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Inventory policy: A BPR perspective

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Abstract

The paper presents a case of Business Process Reengineering (BPR) application to a manufacturing industry in Greece. The company, a manufacturer of plastic packaging and industrial products, has recently been through a process of reorganization. As part of this process the management had a closer look at the levels of inventories held. The first analysis indicated heavy overstocking of both raw materials and end-products and as a result the management decided to revise its inventory policy. The paper looks at both the theoretical framework and the practical steps involved in:

- establishing the optimum inventory policy
- introducing all the organizational changes needed in order to implement this policy

Keywords: Inventory, BPR, Process, Activities, Reorganization, Management.

1. Introduction

Inventory Control is a major problem for many industries especially when the cost of materials accounts for a considerable percentage of their total cost. The problem is getting even bigger in the case of manufacturing industries which apart from stocking raw materials they also have to stock intermediate and end products. In a manufacturing industry organized by function the inventory control for raw materials lies within the responsibility of the Materials Administration Department whereas the inventory control for intermediate and end products lies within the responsibility of the Commercial Department. Production Department is also involved in this process in two ways:

i. It transforms the raw materials purchased into the end products ordered
ii. It has, in many cases, the responsibility of controlling the stocks of intermediate products.

Obviously the best way of facing an inventory control problem is a close cooperation between the 3 main participating Departments and any other section of the business involved, in any way, in it. The fact, however, that in the classical approach to the problem the activities of the Departments involved are treated independently makes the coordination job extremely difficult. Every Department looks inward, sees only its own part of the process and has no interest for the end customer at all.

Business Process Reengineering (BPR) offers a new perspective to this problem.

2. Inventory control from a BPR viewpoint: A brief theoretical outline

According to Hammer and Champy (1993), Reengineering is 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. Reengineering strives to break away from the old rules about how we organize and conduct business. It involves recognizing and rejecting some of them and then finding imaginative new ways to accomplish work. Reengineering requires looking at the fundamental processes of the business from a cross-functional perspective.

One of the key words in Hammer's definition is process. According to him process is a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer.

Similarly, Davenport (1993) defines the process as a structured, measured set of activities designed to produce a specified output for a particular customer or market. It implies a strong emphasis on *how* work is done within an organization, in contrast to a product focus on *what*.

A process is thus a specific ordering of work activities across time and places with a beginning, an end, and clearly identified inputs and outputs: a structure for action. This structural element of processes is key to achieving the benefits of process innovation.

Process structure can be distinguished from more hierarchical and vertical versions of structure. Whereas an organization's hierarchical structure is typically a slice-in-time view of responsibilities and reporting relationships, its process structure is a dynamic view of how the organization delivers value. Furthermore, while we cannot measure or improve hierarchical structure in any absolute sense, processes have cost, time, output quality and customer satisfaction. When we reduce cost or increase customer satisfaction, we have bettered the process itself.

To understand the scope of a process one has to identify the activities it consists of. According to Ould (1995) activities are what actors do as "individuals" in the roles they have in a process. Actors are people who participate in a process and have roles in it. Obviously, a process is completed and gives the desirable results only if its activities are completed and the output of each one acts as a stimulus for the next.

Having presented the key points of BPR we now come back to our inventory control problem. Looking at it from the point of view of BPR we may say that it can be seen as a set of activities lying in the heart of the basic business operation.

The basic business operation (i.e. transformation of sales demands into end products) may be graphically presented as shown in Figure 1

Its main activities are the following:

- Estimation of sales demand
- * Transformation of sales demand into production needs and production plan
- * Transformation of production plan into materials' requirement and purchasing plan
- Purchasing of raw materials
- Production
- * Storage of raw materials and products
- Delivery to the customers

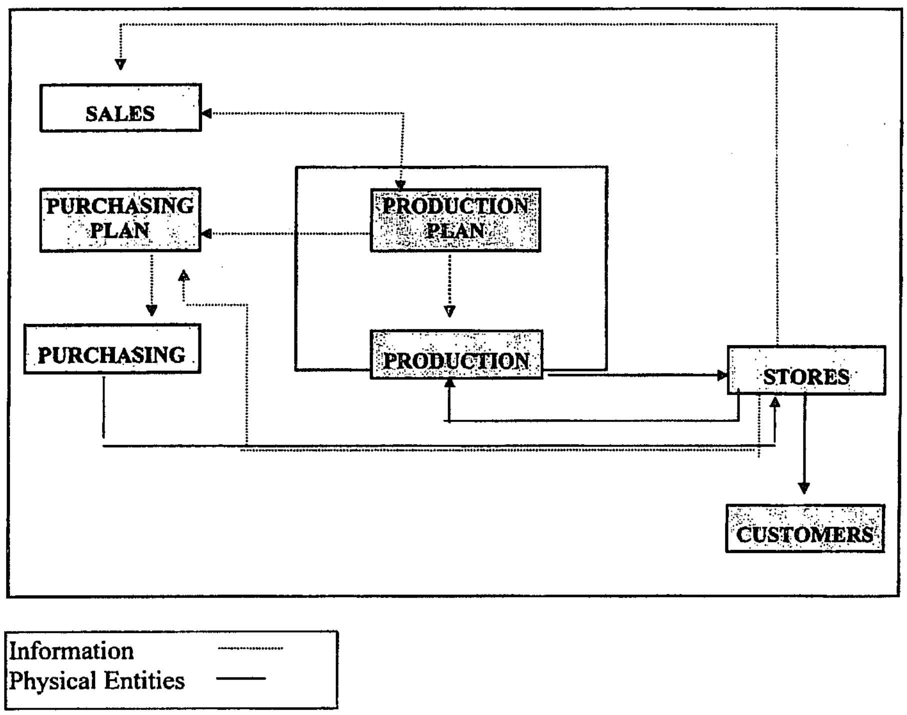
Of all the above activities those denoted by (*) are the key ones for the inventory problem. Those activities may be seen as comprising what it may be called the Inventory Control (IC) process.

Figure 2 presents a more detailed graph of the basic business operation process showing the main activities involved in it and indicating those comprising the Inventory Control (IC) process.

We have so far presented the basic steps involved in a typical inventory control problem in terms of a set of activities or in other words in terms of a process . This is a necessary prerequisite for a BPR approach to the inventory control problem. The next step is to see how this approach may be applied to our case.

Implementation of this approach however requires that a company which is planning to introduce it has previously undergone a series of organizational changes the most important of which are listed below:

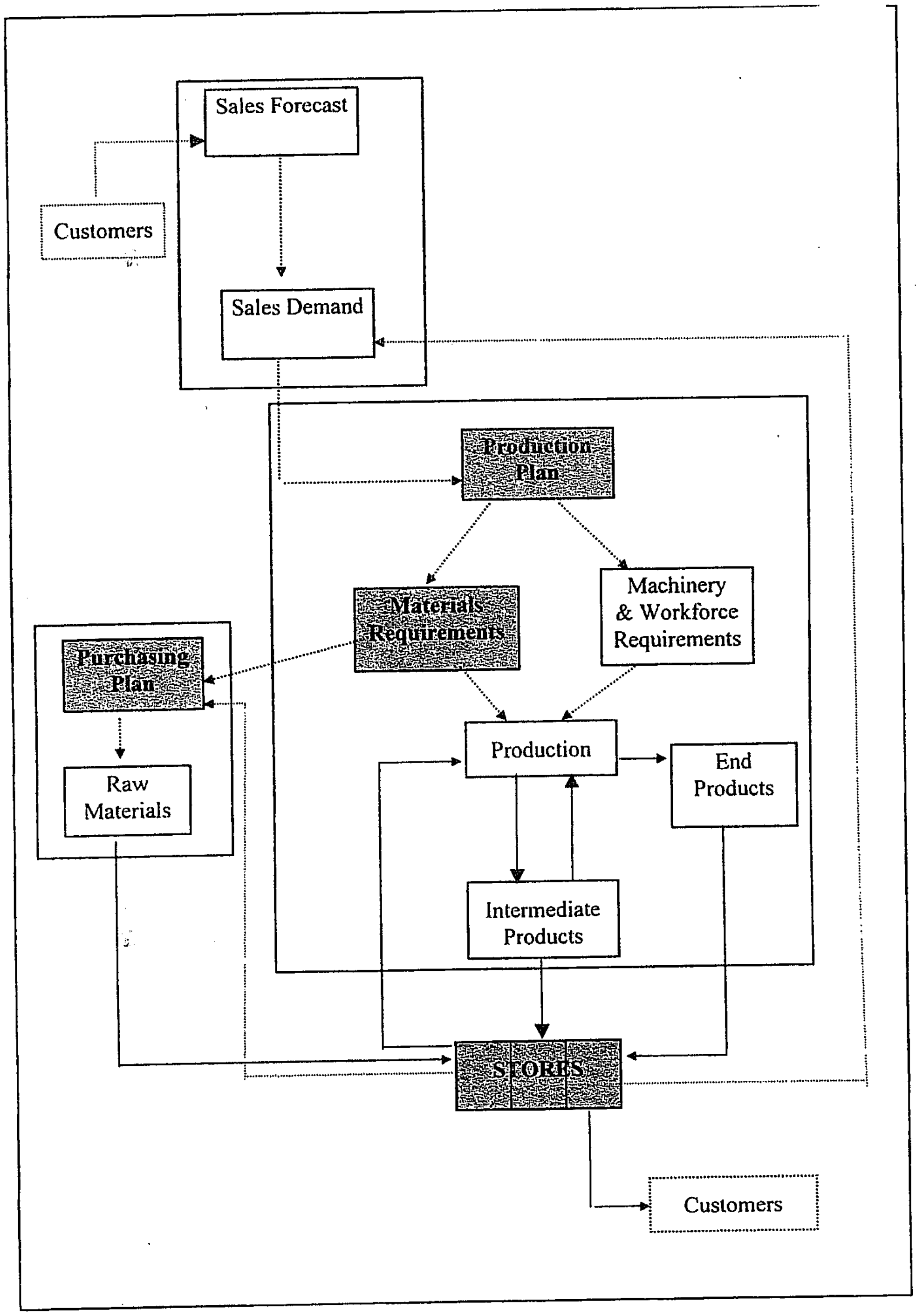
Figure 1
The Basic Business Operation



- ➔ Assign somebody as responsible for the Inventory Control (IC) process.
  The IC process is a specific ordering of work activities across time, places and business functions with a beginning an end and clearly identified imputs and outputs. Obviously, the persons in charge of the various business functions will remain, at least for a transition period, administratively responsible for the parts of the process going through their Departments. The efficient running of the process, however, demands a "Process manager", a person with an overall view of the process which can intervene at any moment in order to secure and restore the smooth operational running of the process

- ➔ Modify the company's Information System so as to support the IC process.
  Effective and efficient supervision of the IC process requires timely and reliable information. Information is an intangible asset of great value that can be used to enhance the process' performance. Hence the company's information system may be properly modified to exploit that asset by generating and transmitting the required information to the key points of the IC process.

Figure 2
The Inventory Control Process within the Basic Business Operation

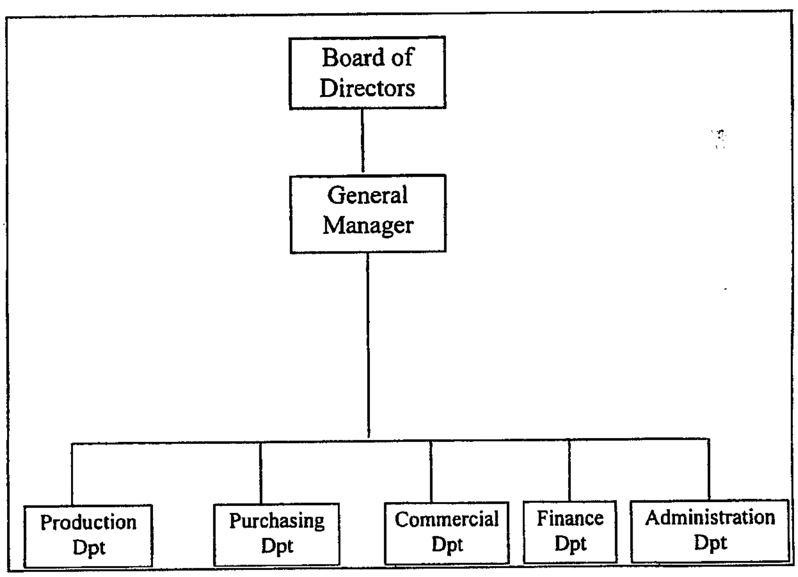


3. Inventory control from a BPR viewpoint: A case study

3.1. The case

Having approached the inventory control problem from the BPR point of view, we will now see how this can be applied to a real case. The case chosen is that of a typical medium-sized manufacturing company organized by function as shown in Figure 3.

Figure 3
The company's organization chart



Its basic activity is the manufacturing of plastic packaging materials
The main items produced are:

- cups & containers
- Plastic sheets
- trays & crates

The basic raw materials used are:

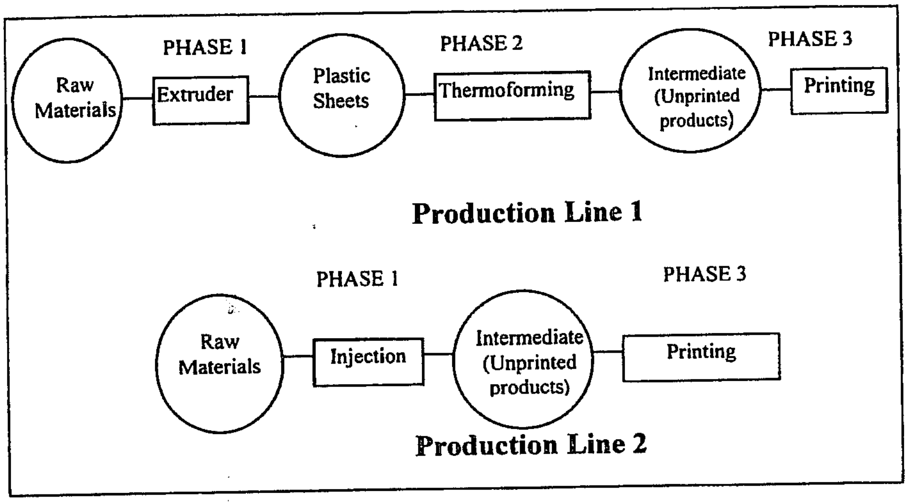
* polystyrene
* polypropylene
* polyethylene

The transformation of raw materials into intermediate and end products is achieved through the 2 main production lines presented in Figure 4.

Due to the nature of its activities the company's cost of raw materials accounts for a high percentage of its total cost. Hence, a well designed inventory policy is a matter of great importance for the company.

Up to now, however, as a result of both its culture and organizational set-up the company has faced its inventory control problem as consisting of a number of independent steps each controlled by the Department to which it administratively belongs.

Figure 4
A outline of the company's 2 Production Lines



This approach has led to the appearance of two serious shortcomings:

- Large stocks of raw materials and end products (i.e. high financial cost of the stocks kept)
- Unsatisfactory customer service (i.e. long delay times, delays in delivery)

To give an indication of the size of the problem we say that in certain cases:

- Stocks of raw materials may exceed expected production needs of 1.5 months.
- Stocks of end products may exceed expected sales demand of 1.5 months.
- Delivery times may exceed 40 days

A BPR approach to inventory control was then considered as an alternative which may alleviate those problems. The remaining part of this paper presents the steps taken towards applying this approach and the results obtained.

3.2. Solution outline

As we have seen so far, a BPR approach to this problem implies viewing the various activities involved in it as part of an overall process including all steps from estimating sales demand to delivering the goods to the customers. Such a process, the IC process, has been outlined in the previous section.

In approaching the problem in such a way the following steps will be followed:

Step 1: Estimation of sales demand per production phase.

Starting from the estimated sales demand for a given period and the priorities set by the Commercial Department we can then for each product do the following:

- Allocate sales demands to production lines
- Determine demand per phase within each production line
- Allocate demand per machine within each phase

As a result, at the end of this process we have the sales demand per machine for every production phase

Step 2:Transformation of the sales demand per production phase into production needs and production plan

Every phase has its own characteristics and it will be analyzed separately.

PHASE 1

Phase 1 differs between the 2 production lines. In Production Line 1 Phase 1 refers to the transformation of raw materials into plastic sheets which are either sold as they are or they are transformed, in the next stage, into intermediate products (unprinted products).

In Production Line 2, on the other hand, Phase 1 refers to the transformation of raw materials directly into intermediate (unprinted) products.

In any case, however, Phase 1 is very important. The quantity of items to be produced in this phase determines to a large extent the raw materials requirements.

In order to determine the quantities to be produced we work as follows

Production Line 1

The various types of plastic sheets to be produced by the same extruder are considered as parts of the same production run. A model that has been developed (Appendix 1) is then used to determine the number of production runs, the quantities of each type of sheet to be produced within each run and hence the total quantities to be produced.

The quantities to be produced are calculated in such a way as to:

- satisfy demand (in case this is not possible the difference between demand and actual production is noted)
- minimize total production cost

The production priorities depend on the respective delivery dates for the end products set the Commercial Department.

Finally, the production quantities calculated may be easily transformed into raw materials requirements.

Production Line 2

The same procedure is followed for this Production Line too. The only difference lies in the fact that the physical outcome in this case are not plastic sheets but intermediate products

The various types of items to be produced by the same injection machine are considered as parts of the same production run. Hence, in this case, the model calculates the number of production runs, the quantities of items to be produced in each run and hence the total quantities of intermediate products to be produced.

The production priorities depend on the delivery dates set for the end products.

Finally, the quantities calculated may be easily transformed into raw materials requirements.

By summing up the raw materials requirements for Production Lines 1 and 2 respectively we get the total raw materials requirements per type of material.

PHASE 2

Phase 2 refers to the transformation of plastic sheets into intermediate products. It is restricted to Production Line 1 only since for Production Line 2 this part of the production process is included in Phase 1.

For every machine in this phase we know, as outcome from Phase 1 of Production Line 1, the quantities of the various types of plastic sheets to be used for the production of given intermediate products as well as the priorities attached to each one.

All the products allocated to the same machine are considered as parts of the same production run and the model is used to calculate the number of production runs, the quantities of the items to be produced in each run and consequently the total number of intermediate products to be produced in this phase.

By summing up the production requirements of Phase 1, Production Line 2 and Phase 2, Production Line 1 respectively we get the total production requirements per type of product.

PHASE 3

Phase 3 is identical for both Production Lines and refers to the transformation of intermediate (unprinted) products to end (printed) products.

For every printing machine in this phase we know, as outcome from Phase 1, Production Line 2 and Phase 2, Production Line 1, the total number of unprinted products to be transformed and the priorities attached to each one.

All the products allocated to the same machine are considered as parts of the same production run and the model is used to calculate the number of production runs, the quantities of the items to be produced in each run and consequently the total number of final products to be produced in this phase.

Finally, the production quantities may be easily transformed into auxiliary materials (paints, ink, volatile liquids) and packaging materials (carton boxes, crates) requirements.

Step 4: Transformation of the production plan into materials requirements and purchasing plan.

We have so far outlined how we can

- estimate demand for the various types of products
- transform demand into production plan

In Step 4 we will transform production plan into materials requirements and purchasing plan.

We have already stated that the total number of items to be produced in Phase 1 of Production Lines 1 and 2 may be easily transformed into basic raw materials needs.

Similarly the total number of items to be produced in Phase 3 of Production Lines 1 and 2 may be easily transformed into auxiliary materials and packaging materials needs.

A model that has been developed (Appendix 2) is then used to determine the number of orders to be placed and the quantities to be ordered each time. Those quantities have been calculated in such a way as to:

- satisfy the production needs
- minimize the total purchasing cost

3.3. Data requirements

For the solution described above to be implemented the following data are initially required:

➔ For every type of product

- → Estimated sales demand for a given time period
- → Production line used for its production
- → Phases within the production line
- → Machines used within each phase
- → Materials used in every phase
- → Quantities of materials required per unit
- → Unit cost (in full analysis, i.e. labor cost, material cost, overhead cost, waste)

➔ For every type of material
- → Main suppliers
- → Storage cost
- → Ordering cost

On the basis of the above we can then allocate:
- ♦ Products to production lines/phases
- ♦ Products to machines
- ♦ Materials to products
- ♦ Materials to Suppliers

Then

➔ For every pair (machine, product) we need:
- → Production capacity per time unit
- → Minimum quantity to be produced in each run
- → Set - up time
- → Set - up cost

➔ For every pair (material, supplier) we need:
- → Unit cost
- → Delivery time
- → Minimum quantity to be ordered

3.4. Solution implementation

The approach outlined so far will now be implemented in the case of the company presented in section 3.1.

All initially required data (i.e. data per type of product and data per type of material) were available. Hence, on the basis of those data we were able to produce the "allocations" shown in Tables 1-3.

In this particular application the emphasis is placed on Phase 1 of Production Line 1. During this phase certain types of raw materials are used to produce various types of plastic sheets.

As we can see from Table 1 all products in this phase are going through the same machine. Hence all of them may be considered as parts of the same production run. Moreover, the data required for every pair (product - machine) is available.

Therefore by running the model presented in Appendix 1 we get the following results:

i. Number of production runs
ii. Duration of each production run
iii. Machine occupation time
iv. Machine idle time
v. Excess requirement for machine time
vi. Quantity produced per product per production run
vii. Total quantity produced per product
viii. Unsatisfied demand per product

Given the production needs for plastic sheets generated so far and the raw materials requirements per unit of each type of plastic sheet we can easily transform production needs into raw materials requirements.

Moreover the data required for every pair (material - supplier) is available.

TABLE 1

An extract of the allocation of products per production line and production phase within it

	PRODUCTS									
MACHINES	P.1	P.2	P.3	P.4	P.5	P.6	P.7	P.8	P.9	P.10
PL1-PH1										
MACH 1		●			●	●	●	●		
PL1-PH2										
MACH 1		●			●	●				
MACH 2							●	●		
MACH 3										
MACH 4										
MACH 5										
PL2-PH1										
MACH 1										●
MACH 2										●
MACH 3										
MACH 4										
PL1&2-PH3										
MACH 1								●		
MACH 2										
MACH 3									●	
MACH 4	●	●				●				
MACH 5			●	●	●	●				●
MACH 6										
MACH 7						●				

TABLE 2
An extract of the allocation of materials per product

PRODUCTS	RAW MATERIAL 1		RAW MATERIAL 2			RAW MATERIAL 3			RAW MATERIAL 4
	TYPE 1	TYPE 2	TYPE I	TYPE II	TYPE III	TYPE A	TYPE B	TYPE C	
P.1				●					
P.2				●					
P.3				●					
P.4				●					
P.5				●					
P.6				●					
P.7				●					
P.8				●					
P.9				●					
P.10		●							
P.11		●							
P.12							●		
P.13							●		
P.14									●
P.15			●						
P.16			●						
P.17		●							
P.18				●					
P.19		●							
P.20				●					
P.21		●							
P.22		●							
P.23			●	●					
P.24		●							

TABLE 3
An extract of the allocation of materials per supplier

SUPLIERS	COUNTRY	TYPE 1	TYPE 2	TYPE I	TYPE II	TYPE III	TYPE A	TYPE B	TYPE C	RAW MATERIAL 4
S.1	C1			●	●			●	●	●
	C2									●
S.2	C3									
	C4			●	●					
S.3	C3	●		●	●					
	C5		●							
S.4	C6	●								
S.5	C3		●							
	C7	●						●	●	
S.5	C8									
S.6	C9	●	●	●	●			●	●	
S.7	C7									
S.8	C7	●	●						●	
S.9	C2	●	●				●			
S.10	C2						●			
S.11	C3						●			
S.12	C3									
S.13	C9									
S.14	C9									

Therefore by running the model in Appendix 2 we get the following results per type of material,

→ economic order quantity
→ reordering time

3.5. Conclusions and suggestions for further development

The model described so far is in process of being applied to data obtained from the company presented in section 3.1. The first results are quite promising and it is firmly believed that by using the model in planning the Inventory Control Process we will succeed in:

- reducing the stocks of both raw materials and end-products by about 30%
- reducing delivery times by about 35%

In presenting the case study we have used a number of relaxations so as to make the problem easier to tackle. Once, however, the basic problem has been solved some of those relaxations may be withdrawn and new constraints may be introduced so as to make the problem more realistic. Such constraints may include:

◊ variable demand for the various types of products
◊ seasonality of demand

As we have already mentioned an effective implementation of the BPR approach to Inventory Control requires that the company which is planning to introduce it has previously undergone a series of organizational changes such as:

- Assignment of an Inventory Control Process manager
- Modification of the company's Information System to support the Inventory Control Process

An area of further research would be to elaborate on those changes.

Appendix 1

Model for calculating the number of production runs for a machine which produces more than one product

Total Cost = (Production Cost)+(Storage Cost)+(Set-up Cost)

$$TC=\sum_{i=1}^{m} c_{p_i} D_i + \frac{1}{2n}\sum_{i=1}^{m} c_{H_i}\left(1-\frac{d_i}{p_i}\right) + n\sum_{i=1}^{m} c_{R_i} \qquad \text{(A1.1)}$$

$$n_0=\sqrt{\frac{\sum_{i=1}^{m} c_{H_i}\left(1-\frac{d_i}{p_i}\right)D_i}{2\sum_{i=1}^{m} c_{R_i}}} \qquad \text{(A1.2)}$$

$$Q_i = \frac{D_i}{n_0} \qquad \text{(A1.3)}$$

NOTATION

n_0 : Number of runs

Q_i : Quantity produced for product i

c_{p_i} : Production cost per unit of product i

c_{R_i} : Set-up cost per unit of product i

c_{H_i} : Storage cost per unit of product i for a period of time

d_i : Demand for product i per unit of time

p_i : Production for product i per unit of time

D_i : Total demand for product i for a period of time

Appendix 2

Model for calculating the Economic Order Quantity (EOQ) for raw materials

Total Cost Of Stock = (Purchasing Cost)+(Storage Cost)+(Replenishment Cost)

$$TCS = pD + \frac{Q}{2} c_h + \frac{D}{Q} c_p \quad (A2.1)$$

$$EOQ = \sqrt{\frac{2c_p D}{c_h}} \quad (A2.2)$$

$$t_o = \frac{EOQ}{D} \quad (A2.3)$$

NOTATION

TCS : Total cost of stock
EOQ : Economic order quantity
t_o : Reordering time
D : Demand for raw materials for a period of time
p : Purchasing cost per unit
c_h : Storage cost per unit for a period of time
c_p : Ordering cost

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