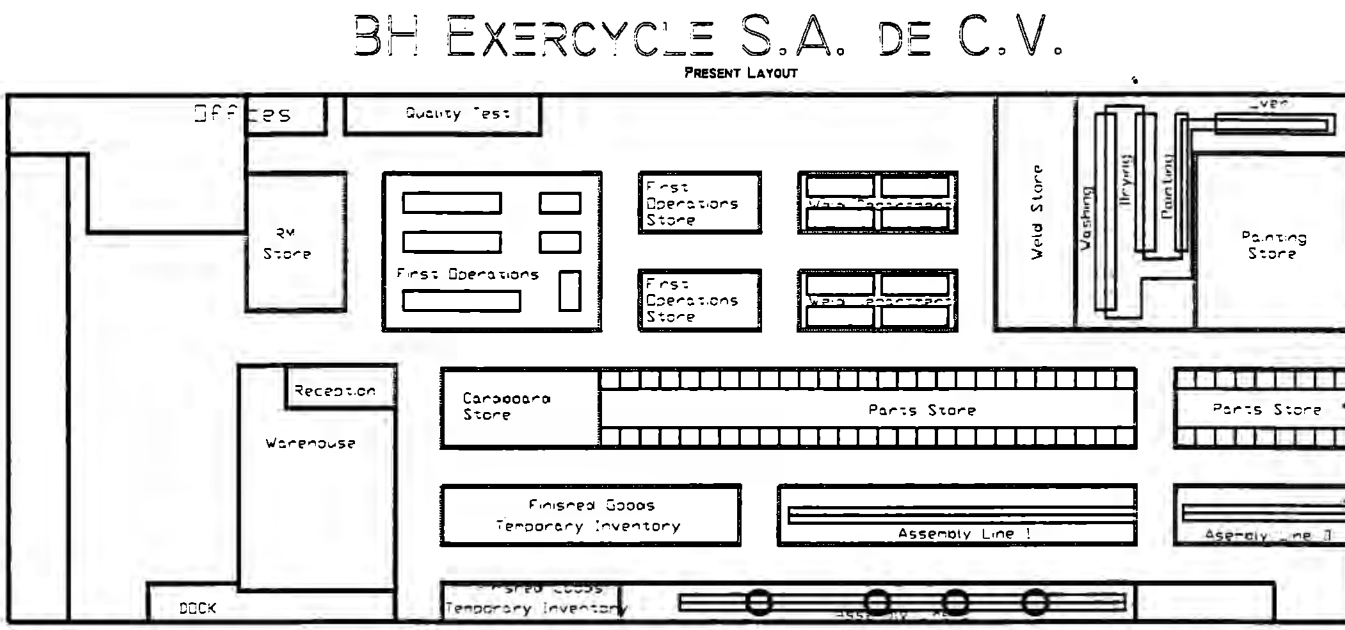

Figure 5.2 Layout of BH Excercycle

The BH's stage in the life cycle curve of an organization (Miller, 1990), is between the Barbarian and constructor (see figure 5.3). According to Miller's model an organization begins its life cycle with an idea of producing a new gproduct (professer), then, if the idea is good, the company starts growing passing through the Barbarian and the constructor stages. Here these stages are represented by hard work and continuous effort to keep the business growing. In the synergetic stage a minimum effort is required to keep the company working, but sooner or later, if no care is addressed, the company lies in the administrator stage, where management and operational policies are put in practice. After this stage, the organization passes to the Bureaucratic stage, and then begins to die in the Aristocratic stage. BH is still in the growing process, and its messy management is complicating its evolution. In the other hand, BH has a lot of opportunities to become a world company. As some specialists recommend, companies need to keep growing in a continuous process between the constructor and the synergetic stages (see figure 5.3c), so this is the case for BH.

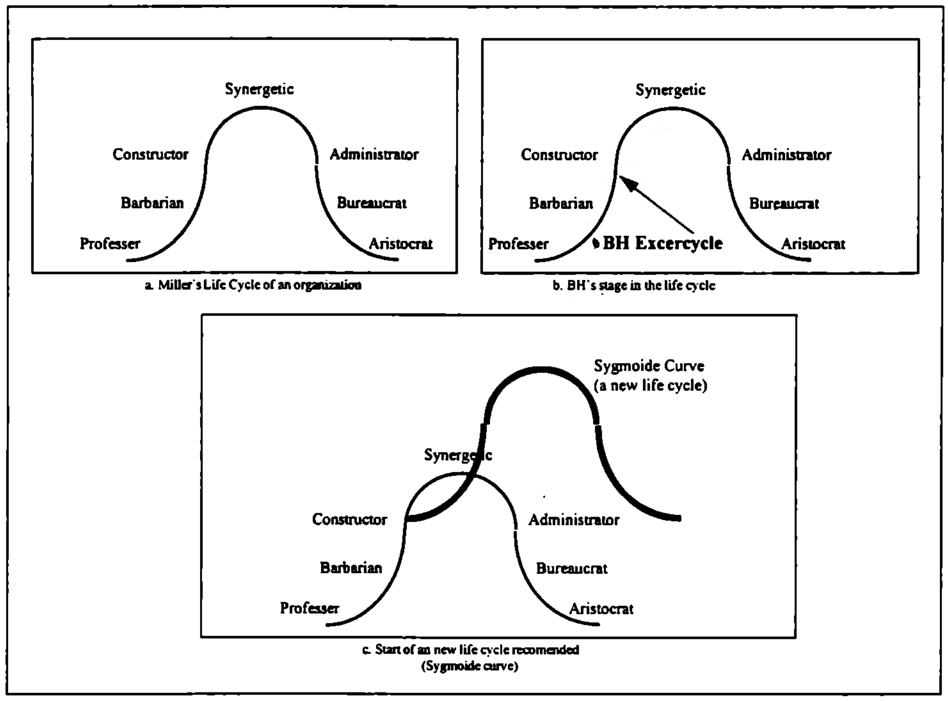

Figure 5.3 BH's stage in the life cycle of an organization

My participation in BH Excercycle was accepted as a consultant in the operations management area. The BH's owner agreed with my participation to provide consulting through the IMOM model and at same time obtaining information for my the research.
The first problem that I found was that in the raw material and finished goods inventories weren't managed properly, that is, no status about the inventory could be provided, even BH had two "Information System" available (MPR II).
In order to have a better understanding of the BH's problema and have a structured methodology to diagnose it, I used the Checkland's soft systems Methodology (SSM) (Checkland and Scholes, 1990; Jackson, 1991). This methodology is composed of seven stages or activities as shown in figure 6.2, but for the purpose of this thesis, only stages 1, 2, 3 and 4 are going to be used in order to clarify or have a well understanding of the BH's problematic situation. Even the stages 5, 6 and 7 would represent the application of the IMOM, I rather not use Checkland's methodology to avoid any confusion during those stages.

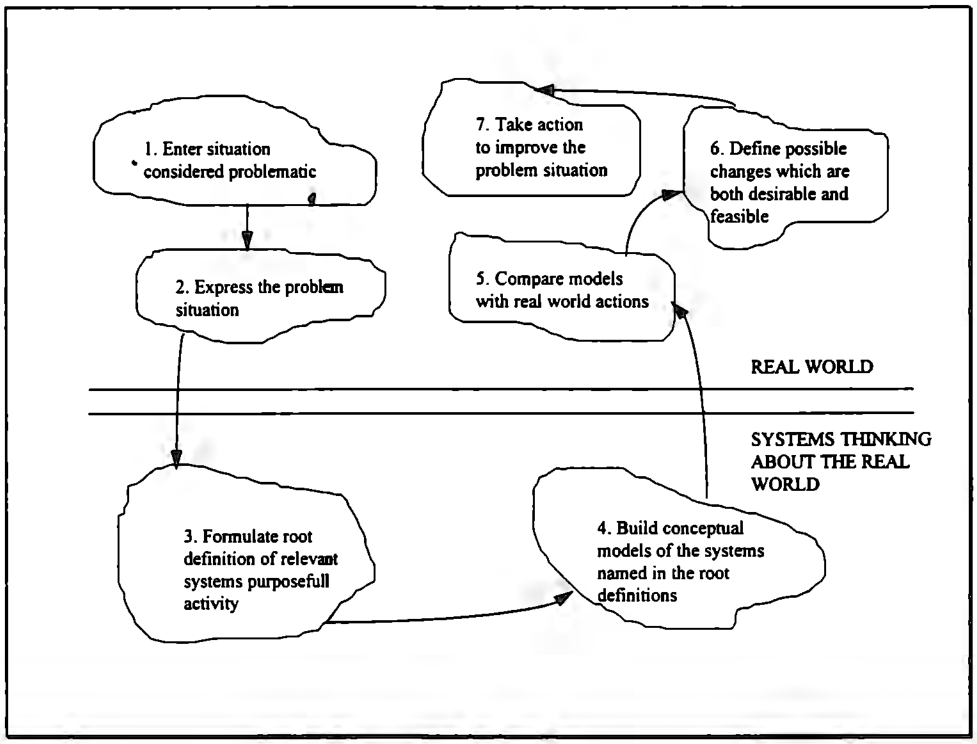

Figure 5.4 The learning Cycle of soft Systems Methodology (after Checkland 1989)

Not structured problematic situation

A rich picture on the non structured problematic situation is shown in figure 5.5, and represents the problem found in regard to the materials storing and finished goods warehousing (those areas are considered in the IMOM model). The following points represent an explain that is stated in the Rich picture:

☑ Lack of definition of activities

☑ The production process stopped due to lack of raw material purchased

☑ Lack of organization in stores and warehouse

☑ Obsolete products in both stores and warehouse

☑ Finished products damaged

☑ The information systems is not updated

☑ There isn't information about inventory status (both raw material and FG's)

☑ The consumption of materials is discharged by exploiting the finished goods entered to the warehouse

☑ Unbalance inventory. High volume of materials with slow movement and short volume of materials with high consumption

☑ There isn't an inventory policy

☑ There isn't definition of functions

☑ Production focus on high volumes

☑ Sales forecast is not accurate

Even when the above statements appears dramatic, they represent the first five years of the life of the cycle of Mexican manufacturing enterprises. This is not the case for the small or medium sized companies with almost 100% of assets from countries as: USA, Germany, France, Japan, etc.

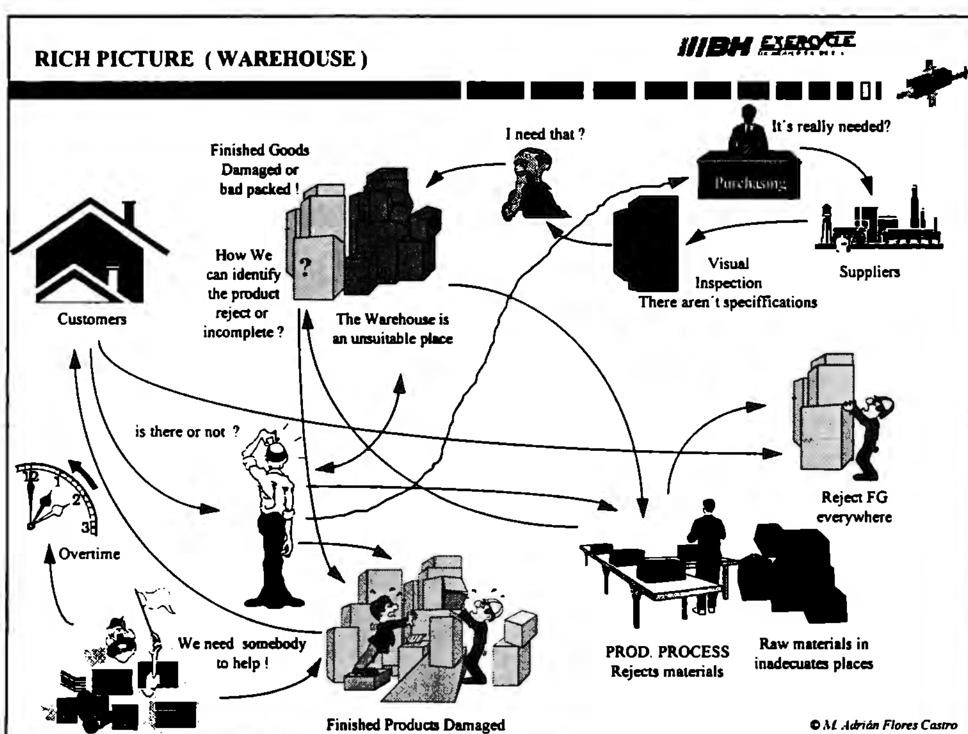

Figure 5.5 Rich picture of the storing and warehousing problematic

A root definition was also developed in order to clarify and formulate the relevant system of purposeful activity . The root definition includes a CATWOE test that explains who is the Customer, who is the Actor of the system, how is the Transformation process, what is the Weltanchaung or world view which makes T meaningful in context, who is the Owner and what are the Environmental constraints.

The root definition for the BH's case is as follow:
BH Exercycle design, produces and sales fitness equipment for domestic and international market. The finished goods have the quality requested by client and they are delivered on time and site adequate.

As a part of the root definition a CATWOE test is developed as follow in table 5.1:

CATWOE	***Description***
Customer	Retail chains and supermarkets
Actor	People from the functional areas
Transformation	Customer orders and raw material ⇨ Finished Goods in customer's dock
Weltanchaung	Do transformation with the quantity, quality and time specified by customers.
Owner	BH Excercycle
Environmental Constraints	National and international competence. Also the staff people from the corporate

Table 5.1 CATWOE test

A conceptual model was also necessary to represent in a general manner the operation of BH. The conceptual models are also recommends by the Checkland's methodology as a part of its fourth stage. Figure 5.6 show the activities involved in the BH's system. Even when there are some activities that weren't performed properly, they are represented. For instance, Design and Development wasn't working well, because the new products appear without any technical and formal support. The other entities like *Purchasing, Storing, Production, Warehousing and Sales* weren't working as an integrated process, it means, no information was shared, there was lack of communication, functional approaches (local objectives), not focus on customer (internal and external), and fights over power. These symptoms have justified the implementation of the IMOM model.

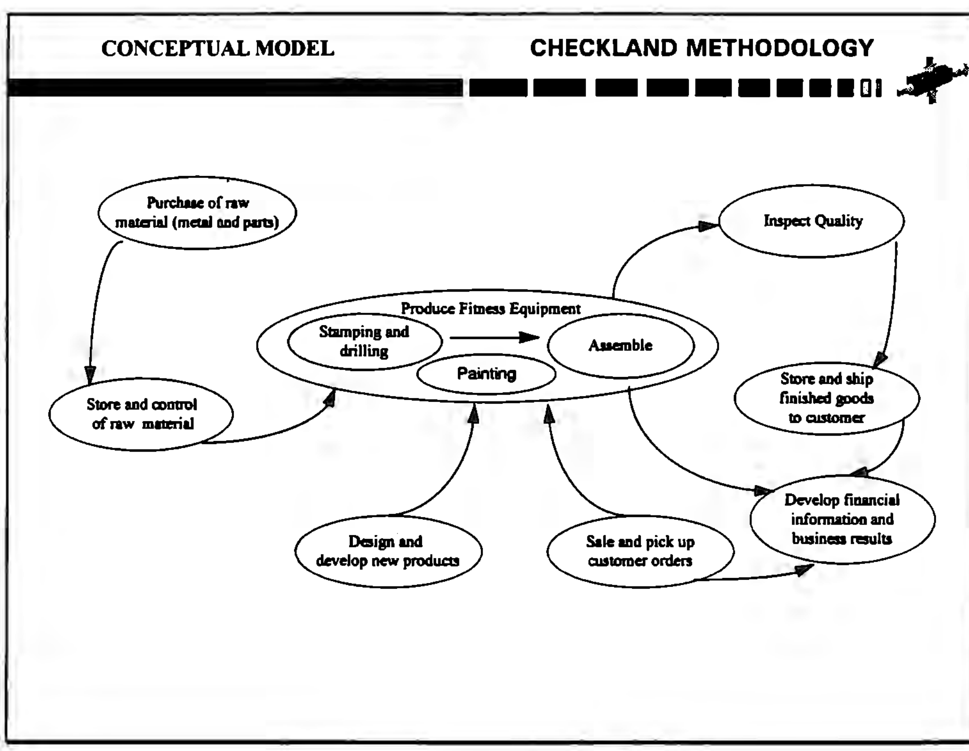

Figure 5.6 BH's Conceptual model

If we compare the conceptual model and the root definition of BH with its real situation, we will find a lot of opportunity areas that need to be improved or modified. These opportunities result from the problematic situation and undesirable effects analyzed with the Checkland methodology.

5.3 Opportunities

The reason why to understand the problematic situation of BH is because it results in several opportunity areas that will help to the implementation of the IMOM model, and as a consultant and researcher for BH, I can have a better understanding of the company's behave and current situation. The market's behavior is promising good sales and the five years of evolution of BH, represent great opportunities to improve mainly in the internal productivity factors (see chapter 2).

Next a list opportunity areas for BH are shown:

- ⇨ Become the leader of fitness products in México (increasing its market share)
- ⇨ Increase exports to South America
- ⇨ Reduce cycle times
- ⇨ Reduce inventories
- ⇨ Increase productivity through improvement of the internal factors
- ⇨ Development of a customer service department
- ⇨ Improve communication an integration using an information system
- ⇨ Improve inventory management
- ⇨ Wiliness to change some traditional practices
- ⇨ Create a formal division for design and development of new products

This list is not a causality or invented good desires. They are the result of a deep intervention by observing and having talks with people involved in all the areas of the company.

Now, having a clear knowledge about what are Strengths, weakness and opportunities of BH are I am going to develop the implementation of the IMOM in each of its elements explaining and showing the results obtained. Note that some elements have deep analysis and others don't. This is a consequence of the degree of the people's involvement in the implementation of the IMOM model. Fortunately at the beginning I got the confidence of the owner and the general manager to have good results.

5.4 Implementation of the IMOM model

5.4.1 Inventory policies

As purposed in the IMOM model (see figure 4.8 chapter 4), the inventories are the end points of the manufacturing system (raw material and finished goods), and if these strategic end points are not well managed, then the production process and customers will be affected by lack of raw material or lack of finished goods (work in process will be analyzed later). This is without considering the cost savings due to the reduction of inventories. An inventory model called MAFC was developed (Flores Castro M. A., 1993) to control and manage inventories in an easy and practical way. The MAFC model has different structures and compared with EOQ (Economic Order Quantity). The EOQ concept makes some very questionable assumptions (Stein, 1996) and if any one of these assumptions are broken, the entire EOQ lot size process would be invalidated. MAFC model doesn't include costs to calculate the order quantity.

The Assumptions considered does not include cost in the calculation because of the following statements:

- Most of the times in the small and medium sized companies costs related inventories are not available
- The order or set up cost is assumed linear and in reality its behavior is non linear
- The EOQ is based on optimization of cost, and is not considering the increasing of profit due to better deliveries to the customer
- The EOQ average inventory is higher than the MAFC model
- People who handle inventories in stores and warehouses are not prepare to calculate the EOQ and its costs. They prefer an easy model

As described in chapter 4 about MAFC model, there are several important elements considered as: demand of the products, lead time and safety stock (only if it is necessary). Figure 5.7 represents the MAFC model.

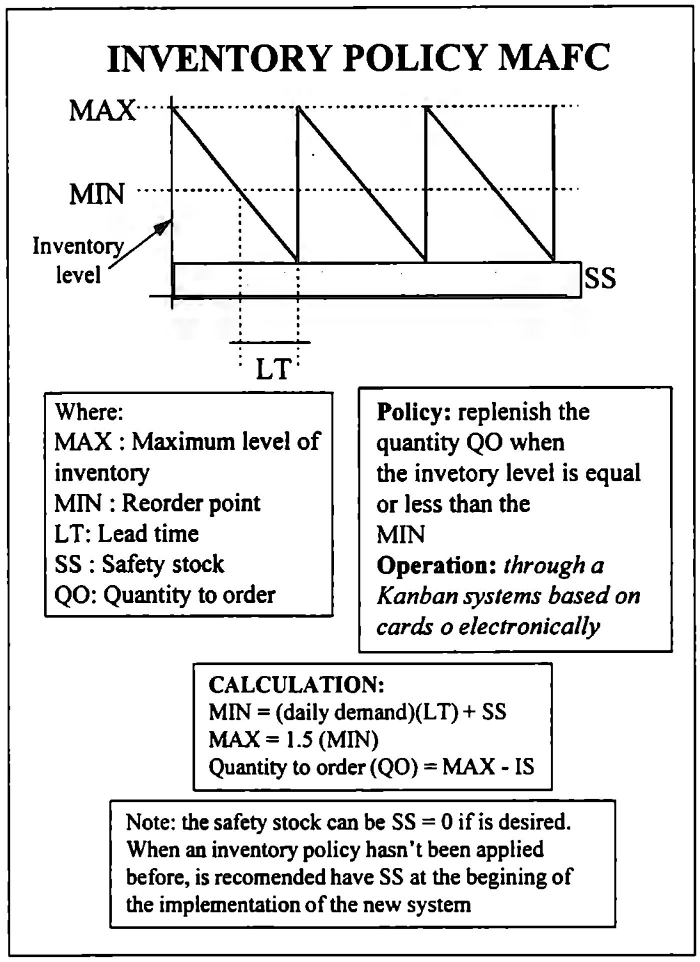

Figure 5.7 MAFC inventory model (Flores Castro M. A., 1993)

This model is based on an heuristic approach. The contribution to the inventories discipline is the maximum level of the inventories. That is, 1.5 times the minimum level. This factor was surveyed with several material managers and evaluated in practice with very good results. Also an optional safety stock is included. When a company is not managing its inventories is recommended for a short period of time the use of safety stocks, after this, if the inventories are under control the safety stock can be eliminated.

The way the MAFC model was applied to the case of BH was at first involving the people related with inventories (raw material and finished goods only). In a meeting celebrated in the plant the MAFC model was presented and explained. The model requires as inputs the daily demand and the lead time. The calculations were made for raw material and finished goods. Because of the continuos stops of the production process due to the lack of raw material (even BH had high inventories), the raw material inventory was the first priority to control.

Data was concentrated to estimate the monthly demand of finished products. The data obtained was considering the sales per month from 1995 to September of 1996. Using the exponential smoothing forecast technique the monthly demand was obtained for each finished good (see appendix A1). This monthly demand was exploited using a bill of material developed in EXCEL work sheet. As a result the monthly demand was obtained for the raw materials. Then, after working with the purchasing manager, the lead time for each material was obtained. The lead time considers the time spent since the purchase order was placed till the material arrives to the plant. For local suppliers (in San Luis Potosí) the lead time is between 3 to 10 days depending of the material. For national suppliers (inside México and excluding SLP) the lead time is between 10 and 30 days depending of the material. For international suppliers (mainly for electronic devices from Taiwan), the lead time is 40 to 60 days, also depending on what type of product is being required. The safety stock was also considered as relevant while the inventory system works efficiently and effectively. After this (two or three months) the safety sock can be eliminated or reduced depending on the reliability of the suppliers. This implies to work closely with suppliers. A perfect suppliers development was at that moment almost impossible, because of the low quality culture of most suppliers. Any way, new lead times and better delivery conditions were achieved during negotiations with some suppliers. With the information of the monthly demand, lead times and the level of safety stocks purposed by the purchasing manager, the calculation of the MIN's and MAX's was made. Lets considers a Bushing 1 1/8" R-25 (6693002 - Buje de fricción 11/8" R-25 in Spanish) as an example of how the calculation was made for the information presented in appendix A3. The monthly demand is 963 pieces per month (from the forecast analysis), dividing this quantity by 24 working days, the daily demand is 40 pieces. With a lead time of 8 days (from a local supplier) and a safety stock of 8 days, the MIN and MAX are calculated as follow:

$$MIN = (40)\,(8) + (40)\,(8) = 640 \text{ pieces}$$
$$MAX = (640)\,(1.5) = 960 \text{ pieces}$$
$$QO = 960 - (40)\,(8) = 640 \text{ pieces}$$

With this information a new policy for inventory management in raw materials, was put into practice. When the inventory reach the MIN, a replenishment must be fill ordering 640 pieces. There are two ways to manage the replenishment: one is by using a Kanban system (using cards), and through the use of an electronic kanban system. If an information system based on computers is being used the electronic kanban can be used. It works by placing the MAFC policies in the system, and every day a list of materials that reach the MIN can be printed and used to place purchase orders or to activate one already opened.

In the situation of BH, an information system (called ASPEL) was beginning to be implemented, but not enough confidence was gotten from it. A manual Kanban System was considered as a better option because the company needs at first to develop a new job culture, so the manual kanban system was put into practice. Figure 5.8 represents the replenishment process of raw material using the MAFC model and the Kanban System.

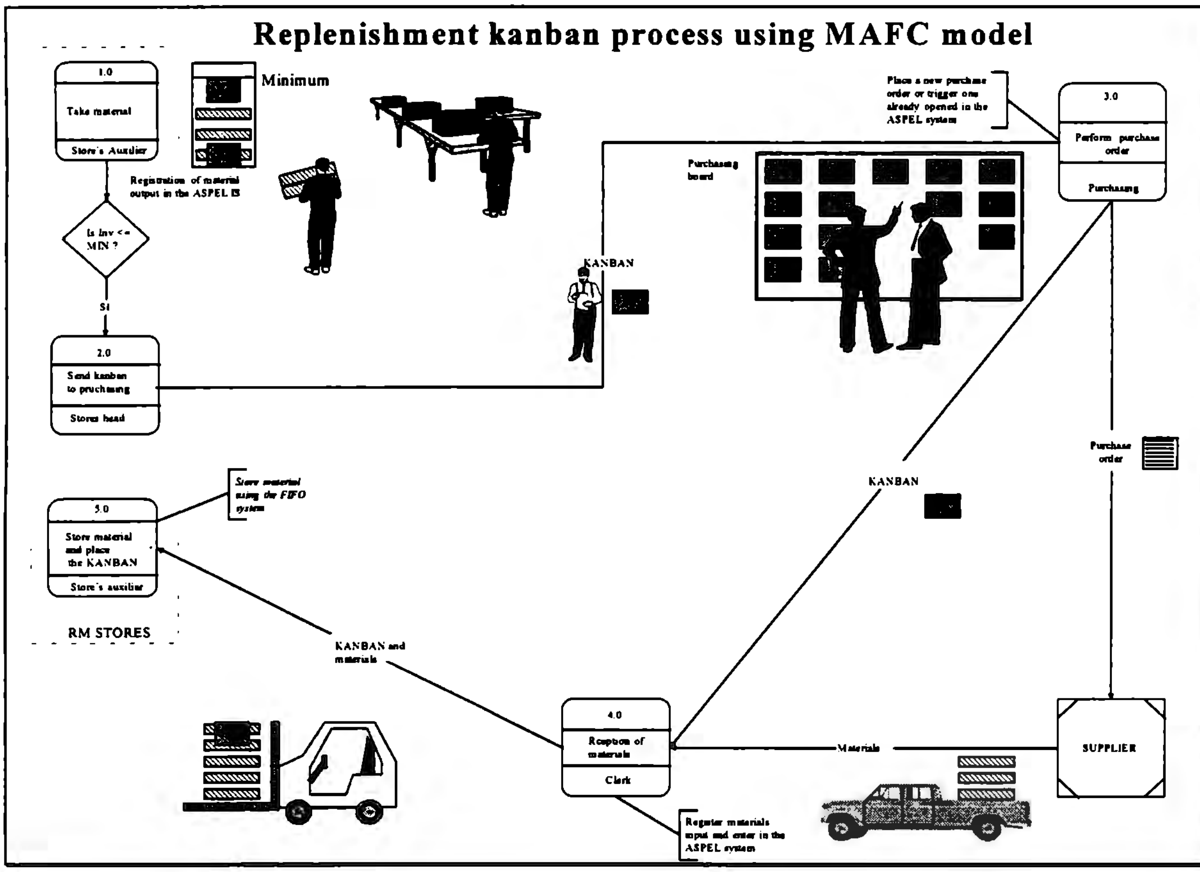

Figure 5.8 The replenishment kanban system using the MAFC model

Working with the people in charge of storing raw material, the cards (kanbans) containing information as shown in figure 5.9, were placed on the top of the MIN level. When the inventory drops till the MIN, before taking any material, the card needs to be picked up by the people in charge of deliverying the materials to production, and then place it in the purchasing board (see figure 5.8). Three times a day the people in the purchasing department have to pick the cards up and place the purchase order or activate the ones already opened. The card is then placed on the board of the reception office. With the cards on the board the receptionist is able to realize what material are coming. Once the material arrives, the card is placed on the top of the material received. When the material is being stored, the card is put again on the top of the MIN level and the cycle is repeated again.

PART NUMBER:__________				
Description:				
Ubication	SPECIFICATIONS			
MAX	**Supplier**	**Requirement date**	**Purchase Order Date**	**Reception date**
MIN				
Quantity Order				

Figure 5.9 A sample of the Kanban card used to replenish materials

In order to validate the MAFC model a simulation model was built using the ARENA software (Windows 95 version). The simulation proves the robustness of the MAFC model, and also allows to adjust or reduce more the MAX and MIN levels as a part of a continuous improvement process. Figure 5.10 shows the distribution obtained for the part 7831001 (sit G-60). The distribution for the daily demand is assumed BETA with the parameters of 6+7 * BETA (2.38,12.2).

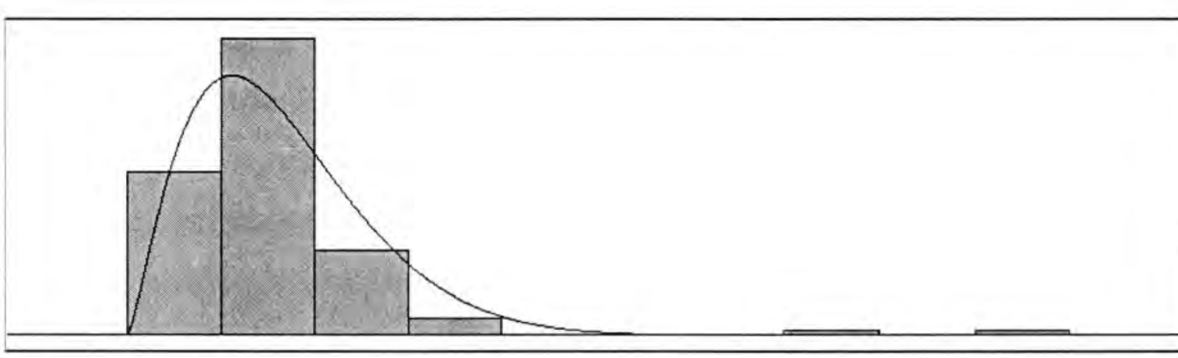

Figure 5.10 BETA distribution for the daily demand for part 7831001 (sit G-60).

Using above data for the daily demand, a simulation was run for this part and the behavior of the MAFC model is shown in the figure 5.11.

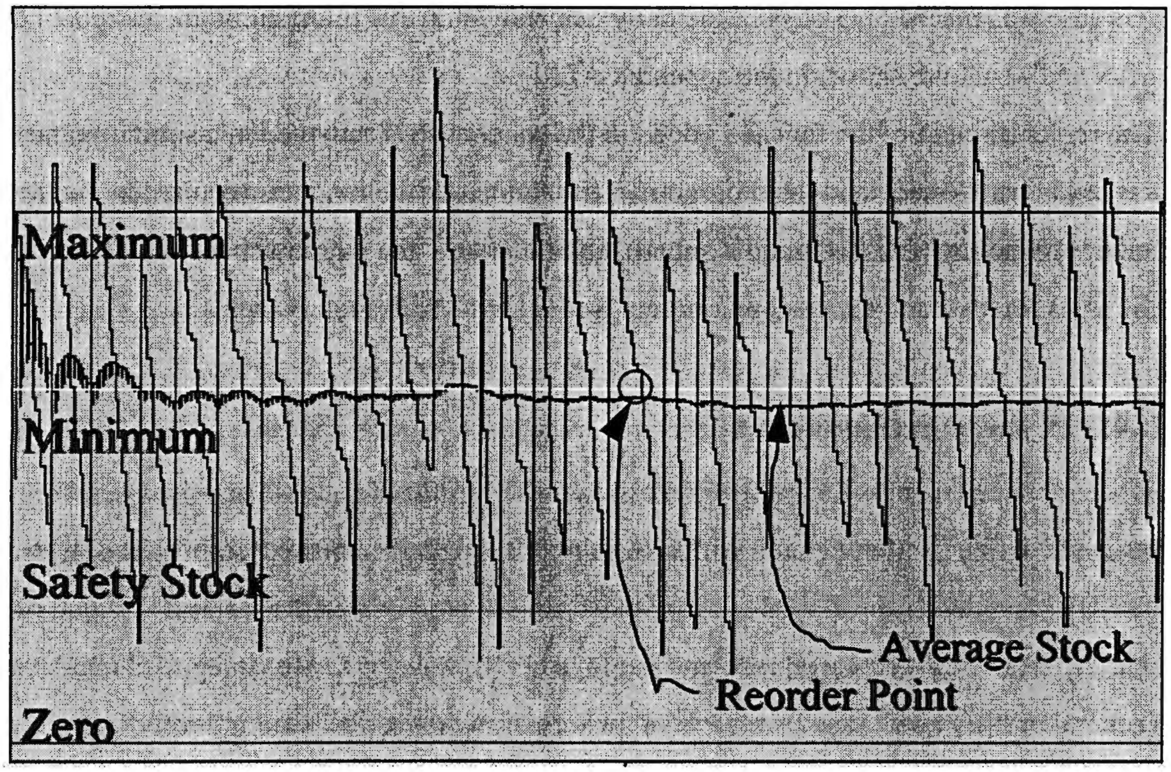

Figure 5.11 Simulation of the MAFC model through the time

As we can observe the average inventory **(94 units)** is almost the Minimum level (MIN), so comparing this with the current inventory at the beginning of my intervention **(700 units on average)**, we get a dramatic reduction using the MAFC model. Also we can observe in figure 5.11 that sometimes the inventory level is above the MAX and below the Safety stock. This is the behavior that we can expect in reality and the simulation demonstrates and validates that the inventory management policies included in the IMOM model work effectively.

In regard to the finished goods inventory, the calculations were made in the same manner as the policies found for the raw material inventory. The forecast of the demand for each product was exactly the same as used the onebefore exploiting the monthly requirements of raw material. The lead time in this case is considered as the time needed to produce a product in the shop floor. It was calculated as 5 days, that includes the time to release the work order, time to produce the order, inspection time and shipping. The safety stock for this case was placed on 3 days of the daily demand. With this information the results of the MIN and MAX are shown in the appendix A2.

The replenishment of the finished goods in the warehouse is activated in a similar manner as the kanban system, and the programmer has to include the products required by the MIN and MAX policy (finished good Kanban), and integrates the master schedule together with the sales forecast and the customer orders (see Hybrid Production System).

5.4.2 Process management

Process management is the key element of the IMOM model, because here is where the tasks are defined and integrated with clear input rules and information outputs or objects. The BH's processes developed here are those considered in the in the figure 5.10. The way that the processes were developed and deployed is from the processes integrated in a level 0 (general or high level), and then each subprocess is deployed in a second level of detail. A third level of detail for this case was considered unnecessary.

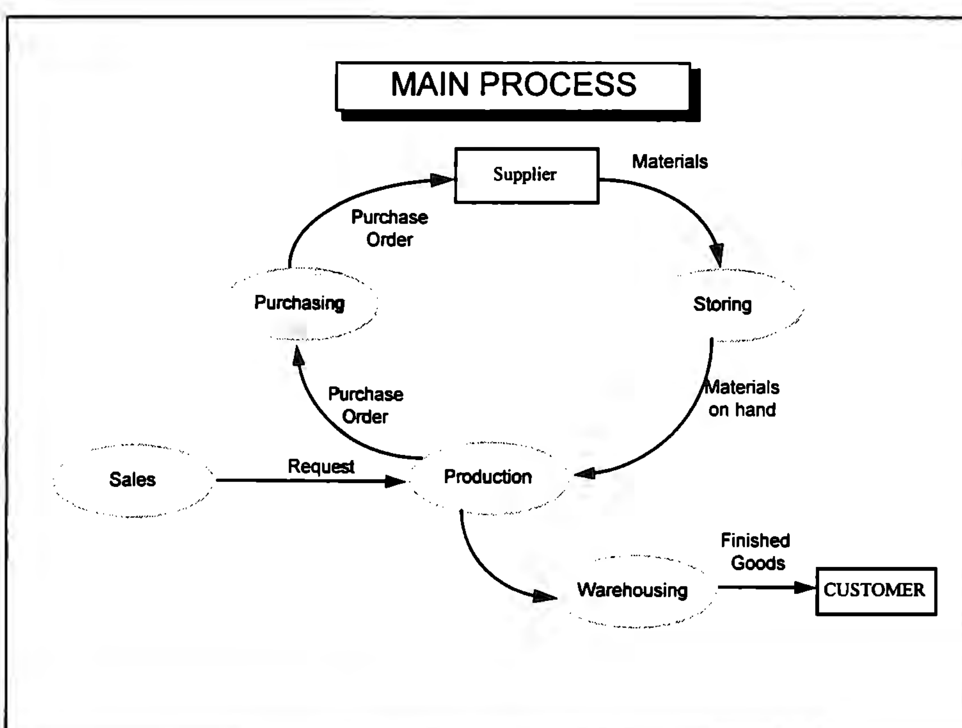

Figure 5.12 Conceptual representation of the BH's processes considered in the IMOM

Each process and subprocess has performance measures that need to be followed if the IMOM model wants to be implemented properly.

The INPRO process considered in the IMOM model states the normalization of entities like a Customer Service section working in coordination with the Production Planning and Control section. With the integration of these two sections the customer will be the winner, because now, only one entity is going to be responsible for tracking the customer orders. Also a very important elements appear in the process, they are the CUSTOMER and the SUPPLIERS. In order to develop the integrated process (sales, production and materials supplying), a meeting with the people related with the process of BH was celebrated.

A dynamic group was performed to map the content of the integrated process at the level 1. In figure 5.11 the symbols used to map the process are presented. The technique used to map the processes is called DFD's or Data Flow Diagramming (Johansson and Pendlebury, 1993). This technique is also used in Business Process Reengineering projects.

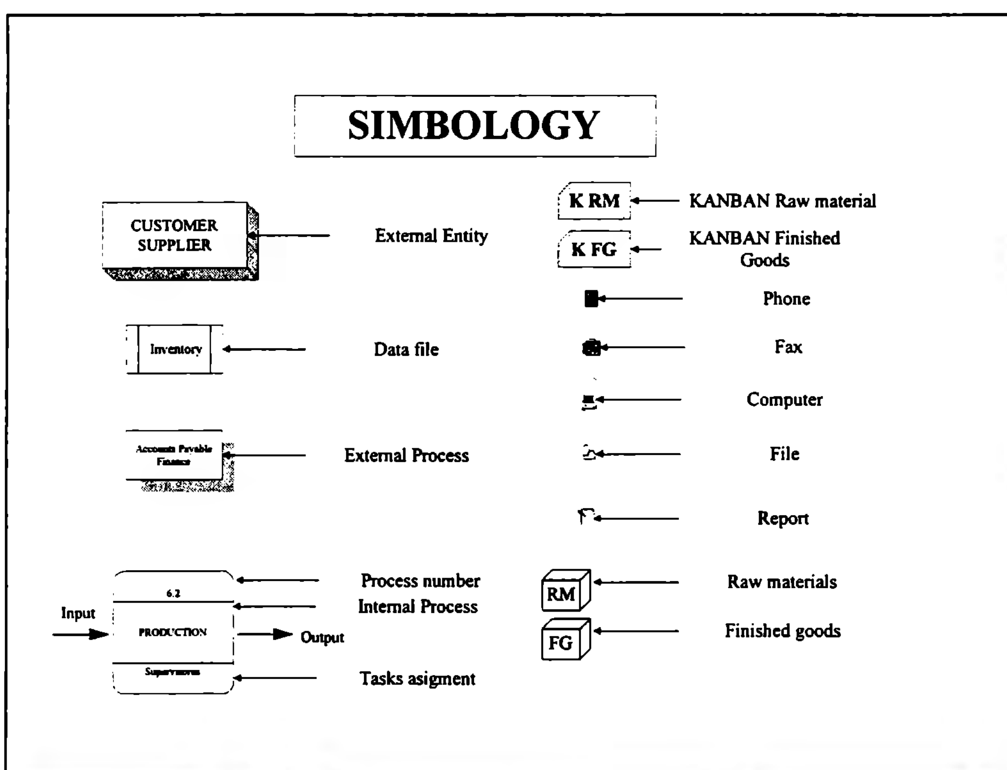

Figure 5.13 Symbols used to map the process

The map of the integrated process (INPRO) at level 1 is shown in figure 5.13. The way to develop the level 1 process was by asking the people how their process should be performed. While the mapping was in process had been mapping, a lot of discussions took place between the people from the different departments. For instance, sales and production discussed about the late deliveries to the customers, the poor reliability of the sales forecast provided by the sales department, and some miscommunication pórblems between their areas. A similar discussion came up with the purchasing department and the production department. Every entity analyzed demonstrated a lack of communication, coordination and integration. After the process was mapped, the Integrated Process (INPRO) of the IMOM model was shown to benchmark the one that was developed by the BH people, and a final version of level 1 was elaborated (see figure 5.15). After the mapping session and the final version of the Integrated Process, the people shared the same vision of the process, and the word departments (functional) wasn't mentioned. After level 1 was developed, internal meetings with people related with specific activities of the subprocesses were executed to develop level 2 of each subprocess in order to detail the activities, inputs and outputs inside the Integrated Process (INPRO) . Only two subprocess in level 2 are shown in this section. The remaining subprocess are presented in appendix 5.

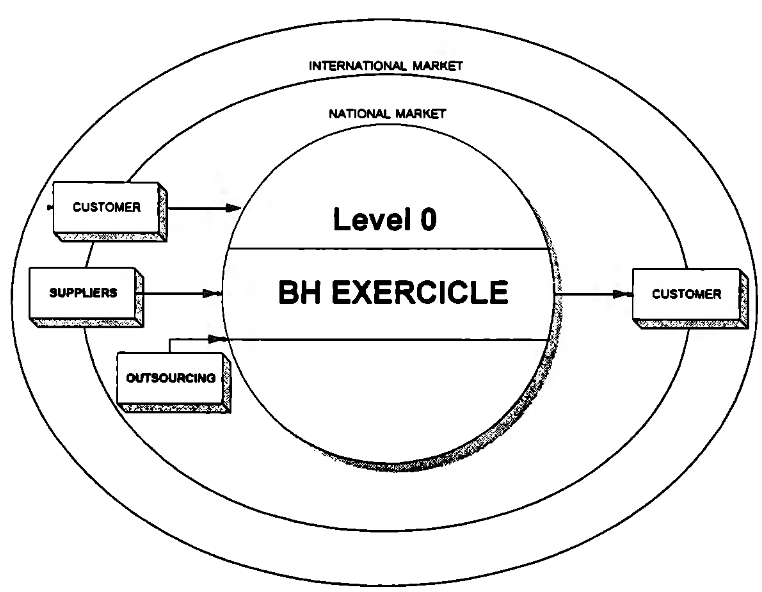

Figure 5.14 Mapping of the BH's Integrated Process at level 0 (high level)

area. This is a new area in the company and the customer can receive personal service now. In figure 5.17 we find the Production Planning and Control subprocess area part of the Customer Service area. While a new person is hire for the Production Planning position, the production manager is executing those activities. A new role for this job is has appeared, so now considering the Constrained resources for scheduling the plant. The Hybrid Production System will help in the execution of this subprocess.

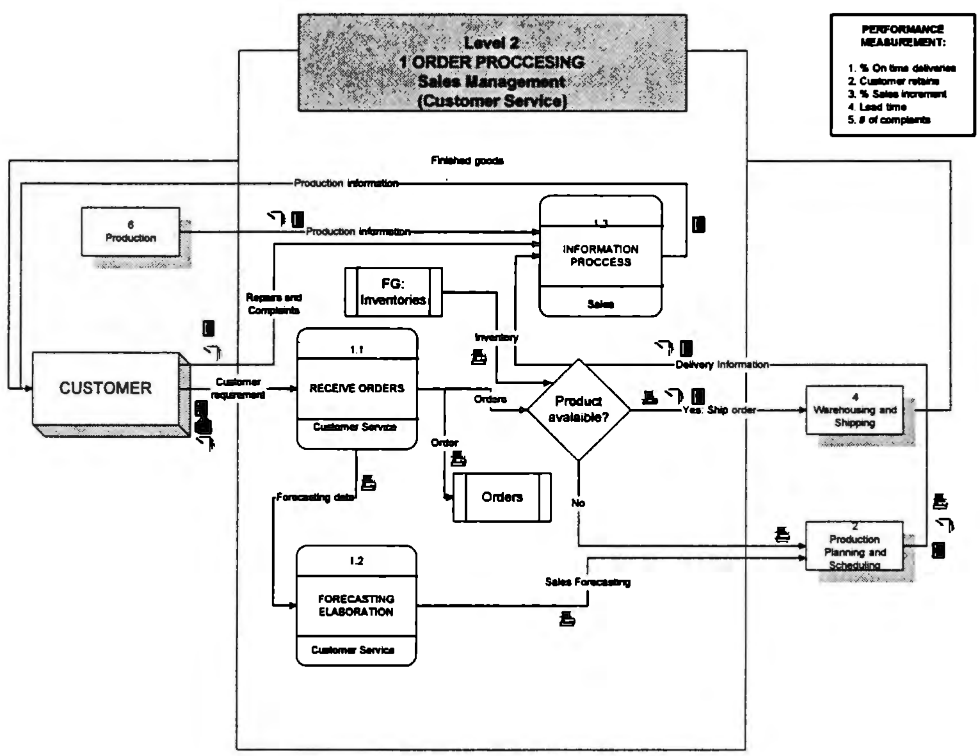

Figure 5.16 Sales Management subprocess detailed in second level

In figure 5.15 we can observe that the customer is closing the loop, that is, the input and the output of the process for the customer. The effects of this map are so important because the people involved in the process now know where they are in the company and what kind of job they are doing. Another important benefit is that we are closing the gap between the shop floor and the administrative processes. Often they work without any integration. We are going to close the gap completely when we have defined the way to manage the shop floor with the hybrid production System. We need to observe also that in the level 1 processes (figure 5.15), was defined a set of performance indicators for the five areas of BH. Now, customer satisfaction is responsibility of the five areas and not only of the sales department as believed in the past. This issue will help promote team work.

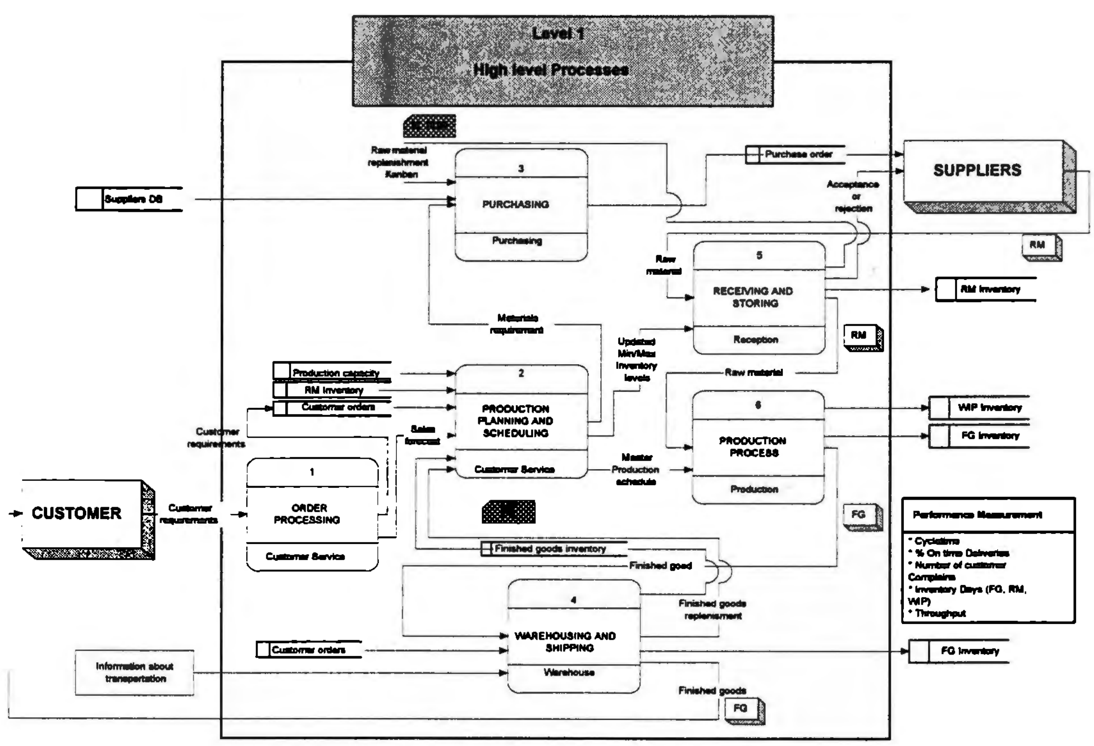

Figure 5.15 Mapping of the BH's Integrated Process at level 1

In figure 5.16 a deployment of the subprocess of Sales Management is represented in a second level. This subprocess is mainly executed by the people in the Customer Service

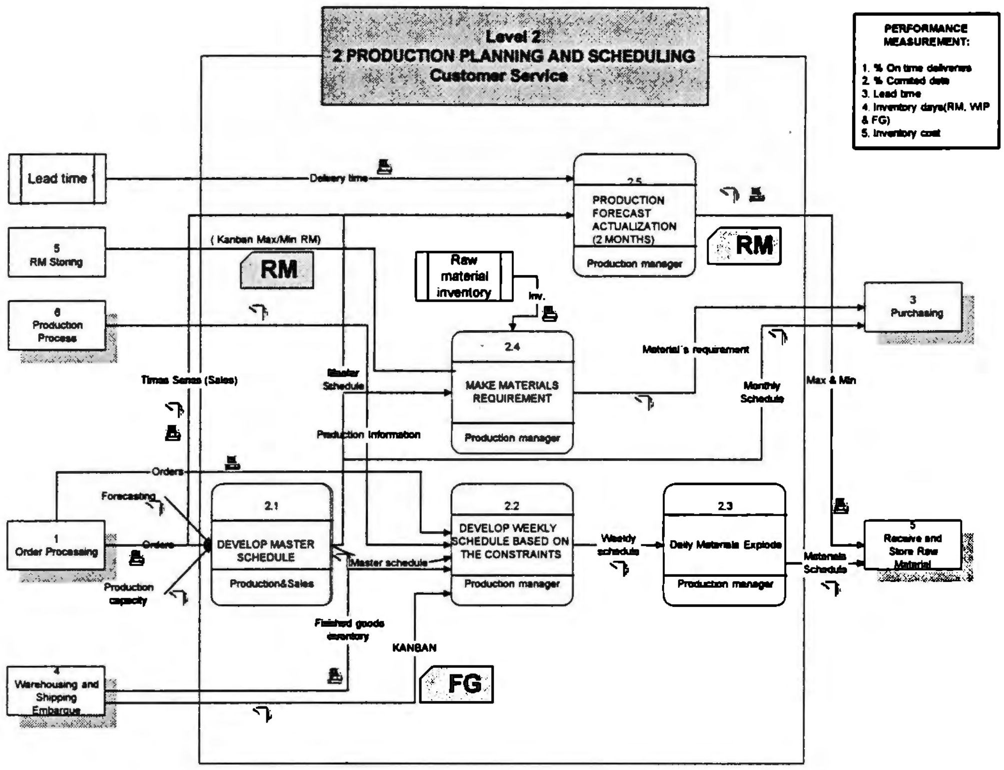

Figure 5.17 Production Planning and Control subprocess in level 2

In every level of the whole process a performance measures was stablished in order to evaluate the improvement that will be reach and to monitor if the key indicators as profit, customer service and market shared of BH are being achieved. This indicators are going to be developed in the next section of this chapter (5.3.3).

The expected results from the integration of the areas involved in the Integration Process (INPRO), are represented in a conceptual model in figure 5.14. Here appears an important structure, the customer service and Production Planning areas are now integrated in the same entity. The benefit of this integration is going to impact in a good way in the customer. This integration can be seen as a logistic approach, and it can reduce the lead times, increase the customer service and reduce delivery times. The lead time for a customer order is typically composed as follow:

I. time to register the order

II. time to schedule the order

III.time to ship the order or time to produce the order

IV.transit time till the order is received by the customer

Often a lot time is wasted in the stages I and II. With the Integrated Process these times can be almost eliminated.

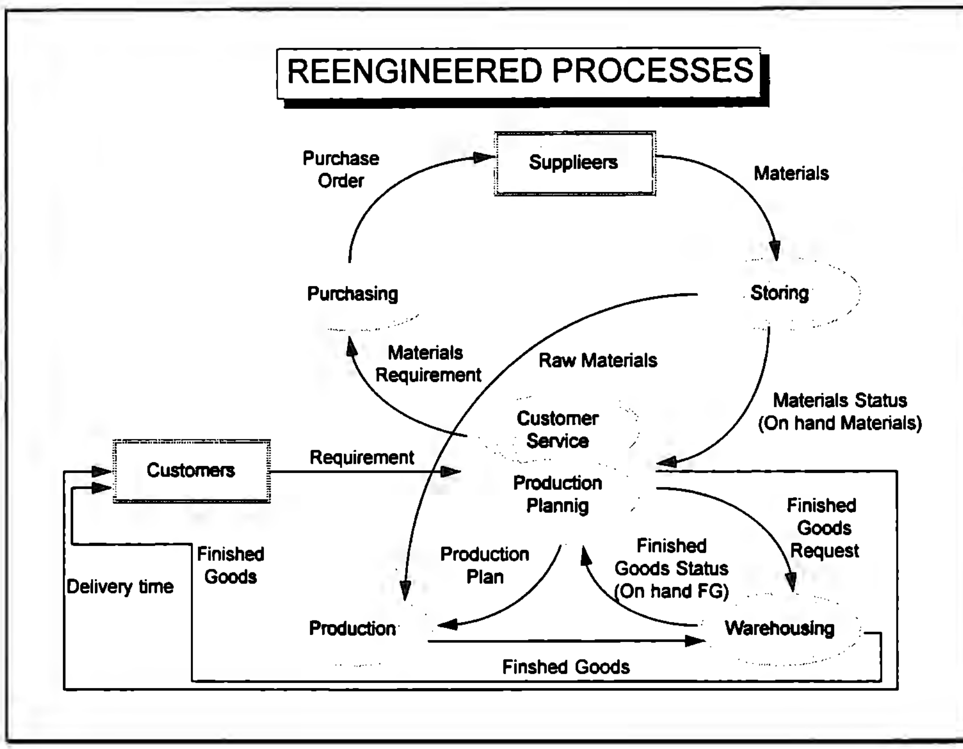

Figure 5.18 The Integrated Process (INPRO) after Reengineering

5.4.3 Hybrid Production System

Once the INPRO process was developed and put into practice by the people of BH, the time has to be Synchronize with the production process through a Hybrid Production System. As explained in chapter 4 in this section, a Hybrid Production System is recommended to put it into practice in a manufacturing company. The first thing that has to be made, is the master schedule. In the case of BH, the master schedule is composed by orders from customers and the end products required to replenish the inventory in the warehouse (demand forecast). The reason why is required to stock the finished products for the case of BH, is because the behavior of the sales are not regular. The short age of BH is projected to the low mature of some products, and it makes almost impossible to fill orders without finished goods inventory on hand. The general structure of the shop floor control by the hybrid production system is presented in the figure 5.19. In this draft is shown how the master schedule is used to generate production requirements that then need to be scheduled in a daily basis in the shop floor. Also the materials requirement is generated to replenish raw material in the stores.

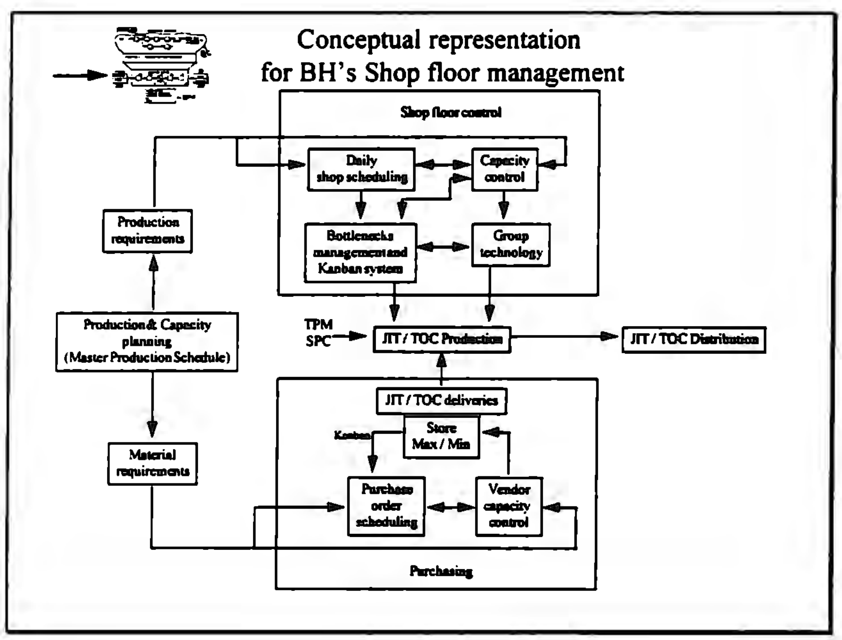

Figure 5.19 Structure of the shop floor management from the master schedule for BH[1]

Some forms were developed to generate the production requirements process. In figure 5.20 those forms are presented in order to show how they should be filled. The structure in figure 5.19 and the process in figure 5.20 are used as a complement for the INPRO process of the section 5.3.2, because INPRO just defines the administrative information flow, and the details regarding the production shop floor management are developed here for the case of BH.

[1] Adapted from Coong Y. Lee, "A recent Dvelopment of the Integrated Manufacturing System: A Hybrid of MRP and JIT", International Journal of Operations and Production Management 13, no. 4 (1993), p-9.

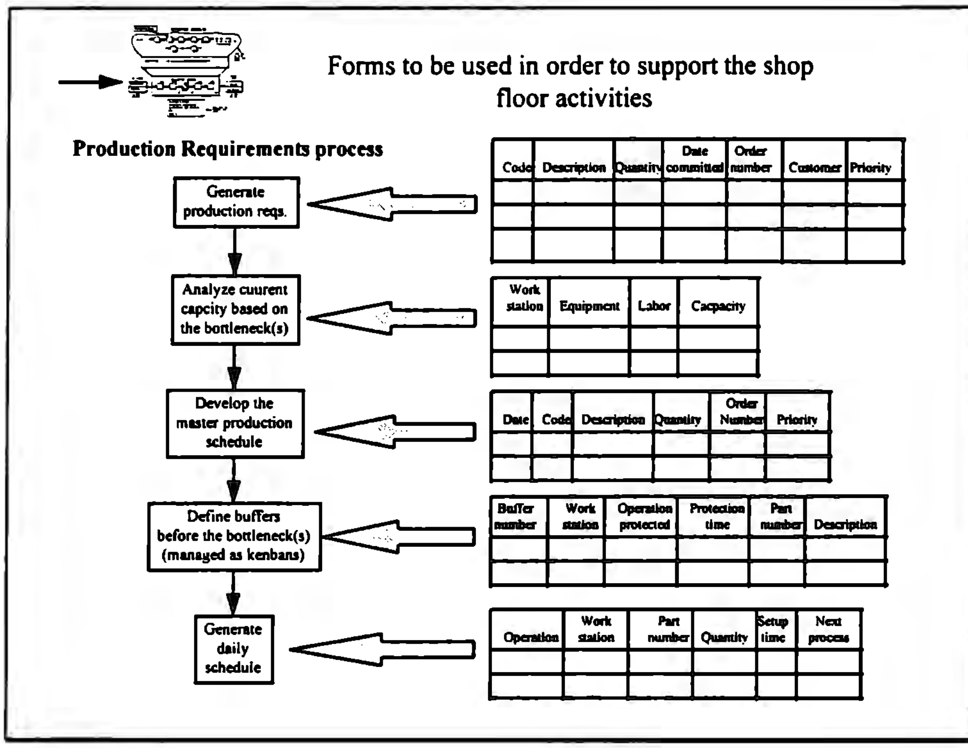

Figure 5.20 Forms recommended for the shop floor control

In the production shop floor of BH, I found a high inventory in process, specially in some particular areas, so this is a symptom of an unbalanced flow and a clear presence of bottle necks in the process. As we have stated in the section 5.1 (Introduction), the Objective of this section is to synchronize the production process,. The first thing I did was to analyze the capacity of the different stations in the process (see table 5.2), after this, a hybrid production model was developed for the case of BH

Products by Family	*Drilling and Stamping*	*Welding*	*Painting*	*Assembly line 1*	*Assembly line 2*	*Assembly line 3*
Troters	128	**106**	1973	-	283	-
Scales	127	**112**	1564	284	-	-
Bikes	195	**108**	1627	278	-	-
Benchs	171	**97**	1541	-	-	435
Gyms	32	**18**	202	-	94	-
Rowers	**164**	**167**	2592	-	345	
Roman Chairs	**198**	221	3840	-	-	805

Table 5.2 Work stations capacity (products by family) in units per 8 hours (one shift)

As we can observe in table 5.2 the Constrained Capacity Resources (CCR) are the Welding Station (WS) and the Drilling and Stamping Station (DSS). Normally the Welding Station (WS) is the bottleneck of the process, but in some products as Roman Chairs and Rowers both WS and DSS are bottlenecks. The Hybrid Production System purposed here requires that the production schedule of BH needs to consider the capacity of the of the Welding Station and the Drilling and Stamping Station. By doing this we are balancing the production flow through the shop floor. Using the steps shown in the production management process in figure 5.20, the BH's production scheduling process is represented as follow:

1. The first step is the generation of the BH's production requirements are shown captured in the table 5.3. In this step the finished goods inventory was already taken into account, so the goods that are available to meet customer's orders are assigned and then shipped. In the column of requirement type are two kinds of requirements: (a) The customer order and (b) The replenishment Kanban which represents a replenishment of the inventory defined in the warehouse according to the demand forecasted.

Code	Description	Quantity	Due date	Requirement type	Customer
G-60	Troter MIS	25	15-dec-96	Customer order	Sears
G-60	Troter MIS	14	18-dec-96	Customer order	Carrefour
G-60	Troter MIS	78	20-dec-96	Replenishment Kanban	BH
M-21	GYM PRO	10	10-dec-96	Customer order	Sears
M-21	GYM PRO	15	14-dec-96	Customer order	Electra
M-21	GYM PRO	40	20-dec-96	Replenishment Kanban	BH
B-15	Bike PRO	50	12-dec-96	Customer order	Electra

Table 5.3 PRODUCTION REQUIREMENTS OF BH'S PRODUCTS

2. Define the current constraints or bottlenecks in the process. In the case of BH the bottlenecks are the Welding Station and the Drilling and Stamping Station. Their capacity depends on the product to be produced (see table 5.2)
3. The next step is to develop the weekly master schedule . Here is where the capacity of the bottlenecks is considered for scheduling the week. Considering that today is September 5th of 1996, so the product with the shortest delivery day (M-21 with due date on December 10th of 1997) is scheduled first in the table 5.4. At this moment the capacity of the bottleneck (WS) is taken in account. The schedule the September 5th is

the production of 18 units of M-21(the capacity of the WS) for two customer orders (Sears and Electra) with priority of 1.

Code	Description	Quantity	Production date	Requirement type	Customer	Priority
M-21	GYM PRO	10	5-dec-96	Customer order	Sears	1
M-21	GYM PRO	8	5-dec-96	Customer order	Electra	1
M-21	GYM PRO	7	6-dec-96	Customer order	Electra	1
B-15	Bike PRO	50	6-dec-96	Customer order	Electra	1
G-60	Troter MIS	15	6-dec-96	Customer order	Sears	1
G-60	Troter MIS	10	7-dec-96	Customer order	Sears	1
G-60	Troter MIS	14	7-dec-96	Customer order	Carrefour	1
G-60	Troter MIS	78	7-dec-96	Replenishment Kanban	BH	2
M-21	GYM PRO	12	8-dec-96	Replenishment Kanban	BH	2

Table 5.4 WEEKLY MASTER PRODUCTION SCHEDULE BASED ON THE BOTTLENECK

4. In this step the buffers before the constraint or bottleneck are calculated. For instance, in the day 5-dec-96 a buffer of 4 hours of production (inventory) before the Welding Staion is placed and replenished when the buffer drops to 2 hour of production the Welding Station. For every day and for every product these buffers are placed and calculated.
5. The last step is the daily schedule. The daily schedule is a replicate of the Weekly Master Production Schedule, so the only difference is that now one day is scheduled. The reason why this steps is recomended, is because the daily scheduling is more flexible than the weekly or monthly schedule (Duncan, 1988). With this approach the customer is the winner.

A final representation of the Hybrid Production System is shown in figure 5.21. Here we can observe that one drum appears in the Drilling and Stamping Station and other drum appears in the Welding Station. The drums represent the daily production schedule for the company and each has a buffer protecting them. Note that depending of the product to be scheduled the drum is placed in the WS or in the DSS (see table 5.2). In the figure 5.21 we also observe that three buffer are placed in the process and they work as a Kanbans. The K1 and K2 are placed to protect the DSS or the WS. The K3 is an assembly buffer. The reason why this buffer is placed (K3), is because in the in the assembly lines too many small parts are added to the product, so if we are scheduling the plant based on the bottlenecks, we can't stop the process in the assembly lines due to lack of one bolt or a nut. In figure 5.21

also we can observe that two zones are marked as inventory reduction, that is, at the beginning of my intervention in BH these zones were with too much product in process.

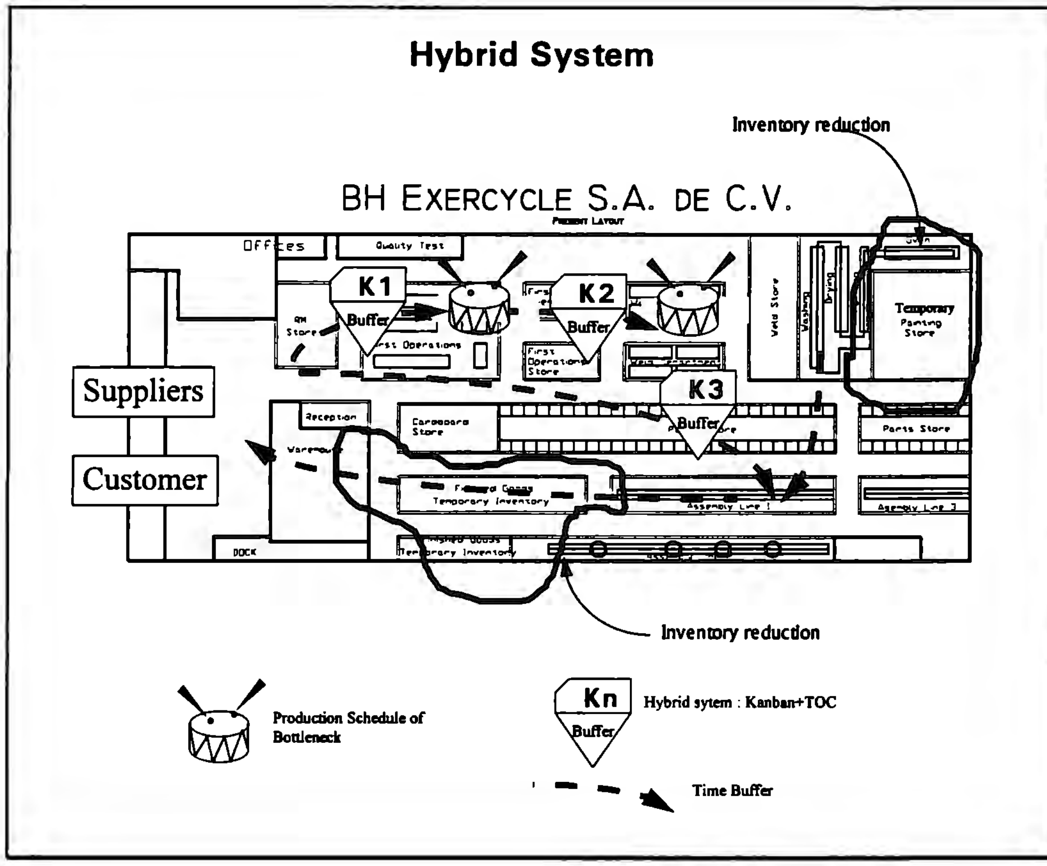

Figure 5.21 The hybrid production model for BH

5.4.4 Information System (ASPEL / MERCURIO)

At the beginning of the intervention BH had two "information systems" used for some limited purposes. They had a commercial MRP II called ASPEL (for small and medium sized companies), and a system developed in a house called MERCURIO (built in debase). ASPEL was without any use at that time, and MERCURIO had only partial information about the bill of material with a poor accuracy of 50% in the confidence of this data, and some features for production scheduling.

In this section it is very important to get clear that the Information System approach presented in this thesis is not in the traditional, that is, first the software to be bought is selected or built and then applied to the company. This approach makes the company to work for the software and not the software to work to cover the needs of the company. This is one of the reasons why the application of the MRP II software's has failed and it is used as a data system instead of as an Information System (Goldratt, 1990; Stein, 1996). The approach in this thesis regarding the Information System, is first, define the INPRO process (process map), by putting the people involved in the processes to work together. Once the final version of the mapping processes is done, the next step is to establish the structure of the Hybrid Production System, that is, where the bottlenecks and buffers have to be placed and managed in the shop floor. After these two steps, the structure of the new Information System is ready, it is only necessary to select or develop the software to be applied to this structure. In the case of BH the ASPEL system (MRP II) was used mainly for inventory management, accounting and invoicing. The MERCURIO system was used for production planning and scheduling.

To explain how those systems were finally used, their application is divided in three sections: a) *Receive, Storing and Distribution of Materials*, b) Production and c) Customer Service.

a) Receive, Storing and Distribution of Materials

There were two computers in this area, one computer is located in the Purchasing department and the other one in the Materials Reception Department. The main problem at the beginning, in this area, was poor inventory reliability. It means that no information about inventories was available.

Another problem, in this area, was inventory actualization, the inventory transactions were updated at the end of each month because the accounting department asked for this data and not for production and scheduling purposes. For inventory management and purchasing the ASPEL system was applied. After defining the INPRO process the ream involved in these areas was committed to enter the information required on time, so everyday inventory transactions were updated and all the purchase orders were elaborated throughout the

ASPEL. For the reception of raw material these application was accepted in the plant, only if a purchase order for the material was made and it been received.

b) Production

With information inconsistency the production department was affected the most. The master schedule was based on mistaken information and the effects could be seen in the Inventories. The inventory cost was high ($812,000 USD on average per month in raw materials) and no information about inventories was available. Frequently raw material and part shortages happened in the production process, even though the inventories were high. MERCURIO's software was adapted to the production planning and control, so the work orders and the materials requirements were obtained from this module.

c) Customer Service

The customer service is a new entity in the company, at the beginning it was made up of the sales management department. Now Customer Service is integrated by the Order Processing, Production Planning and Scheduling activities. With this new concept the customer is attended by only one entity who takes the orders and is responsible of their status through the Production Planning and Scheduling, Production, Quality Certification and shipping activities. Initially, in this area, the lack of customer information and complaints were found. The information system available didn't include this important information. So no information related to the customer was know, neither of finished goods inventory.

In order to support the Integrated process of the IMOM model, both information systems were implemented. Those systems had advantages to take into account, and putting them to work made it easy to generate information. ASPEL was considered to work in the following areas:

- Raw material inventory
- Receiving
- Purchasing and finished goods inventory

MERCURIO was used only for scheduling. The main reason to used both systems instead of selecting a new one, was because the financial status didn't allow to buy a better system. At that time in BH, the challenge was to promote the use and generation of information, and share it with other areas of the company. The partial use of the systems was possible after seven months of hard work. Now, inventory (both raw material and finished goods) status and its costs is available. Reliability in the inventories is now about 75 %. Even when this is not a good situation, employees are working in its improvement.

Invoicing is now available to be processed by the use of ASPEL. And soon, sales reports will be available. The use of the information systems in BH, is now improving customer service and quick responses due to the information on finished goods and raw material. In the past, the production was always being stopped due to lack of materials, even the inventory was considered too high. Now the information about finished goods is available, customer service and responses begun to improve. Without this improvement, the Integrated Process could begin working well.

Both systems, ASPEL and MERCURIO are not the best choices for BH, so I have recommend to buy a new information system that offers better conditions for its implementation and use, and also that has the flexibility to be shared (export and import) easily. Some of the software I recommended is: Fourth Shift, Platinum or Prod star. They are based on the MRP II philosophy with the EDI (electronic data interchange). The only modification that has to be done, is in the production and planning modules, they need to be adapted to the Hybrid Production Systems approach to get a good information system (Flores, 1997).

5.4.5 Team work

As presented in the introduction phase about BH's initial situation in this chapterthey didn't work in teams, but after the mapping of the Integrated process, team work started to appear. The team begun to sharing the responsibility on performance indicators for the process, and the people's behavior started to be team. Oriented people, in the company that do not belong to a team, are considered isolated. In the case of BH the team was integrated when, for the first time, the six areas of the value chain were put together in a meeting to develop the INPRO process. The first session was complicated because the people from sales and warehouse started to discuss with the production and purchasing people about no committing with the customer expectations, this is normal when no team work is promoted in a company. After two months of working in the INPRO process the employees, of the areas involved, begun to share the same vision of the process. This was a very important success because everybody knows the output of the INPRO process (meet the customer expectations) and they know each others responsibilities, very clear.

Different levels of performance measurements were develop for the people involved in the process: (a) General performance measurements for the level 1 of the process and (b) Specific performance measures for the subprocesses (level 2). General performance measurents (see figure 5.15) were defined as: (1) Cycle time; (2) % of on time deliveries; (3) number of customer complains; (4) inventory days for RM, WIP and FG; and (5) throughput[2].

Unfortunately we didn't have enough support to establish a policy to reward the team's performance.

Several changes in some positions of the company as the General manager and the purchasing head section, provoke that the team started to fall apart and the lack of leadership made the situation of the company bad for team working. It is not strange that a team ends its life cycle (Chip Robie, 1997), but we couldn't make the situation clear for the team. I would like to discussed more about the factors that affected the development of the IMOM during its implementation in the conclusion of this chapter because even when I got good technical results the social factors domain the implementation, in chapter 6 these experiences will be taken as part of the learning's from the implementation.

[2]Throughput as defined by Goldratt in his book 'The Goal" is the amount of money input to the system through the sales.

5.4.6 Organizational culture

Part of the Organizational Culture was covered at the beginning of this chapter in the section 5.2. The Organizational Moment shows that BH has great potential to become a world class enterprise. This can be explained because BH is between the Barbarian and the Constructor stages according to Miller's life cycle model (see section 5.2).

BH needs to promote a new organizational culture by establishing its Vision and Mission. In the Mission the customer and employees need to be considered, and as a result the employees' commitment will come upon. This implies a change in the current culture, a change in management has to be made to close the gap between employee's vision and the company's vision. This change of organizational culture needs to be driven by the leaders. Due to the lack of management support the Vision and Mission for BH wasn't define and as a consequence actions were taken in odds direction.

Even when the Mission and Vision wasn't establish, a series of training courses were provided to most of the people BH. The trainning courses covered the follow themes:

☑ Total Quality

☑ Personal Quality

☑ Leadership

☑ Just In Time and Kanban System

☑ The Theory of Constraints

☑ The seven Quality Tools

After the training the people were participating more compares with the beginning of my intervention, so the courses help a lot to implement some elements of the IMOM as the INPRO process, the Inventory Management policies, part of the Hybrid Production System, and a temporary team work. In chapter 6 these experiences are going to be considered again and improve the IMOM from the learning's of the implementation.

5.4.7 Validation of the Implementation through performance measures

The performance measures have such importance as the mapping of the Integrated Process (INPRO). A lot of problems may appear due to lack of direction and lack of measure the purpose of the IMOM model. A series of performance measures were developed by the people participating in the Integrated Process. These are shown in the table 5.5. This table also show what are the measures that need to be monitor for each subprocess. Is important to notice that we are starting to promote the team work, because one indicator could be a responsibility of several subprocess and the people participating there. For instance, the indicator of On time Deliveries (II) that means meeting the customer order in the date promised or agreed, is not only responsibility of the area of Order management (1), is also responsibility of the areas of Production Planning, Warehousing & Shipping and Production. These indicators were considered to evaluate the people in the Integrated Process, and this evaluation is being considered as essential element for rising earnings. Other indicator that is important to analyze is the holding cost of inventory. In the stores of raw material, BH had an average inventory of $769,230 US dollar ($6000,000 pesos), and the annual holding cost was $230,769 US dollar ($1800,000 pesos). The holding cost is only considering the capital cost, the costs of personal, and equipment for stores are negligible. This indicator also is sharing responsibility with the subprocesses 2, 3, 4, 5, and 6, so the team composed with the people in these process are following the behavior and reducing the holding cost. Literature doesn't show a formal way to manage these indicators related with subprocesses considered in the IMOM model.

Most of the performance indicators placed on table 5.5 need time (months) to measure their real behavior, so even the implementation took 12 months most of these indicators are going to be ready to start measuring good results in 16 months after the implementation, because at the end of my intervention (12 months later) I left the necessary conditions to start having the results expected. In order to have a better criteria to partialy evaluate the results obtained, I develop the table 5.7 in section 5.5 (other experiences) wich show some key elements taken in account to validate the IMOM model.

Indicator	1. Order management	2. Production Planning	3. Purchasing	4. Warehousing and shipping	5. Storing of raw material	6. Production	Description
I. Cycle Time	X	X		X		X	Current lead time Vs new
II. On time deliveries	X	X		X		X	% of on time deliveries
III. Number of complains	X	X		X		X	Current complains Vs new data
IV. Inventory turns		X	X	X	X	X	Current turns Vs new turns
V. Inventory holding cost		X	X	X	X	X	Current Vs new cost
VI. Days in inventory		X	X	X	X	X	Current days Vs new inv
VII. Accurate information of Inventory				X	X	X	% of accurate
VIII. Obsolete products				X	X	X	% of obsolete
IX. quantity delivery required	X	X		X		X	% accomplishment
X. Production stops due to lack of raw material		X	X		X	X	Number of production stops. Current Vs new
XI. Over production		X		X		X	Monthly demand forecast
XII. Profit of the business	X	X	X	X	X	X	Current net profit Vs new
XIII. Customer satisfaction	X	X	X	X	X	X	% customer satisfaction based on a survey
XIV. Market share	X	X		X		X	% of market share

Table 5.5 Performance measures used to validate the implementation of the IMOM model

5.5 Survey applied to BH based on the Malcoln Baldridge award 1996

In November of 1996 a survey was applied to BH in order to verify how is compared with international standards. The survey was developed by Téllez Carlos (1996) based on the Malcoln Baldridge Award version 1996. The purpose of applying the survey is in order to know the BH's status about its approach in Total Quality advances. In figure 5.22 a summary of the survey results are presented. We can see that most of the elements evaluated present improvement opportunities. These results explain why some elements of the IMOM couldn't be implemented at all. In my opinion, if we improve the elements like Leadership, Strategic planning, Process Management and Information and Analysis, BH can also impact the elements of Customer Satisfaction, Business Results and part of the Human Resource issue. Is important to notice that a world class results are close to the 70% accomplishment in each element. This means that BH has a big gap of opportunities to become some time a world class company.

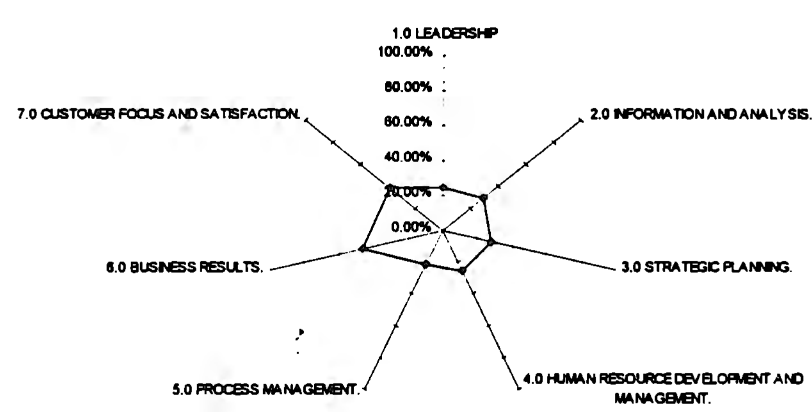

Figure 5.22 Summary of the Total Quality survey

Table 5.6 show the percentage got by each element and in figure 5.23 there is a different view of the results in graphic bars. The detail of how each element was evaluated is presented in the appendix 4.

Criterion	Percentage
1.0 LEADERSHIP	24.49%
2.0 INFORMATION AND ANALYSIS.	29.44%
3.0 STRATEGIC PLANNING.	28.46%
4.0 HUMAN RESOURCE DEVELOPMENT AND MANAGEMENT.	25.78%
5.0 PROCESS MANAGEMENT.	21.48%
6.0 BUSINESS RESULTS.	46.67%
7.0 CUSTOMER FOCUS AND SATISFACTION.	38.22%

Table 5.6 Percentages of each element of the survey

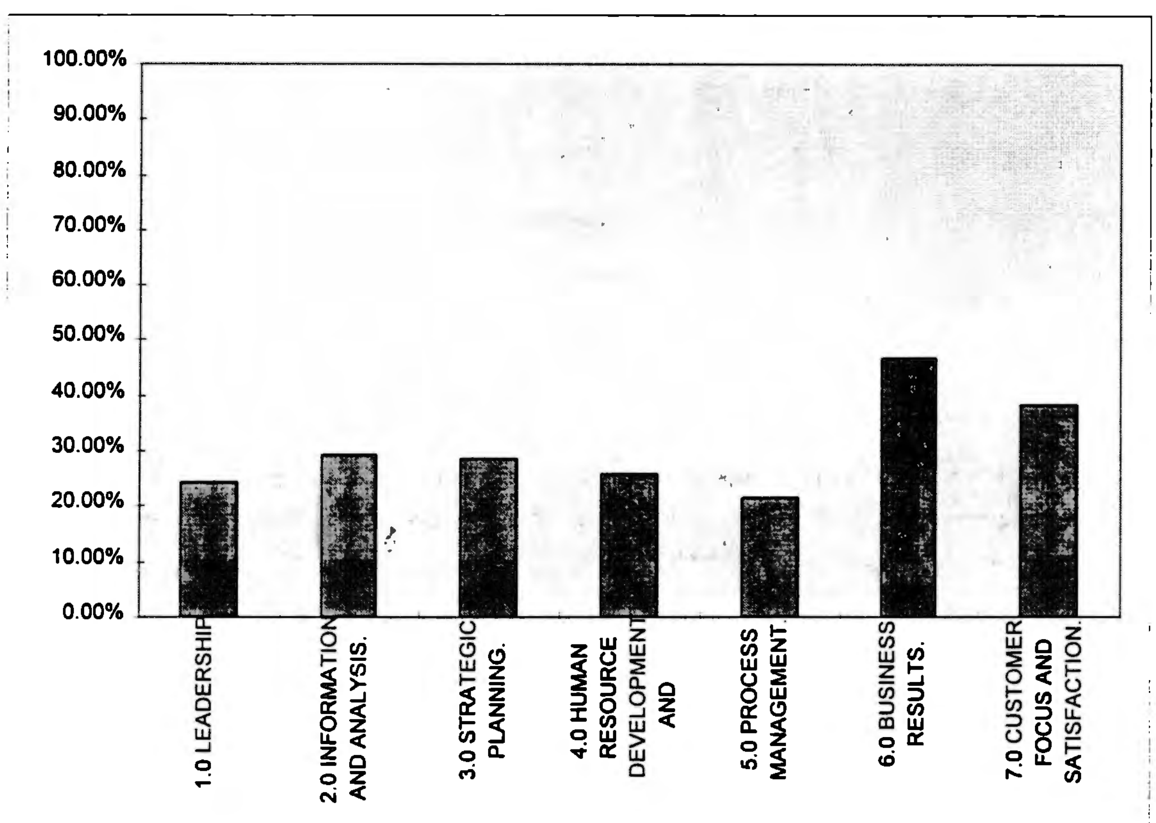

Figure 5.23 Other view of the survey results

CONCLUSIONS OF THIS CHAPTER

One of the objectives of this thesis was to focus the research in a action-research approach through implementing the IMOM model in a real Mexican enterprise. I spent several months working with the BH people implementing the elements of the IMOM model. At the beginning of my intervention I could joint a group of people willing to implement the IMOM elements because of the advantages that they were offering to the company. We could get good results in the elements such as: INPRO PROCESS, Inventory Management, Information System and the Hybrid Production System. But the good results of these elements were during the beginning and middle of my intervention. The Leadership and the Organizational Culture were affecting too much to the rest of the elements. Several changes in important job positions disintegrate the team work of the value chain areas related with the IMOM model, an as a consequence the good results in the technical elements were inconsistent. I could observe that the lack of leadership and the lack of an organizational culture focus on quality are very important to the success of a company.

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6. OTHER EXPERIENCES

6.1 Introduction

The objective of this chapter is to provide extra feedback to this thesis validating the IMOM with two extra cases of study. What we will see is that the success of the IMOM model depends on the implementation of all its elements and not only a few of them, even if it promises good results from the technical point of view. These experiences (cases of study) were generated when these action-research projects were implemented in several Mexican manufacturing companies (CCI ITESM, 1994 and 1995). When I talk about implementation I'm considering the application of some elements of the IMOM model, and not necessary all of them. For the purpose of this thesis only two cases are going to be presented in this section. One is from the Operational Effectiveness project in a chewing gum company called CANELS and the other case is referred as TISAMATIC (a foundry company). In both projects the implementation was drove by a group of professionals from the Center for International Competitiveness of the ITESM Campus San Luis Potosi (CCI). It is very important to mention here that the work developed in these projects was performed by a group of people from the CCI in which I had a partial participation. In order to evaluate these experiences a the following criteria is presented to review what points are involved in the IMOM model. In order to remember the components of the IMOM model, I will present them as follow:

1. INTEGRATED PROCESS OF SALES, PRODUCTION, PURCHASING, WAREHOUSING AND STORING (INPRO PROCESS)
2. INVENTORY POLICIES FOR RAW MATERIALS AND FINISHED GOODS
3. HYBRID PRODUCTION SYSTEM
4. TEAM WORK
5. ORGANIZATIONAL CULTURE
6. LEADERSHIP

7. INFORMATION SYSTEM

The above elements of the IMOM model will be described according to each case study, that is, some of these elements have different application depending of the needs and situation on the companies presented.

6.2 Case 1: Operational Effectiveness in CANELS[1]

This case has special meaning in this dissertation. During the time I was participating in this project (CCI ITESM, 1994 and 1995), I observed a real need to integrates the Sales, Production and Material Supplying functional activities. I saw how the sales people ignored the way the production department operates and vice versa. Also I observed how the purchasing department was ordering materials without any reliable data about inventories. After this consulting project, I started thinking about how integration can really be achieved for Mexican companies. This was the origin of the IMOM model.

CANELS is a chewing company gum that has been working since 1940 in the domestic market in San Luis Potosi, Mexico. Now it is exporting its products to several countries around the world. This company is national leader in the market segment of four chips chewing packages. Its production process is a combination of job shop at the first production stages, and a continuous process in the last stages. Regarding the IMOM model the elements involved are: the "INPRO Process", "MAFC Inventory replenishment System", the "Information System based on a MRP II", and the "Team Work".

The results found are described as follows:

☑ *Linkage between the areas of Production, Purchasing and Sales based on the mapping processes (INPRO process).* One of the stages of this project was the development of

[1]This project was developed by a team composed of consultants from the Center for International Competitiveness (CCI) in the ITESM campus San Luis Potosi in 1995.

process mapping, which was analyzed using flow diagramming tools as Data Flow Diagramming (DFD). The most important result at this stage was that the people representing the areas analyzed shared a common vision of the process in which they participated. The resistance to change for some of the members made difficult the implementation and we had just a partial results. Finally we made a redesigned process for the sales, production and purchasing activities.

☑ *Better team work practicing by the employees (TEAM WORK).* During the beginning of the process mapping a real team started to appear. People begun to share information that in the past had never been provided on time and complete. During a period of time in the project, there was uncertainly about getting quick results and this made the team confused and reactive to some actions propoused by the consulting group. In order to avoid confusion we suggested quick improvement actions in the processes to let the team see real results from the project.

☑ *Inventory management.* The MAFC inventory model for finished goods was developed to propouse a better way to manage inventories. According to the calculations made, about 50 % of the reduction in the invested inventory could be reached. We didn't see the real results because the implementation of the MAFC model wasn't put into practice, but a great amount of savings should have been reached.

☑ *Information System.* CANELS used a commercial MRP II software called MCBA as information System. At the beginning of our implementation the use of this system was very limited and only a few people were using it. After the development of the process mapping a clear use of this system was propoused to be used at least for inventory management. This use was implemented and people from stores started to use it as their real information system.

CONCLUSION

As I mentioned before, this project gave me the idea to build something that integrated the areas involved in this research, and as a result the IMOM model appeared. During the project the team was integrated by people from CANELS and the ITESM. CANELS' people argued about the need of quick results because they didn't see any result during the process mapping of the INPRO process. We suggested those quick actions and only some of them were implemented. This shows how the commitment from the canels team was. Even an excellent technical consulting said social elements as leadership, real team work and organizational culture were affecting the good success of the technical elements.

6.3 Case 2: Operational Effectiveness TISAMATIC[2]

After the implementation of the BH case, the need of extra validation for the IMOM was considered important, so the TISAMATIC case was taken into account as a good opportunity to represent how the IMOM would be implemented. We considered the TISAMATIC case an excellent opportunity to enrich the IMOM in a different enterprise. I started to participate in this project as a part of a consultant team of the ITESM in August 1996 in order to give support to the company in a productive diagnostic. After that, I observed how the technical elements of the IMOM model were applied to a different production process (continuous process). According to TISAMATIC's requirements, the improvement areas the company focused on were the Information System and improvement of the last production stage (finishing), so considering those needs the elements from IMOM model that will be represented in this validation are: *a) Information System, b) INPRO process, and c) the Hybrid Production System.* Also some comments

[2]This project is being developed by a group of consultants from the Center of Productive Technologies of the ITESM campus San Luis Potosi, which is commanded by Dr. Mariusz Bednarek.

about the social elements will be presented as a confirmation of how they can affect an IMOM implementation.

TISAMATIC is a foundry that produces goods such as automotive parts and components for compressors used in refrigerators (appliances). The company is located in San Luis Potosí, Mexico. The production process has three main production areas: (1) Foundry, (2) Molding and (3) finishing. The first two stages of the production process are a continues processes, and the third production stage (finishing) is a discrete process based on job shop and cellular stations. This company was having problems in the last stage of its production process mainly(finishing area), and the problems found were due to the lack of synchronization between the molding and the finishing areas.

The elements of the IMOM model that are going to be developed are mainly the Information System and The Hybrid Production System, we will discuss about the role of Team Work, Leadership and The Organizational Culture as a social elements. Also an INPRO process at level 1 will be developed considering the use of the information systems.

6.3.1 Information system

TISAMATIC has a MRP II commercial software called PLATINUM, but they were only using it for invoicing the products shipped to the customers. This software doesn't include the production module that typically offers the MRP systems. TISAMATIC is going to buy a production module named INDUSTRIOS that will performed the tasks that a normal MRP systems does for production planning, control and scheduling. This system can share information without any problem with the PLATINUM software. The problem that TISAMATIC is facing now, is that they need help to put into practice both systems in an effective way. The consulting team, from the ITESM, in charge of this task is presenting the structure in figure 6.1 for the application of both systems.

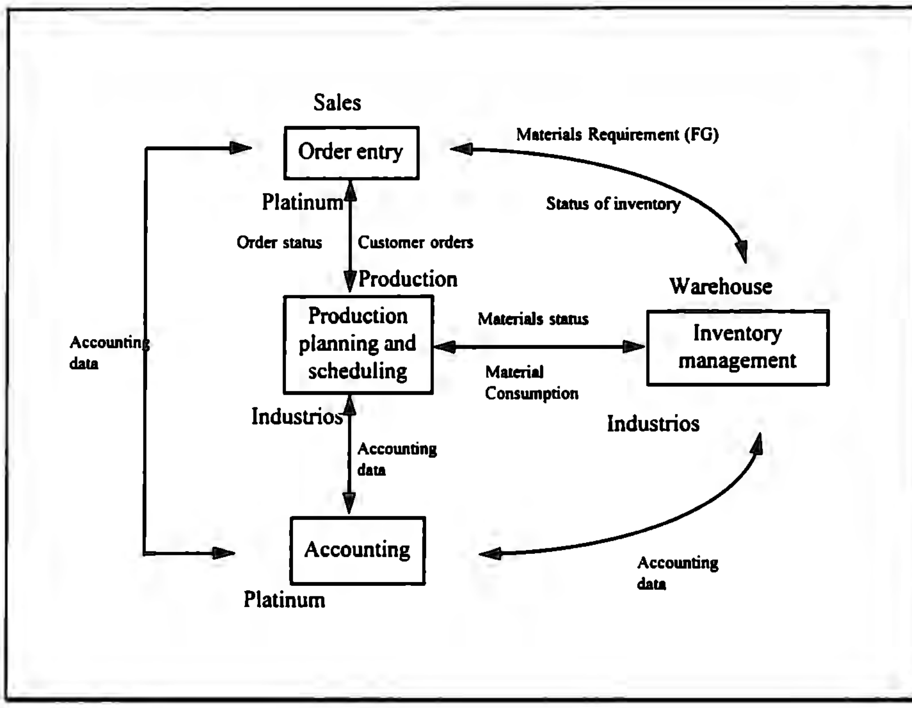

Figure 6.1 Operational structure for Platinum and Industrios systems

Figure 6.1 is showing, where each system has to be used. The Platinum system is going to be applied for sales management (order entry, invoicing, sales statistic, etc.) and the Industrios system will be needed for production planning and control, including inventory management. Platinum can also handle the inventory management module, but according to the last information from the vendor of this software, that module is going to be removed. This doesn't matter because the Industrios includes an inventory management module. Remember that IMOM model promotes the used of an Information System as a necessary element for integration purposes, so it is very important to define the scope of the systems that will be used in order to know what modules are going to be applied. To have a real integration it is very necessary to define the INPRO process to clarify the role of each of the departments involved and when to the information systems are used.

6.3.2 Integrated Process for Sales, Production, Scheduling and Warehousing (INPRO process)

One of the main concerns of the IMOM model, in this dissertation, is the real integration of the Sales, Production and Material Supplying functional areas, so to define how this integration must be achieved a process mapping is develop in figure 6.2.

In this process mapping from figure 6.2 we can observe how different areas are being linked through the application of both systems (Platinum and Industrios) and clear rules about information interchange, so I may say that ***there are no barriers between departments, only bridges for effective communication***. TISAMATIC is concern about how their systems are going to be used, so with this process mapping now they know how to work as a team sharing information and using the information systems as a mean to meet customer needs and an expectations.

Figure 6.2 is a level 1 process mapping. Two important symbols are used in the map, and they are described as follow:

P	Information	File from the Platinum system. Data input or output
I	Information	File from the Industrios system. Data input or output

What we can observe in figure 6.2 is that only one vision of the process is now shared between the different areas involved, and they will know what system is involved in the activities. This map is presented only as an alternative to integrate the activities involved in

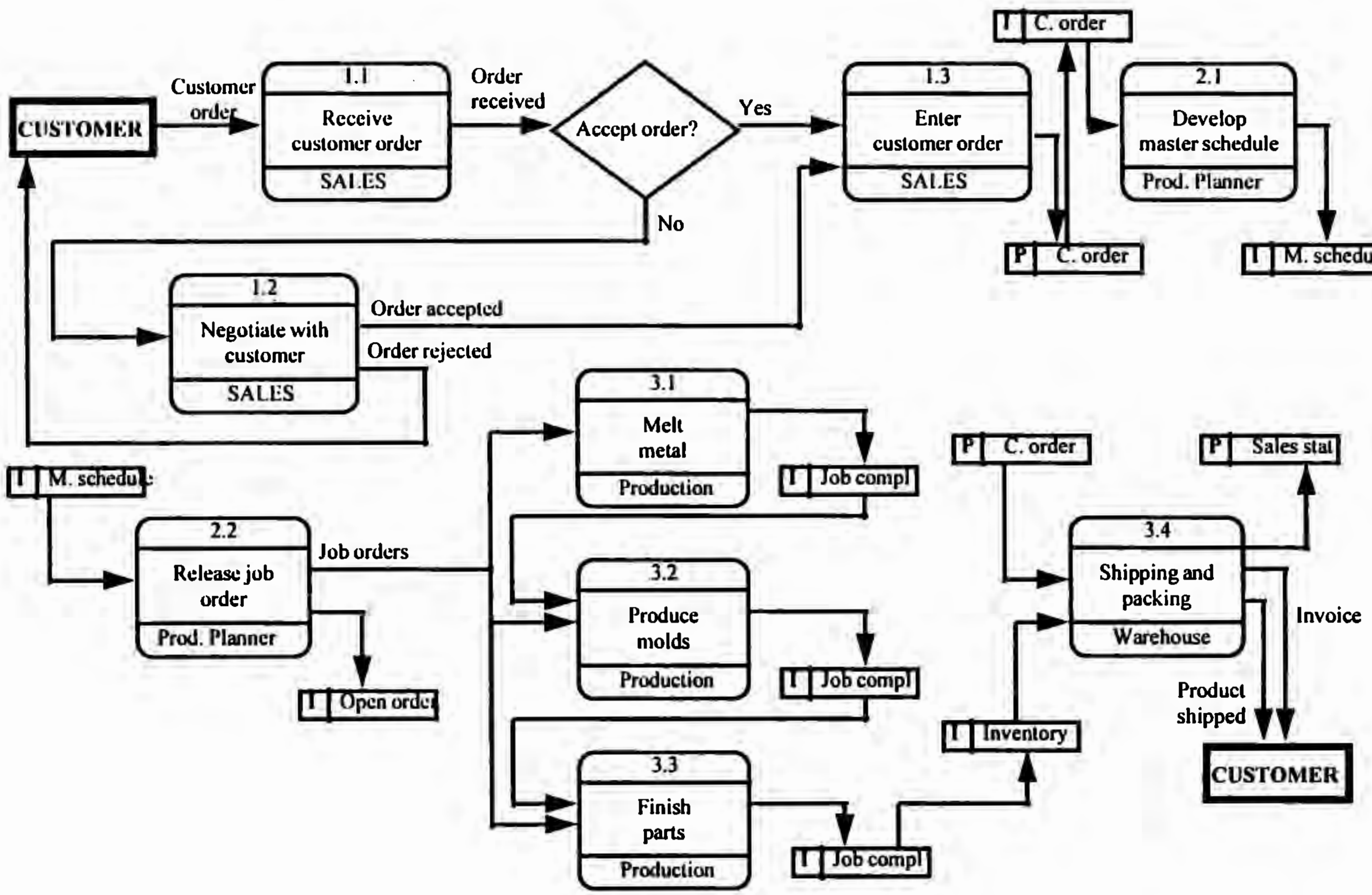

Figure 6.2 Process mapping for the integration of sales and production using the two information systems

the processes analyzed for TISAMATIC, so its processes need to be reengineered comparing current processes to the one presented here.

In order to detail how the Industrios system needs to work, a second level process mapping is presented for the areas of Melting, Molding and Finishing. In figure 6.3 a map for the melting area is develop. As we can see in the first level process map in figure 6.2, job orders are released by the Industrios System to the different production areas. Once the production of the order is completed, it has to be registered in as a complete job, putting the exactly amount of production produced.

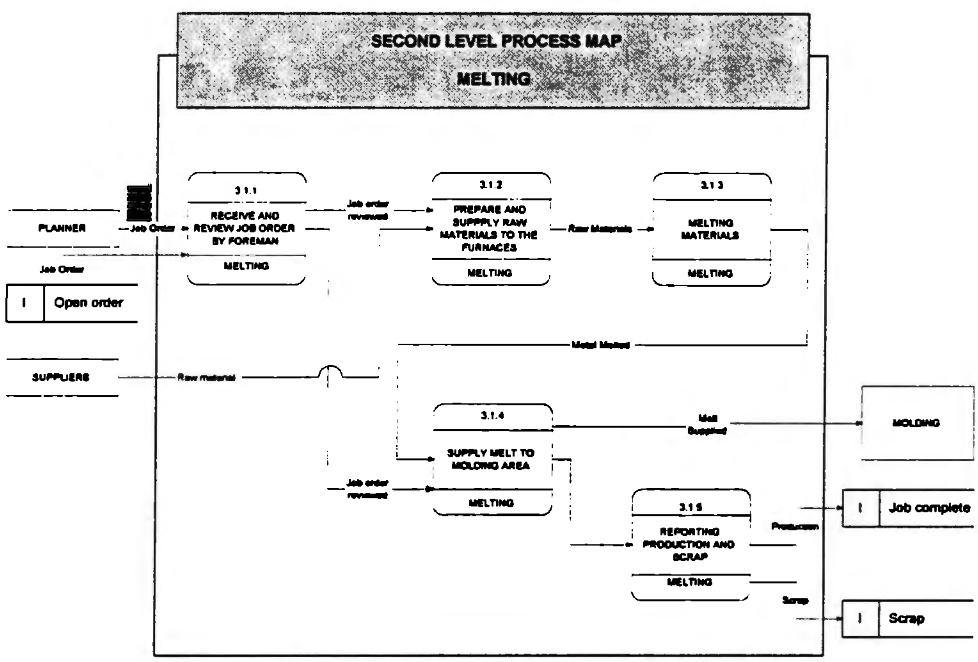

Figure 6.3 Second level map of the Melting process

In the figure 6.4 and 6.5 a second level process map of the Molding and Finishing areas is presented. Also this process presents the way how a job order is managed in the shop floor from it is release till the closure of the job order. Additional information that needs to be registered is the scrap and waste from the production processes. As we can see in figure 6.5 the output of the three processes ends with the product being shipped to the customer. This is a very important analogy because now with the process mapping all the people from the areas involved, will think about customer first and then about how to manage the shop floor according to the requirements. In Figure 6.5 we use the platinum again to close the customer's orders in the system.

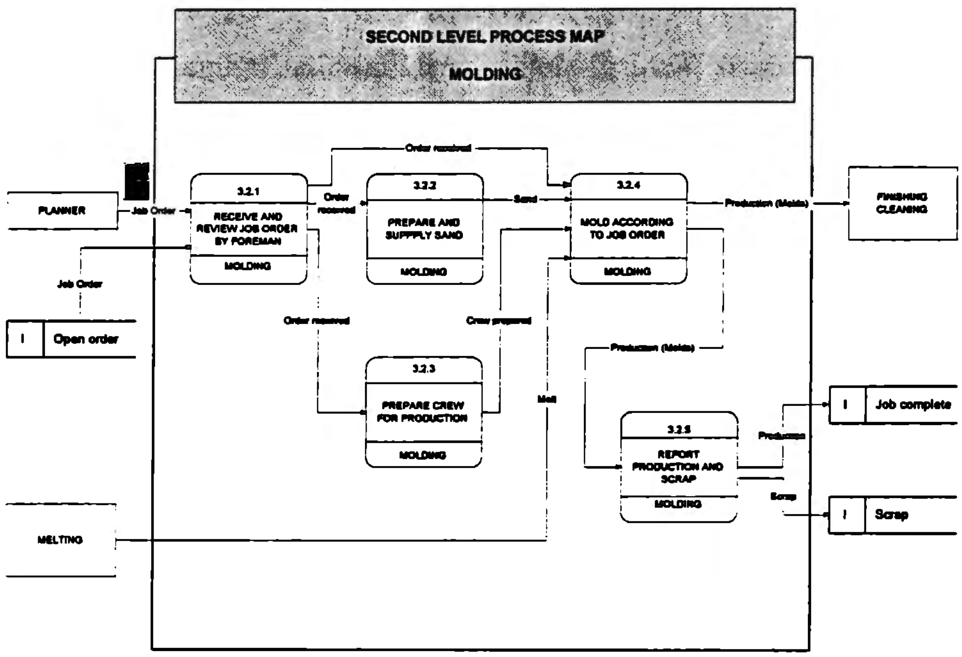

Figure 6.4 Second level map for the Molding process

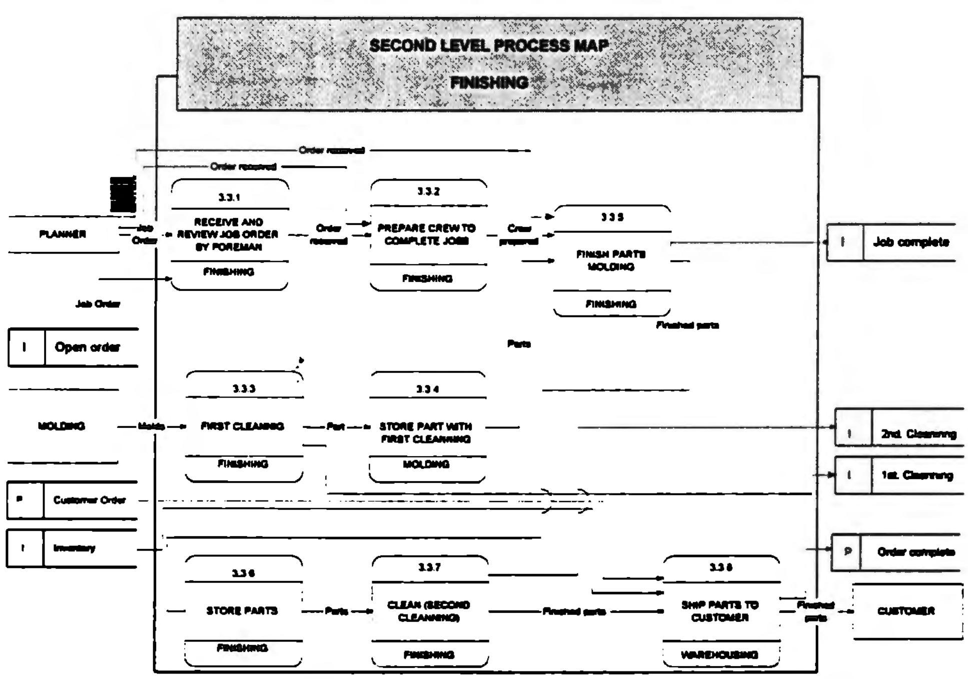

Figure 6.5 Second level map of the finishing area

6.3.3 Synchronous Production

One of main problems for TISAMATIC is production management in the shop floor. Too many parts are produced (about 150 different products) for about 10 different customers. This situation made the production system complex to manage, so TISAMATIC requires a effective production model to be applied in order to meet customers' needs and with the minimum cost. The current TISAMATIC situation when the ITESM consulting team begun itis activities (August 1996) showed some of the following conditions:

- ⇨ High work in process inventory(about 800 tons in average per month)
- ⇨ Frequent customer shortages due to late deliveries
- ⇨ Low integration between the departments of sales and production
- ⇨ Excessive overtime in the finishing area

Figure 6.6 represents TISAMATIC's production process. As we can observe it is compose of three main areas: Founding, Molding and Finishing. The normal schedule of the company is based on the capacity of the molding area and at the same time a shipping schedule is released. The bottle neck of the production process is the molding area. The problem with this station scheduling process is that the capacity of the finishing area was unknown and excess inventory and overtime were typical here. In the shipping area the typical job was expediting the products on hand. The finishing area was always rushing the products needed for shipping. Also the scheduling of the molding area typically has big process batches in order to save set up times. Each set up time takes about 10 minutes and TISAMATIC was estimating a cost of about $500 USD per set up.

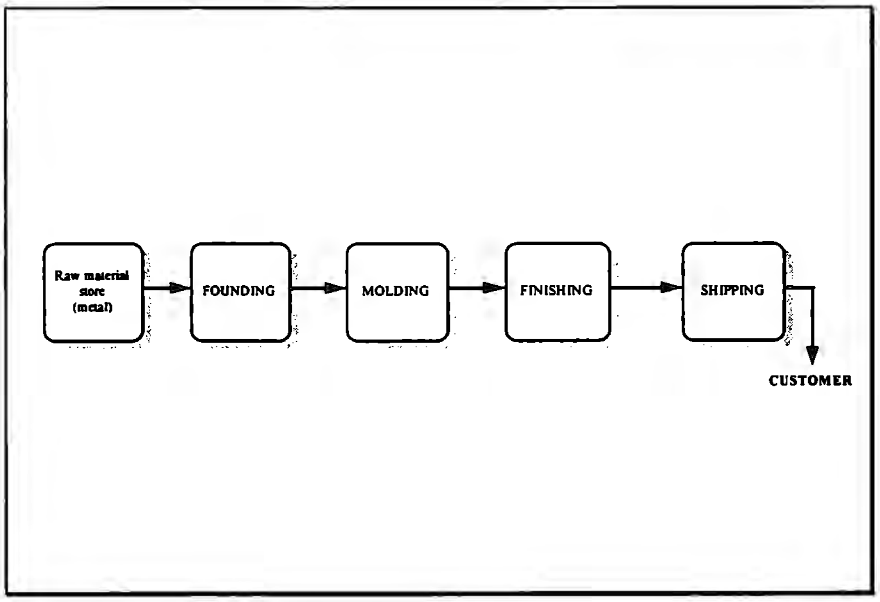

Figure 6.6 TISAMATIC production process

Figure 6.7 shows representation of the recommended way to manage the production process. The ITESM consulting team tested this model with several simulation scenarios considering the most important products for TISAMATIC (appliances), and the recommended model is scheduling the molding area every two days the same products, and it compares it with the former scheduling way with one day (one run) of each product per week, that is, big production batches. It normally results on high in process inventory in the finishing area.

The consulting team also developed a Kanban system with one of the most important customers located in the same city. This Kanban system pulls the shipping area of TISAMATIC and the products are replenished according to the empty containers brought every day by the customer to TISAMATIC's dock.

What I am explaining above, about the production management proposals of the consulting group is that it represent aHybrid Production System. The hybrid system combines the Pull and a Push production approaches. The schedule for the molding area pushes production to the finishing area and the finishing area is pulled by the Kanbans by the customer. Is important to take into account that now the capacity of the finishing area in known and the real set up cost for the molding process is $300 USD. With this data and the customers' demand, the scheduling of the molding area has an intelligent push approach, because now the inventories in process can be reduced and handled according to the needs of the company and the customers.

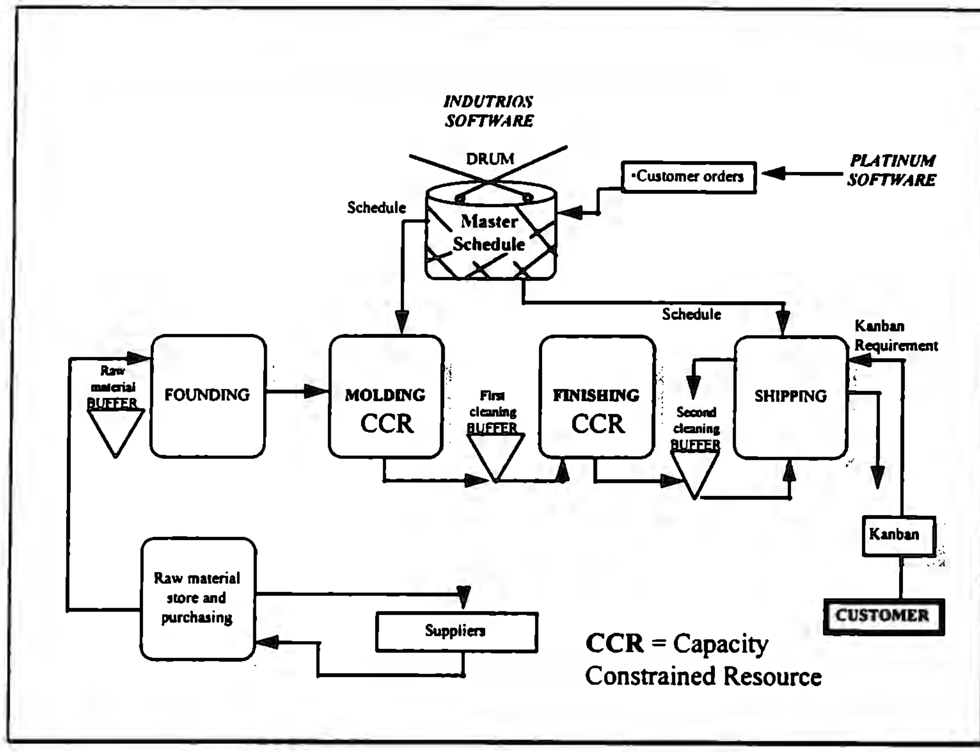

Figure 6.7 A representation of the Hybrid Production System in TISAMATIC

The results with the implementation of this Hybrid Production System will result in higher customer satisfaction and less operational cost. The company is now evaluating the implementation of this model because some products will probably be moved to another factory located in Monterrey city (550 kilometers from San Luis Potosi).

A simulation of the production process is presented in order to validate the proposal of TISAMATIC's hybrid production system. The reason for this simulation is that we may not have the opportunity to implement this approach at TISAMATIC and for research purposes the simulation will validate it. The simulation model was made using the professional version of Promodel 3.5 for windows 95. The assumptions for the simulation model are as follow:

- The molding area is scheduled for one or two days of production during a week

- The process batch in the molding area represents the weekly demand spread in one or two days of production
- An inventory in process is going to be held before the second cleaning of the parts. This inventory will be triggering the activities in the finishing stations and will be filling the daily customer requirements. The way to manage this inventory will be according to the MAFC model for inventory management (see chapter 4 and 5).

A layout view of the simulation is presented in figure 6.8

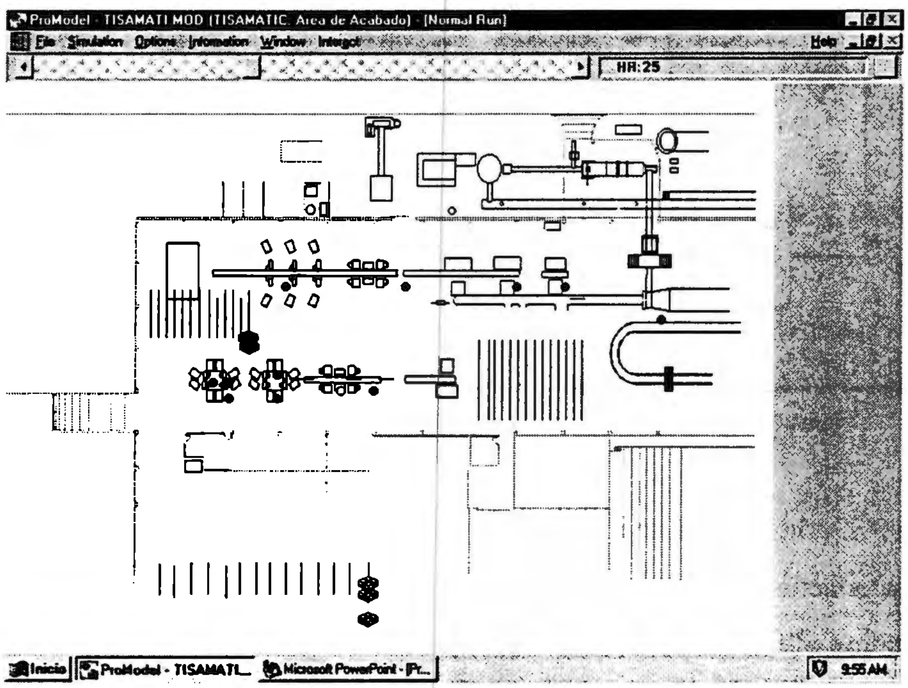

Figure 6.8 Layout of the simulation of the TISAMATIC production process

The aim of this simulation is to validate the Hybrid Production System (see figure 6.7) for the case of TISAMATIC, The molding area is scheduled to push production to the finishing area according to the customer's requirements (an intelligent push), and then the finishing work stations will be pulled by the inventory in the second cleaning, which is also going to be filling the daily customer requirements. If the inventory in the second cleaning get its maximum level, this signals the production from the molding and finishing area to stop until a the customer demand triggers again the production. The production flow is balanced according to the capacity of the constrained resources and the customer's demand, with this production strategy high inventory levels will be avoided. The output of the simulation is presented in appendix 6 and the results show that the production cycle time is reduced to 4.78 days compared with the former cycle time in 1996 of four weeks in average. Also the simulation proves that the inventory in process can be dramatically reduced to one day of the customer demand, compared with the former process inventory level in 1996 of more than four weeks. This results reflects how the Hybrid Production System can help TISAMATIC.

6.3.4 Social elements

Regarding the elements of the IMOM model such as Leadership, Team Work and Organizational Culture it is very important to notice that they affect the quick results during the project. The team work approach was getting good results during a short period of time (two months), and after this period of time their typical daily tasks consumed the time available for project team work. We started the project on August 1996 and it continued till June of 1997 trying to put into practice the proposals, but TISAMATIC is still analyzing the feasibility to implement them. An Additional problem found was the culture of the organization, it wasn't the best style for this kind of improvement projects. Even though they were certified with QS9000 standards, that doesn't mean that it is well prepared for a continuous improvement process. People were rejecting several proposals from the consulting group, so the best and fastest results can happen with a better organizational culture. In this case leadership had a regular impact in the project, but again only if the top management is committed with a project, this will have good results because of management support and monitoring.

CONCLUSION

This case proves that the technical elements of the IMOM model can work successfully in a different production process, comparin it with the BH case; but with similar results in other cases, the social elements of the IMOM model affect the success of the whole model. Lack of leadership, team work and a proper organization culture are essential elements that blocked the appropiate success of the IMOM model. Good results can be achieved in a company with the implementation of only the technical elements, and a partial support with the social elements, but in the long run the social elements will domain the success of the whole company.

6.4 Elements for the evaluation criteria

In order to evaluate the validation of the IMOM model in each different case of study, six elements are considered as a criteria to asses those cases. Customer Service, Organizational Culture, Inventory Management, Cycle time, Team Work and Leadership are those six elements taken into account. They have a strong relationship with productivity and competitiveness issues. In the case of Mexico, these elements are now considered as relevant regarding productivity and competitiveness (Sada M., 1995). In the case of the cycle time, its reduction is an essential element for an agile factory, that is, quick responses to the market demand to get a differentiation from the competence (Cassis S., 1994)

1. ***Customer satisfaction.*** This element is measured by getting to know the customer's perception about the suppling company. The customer satisfaction is mainly affected by the quality of the products, on time deliveries, accurate quantities delivered, order processing service, post sale service and quick responses. The way to really know the status of this element compared with a former situation is by applying a survey to the customer. The way to give an opinion about the evaluation of this element will be by according to the benefits found by the customer in on time deliveries, accurate quantities delivered and quick responses. Due to the impossibility to measure or survey the customers because there is no commitment on the companies to talk with his customers a scale from 1 to 10 will used. To support the evaluation an internal survey based on the Malcoln Baldrige Award is going to used.
2. ***Change in the organizational culture.*** During the implementation of a project, in my opinion the culture of an organization may have three stages: (a) enthusiasm in the people involved in the project due to the expectation of having positive results, (b) no

cooperation of the people because of uncertainly about the expected results, and (c) finally good cooperation to finish the job or in the opposite situation, no cooperation because of having bad results. The way to measure this element is by analyzing the level of cooperation of the people involved in the project before and after the implementation. Again a scale of 1 to 10 will be used to the evaluation.

3. ***Inventory Management.*** The IMOM model promotes the use of an inventory policy (the MAFC replenishment formulas), and its result must impact the reduction of inventories and inventory balance (to have in stock the necessary quantity, no more and no less of the quantities required). The evaluation will be made according to this criteria.
4. ***Cycle time reduction.*** The content of this period of time is since the order is placed by a customer till the order is shipped and delivered to the customer. In the cases that I am presenting, the response time to fill an order has several components that have to be reduced. For instance, the customer order may wait several days (some times 10 days) until the it is passed to the production shop floor. So in every stage the order can be delayed, and it has to be rushed. Comparing the former cycle time and the new cycle time with the modifications, is the way that will be used in the evaluation.
5. ***Team Work.*** The IMOM model needs the participation of the people involved in it. A team work is mandatory. Every time that the IMOM model is going to be implemented, a team needs to be built. Focus a company in terms of processes, it represents communication and integration by team buildings. To evaluate this element can be by applying a survey (like Malcoln Baldridge questionnaire) or by watching the behavior of the team. In this both ways are going to be used.

6. ***Leadership.*** In my personal opinion, after the implementations, leadership was the key element for a positive change (improve) or a negative change (bad results and bad perception of the project). To evaluate we also can use a survey (Malcoln Baldridge questionnaire) or by simple attitude of the head of the company. In the case of BH EXCERCYCLE I used the Malcoln Baldridge questionnaire, and in the other cases my opinion is going to be placed from 1 (bad) to 10 (excellent).

CONCLUSIONS ABOUT VALIDATIONS OF IMOM MODEL

IMOM model is composed of four technical elements and three social elements. The technical elements are: INPRO process, inventory policies, hybrid production system and information system. The social elements are: team work, leadership and organizational culture. The technical elements prove that they are well developed from the theoretical and practical point of view. They also present good results in all the cases in inventory, cycle time reductions, and better customer satisfaction (real results in BH and canels cases and potential results in TISAMATIC case). As it is presented in IMOM model, social elements are essential for its whole success. When the IMOM model was developed, leadership, team work and organizational culture were considered as very important issues, but according to validations, I can conclude from the epistemological point of view that they are more important than the technical ones in some periods of time during the implementation. So, good results can be achieved with the technical elements, in the long run, they will be affected by the social elements, and people may say that technical elements don't work.
If we get the three cases together, we can analyze their results regarding the IMOM model's validations using, as a reference, the elements of the evaluation criteria described above in section 6.4.

Evaluation Criteria	BH EXCERCYCLE	TISAMATIC	CANELS
Customer satisfaction	6	3	5
Change the organizational culture	5	2	5
Inventory reduction	8	5	6
Lead time reduction	7	4	5
Team Work	5	2	6
Leadership	2	4	5
TOTAL	**33**	**20**	**32**

Table 6.1 Evaluation of the implementations

The reason why only these elements were included is because they are critical for Mexican business success and at the same time are considered as international elements for competitiveness (Sada M., 1995).
The results of the three validations regarding IMOM model, are presented in the table 6.1.
A weighting method was used to describe the level of success during the validations, where 1 means a bad result and 10 an excellent result.
For those cases with partial or no implementations of some IMOM elements, the same range from 1 to 10 was used. If an element wasn't implemented in a case. It is important to notice that three different companies with three different production processes provide common outputs. The results found in table 6.1 describe how important it is the **leadership** element in the implementation of an improvement tool or set of tools as IMOM model. In the case of BH EXCERCYCLE, leadership affected way too much the success of other elements, as team work, INPRO process, hybrid production system, inventory management and information system. In the case of TISAMATIC, leadership is perceived with regular impact (4 was assigned), and it is resulting in a regular success for the rest of the criteria elements. In the Canel's case, leadership was found also with regular impact (5 was assigned). Analyzing total scores from table 6.1, BH got the highest weight because of good results on the IMOM technical elements, but social elements influenced IMOM model reducing its effectiveness. TISAMATIC presented the lowest score because technical elements couldn't be implemented due to the influence of social elements. Canels case has a similar total score as BH, but here, the social elements were stronger than BH. Even this results are not satisfactory enough for the research and practical point of view, they can be improved. If the leadership role is played properly, that is, working with a leadership based on facts, and not with words, speeches or promises, better results can be reached.
Particularly for the case of BH, good results started to appear at certains period of time during my intervention, but several changes in some positions of the company were affecting the continuity and good success of the implementation. To start again with the implementation of the IMOM model in BH would take at least six extra months because it is necessary to construct, educate and train the team of the people again in the activities

considered in this thesis. The results of the validations and the learning's from the implementations will be presented in the next chapter (chapter 7) in order to improve and adjust the IMOM model.

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7. LEARNING'S FROM THE IMPLEMENTATION

7.1 Introduction

The general objective of this chapter is to show and develop the improvements of the IMOM model after the learning's from the BH implementation. The kind of implementation that is needed for the IMOM model is about 18 months considering a complete monitoring of all the performance measures that are necessary to validate it, so after 12 months of working in the BH case I learned from implementation experiences, and recomend some improvements out of the scope of IMOM model. Both experinces and extra recomendations are presented in this chapter. The section 7.2 will be used to defined the framework of the learning loop considered for this thesis. In section 7.3 I will show some improvements that are out of the scope of this thesis, but are important to mention them in order to get to know all the work done for BH. Some of these recommendations are simple but gave great impact in the improvement process held in BH at the time of my intervention. They are not trying to represent a research success for doctorate purposes. Section 7.4 aims to describe a general evaluation of the implementation of the IMOM model and its possible improvements. In section 7.5 I will present a methodology to implement the IMOM model considering the learning's from the implementation. This methodology aims to serve as a guide to implement the IMOM model, and it can be modified or adjusted to a special situation of a company. Most of the big mistakes occurr when a methodology or a modèl is presented to solve a problem is that they are sold as a solution for any case (Jackson, 1991). Finally, section 7.6 I will develop the general conclusions of this thesis and further research.

7.2 Conceptual Framework (learnning loop)

As we shall try to demostrate, that the conception of the theory is divorced from real world practice and it is grounded in a misunderstanding from the nature and purpose of theory.

According to Kolb (1979), learning might start with the experience of an event or stimuli, that the individual then reflects upon trying to make sense of it. Next figure 7.1 I will show how it can make sense for the case of this thesis. Regarding the approach of this thesis, I started with a formation of an asbtract concept of the IMOM model, which took into account the literature and facts found during some experiences in the practice (chapter 2).

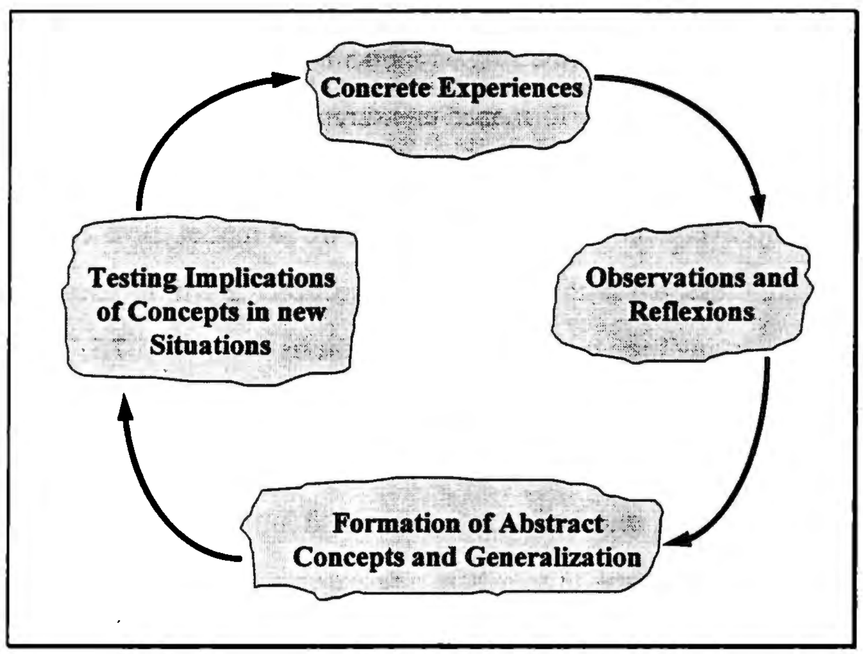

Figure 7.1 The Kolb's learning Cycle

Considering the Testing stage of figure 7.1, the IMOM model was compared with the real world, so with its implementation (case of study), it generated a feed back and experiences that will be observed and produce reflexions on. After the implementation I found those changes that are desirable and feasible. Unfortunately not all the content of the IMOM model was implemented. Some of the reasons are as follow:

☑ lack of commitment with the implementation from the top management

☑ lack of leadership

☑ the company didnt' have the basic operational conditions

☑ the lack of vision and mission affect the implementation

☑ the information system never worked properly

☑ Several consultants were working at same time in the company

The main reason of this chapter was to consider a powerful feed back from the real world. This chapter also will be supported on section 5.4 from chapter 5 (Malcoln Baldridge survey), that shows how the some very important elements were attempting to a good implementation. these elements are:

1.0 LEADERSHIP
2.0 INFORMATION AND ANALYSIS.
3.0 STRATEGIC PLANNING.
4.0 HUMAN RESOURCE DEVELOPMENT AND MANAGEMENT.
5.0 PROCESS MANAGEMENT.
6.0 BUSINESS RESULTS.
7.0 CUSTOMER FOCUS AND SATISFACTION.

Even elements like Leadership, Information and Analysis and Process Management are considered as part of the IMOM model, they were affected mainly by the Leadership issue.

7.3 Recommendations of improvement and unanticipated results

During my intervention in BH I found several improvement areas, out of the content of the IMOM model, which I recomend to put in practice because of they were basic operational conditions for any manufacturing company. Those areas are:

⇨ a new plant layout

⇨ the opening of a Product Development department

⇨ strategic planning

A new plant layout

A new plant lay out was required because the *Initial Operations* station (cutting, blending and welding) was moved to an other plant. This plant is very close to the current one. BH is considering increasing its production capacity, by adding a new assembly line to the assembly of gyms for a customer in the United States. The methodology used to develop the new layout is the Systematic Layout Planning (SLP).

In figure 7.2 and 7.3 the relationship matrix shows the entities considered for the layout. In this layout the store of raw materials is now located next to the left wall of the plant. In regard to the new assembly line, there are two possibilities, one is having a straight line as always, or modifying the line by changing it into a manufacturing cell as shown in figure 7.4. These proposals are now being considered to modify the plant.

Layout Analysis

Method: SLP Systematic Layout Planning

Relationships Matrix

	Process	A 2	A 3	A 4	A 5	A 6	A 7	A 8	A 9	A 10	A 11
	Reception	U	A	E	U	U	U	U	A	A	U
	Warehouse		U	U	U	A	A	U	U	U	U
	Store RM			U	U	A	U	U	I	U	U
	Pre-paint Store				U	U	U	A	U	U	U
	Paint Store					A	U	A	U	E	U
	Assembly lines						U	U	A	E	E
	Dock							U	U	A	U
	Painting								U	E	U
	Cardboard Store									U	U
	Quality Control										A

Simbology	
Value	Closeness
A	Absolutely necessary
E	Especiallly important
I	Important
O	Ordinary closeness OK
U	Unimportant
X	Undesirable

Figure 7.2 Relationship matrix

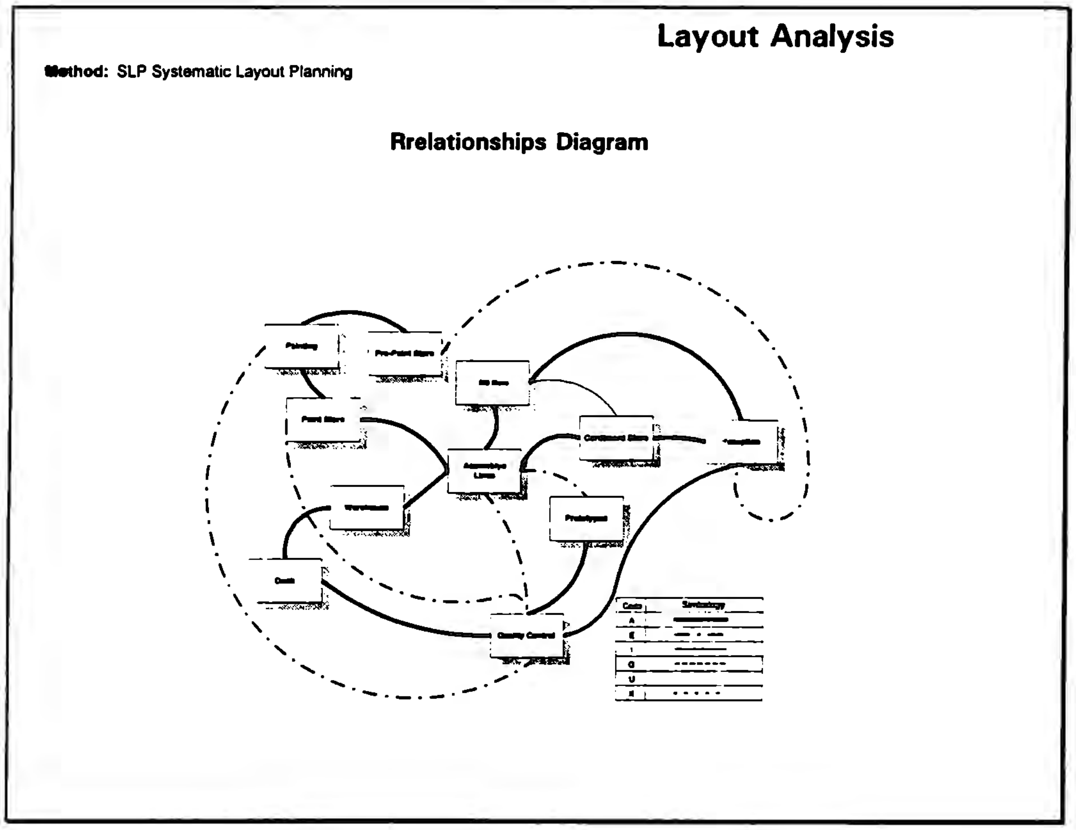

Figure 7.3 Graphical relationship with the entities

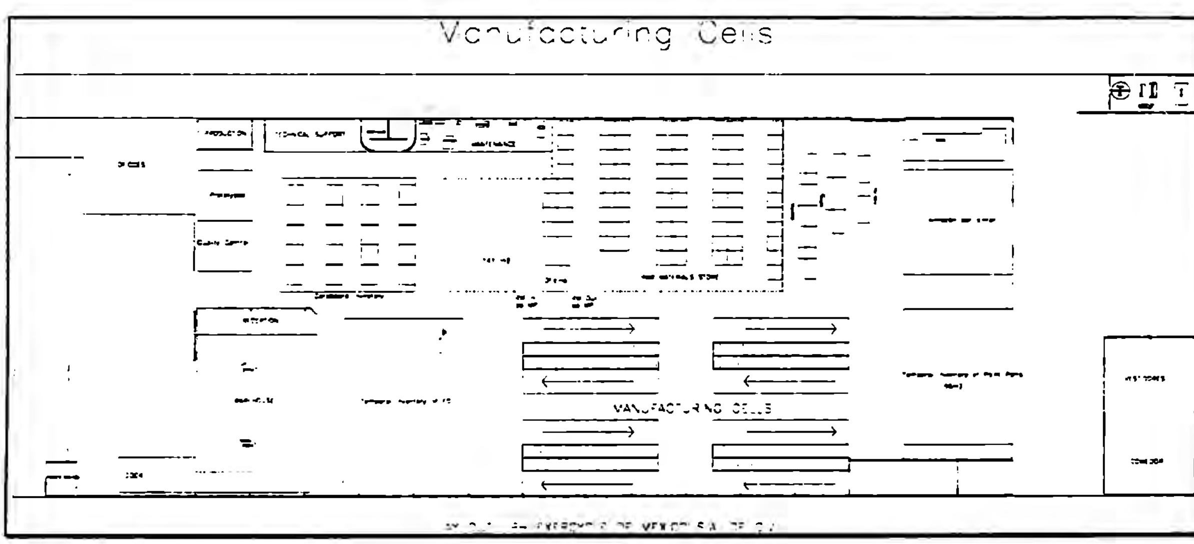

Figure 7.4 New layout plan proposed

The opening of a Product Development department

A lot of quality problems have a root on the source of their development, that is, there isn't a standardization in the specification of the product, and in the production process. BH is considered a company that needs to the developing of new products frequently, because of competition. So one thing is true: new products have to be developed. The process of designing and developing new products needs to be modified. The first thing is to establish a new area or department to be in charge of the following activities:

- Design of the new products
- Actualization of the current products
- develop of specifications (manual and in computer) of new and current products
- specify quality standards
- Test and deliver the new in the production process

The organization of this process has to be based on a team composed of several disciplines like: production, sales, engineering, finances and purchasing. The concepts of Concurrent Engineering and Quality Function Deployment are also recommended to be implemented by the team. To open this, a new manager has to be hired.

Strategic planning

BH is an enterprise that has a great future in the fitness market, national and international. The time to become a leader in the domestic sector depends on how the company is driven. BH has clear objectives, so they need to set them in a Vision and a Mission in order to share them with all the people in the company. A recommended way to lead the company is by following the model presented in the figure 7.5. This figure represents a model for strategic planning focus in Quality. The vision is an objective to be reached in the long run, normally for about five to ten years, or more. The function of the vision is to pull the company through the time to get the desired conditions. The role of the Mission is the stair to reach the Vision. The content of the mission needs to have at least the following issues:

- the customer (s)

- product to be offered
- market segment
- values of the company
- people and company success

Once the vision and the mission are established, the strategies come up and then actions need to be put in practice. In the case of BH, this model can transform it into a world class manufacturing company.

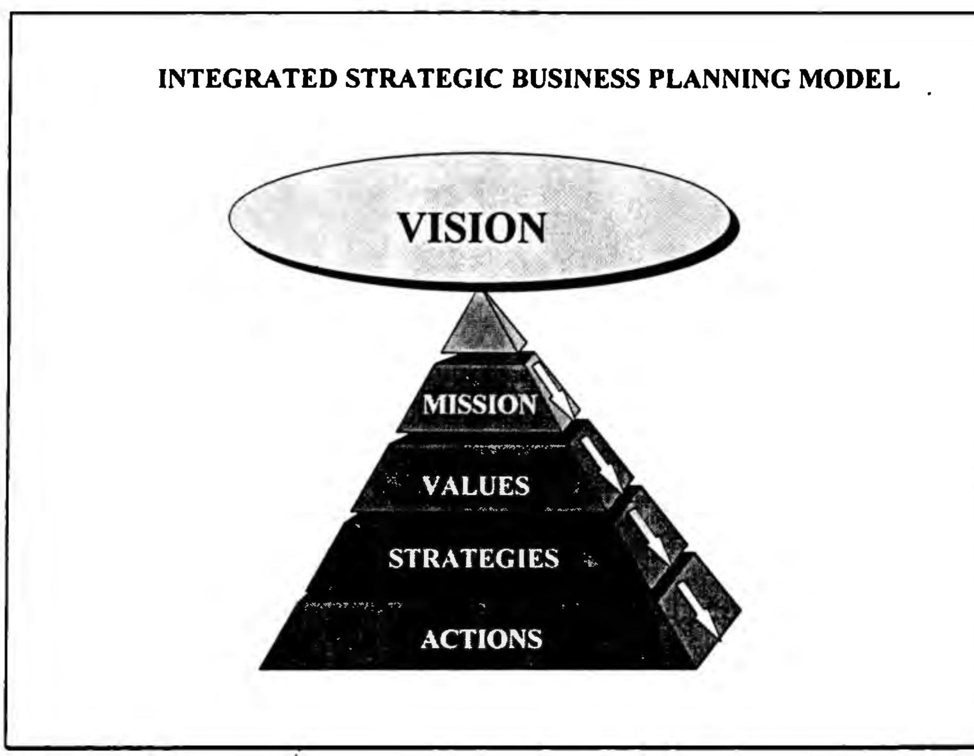

Figure 7.5 Strategic Planning model focus on quality

7.4 Evaluation of the IMOM and improvements

The initial content of the IMOM model was stated according to the weakness of the literature and my life experience, but to implement all its elements effectively, is necessary to define a methodology to warrantee its success. The elements coinained in the IMOM model, are as follow:

1. Integrated Process (INPRO) of sales, production and materials supplying
2. Inventory policies (MAFC model)
3. Hybrid Production System
4. Team Work
5. Organizational Culture
6. Leadership
7. Information System

Initialy a Production Function as aelement of the IMOM model was porposed, but it was eliminated from the model, because its operational purpose is covered in the Master Schedule. The main idea of including a Production Function is to provide the amount of goods to be produced, but when the master schedule works effectively, this information can be provided in detail.

The key operational elements in the IMOM model are the: Integrated Process (INPRO), The inventory Policies, the Hybrid Production System, and the information systems. But, in order to put these elements to work efficiently and effectively, the organizational culture needs to be driven in the same direction of the actions expected in the IMOM model. As Peter Senge says, the organizational structure generate the company's behavior. The strategic planning model in figure 7.3 helps to define the structure of the organization, it means, if the Vision and Mission are defined, the organizational structure enables the actions needed to implement successfully the IMOM model. Team work and leadership are other two elements that need to be explained, cultivated and promoted to make the model reality. For instance, the Integrated Process (INPRO) wont work without a team well coordinated, and the team wont work if the leadership element is not present and applied in the company. What I am trying to say, is that the elements of Organizational Culture, Team Work and Leadership are the basic necessary conditions for the implementation of the IMOM model. So the new general contest of the IMOM model is now shown in figure 7.6.

As we can see, the Information System element appears as part of the operation, and the blocks representing the Organizational Culture, Leadership and Team Work are now considered pillars to allow the operational elements work. The IMOM model is now composed of two classification: a) Technical elements and b) social elements (intagibles). Not one element is more important than the others. If we see in the center of figure 7.4, the customer needs and expectations are now driving the efforts of all the elements.

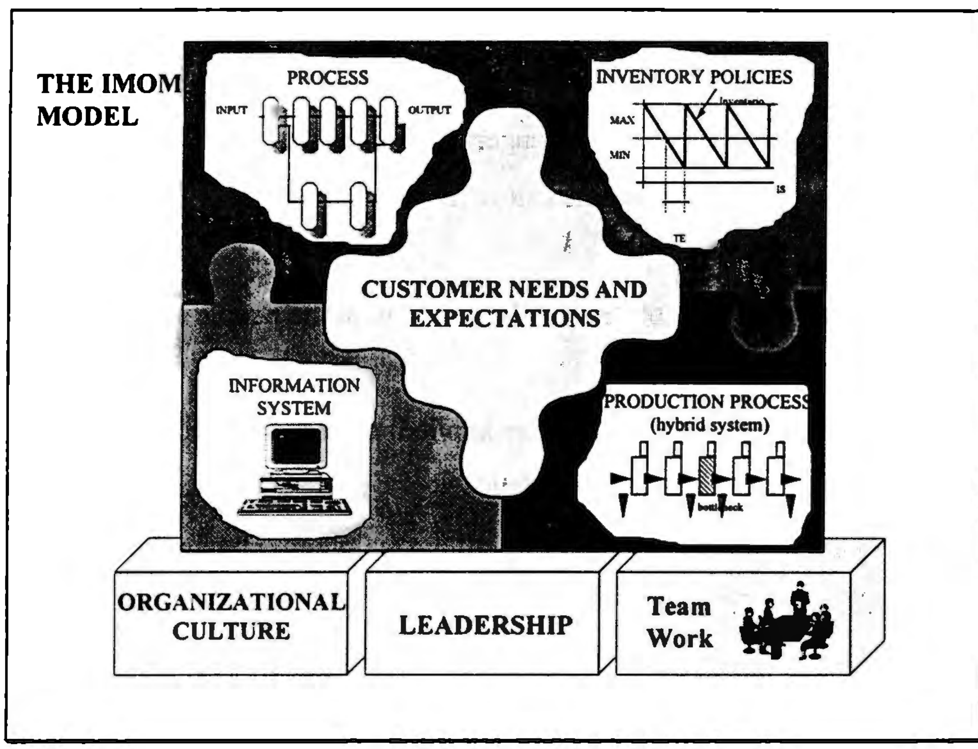

Figure 7.6 The new representation of the IMOM model

7.5 A methodology for the implementation of the IMOM

The learning's from the implementation are plenty. The success of the IMOM model depends a lot on the methodology to be used for its implementation, and the change management. The IMOM model aims a great improvement in productivity and competitiveness in the company, but according to most of the Mexican companies basic operational conditions have to be implemented at first, if good results and less pain is desired. The basic conditions are three blocks that are supporting the operational elements (see figure 7.7). It means, that the Organizational Culture needs to be defined at first by establishing the Vision and Mission of the company, after that the leadership role of the head of the organization (general manager or director) and middle term management is crucial to move the people to the purposes placed on the Vision and Mission. Next a methodology to implement the IMOM model is developed to achieve the desired results. The stages considered in the methodology are:

1. Analyze the current situation of the company
2. Development of the Vision and Mission of the company (if they don't exist)
3. Formalize the organizational structure
4. Enable the leadership role with the managers based on the stated in the vision and mission, and an enthusiastic commitment with the continuos quality improvement in the hole company
5. Promote the implementation of the IMOM model with the people involved with it (team work)
6. Provide a training seminar about the tools applied in the IMOM model.
7. Implement the inventory management policies
8. develop the integrated process (INPRO) with the people involved in the process
9. define performance indicators
10. Obtain the capacity of the production process
11. develop the Hybrid Production System (master schedule, kanban system and bottleneck management)
12. Select an Information System to be used, and (or) the developing of software to customize the information system
13. Review the expected results

A graphical sketch (figure 7.7) represents the stages that have to be followed and performed in order to have good results .

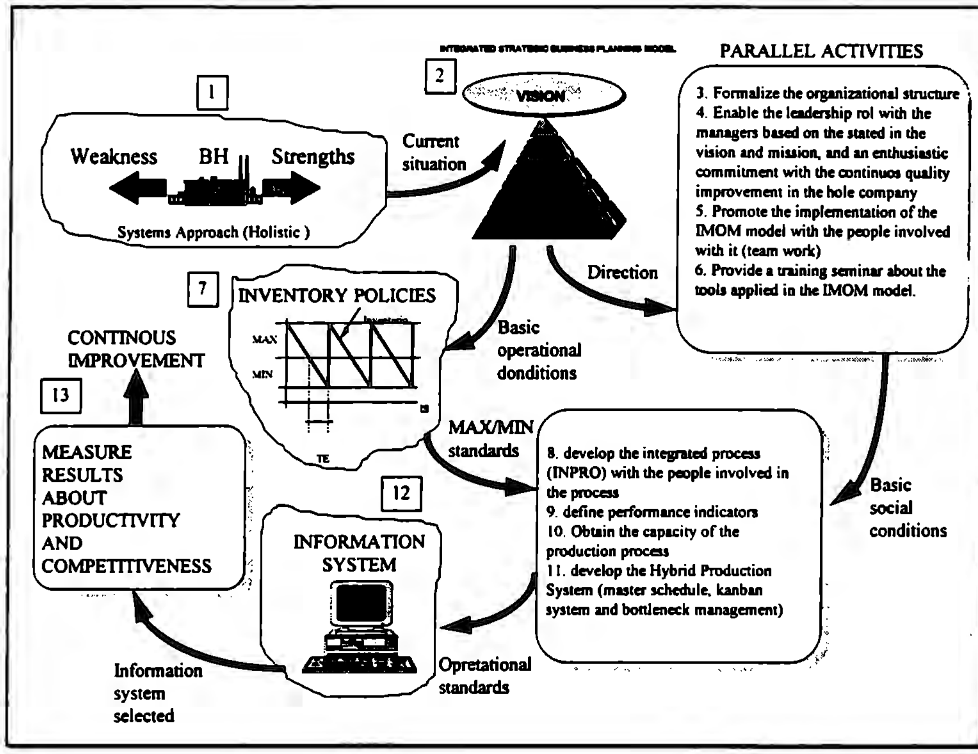

Figure 7.7 A methodology for implementing the IMOM model

This methodology implies a change in the cultural organization, and a change management arises as something to be treated. Luisa Deal[1] explains how a model for managing change can guide the expected change in people's culture and commitment. Figure 7.8 shows the stages of effective change management, and also illustrates the consequences if an stage is missed. Something important to notice is that the components in figure 7.8, need all to be performed if a good change is desired. The methodology of figure 7.7 has to be complemented with the Change Management Components in order to have success with the implemenation of the IMOM model.

[1] Luisa Deal has developed a model for change managemengt that was presented in Tijuana, Mexico on October of 1996. This model promise good results for manufacturing and services enterprises.

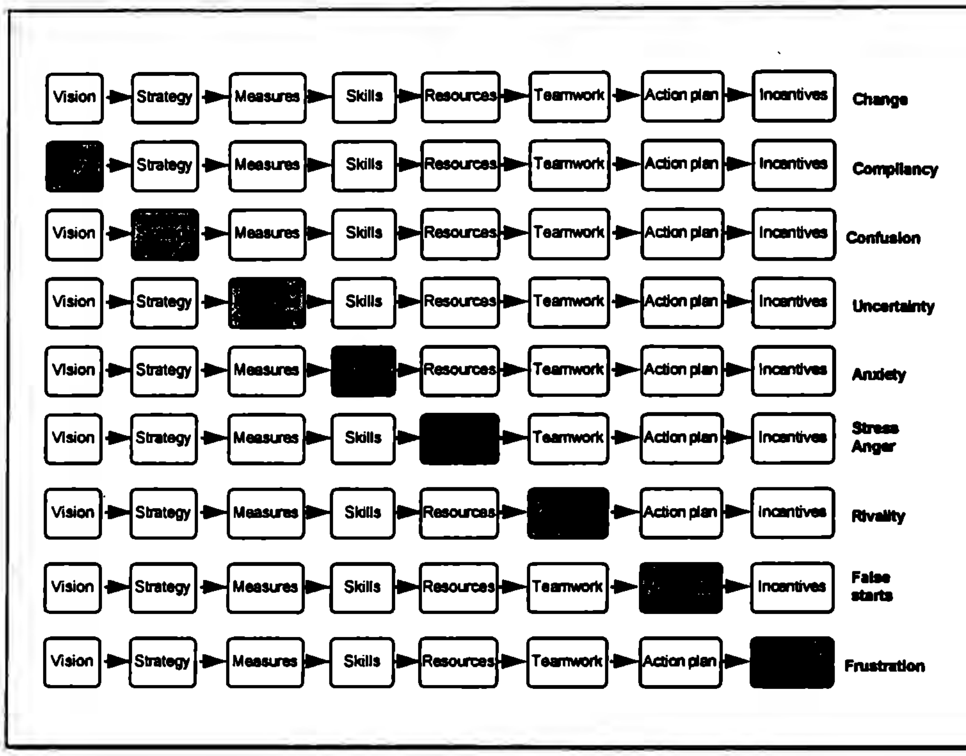

Figure 7.8 Change Management Components (Luisa Deal 1996)

CONCLUSION OF THIS CHAPTER

During the writing of this thesis I have been discussing the wrong way to promote a new improvement technique or tool, they are sold as a solution for every situation. In the case of the IMOM model it was presented initially without any formal methodology for its implementation. So the IMOM model aims to increase the productivity and competitiveness of the small and medium sized Mexican manufacturing enterprises through the integration of the sales, production and material supplying activities. But I want to be aware about the initial paragraph described in the conclusions that the IMOM model help the kind of companies described above, but it has to be adjusted depending of the production process of each enterprise. The learning's from the implementations have leaded me to develop the methodology that can be adjusted depending of the situation of each company.

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8. GENERAL CONCLUSIONS AND FURTHER RESEARCH

8.1 General conclusions

During several years I have observed a lack of integration phenomenon amog departments and even more, among people. Through the development of this thesis I have also observed that this phenomenon not only happens in the departments that I have studied in Mexican enterprises, but it also happens in other companies from different countries[1]. One of the biggest challenges of the Small and Medium sized Mexican companies is the improvement of internal factors for productivity, which are based in the degree of integration. To talk about integration, we first need to define and establish two basic conditions: the technical structure and the social structure. The technical structure defines the necessary means to get people to communicate and in effectively operational conditions, and the social structure refers to the culture of the organization, team work and leadership. We have listened a lot about culture and leadership, but little efforts have been made to improve each of these elements. To really have success implementing the IMOM model, TQM, TOC, JIT or whatever other technique, we must first prepare the company with the appropriate organizational culture and clear and convinced leadership from the person or people involved in the continuous improvement process of a company. Without it, poor results will be obtained.

The IMOM model is presenting a real alternative to get a big impact on productivity and competitiveness through the integration of the activities in the value chain in manufacturing companies. Some of the elements of the IMOM model can also be applied to the service industry, for example the team work approach, leadership, organizational culture and the INPRO process for a particular company.

[1] It was mentioned during the 1997 summer course held in ITESM Campus San Luis Potosi by Keith Ellis (System Thinking specialist from UK)

The IMOM model is composed of four technical elements and three social elements. The technical elements are: INPRO process, inventory policies, hybrid production system and the information system. The social elements are: team work, leadership and organizational culture. The technical elements prove that they are well developed from the theoretical and practical point of view. They also present, in all cases, good results in inventory and cycle time reductions, and better customer satisfaction (real results in BH and CANELS cases and potential results in TISAMATIC case). As it is presented in the IMOM model, social elements are essential for its whole success. When IMOM model was developed, leadership, team work and organizational culture were considered as a very important issues, but according to the validations, I can conclude from the epistemological point of view that they are more important than the technical ones in some period of time during the implementation. Even though good results can be achieved with the technical elements, in the long run, it will be affected by the social elements, and people may say that the technical elements don't work.

The validations developed in this thesis have shown that it is not easy to integrate different departments, and even more, departments such as sales, production and materials supplying. The IMOM model presents an excellent holistic structure to achieve the integration and improve productivity and competitiveness through the customer's success, but in real practice it is very difficult to have good results with each of these elements. As happened in the BH case, the INPRO process, the information system, the inventory management model and the hybrid production system gave good results during the implementation, but other elements of the IMOM model such as leadership, team work and cultural organization didn't give good results, so they affected the results of the elements mentioned before, because they weren't continuously supported through the time. In order to avoid any problem during an implementation of the IMOM model as presented in the BH case (chapter 5) and the other experiences (chapter 6), I recommend the use of the methodology presented in figure 7.7 from chapter 7 (learning's from the implementation). This methodology aims to get a good implementation of the IMOM model by first, promoting the proper conditions in the company regarding organizational culture, leadership and team work. Setting up those elements properly, the remaining elements of the IMOM model (INPRO process, hybrid production system, inventory management and the information system) will work.

In figure 8.1 we can observe the impact of the social elements on the technical ones.

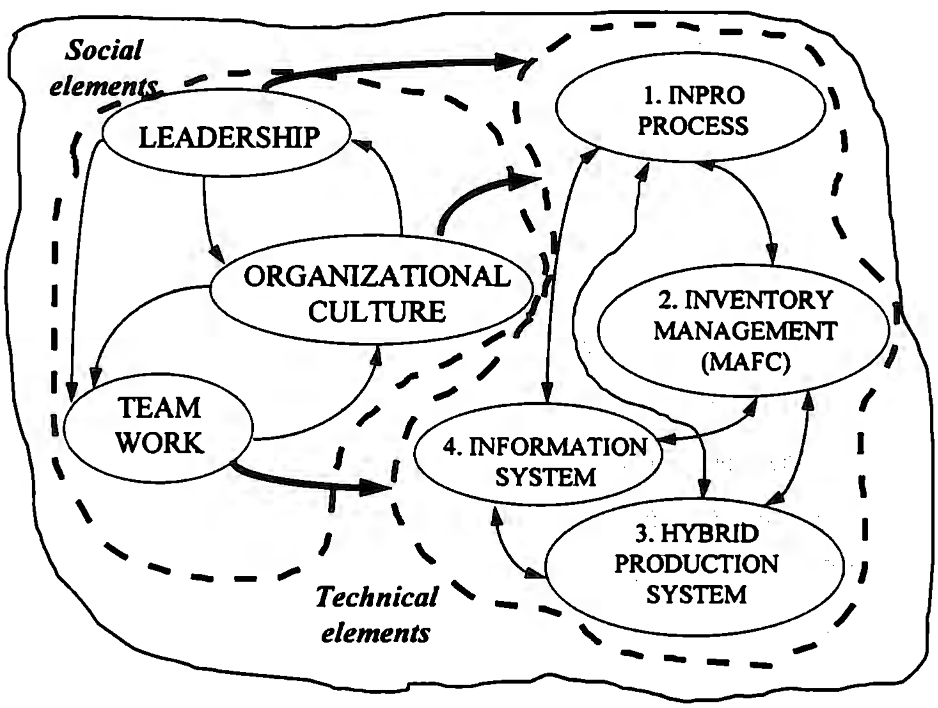


Figure 8.1 Conceptual representation of the relationship between the elements of IMOM model

The relationships between elements, show that all the elements can have an impact, as the INPRO processes impacted the Team Work and vice versa. We can finally observe in figure 8.1 that all the technical elements have relationships among them, so they can not give good results working individually. I recommend to implement the technical elements by first developing the INPRO process, then the Inventory Management Policies, the Hybrid Production System and finally the Information System.

The above arguments reflect the facts found in the implementations presented in this dissertation.

The hypothesis of this thesis (section 2.4 from chapter 2) was initially presented as follow:
Hypothesis 1: The culture of Mexican companies is not focus on integration
Hypothesis 2: Mexican companies need to increase their productivity and competitiveness
Hypothesis 3: The Sales, Production and Material Supplying activities normally work with local goals instead of seeking the global goals of the company
Hypothesis 4: There is no model in Mexico that really integrates Sales, Production and Material Supplying activities

The above hypothesis were covered with the development of the IMOM model in chapter 4 from the theoretical point of view, and chapters 5 and 6 those hypothesis were covered with the implementation of the IMOM model from the practical point of view. Because the IMOM model was developed for the first time, it was improved along with the development of the methodology in chapter 7 (figure 7.7), which present a formal way to get good success in future implementations. It is very important to notice that the social elements of the IMOM model were considered in the first approach presented in chapter 4, but after the implementation, I found that they need to be part of a formal methodology in order to warrantee their support and success over the technical elements. The aim of the methodology is presented in figure 7.7. About the lack of integration presented in Hypothesis 1, this was improved by applying the INPRO process and team work approach. Regarding Hypothesis 2, the technical elements responded well, but for a continuous improvement in any company in the long run, social elements have to work properly.
The IMOM model was validated in three different enterprises, and in each one I participate as a consultant, so I think that better results will be achieved when a company uses the IMOM model a its own improvement strategy, just with little help from outside.

8.2 Further research

There are many things that can be researched in future results with the IMOM implementation, but I would like to recommend all the research related to Human behavior in manufacturing enterprises, specially in Mexican companies, and the creation of a Computer Information System using the structure presented in the IMOM model.
Human behavior in manufacturing enterprises is an issue that has to be studied in order to know exactly what kind of intervention on education and training needs to be provided. This will depend on the case study.

Computer Information Systems have changed with a wide variety of options as MRP II, SAP, ManMan/X, or COMMS[2], but they are still missing something every company is a special case to be improved. Following the structure presented by the IMOM model promises a very good alternative to get an effective Information System customized according to the needs of a company.

Some other topics that are highly recommended for further research are: (1) Performance Measurement in Manufacturing Companies, (2) A MAFC Dynamic Inventory Management and (3) the IMOM for International Logistics (export products).
Performance Measurement is a very important issue that can be developed to really know how a company is working according to its vision, goals and objectives. It requires special attention by the researchers. A MAFC Dynamic Inventory Management can adjust instantaneously the logic of the MAFC model to changes the market's demand. It has to be developed as a part of an information System.
In current days global markets demand new approaches on international logistics, and the IMOM model can be oriented to export and import products. Some of the elements that need to be adjusted are the INPRO process, Inventory Management and Information System.

[2] ManMan/X is a Unix-based software based on the Enterprise Resource Planning logic. COMMS refers to Customer Oriented Manufacturing Management System (Chase and Aquilano, 1995)

Appendix 1

Sales Demand History January 1995-August 1996

		1995												1996								
Part #	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ene	Feb	Mar	Abr	May	Jun	Jul	Ago	Sep
BJ-240	Rem Kayac Viva Fit (BRA)	0	0	0	0	0	0	0	0	238	0	474	40	0	0	856	0	0	1	0	0	140
BJ-440	Bic. "Tempo C/E" Viva Fit (BRA)	0	0	0	0	0	0	0	0	580	0	0	0	0	0	560	0	0	0	0	0	83
BJ-600	Cam "Mississipi" Viva Fit (BRA)	0	0	0	0	0	0	0	0	116	0	230	230	0	0	490	0	0	0	0	0	93
BJ-620	Cam "Pasific" Viva Fit (BRA)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	596	0	0	601	0	0	173
G-13	Banco "Dinamic"	952	32	0	1019	35	528	31	0	41	91	13	7	18	28	42	20	43	8	21	18	147
G-49	Ban Titan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	40	110	0	27
G-55	Ban de pesas "Fitness 500"	216	221	181	172	172	210	142	264	105	158	143	206	224	373	217	91	0	132	481	651	302
G-55 CM	Ban de pesas Profitness	0	0	0	0	0	0	0	38	40	20	29	0	74	75	87	26	54	39	0	0	47
G-55 MG	Ban de pesas Mastergym	0	0	0	0	0	0	0	0	0	0	120	0	0	0	84	178	435	220	0	0	145
G-60	Cam "Mississipi"	206	196	121	124	221	263	145	257	298	480	294	289	496	408	181	292	347	163	474	442	408
G-60 CM	Cam Profitness	0	0	0	0	0	0	0	23	20	17	49	13	53	0	1	5	6	39	0	0	18
G-60 MG	Cam Mastergym	0	0	0	0	0	0	0	0	0	0	30	21	0	0	102	272	368	298	0	0	162
G-61	Cam "Trotter"	0	0	0	162	7	75	11	17	5	10	122	9	42	167	1	110	25	96	95	36	79
G-62	Cam "Pasific"	0	0	0	0	0	0	0	0	6	1	0	2	1	1	1	0	0	10	877	120	188
G-66	Cam "Troter" (redondo)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	220	0	49
H-15	Bic. "Viva Pro S/R V"	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H-16	Bic. "Viva Pro S/R"	0	154	103	2	0	0	2	3	2	25	1	10	0	0	1	7	10	0	0	10	17
H-17	Bic. "Viva Pro"	246	278	320	42	453	275	105	50	122	466	757	369	159	284	119	115	205	86	245	165	197
H-17 CM	Bic. Profitness	0	0	0	0	0	0	0	16	0	24	100	67	72	24	68	11	1	60	0	0	41
H-40	Bic. "Tempo S/R"	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	10	0	0	0	0	1
H-41	Bic. "Tempo"	66	36	51	38	48	74	23	44	25	51	127	0	23	43	41	31	22	48	56	38	37
H-44	Bic. "Tempo C/P"	8	33	13	20	32	22	17	5	15	23	41	7	12	29	35	11	4	26	45	5	21
J-00	Esc. Viva Fit	0	0	79	7	6	8	3	8	14	2	0	4	5	0	0	1	1	0	0	0	7
J-00N	Esc. sin selector	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J-03	Silla romana VivaFit	20	0	203	10	31	48	58	61	51	54	75	5	0	33	34	0	17	20	0	0	4
J-03N	Silla romana sin lagartijero	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	2
J-04	Tabla abd. Viva Fit	42	0	0	0	0	0	4	8	0	8	0	0	0	0	0	0	0	0	0	0	3
J-05	Tabla abd. "Body Line" Viva Fit	35	7	110	66	82	130	28	98	30	27	15	0	38	51	33	54	44	5	0	0	11
J-06	Tabla abd. "Junior" Viva Fit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	14	0	0	6
J-15	Bic. Viva sin remo	0	0	0	30	80	15	0	1	0	21	177	0	0	11	17	241	46	0	75	0	63
J-17	Bic. "Viva Pro Viva Fit"	19	0	199	0	3	21	6	60	6	14	7	12	15	14	18	45	14	26	0	0	4
J-22	Gim "Century" Viva Fit	0	0	40	37	2	4	10	16	9	8	37	77	0	0	0	0	0	30	0	0	9
J-23	Rem Economica	0	0	0	0	0	0	382	0	0	21	0	0	0	0	0	0	0	0	0	0	-1
J-24	Rem Kayac Viva Fit	10	0	113	0	35	11	8	12	15	39	7	4	7	0	12	24	14	14	0	0	2
J-25	Rem "multiaction" Viva fit	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
J-28	Gim Viva Fit	0	0	0	0	0	0	0	0	28	80	90	7	8	10	36	17	20	15	0	0	24
J-53	Ban "Sporty"	0	0	0	0	0	0	0	0	11	68	125	55	1	72	91	18	83	124	62	32	87
J-55	Ban de pesas Viva Fit	6	0	73	0	17	10	10	0	10	16	5	4	6	2	0	8	106	13	0	0	15
J-60	Cam "Mississipi" Viva Fit	0	0	65	17	20	21	8	19	19	2	2	0	6	1	0	0	0	0	0	0	9
J-62	Cam "Pasific" Viva Fit	0	0	0	0	0	0	0	54	8	18	14	5	0	0	0	0	0	106	0	0	21
M-00	Esc. "Alpine"	165	155	193	185	128	158	75	85	65	243	305	109	142	293	196	109	84	48	378	429	236
M-00 CM	Esc. Profitnnes	0	0	0	0	0	0	0	25	15	19	38	19	53	22	36	1	16	21	0	0	23
M-00 MG	Esc. Mastergym	0	0	0	0	0	0	0	0	0	0	50	49	0	0	203	260	231	100	0	0	119
M-01	Esc. "Everest"	176	89	96	30	89	110	108	136	142	474	193	229	4	94	11	100	86	82	168	83	114
M-03	Silla romana "Body Flex"	58	99	2057	56	81	508	54	307	54	336	338	214	134	484	101	129	4	52	339	168	81
M-03 CM	Silla romana Profitness	0	0	0	0	0	0	0	134	60	131	150	117	161	56	0	18	146	73	0	0	83
M-03 MG	Silla romana Mastergym	0	0	0	0	0	0	0	0	0	0	300	41	64	6	0	100	210	0	0	0	72
M-04	Tabla abd. "Multi Flex"	342	412	429	184	314	488	272	337	345	520	462	413	285	576	364	231	308	159	264	606	366
M-04 MG	Tabla abd. mastergym	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	210	292	249	0	0	115
M-05	Tabla abd. "Body Line"	0	0	14	0	37	51	46	16	11	91	29	9	1	5	35	3	4	30	274	284	121
M-05 CM	Tabla abd. "Profitness"	0	0	0	0	0	0	0	151	84	148	214	5	190	151	257	29	250	128	0	0	150
M-06	Tabla abd. "Junior"	0	0	0	0	0	1498	194	17	121	196	143	60	2	86	131	16	75	83	113	84	82
M-07	Tabla abd. c/mancuernas	0	0	0	0	0	0	0	0	0	1	244	0	23	89	4	10	30	5	0	0	33
M-19	Gim "B/strong c/escaladora"	0	28	21	12	0	21	11	51	101	37	43	40	12	11	35	37	35	6	16	20	30
M-21	Gim "B/strong Pro"	119	57	102	58	81	201	187	93	61	213	241	223	259	254	67	35	33	29	41	28	93
M-22	Gim "Century"	120	80	111	62	[illegible]	48	39	65	30	48	73	63	20	62	85	13	27	36	37	45	26
M-26	Gim "Form Gym"	0	37	105	53	[illegible]	94	190	228	45	66	233	214	190	326	118	4	17	9	26	6	93
M-27	Gim "Body Gym"	0	0	0	0	1	14	0	12	10	29	26	2	10	2	8	14	23	7	48	15	23
M-28 CM	Gim Profitness	0	0	0	0	0	0	0	0	0	18	77	28	166	79	147	26	105	76	0	0	81
M-29	Gim "Form Gym Pro"	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	70	0	0	19
NG-55	Ban de pesas Negro	0	0	0	0	0	0	0	0	0	3	102	7	0	0	0	0	0	6	0	0	8
R-23	Rem Kayac S/G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-24	Rem Kayac	105	55	124	21	46	92	6	6	6	109	69	83	0	96	177	16	0	4	99	53	50
R-24 CM	Rem Proftiness	0	0	0	0	0	0	0	17	13	14	40	52	69	2	28	0	2	22	0	0	21
R-24 MG	Rem Mastergym	0	0	0	0	0	0	0	0	0	0	50	99	0	0	100	140	355	0	0	0	96
R-25	Rem "multiaction"	108	134	237	24	57	147	11	91	146	232	63	109	59	97	66	42	103	21	159	17	63
RM-15	POTRO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	67	14

Appendix 1

Inventory Cost

		Forecasting			Production			Sales				Forecasting	Production			
Part #	Description	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec	Unit Cost	Aveg.inventory	Aveg.inventory	Inventory	$Forecasting	$Production
BJ-240	Rem Kayac Viva Fit (BRA)	146	152	158	0	0		0	0	0		33	0	1	0.00	0.00
BJ-440	Bic. "Tempo C/E" Viva Fit (BRA)	86	88	90	0	0		0	0	0		19	0	0	0.00	0.00
BJ-600	Cam "Mississipi" Viva Fit (BRA)	96	100	104	0	0		0	0	0		22	0	0	0.00	0.00
BJ-620	Cam "Pasific" Viva Fit (BRA)	184	195	208	0	0	150	0	0	0		43	10	3	0.00	0.00
G-13	Banco "Dinamic"	147	147	147	0	0		20	22	26	330.63	31	0	273	10149.65	0.00
G-49	Ban Titan	29	31	33	150	150	100	150	150	100	399.13	7	28	8	2748.71	11086.94
G-55	Ban de pesas "Fitness 500"	310	317	325	229	233	231	229	233	231	478.71	68	48	80	32457.80	23037.92
G-55 CM	Ban de pesas Profitness	50	52	54	90	130	130	90	130	130	478.71	11	24	38	5389.84	11635.31
G-55 MG	Ban de pesas Mastergym	154	163	172	600	1000	400	600	1000	400	478.71	36	139	66	17105.18	66487.50
G-60	Cam "Mississipi"	420	432	443	305	321	294	270	285	258	747.21	92	64	165	68999.65	47738.42
G-60 CM	Cam Profitness	19	20	20	60	80	85	60	80	85	747.21	4	16	168	3162.18	11675.16
G-60 MG	Cam Mastergym	172	182	192	600	1300	600	600	1300	600	747.21	40	174	60	29807.24	129723.96
G-61	Cam "Trotter"	82	85	88	210	215	315	210	215	315	633.31	18	51	97	11574.57	32545.10
G-62	Cam "Pasific"	201	214	227	4	4	4	4	4	4	567.69	47	1	26	26850.39	473.08
G-66	Cam "Troter" (redondo)	52	56	59	300	300	150	300	300	150	749.56	12	52	1	9225.08	39039.58
H-15	Bic. "Viva Pro S/R V"	0	0	0	0	0		0	0	0		0	0	3	0.00	0.00
H-16	Bic. "Viva Pro S/R"	17	17	17	0	0		0	0	0		3	0	0	0.00	0.00
H-17	Bic. "Viva Pro"	193	189	184	448	615	405	448	615	405		38	102	144	0.00	0.00
H-17 CM	Bic. Profitness	43	44	46	70	110	110	70	110	110	315.96	10	20	223	3042.20	6363.08
H-40	Bic. "Tempo S/R"	1	2	2	2	2	2	2	2	2		0	0	0	0.00	0.00
H-41	Bic. "Tempo"	37	36	35	172	168	148	172	168	148	440.7	7	34	119	3230.49	14934.83
H-44	Bic. "Tempo C/P"	21	21	22	48	38	38	48	38	38	537.26	4	9	69	2406.48	4626.41
J-00	Esc. Viva Fit	7	7	7	78	78	58	78	78	58	521.38	1	15	172	749.48	7748.29
J-00N	Esc. sin selector	0	0	0	132	132	132	132	132	132	373.1	0	28	80	0.00	10260.25
J-03	Silla romana VivaFit	34	4	1	150	150	100	150	150	100	95.04	0	28	57	19.17	2640.00
J-03N	Silla romana sin lagartijero	2	3	3	180	180	180	180	180	180	95.04	1	38	0	52.88	3564.00
J-04	Tabla abd. Viva Fit	3	3	3	0	0		0	0	0		1	0	2	0.00	0.00
J-05	Tabla abd. "Body Line" Viva Fit	7	4	1	150	150	100	150	150	100	124.76	0	28	50	35.57	3465.56
J-06	Tabla abd. "Junior" Viva Fit	7	7	8	300	300	300	300	300	300	106.15	2	63	179	171.26	6634.38
J-15	Bic. Viva sin remo	66	69	71	50	20	20	50	20	20	300	15	6	159	4451.64	1875.00
J-17	Bic. "Viva Pro Viva Fit"	23	4	3	120	120	100	120	120	100	315	1	24	143	170.91	7437.50
J-22	Gim "Century" Viva Fit	8	8	7	50	50	50	50	50	50	1325.23	2	10	107	2028.95	13804.48
J-23	Rem Economica	19	19	19	30	30	30	30	30	30		4	6	44	0.00	0.00
J-24	Rem Kayac Viva Fit	16	16	16	64	66	66	64	66	66	254.6	3	14	249	827.01	3465.39
J-25	Rem "multiaction" Viva fit	0	0	0	0	0		0	0	0		0	0	0	0.00	0.00
J-28	Gim Viva Fit	25	25	26	70	60	60	70	60	60	958.89	5	13	27	5241.60	12652.02
J-53	Ban "Sporty"	92	96	101	160	155	155	160	165	145	307.68	21	33	66	6487.55	10042.33
J-55	Ban de pesas Viva Fit	15	15	16	90	50	50	50	50	50	478.71	3	13	41	1547.63	6316.31
J-60	Cam "Mississipi" Viva Fit	9	9	9	0	0	20	35	36	56	747.21	2	1	127	1401.02	1037.79
J-62	Cam "Pasific" Viva Fit	22	23	24	217	226	156	217	226	156	567.69	5	42	133	2781.27	23614.33
M-00	Esc. "Alpine"	242	247	253	195	221	211	195	221	211	521.38	53	44	92	27474.70	22701.75
M-00 CM	Esc. Profitnnes	23	24	25	60	90	90	60	90	90	521.38	5	17	139	2743.53	8689.67
M-00 MG	Esc. Mastergym	126	133	140	600	800	350	600	800	350	521.38	29	122	273	15199.48	63362.15
M-01	Esc. "Everest"	112	111	110	215	220	170	215	220	170	551.58	23	42	201	12668.11	23174.02
M-03	Silla romana "Body Flex"	62	43	24	464	479	449	464	479	449	95.04	5	97	198	474.95	9187.20
M-03 CM	Silla romana Profitness	86	89	92	150	230	230	150	230	230	95.04	19	42	154	1820.96	4026.00
M-03 MG	Silla romana Mastergym	76	79	83	0	0		0	0	0	95.04	17	0	0	1641.30	0.00
M-04	Tabla abd. "Multi Flex"	366	366	366	595	621	496	595	621	498	152.57	76	119	168	11634.32	18138.88
M-04 MG	Tabla abd. mastergym	123	130	137	600	1000	300	600	1000	300	152.57	29	132	74	4368.58	20130.76
M-05	Tabla abd. "Body Line"	128	135	142	80	84	84	80	84	84	124.76	30	17	72	3701.04	2148.64
M-05 CM	Tabla abd. "Profitness"	157	164	171	160	240	240	160	240	240	124.76	36	44	9	4431.99	5544.89
M-06	Tabla abd. "Junior"	76	71	65	20	20	20	20	20	20	101.15	14	4	111	1375.19	421.46
M-07	Tabla abd. c/mancuernas	34	35	36	100	100	100	100	100	100		8	21	0	0.00	0.00
M-19	Gim "B/strong c/escaladora"	30	31	31	88	95	92	88	95	92	1563.63	6	19	57	10105.55	29660.99
M-21	Gim "B/strong Pro"	90	88	85	256	310	110	256	310	110	1649.06	18	47	82	29340.14	77415.14
M-22	Gim "Century"	23	20	17	32	33	32	32	33	32	1325.23	3	7	8	4596.79	8926.90
M-26	Gim "Form Gym"	93	92	91	29	33	33	29	33	33	1415.63	19	7	29	26863.93	9339.23
M-27	Gim "Body Gym"	25	26	27	51	53	53	51	53	53	1432.2	6	11	65	8055.00	15614.96
M-28 CM	Gim Profitness	85	89	93	410	260	260	410	260	260	1027.34	19	65	68	19979.22	66349.04
M-29	Gim "Form Gym Pro"	21	22	23	150	300	100	150	300	100	1400	5	38	118	6782.89	53472.22
NG-55	Ban de pesas Negro	8	8	8	100	100	100	100	100	100	478.71	2	21	76	801.00	9973.13
R-23	Rem Kayac S/G	0	0	0	0	0		0	0	0	1037.58	0	0	37	0.00	0.00
R-24	Rem Kayac	49	48	47	32	34	34	32	34	34	254.6	10	7	278	2509.75	1768.08
R-24 CM	Rem Profitness	22	23	23	60	110	110	60	110	110	254.6	5	19	422	1238.74	4950.56
R-24 MG	Rem Mastergym	101	107	112	0	0		0	0	0	254.6	23	0	79	5958.33	0.00
R-25	Rem "multiaction"	59	56	53	243	200	180	235	190	170	383.32	11	43	302	4234.17	16583.91
RM-15	POTRO	39	44	49	45	40	40	45	40	40	0	10	9	1	0.00	0.00
		22	23	24	22	23	24	22	23	24			Inventory cost		460215.08	985704.46

Appendix 2

Finished Goods Policies Inventory based on MAFC

Part #	Description	Monthly Demand	Daily Demand	Max.	Min.	SS	LT	QO
BJ-240	Rem Kayac Viva Fit (BRA)	158	7	79	53	20	5	59
BJ-440	Bic. "Tempo C/E" Viva Fit (BRA)	90	4	45	30	11	5	34
BJ-600	Cam "Mississipi" Viva Fit (BRA)	104	4	52	35	13	5	39
BJ-620	Cam "Pasific" Viva Fit (BRA)	206	9	103	69	26	5	77
G-13	Banco "Dinamic"	147	6	74	49	18	5	55
G-49	Ban Titan	33	1	17	11	4	5	12
G-55	Ban de pesas "Fitness 500"	325	14	163	108	41	5	122
G-55 CM	Ban de pesas Profitness	54	2	27	18	7	5	20
G-55 MG	Ban de pesas Mastergym	172	7	86	57	21	5	64
G-60	Cam "Mississipi"	443	18	222	148	55	5	166
G-60 CM	Cam Profitness	20	1	10	7	3	5	8
G-60 MG	Cam Mastergym	192	8	96	64	24	5	72
G-61	Cam "Trotter"	88	4	44	29	11	5	33
G-62	Cam "Pasific"	227	9	114	76	28	5	85
G-66	Cam "Troter" (redondo)	59	2	30	20	7	5	22
H-15	Bic. "Viva Pro S/R V"	0	0	0	0	0	5	0
H-16	Bic. "Viva Pro S/R"	17	1	8	6	2	5	6
H-17	Bic. "Viva Pro"	184	8	92	61	23	5	69
H-17 CM	Bic. Profitness	46	2	23	15	6	5	17
H-40	Bic. "Tempo S/R"	2	0	1	1	0	5	1
H-41	Bic. "Tempo"	35	1	18	12	4	5	13
H-44	Bic. "Tempo C/P"	22	1	11	7	3	5	8
J-00	Esc. Viva Fit	7	0	3	2	1	5	3
J-00N	Esc. sin selector	0	0	0	0	0	5	0
J-03	Silla romana VivaFit	1	0	0	0	0	5	0
J-03N	Silla romana sin lagartijero	3	0	1	1	0	5	1
J-04	Tabla abd. Viva Fit	3	0	2	1	0	5	1
J-05	Tabla abd. "Body Line" Viva Fit	1	0	1	0	0	5	1
J-06	Tabla abd. "Junior" Viva Fit	8	0	4	3	1	5	3
J-15	Bic. Viva sin remo	71	3	36	24	9	5	27
J-17	Bic. "Viva Pro Viva Fit"	3	0	1	1	0	5	1
J-22	Gim "Century" Viva Fit	7	0	4	2	1	5	3
J-23	Rem Economica	19	1	10	6	2	5	7
J-24	Rem Kayac Viva Fit	16	1	8	5	2	5	6
J-25	Rem "multiaction" Viva fit	0	0	0	0	0	5	0
J-28	Gim Viva Fit	26	1	13	9	3	5	10
J-53	Ban "Sporty"	101	4	51	34	13	5	38
J-55	Ban de pesas Viva Fit	16	1	8	5	2	5	6
J-60	Cam "Mississipi" Viva Fit	9	0	5	3	1	5	3
J-62	Cam "Pasific" Viva Fit	24	1	12	8	3	5	9
M-00	Esc. "Alpine"	253	11	126	84	32	5	95
M-00 CM	Esc. Profitnnes	25	1	13	8	3	5	9
M-00 MG	Esc. Mastergym	140	6	70	47	17	5	52
M-01	Esc. "Everest"	110	5	55	37	14	5	41
M-03	Silla romana "Body Flex"	24	1	12	8	3	5	9
M-03 CM	Silla romana Profitness	92	4	46	31	11	5	34
M-03 MG	Silla romana Mastergym	83	3	41	28	10	5	31
M-04	Tabla abd. "Multi Flex"	366	15	183	122	46	5	137
M-04 MG	Tabla abd. mastergym	137	6	69	46	17	5	52
M-05	Tabla abd. "Body Line"	142	6	71	47	18	5	53
M-05 CM	Tabla abd. "Profitness"	171	7	85	57	21	5	64
M-06	Tabla abd. "Junior"	65	3	33	22	8	5	24
M-07	Tabla abd. c/mancuernas	36	2	18	12	5	5	14
M-19	Gim "B/strong escaladora"	31	1	16	10	4	5	12
M-21	Gim "B/strong Pro"	85	4	43	28	11	5	32
M-22	Gim "Century"	17	1	8	6	2	5	6
M-26	Gim "Form Gym"	91	4	46	30	11	5	34
M-27	Gim "Body Gym"	27	1	13	9	3	5	10
M-28 CM	Gim Profitness	93	4	47	31	12	5	35
M-29	Gim "Form Gym Pro"	23	1	12	8	3	5	9
NG-55	Ban de pesas Negro	8	0	4	3	1	5	3
R-23	Rem Kayac S/G	0	0	0	0	0	5	0
R-24	Rem Kayac	47	2	24	16	6	5	18
R-24 CM	Rem Profitness	23	1	12	8	3	5	9
R-24 MG	Rem Mastergym	112	5	56	37	14	5	42
R-25	Rem "multiaction"	53	2	27	18	7	5	20
RM-15	POTRO	49	2	24	16	6	5	18

Appendix 3

Raw Material Invewntory Policies based on MAFC

Part #	Description	Monthly Demand	Daily Demand	Max	Min	SS	QO	LT
6693002	Buje de fricción 1 1/8 R-25	963	40	963	642	321	642	8
7425001	Muelle compresión pesas	223	9	419	279	140	279	15
7427001	Muelle reten piezas G-55	3301	138	6190	4127	2063	4127	15
7601001	Casq. guia barra G-55	1321	55	1238	825	275	963	10
7601003	Casq. 2"x2"x5 (M-26)	236	10	221	148	49	172	10
7604002	Casq. guia maneta M-26	289	12	271	180	60	210	10
7631001	Apoyo trasero	2625	109	2461	1641	547	1914	10
7631002	Taco de apoyo patas G-60	3074	128	2882	1921	640	2242	10
7637002	Taco cuadrado 38x38	1321	55	1238	825	275	963	10
7637003	Apoyo rectangular 2 barrenos	650	27	609	406	135	474	10
7677004	Regaton 20x32	3301	138	3095	2063	688	2407	10
7677012	Regaton cuadrado 32x32	735	31	689	459	153	536	10
7677013	Reg. rect. G-60 30x60	3187	133	2988	1992	664	2324	10
7677017	Portaiman	535	22	502	335	112	390	10
7694003	Buje de fricción der. H-17	825	34	773	516	172	602	10
7694004	Buje de fricción izq. H-17	874	36	819	546	182	637	10
7694006	Buje G-13	0	0	0	0	0	0	10
7695001	Buje nylon para pesas	6584	274	6172	4115	1372	4801	10
7712001	Tapa derecha H-17	321	13	301	201	67	234	10
7712003	Tapa izq. H-17	321	13	301	201	67	234	10
7714001	Carcasa M-26	118	5	111	74	25	86	10
7714002	Contra carcasa M-26	118	5	111	74	25	86	10
7851003	Camilla M-06	195	8	73	49	24	49	3
7852001	Camilla larga M-18	116	5	44	29	15	29	3
7852002	Camilla corta M-18	116	5	44	29	15	29	3
7852003	Camilla biceps M-18	116	5	44	29	15	29	3
7852004	Camilla corta G-55 azul	427	18	160	107	53	107	3
7852005	Camilla larga G-55 azul	427	18	160	107	53	107	3
7852006	Camilla azul M-03	24	1	9	6	3	6	3
7852007	Camilla M-04 azul	366	15	137	92	46	92	3
7852008	Codera M-21 azul	171	7	64	43	21	43	3
7852017	Cojin peck deck negro	230	10	86	58	29	58	3
7852019	Camilla M-05	142	6	53	36	18	36	3
7852020	Camilla larga M-22	142	6	53	36	18	36	3
7852021	Camilla corta M-22	142	6	53	36	18	36	3
7852024	Camilla corta negra j-55	361	15	135	90	45	90	3
7852025	Camilla larga negra J-55	42	2	16	10	5	10	3
7852026	Camilla larga G-55 CM	147	6	55	37	18	37	3
7852028	Camilla M-03 CM	175	7	66	44	22	44	3
7852029	Camilla M-05 MC	171	7	64	43	21	43	3
7852030	Camilla larga NG-55 verde	8	0	3	2	1	2	3
7852031	Camilla corta Ng verde	8	0	3	2	1	2	3
7852032	Camilla larga G-55 MG	172	7	64	43	21	43	3
7852033	Camilla M-04 MG	137	6	-52	34	17	34	3
7853001	Sillin Kayak	428	18	402	268	89	312	10
7857001	Cojin peck deck azul	233	10	218	146	49	170	10
7896007	Caja interior G-55	575	24	1616	1077	359	1257	30
7896008	Separador Int. G-55	676	28	1901	1267	422	1478	30
7896009	Interior G-60	3425	143	9633	6422	2141	7492	30
7897006	Caja exterior G-55	676	28	1901	1267	422	1478	30
7897008	Caja Alpine	1860	77	5230	3487	1162	4068	30
7897019	Caja G-60	950	40	2671	1781	594	2077	30
7897027	Caja G-62	456	19	1283	856	285	998	30
7941002	Mando accionar bulon	955	40	895	597	199	696	10
7941010	Taco de apoyo H-17	1777	74	1666	1111	370	1296	10
7941011	Reposapies	1043	43	978	652	217	761	10
7944026	Rodillo de deslizamiento	1713	71	1606	1071	357	1249	10
7947004	Taco redondo diam 2"	8217	342	7703	5136	1712	5992	10
7947015	Casq. Plas. Suj. Rod	1544	64	1448	965	322	1126	10
7951006	Sillin Bici H-17	304	13	285	190	63	222	10
7954029	Espuma Brazo superior	0	0	0	0	0	0	10
7957001	Caja H-41	470	20	1028	685	98	930	30
7957006	Espuma Ap. pierna	9090	379	8522	5681	1894	6628	10
7957022	Interior cuerpo H-41	470	20	1028	685	98	930	30
6505001	Volante de inercia H-41	149	6	93	62	31	62	5
6505003	Volante rayos H-17	321	13	201	134	67	134	5
6505004	Volante de inercia G-60	2169	90	1356	904	452	904	5
6515001	Pesas Rectangulares 5Kg	3376	141	2110	1407	703	1407	5
6515002	Pesas Esp. Home Gym REct	285	12	178	119	59	119	5

Appendix 4

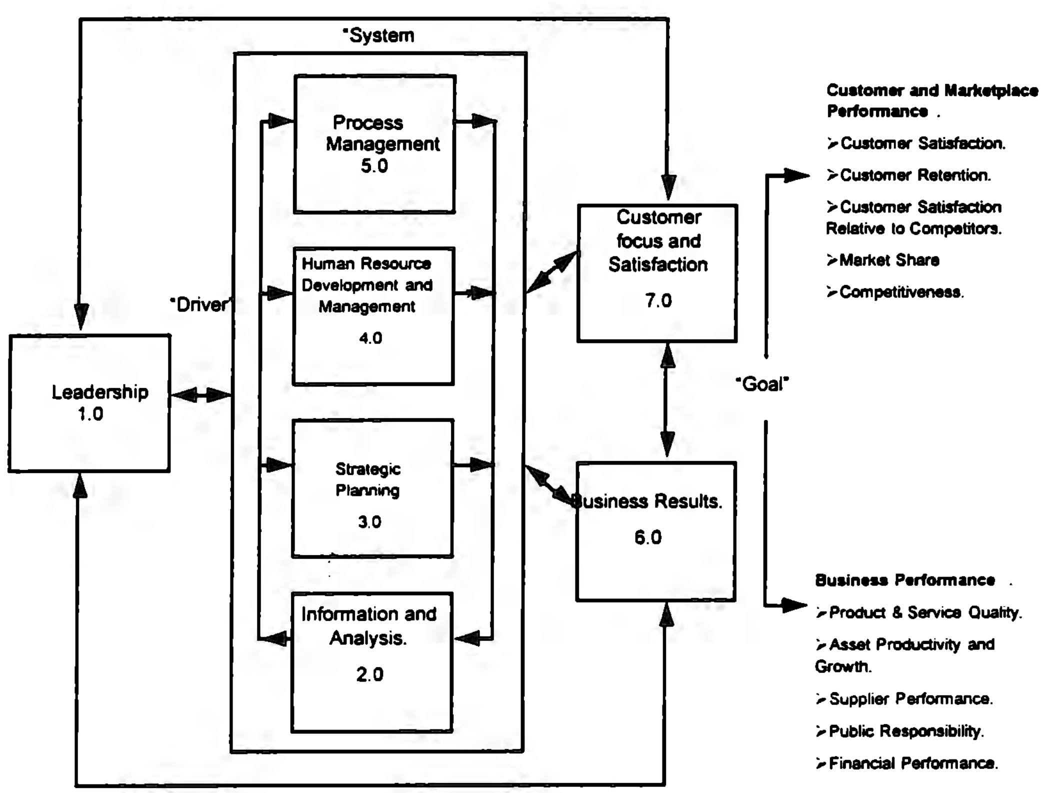
Survey Based on Malcolm Baldridge Award

In the beginning of November of 1996, I'll decide to evaluate the Quality System of BH Exercycle and principally the real advance of the company. Election of evaluation method was base in the creation of a special questionnaire for Mexican industries, then approximation of Carlos Tellez Martínez to Malcolm Baldrigde Award was the solution to problem.

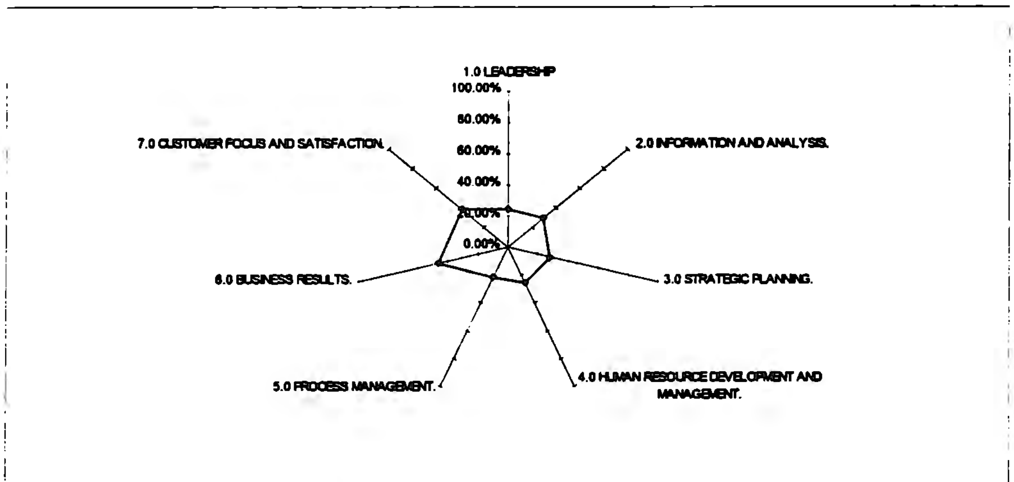
Results of evaluation have the 90% of confiability then this results will be take seriously for company.

Analysis of Malcolm Baldrigde Survey are based on seven criterion that are structured in next figure.

BALDRIGE AWARD CRITERIA FRAMEWORK
(DYNAMIC RELATIONSHIPS)

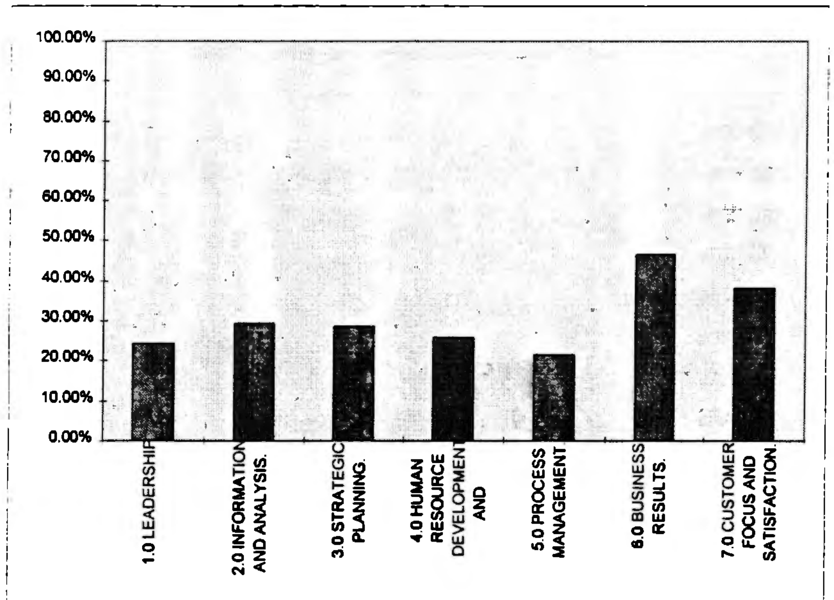


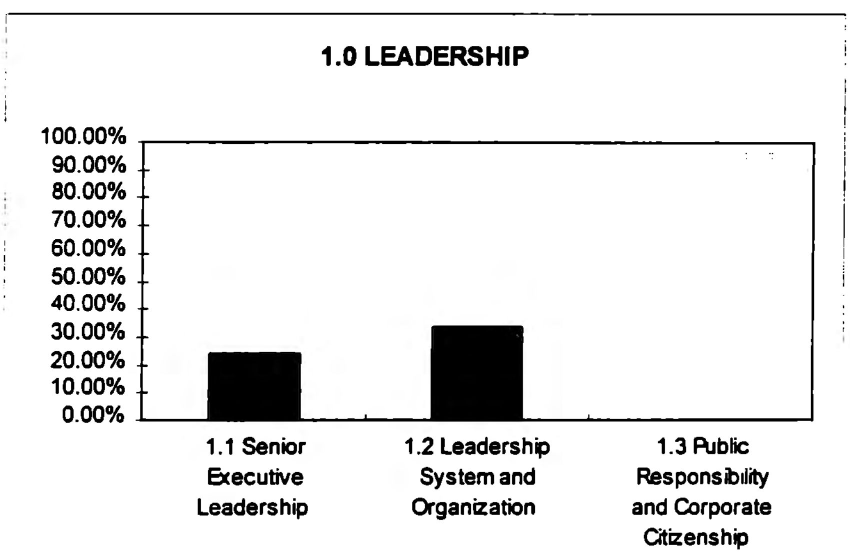
The results of evaluation are in the next graphics, every criterion was evaluated in a 0-100% scale where a 70% value is good for a company. The first graphic is the global result and next graphics have the partial results.



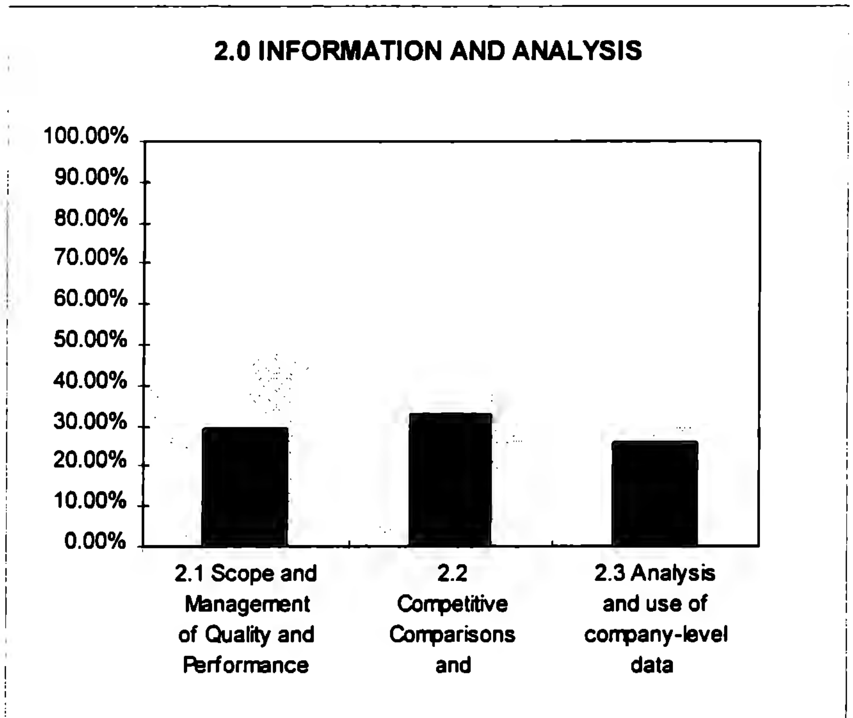
The global result was 28% and the critical criterion are : PROCESS MANAGEMENT. LEADERSHIP and HUMAN RESOURCE DEVELOPMENT AND MANAGEMENT. this criterion will be review, but other criterion have a bad evaluation but not the priorities.

Criterion	**Percentage**
1.0 LEADERSHIP	24.49%
2.0 INFORMATION AND ANALYSIS.	29.44%
3.0 STRATEGIC PLANNING.	28.46%
4.0 HUMAN RESOURCE DEVELOPMENT AND MANAGEMENT.	25.78%
5.0 PROCESS MANAGEMENT.	21.48%
6.0 BUSINESS RESULTS.	46.67%
7.0 CUSTOMER FOCUS AND SATISFACTION.	38.22%

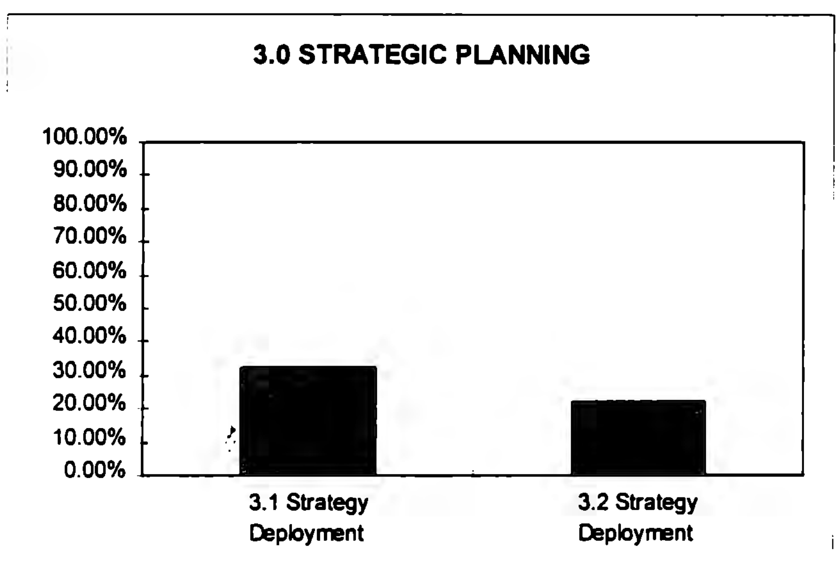




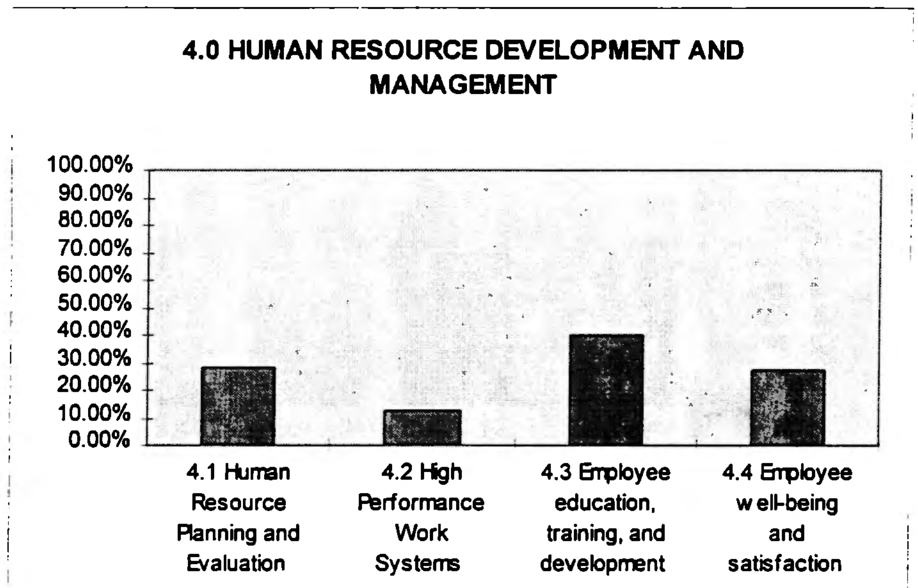
There aren´t responsibility for Ecology and communication with community, the results are clearly and BH needs actions in different areas of Human Resource and Communication.



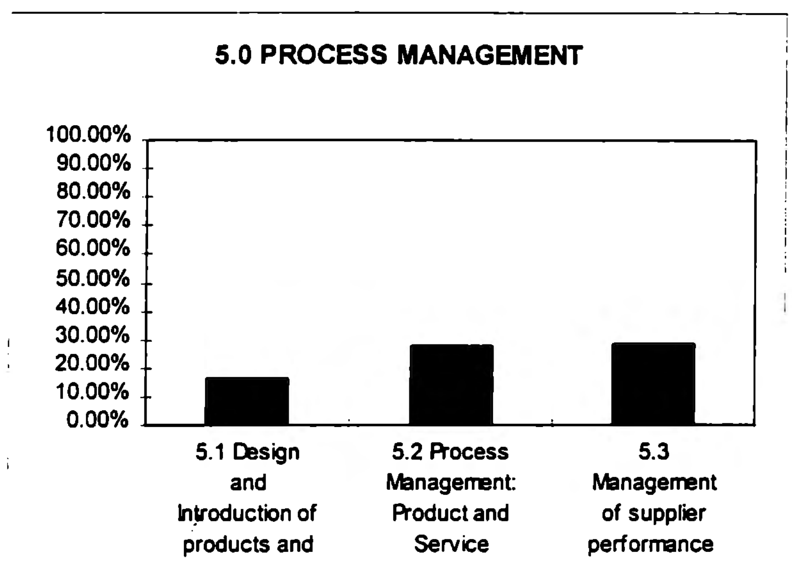
Information technology is subestimated and the result is a poor confiability in data reports, the problems are the different involucrated programs and his results. Ability for manage this technology is essential in company performance.



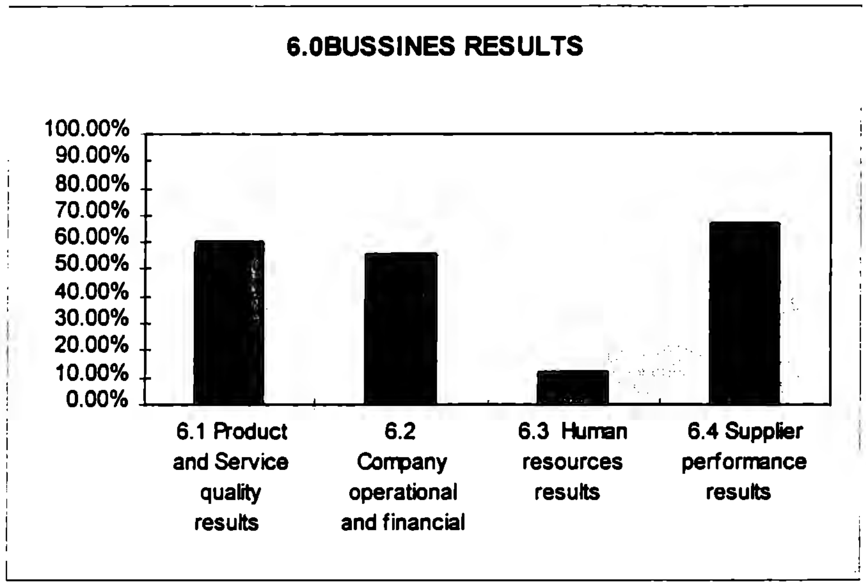
Some things like Mision statement are essential in this criterion. BH lack of a Mission Statement and there are the motor for actions and the really performance of company, in other case the actions will be in different directions.



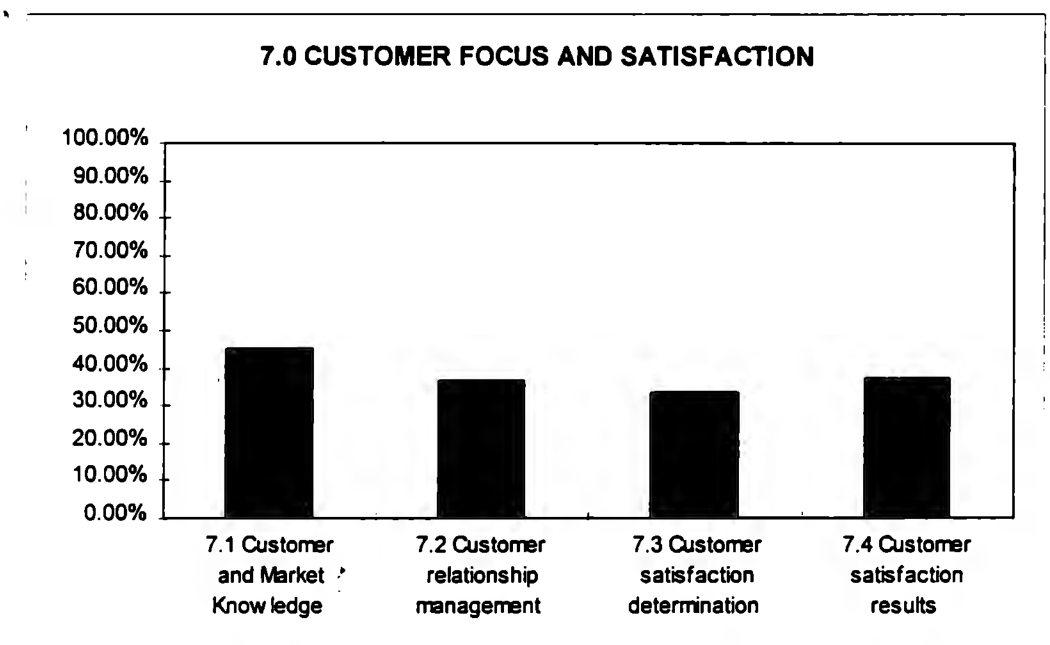
Satisfaction of Human resource is important and in the previous graphic we could see the employ vision, moral is low and the expertise needed for a great work is missing like training or education.



Evaluation in Process is low and the reasons of this are the lack of actions in Quality area, Training, Standardization and others, Design is an affected area and the most important, if design is good all other process have a high confiability.



Business results are clearly good, but we could win money now, but with the quality and type of product in nexts years sales of product will be down.



Customer relations are in a critical state, something is wrong and the company is not clearly direct. In this moment with a few national competition sales are high but the product importation could be mean death for BH Exercycle.

APPENDIX 5

BH'S MAPPING PROCESSES

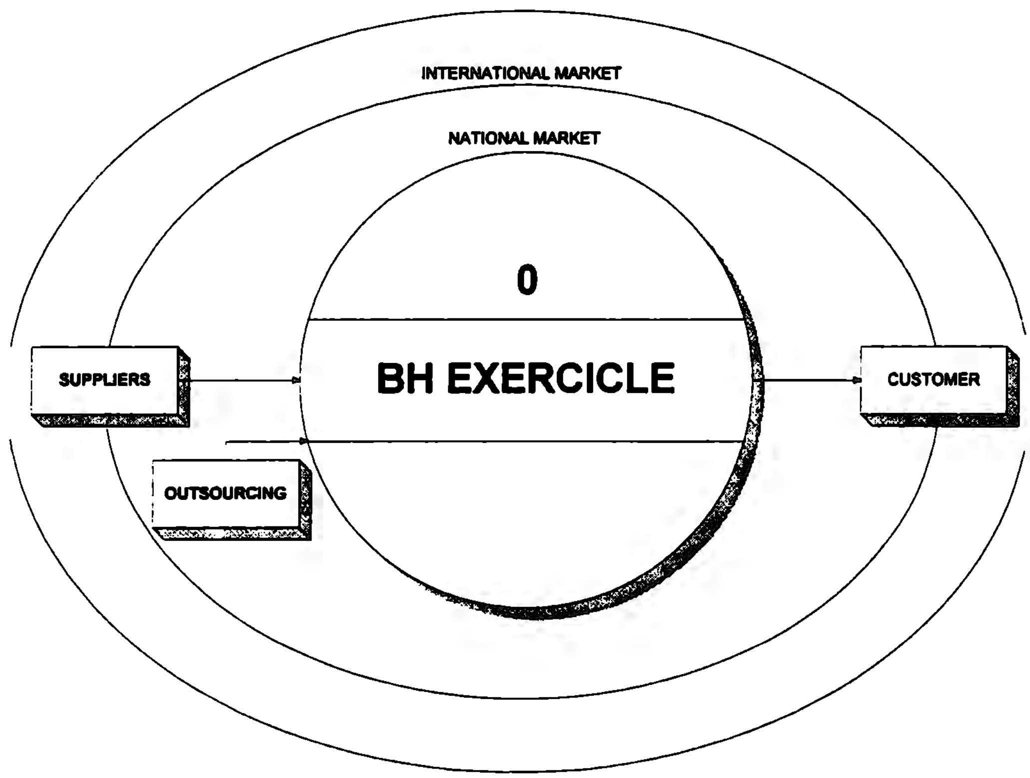


Figure A5.1 Mapping of the Integratesd Process at level 0

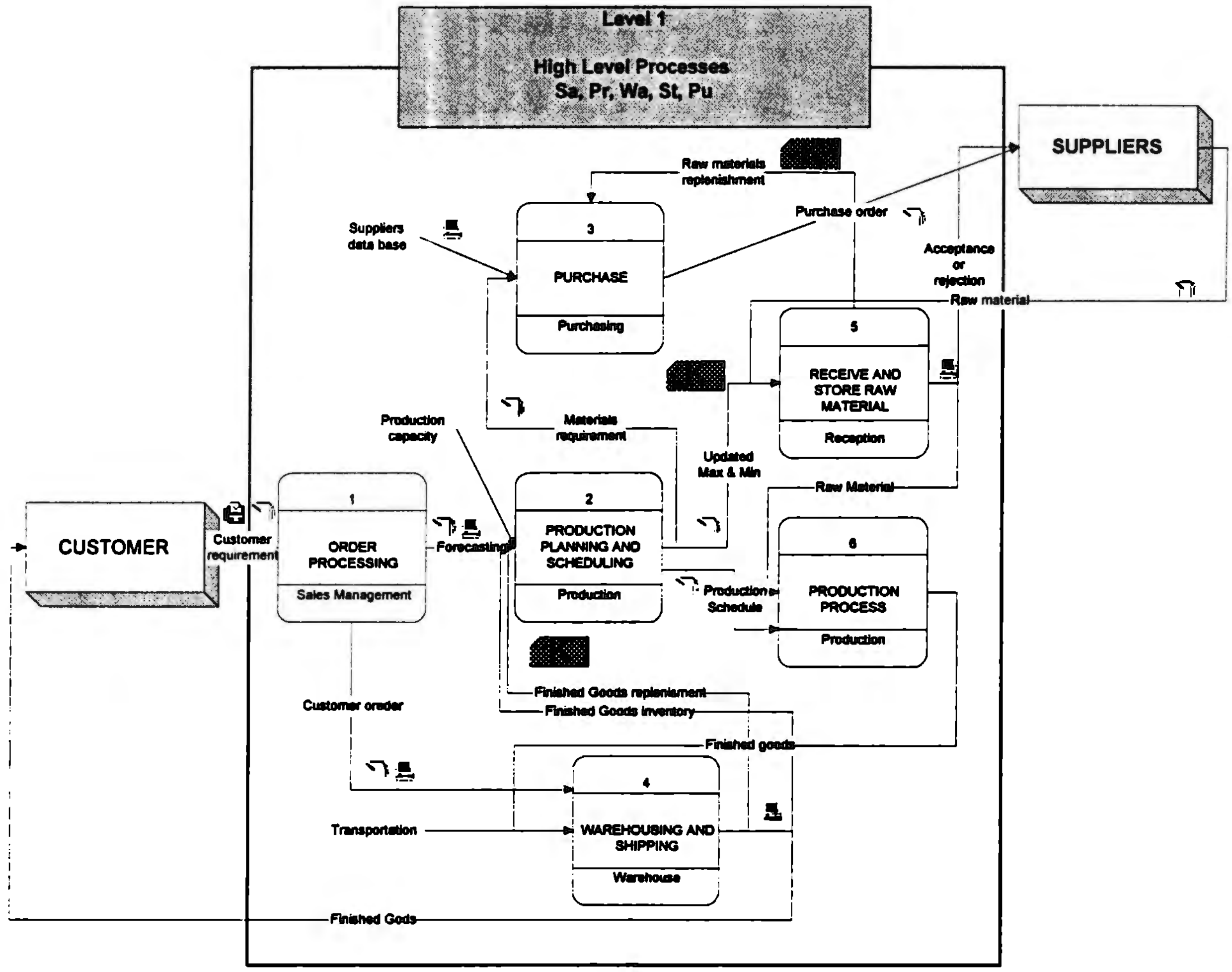


Figure A5.2 Mapping of the Integratesd Process at level 1

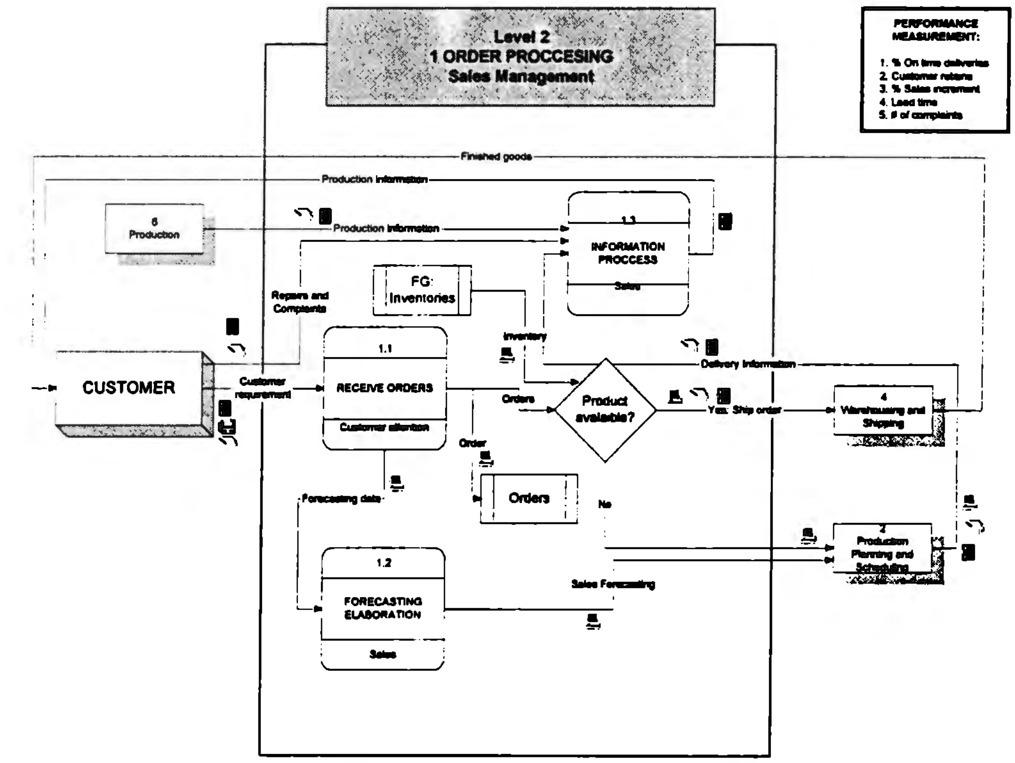


Figure A5.3 Order processing subprocess in level 2

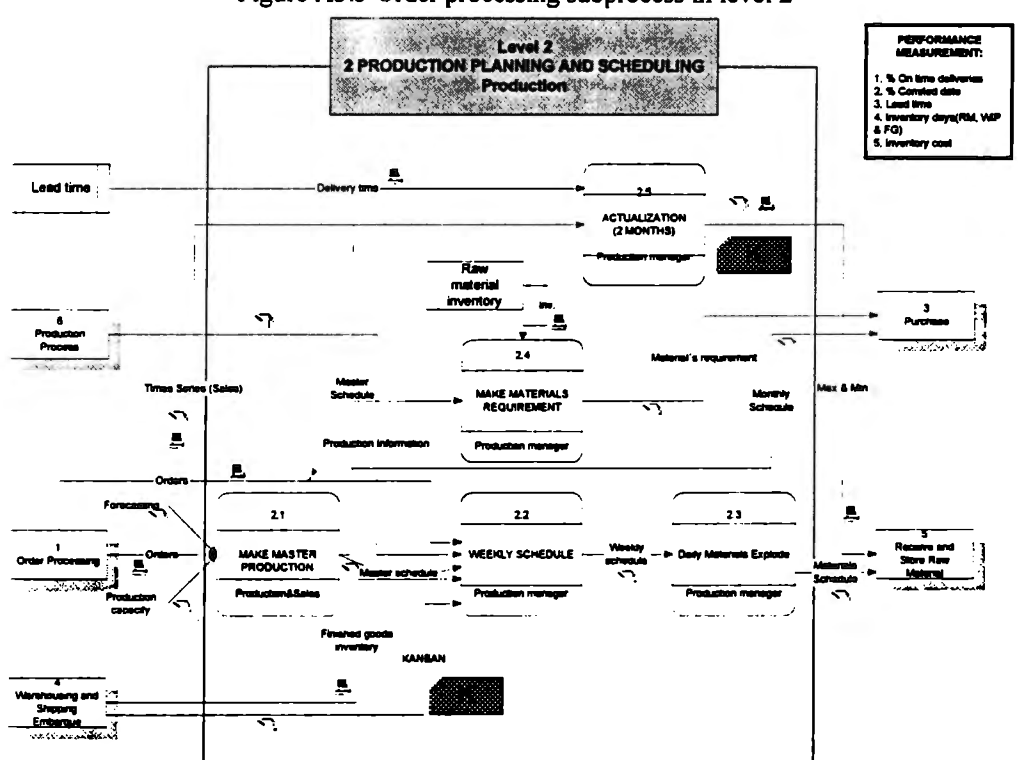


Figure A5.4 Production Planning and Scheduling subprocess in level 2

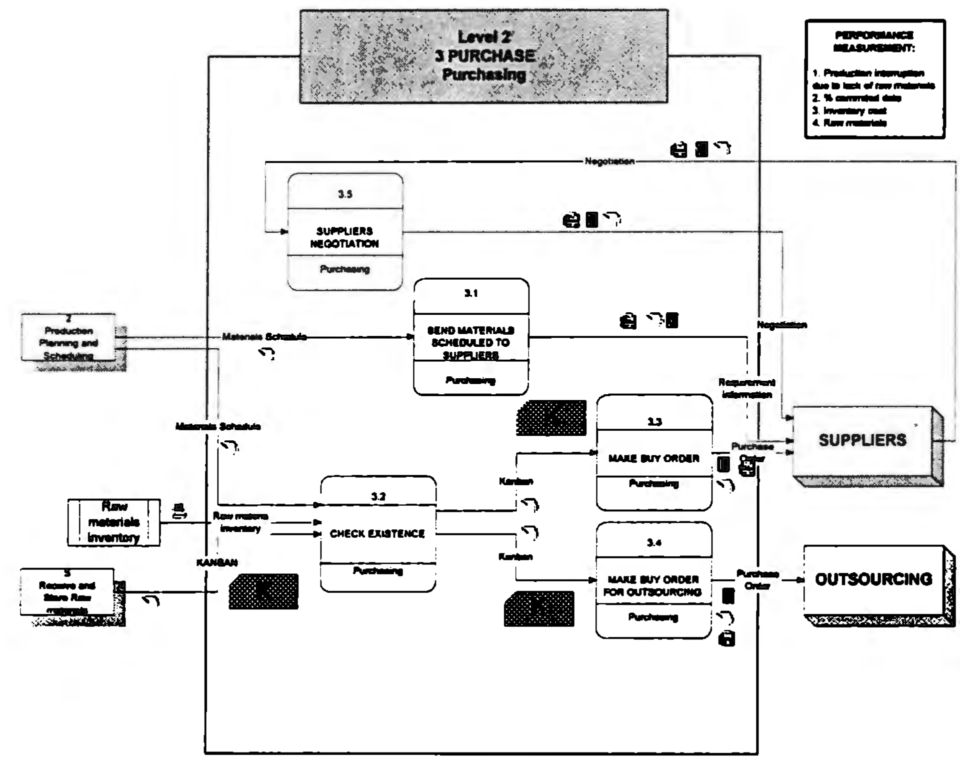


Figure A5.5 Purchasing subprocess in level 2

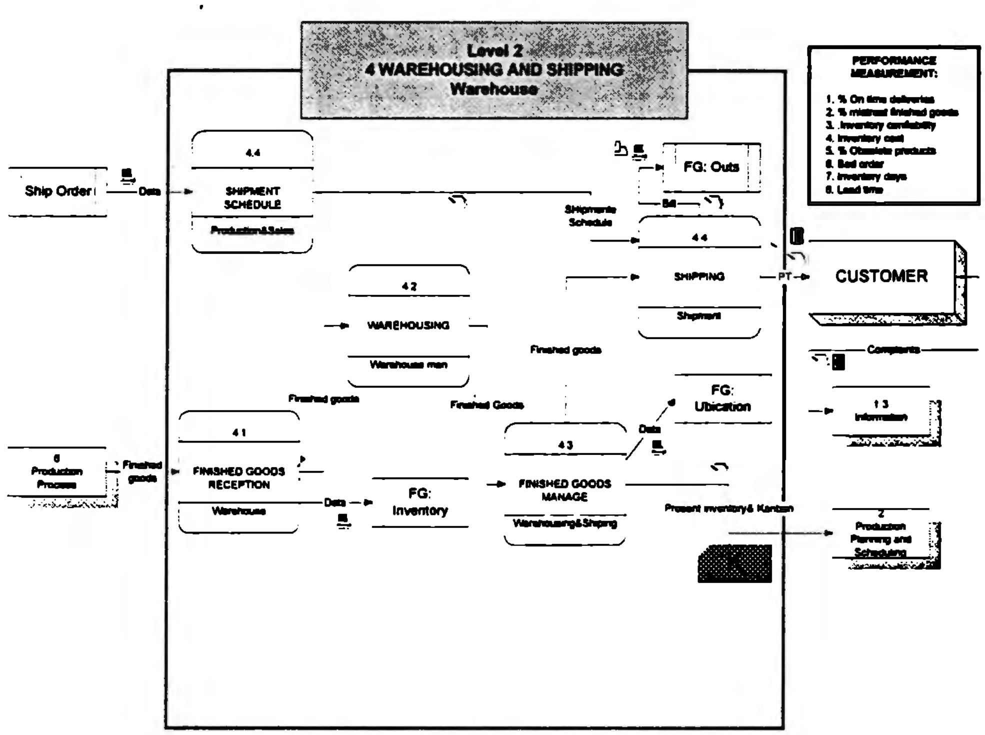


Figure A5.6 Warehousing and Shipping subprocess in level 2

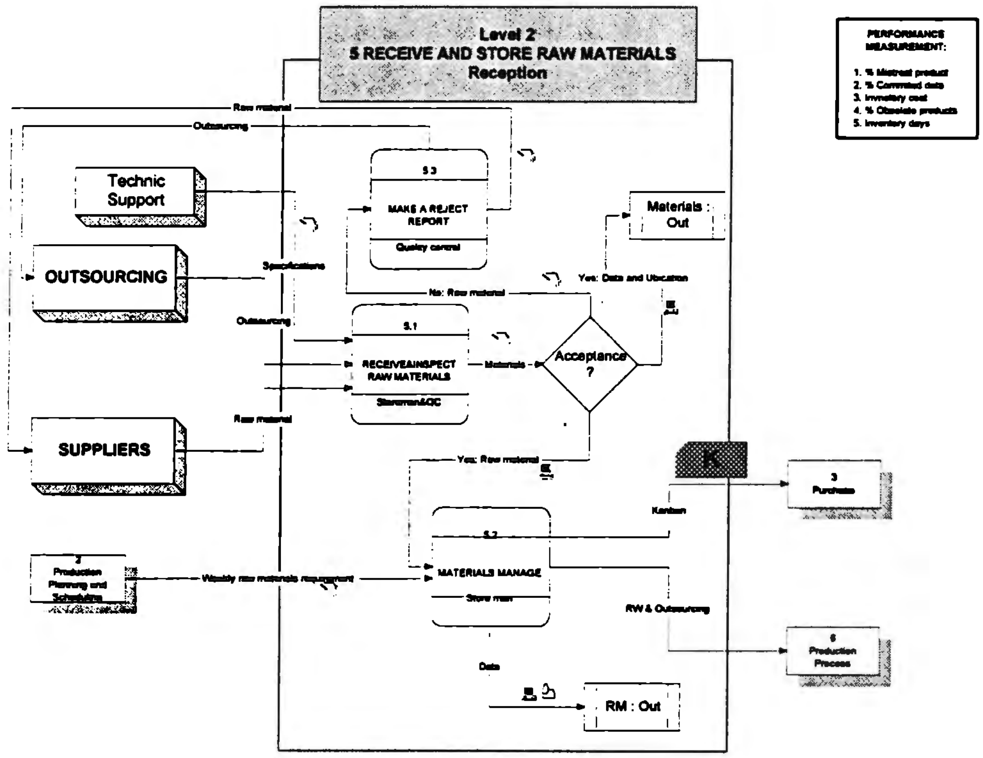


Figure A5.7 Receive and store raw material subprocess in level 2

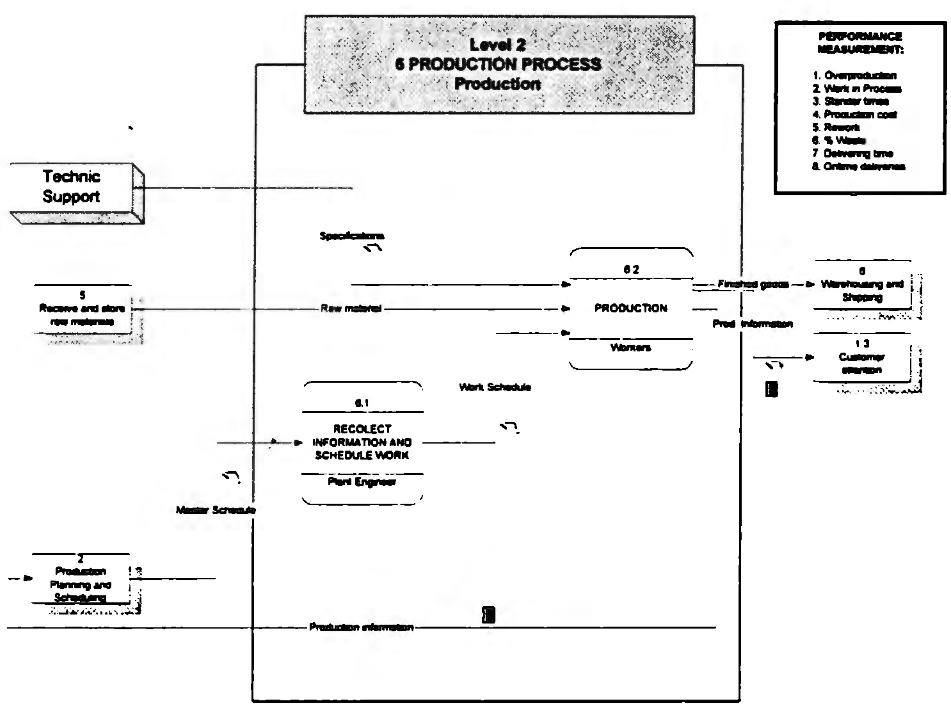


Figure A5.8 Production subprocess in level 2

APPENDIX 6

The objective of this appendix is to validate the job that MAFC inventory model can do. Through its the application in several cases, MAFC has shown that works better than EQO does. Next a simulation is going to be developed using the ARENA software version 2.0 for Windows 95.

As an example I am going to use the part 7831001 (a sit) to demonstrate the simulation. First we need to calculate the parameters of the MAFC. The daily demand of this part was obtained from the month type forecast according to the demand of the months corresponding to the period of 1995 - 1996. So the daily demand for the part 7831001 is 32 parts. Next the maximum, minimum, safety stock and quantity to order are calculated and the results are shown on table A6.1

Part: 7831001	
Daily Demand:	32
Maximum:	384
Minimum:	256
Safety Stock:	96
Quantity Order:	288
Days of SS:	3
Lead Time	5-8 (days)

Table A6.1

In order to simulate the real daily demand. the data of the demand from 1995 to 1996 was analyzed and the results are show below:

Data Summary

Number of Data Points	= 102
Min Data Value	= 6.07
Max Data Value	= 12.6
Sample Mean	= 7.09
Sample Std Dev	= 0.858

Histogram Summary

Histogram Range	= 6 to 13
Number of Intervals	= 10

With the above data collection obtained a couple of goodness test were applied and the distribution suggested is as follow:

Chi Square Test

Number of intervals	= 3
Degrees of freedom	= 0
Test Statistic	= 9

Corresponding p-value	< 0.005

Kolmogorov-Smirnov Test

Test Statistic	= 0.162
Corresponding p-value	< 0.01

Distribution Summary

Distribution:	Beta
Expression:	6 + 7 * BETA(2.38, 12.2)
Square Error:	0.019456

Distribution of demand is represented by a BETA distribution as shown if figure A6.1

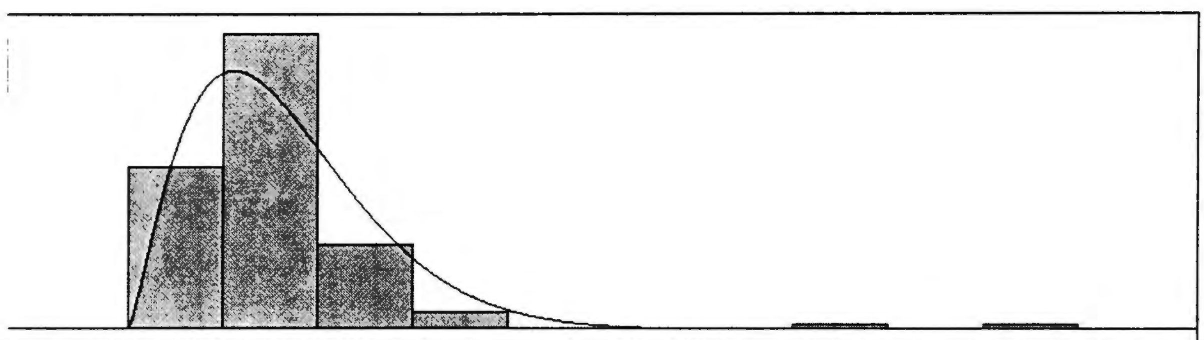


Figure A6.1

The daily demand is now represented by a BETA distribution using the parameters:

6 + 7 * BETA(2.38, 12.2)

Using the parameters of the table A6.1 and applying a daily demand following a BETA distribution the results of the simulation of 365 days are shown in figure A6.2.

As can be observed in the previous in the figure A6.2 the values of the inventory through the time are above the maximum and in regard to the safety stock, the inventory level is never reached it. These results are so good compares with the current inventory levels at the beginning of my intervention, but they can be optimized. Notice that no stockouts are allowed and the average inventory level is 365 units compares with 700 units on average without this inventory policy.

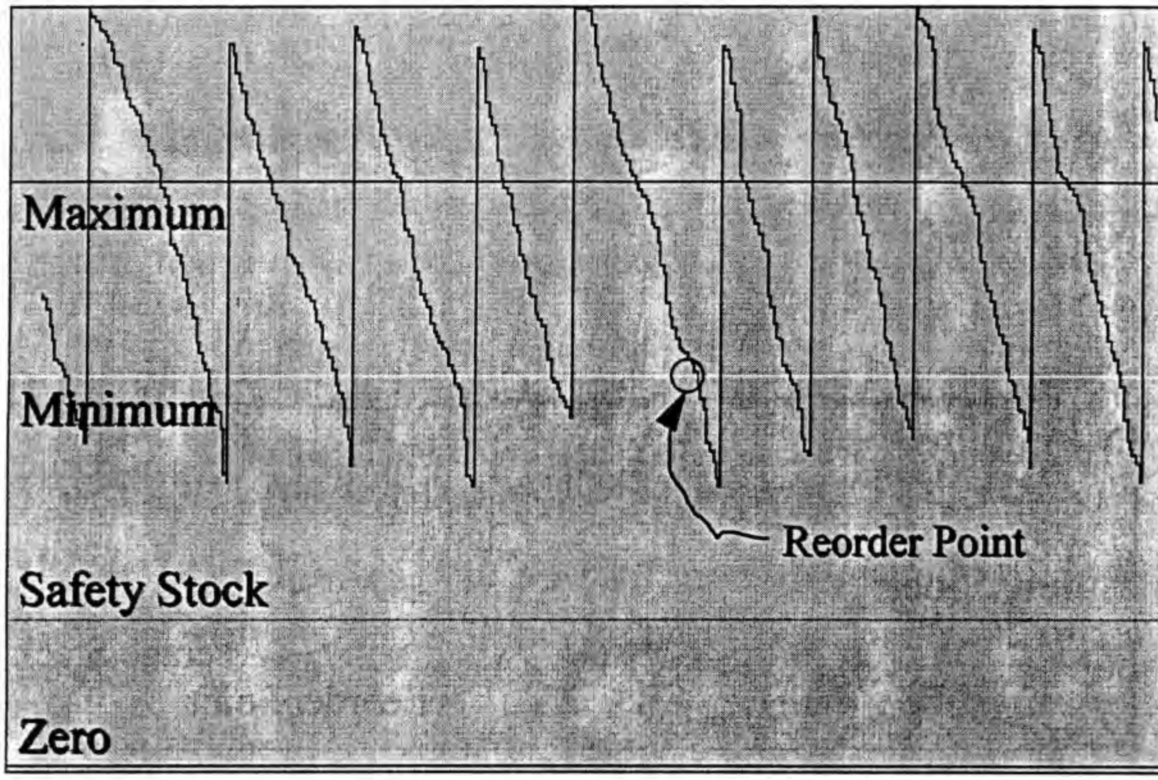


Figure A6.2 Simulation of the MAFC model with a daily demand following a BETA distribution

In order to optimized the parameters of the MAFC model the daily demand is now set on 12 units. This number is the maximum demand presented in the data analysis as the Max Data Value = 12.6
With the daily demand of 12 units the new parameters of MAFC are calculated again proving the following results:

Part:	7831001
Daily Demand:	12
Maximum:	144
Minimum:	96
Safety Stock:	36
Quantity Order:	108
Days of SS:	3
Days of lead time	5-8

Based on those parameters, a new simulation was ran fro 365 days and threw the following results shown in the figure A6.3:

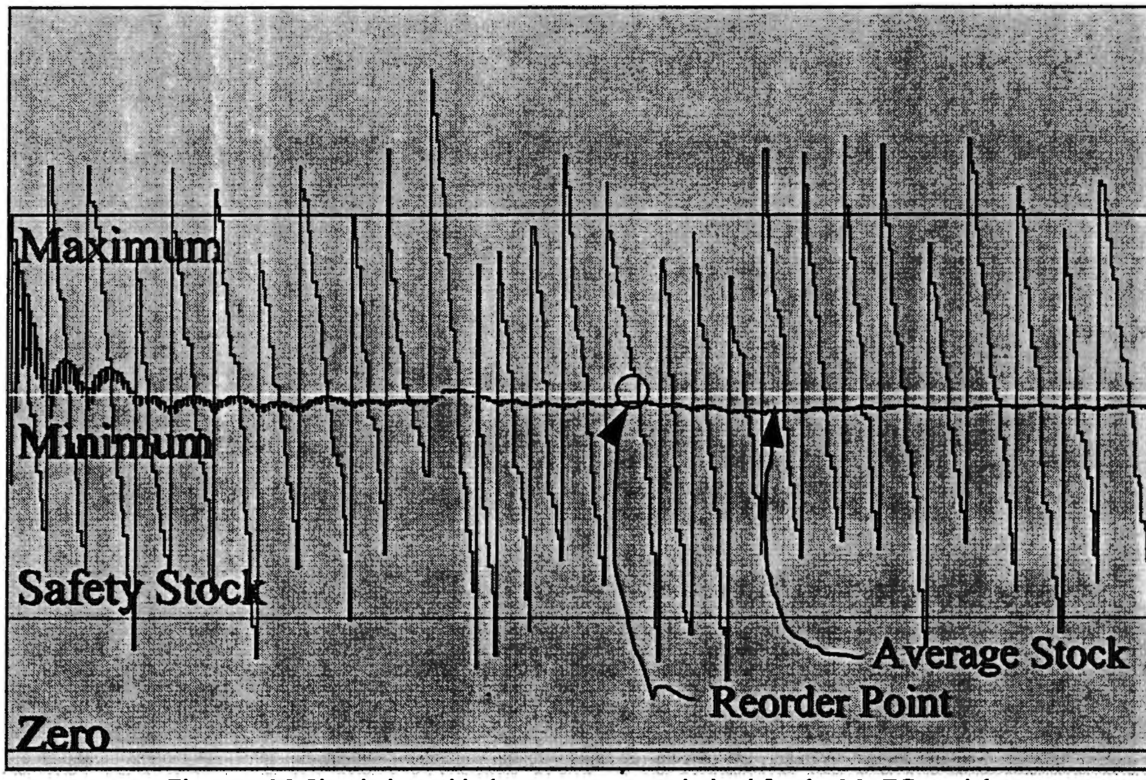


Figure A6.3 Simulation with the parameters optimized for the MAFC model

As can be observed in this in figure A6.3 the average inventory is approximately 96 units (MIN level). A reduction in the average inventory is around 700%. This is not the case for all the parts analyzed, but most of them could be reduced dramatically. The inventory has a standard behavior protecting the company against the statistics fluctuations.

APPENDIX 7

To demonstrate the benefits that have to be upon implementing adequately the IMOM model regarding the Hybrid Production System in their operative part was accomplished the simulation of the area of Finishing of TISAMATIC.

The simulation was developed using the software PROMODEL 3.5 for Windows 95. The simulation consider the production only of the appliances products since these are the pieces were thought to work in greater quantities and with a kanban system requiered by the customer. The boundaries of the simulation starts with output of the molding area and ends with the products delivered at the customer dock.

In the figure A7.1 is shown a picture of the simulation (Finishing area). As we can observe, there are two process inventories for this area, the first represents the parts with a first cleanning, and the second represents the parts finished waiting only for the second cleaning. A warehouse wasn't due to the fact that the parts that leave of the second cleanling go directly to the cutomer.

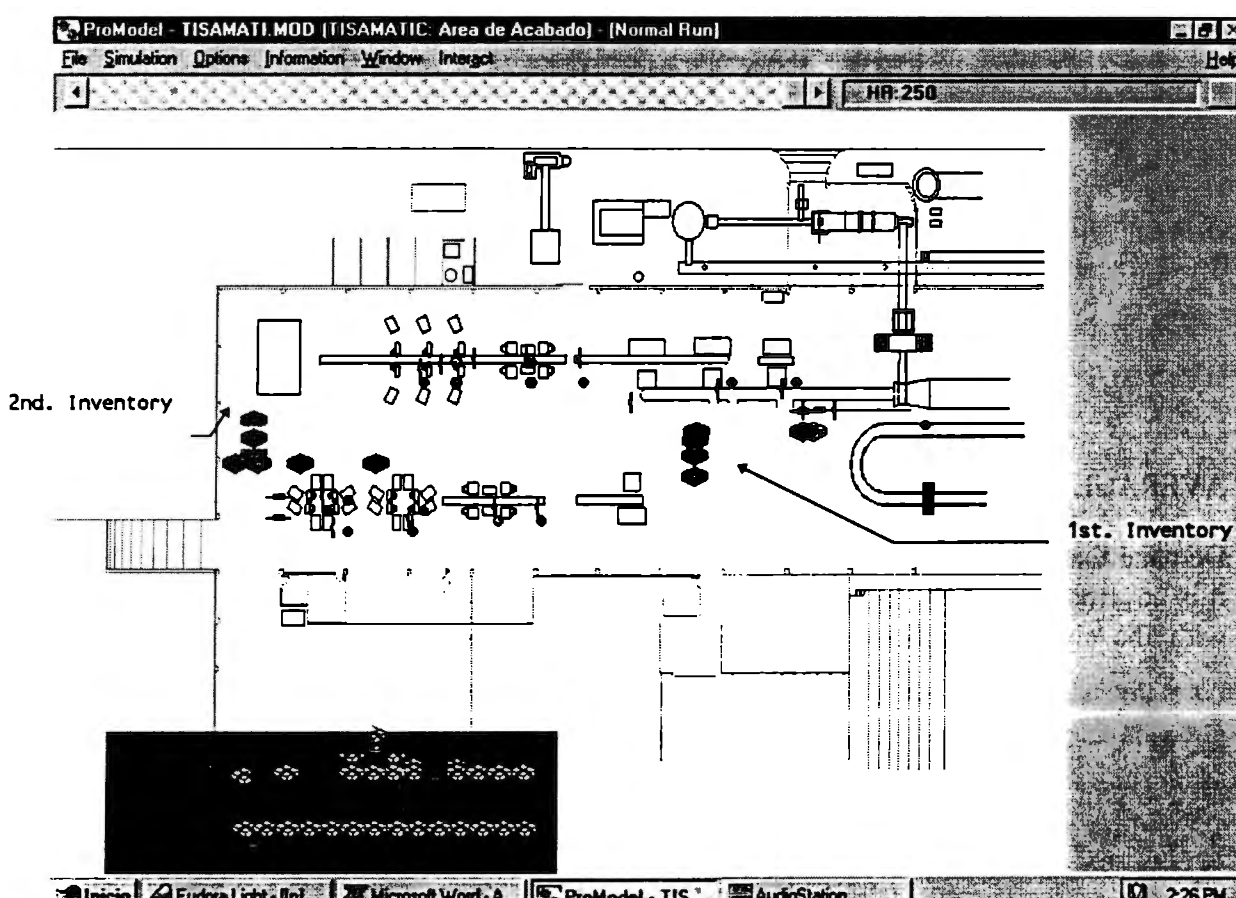


Figure A7.1 TISAMATIC layout for the simulation

The process flow for the appliances parts is as follow: first leave Molding according to a programming schdule proposed by the ITESM consulting team, next the first cleaning is provided to the parts rigth after the molding process, and once this acoomplish, the parts are stored wating to be processed in the Finishing area This is because the capacity of Molding is much greater than the capacity of Finishing, so a temporary inventory is created (first store). Once these parts are processed in Finishing, they are stored and managed using the MAFC model for inventory management plocies. The MAFC works as a Kanban system to replenish on time the custmer requirements and at the same time provide the production schedule for the finishing area. The above arguments represent the Hybrid Production System for the TISAMATIC case. Here these is a combination of an inteligent push system in the molding area and a pull system in the finishing area.

Next the results of the simulation are presented:

CYCLE TIME			
Product	Days.	Hours.	Min.
C_MVA_090	5 days		4.99 min.
B_MVA	3 days	21 hrs.	4.69 min.
B_C_MVA	2 days	15 hrs.	56.83 min.
BARRA_MVA	2 days	3 hrs.	40.7 min.
C_CBZ_120W	5 days	18 hrs.	14.28 min.
B_CBZ	5 days	19 hrs.	14.29 min.
B_C_CBZ_201	8 days	22 hrs.	41.6 min.
B_CBZ_601	10 days		40.71 min.
CQ_009	2 days	19 hrs.	27.27 min.
CQ_011	4 days	13 hrs.	14 min.
CQ_012		21 hrs.	43.29 min.
CQ_008	4 days	22 hrs.	31.95 min.
CQ_07	5 days	7 hrs.	29.95 min.
CQ_002	3 days	13 hrs.	37.35 min.

Table A7.1

AVERAGE CYCLE TIME: 4.78 DAYS

Demand that it is requested by the client, according to the data obtained by the simulation, it is covered in a 100%, by something which we believe that there would not be problems with the clients. The utilization of the resources is presented as follow:

% UTILIZATION	
MOLDING.	28.47%
CASCAREO.	97.57%
ESMERIL.	54.30%
DISCO.	66.53%
TURBINA.	50.79%
LIMPIADORAS.	69.88%

Table A7.2

The work in process inventory in its two stages are presented in table A7.3. What we can observe is the dramatic reduction. At the beginning of our intervention the average inventory per month was four weeks and the simulation provide less than one day of inventory.

FIRST CLEANNING		SECOND CLEANNING	
Product	Aveg. Inv.	Product	Aveg. Inv.
C_MVA_090	0. PZS.	C_MVA_090	299 PZS.
B_MVA	14. PZS.	B_MVA	349 PZS.
B_C_MVA	17. PZS.	B_C_MVA	148 PZS.
BARRA_MVA	10. PZS.	BARRA_MVA	9 PZS.
C_CBZ_120W	2. PZS.	C_CBZ_120W	483 PZS.
B_CBZ	0. PZS.	B_CBZ	485 PZS.
B_C_CBZ_201	10. PZS.	B_C_CBZ_201	770 PZS.
B_CBZ_601	19. PZS.	B_CBZ_601	263 PZS.
CQ_009	12. PZS.	CQ_009	75 PZS.
CQ_011	5. PZS.	CQ_011	102 PZS.
CQ_012	0. PZS.	CQ_012	0. PZS.
CQ_008	155. PZS.	CQ_008	453 PZS.
CQ_07	167. PZS.	CQ_07	556 PZS.
CQ_002	21. PZS.	CQ_002	216 PZS.

Table A7.3

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