

Medium Range Production Planning Of  
Tacer Company  
A Case Study

A Thesis  
Submitted To The Department Of Management  
And  
The Graduate School Of Business Administration  
Of  
Bilkent University

In Partial Fulfillment Of The Requirements  
For The Degree Of  
Master Of Business Administration

By  
Süer, Burak.

September, 1994

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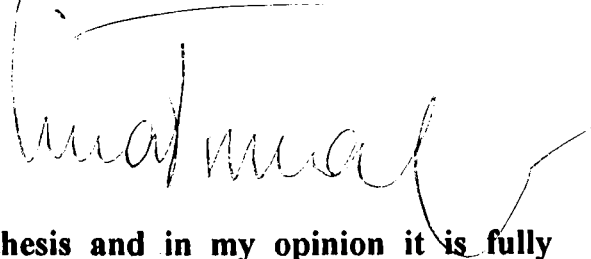
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**I certify that I have read this thesis and in my opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Business Administration.**

**Asst. Prof. Dr. Murat Mercan**



**I certify that I have read this thesis and in my opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Business Administration.**

**Assoc. Prof. Dr. Erdal EREL**



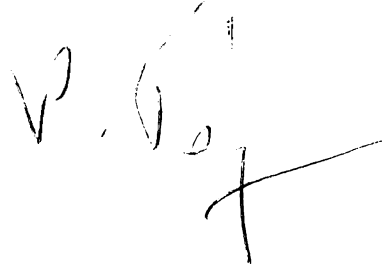
**I certify that I have read this thesis and in my opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Business Administration.**

**Asst.Prof.Dr. Selçuk KARABATI**



**Approved by the dean of the Graduate School of Business Administration.**

**Prof. Dr. Subidey TOGAN**



## **ABSTRACT**

### **MEDIUM RANGE PRODUCTION PLANNING OF "TACER" COMPANY "A CASE STUDY"**

**BY**

**Burak SÜER**

**M.B.A. THESIS**

**BILKENT UNIVERSITY - ANKARA**

**SEPTEMBER, 1994**

**Supervisor: Asst. Prof. Dr. Murat Mercan**

In order to foresee the potential problems related with production, a production plan is undertaken for the year 1994. Product classification is determined according to the annual sales volume of the company "Tacer". A production schedule is prepared in relation with the forecast data of 1994. The schedule is examined by capacity requirements and financial analysis. Some capacity problems that are highlighted were investigated in the analysis section. Short and long term solutions were made to overcome the insufficient capacity.

## **ÖZET**

### **TACER FIRMASININ ORTA DÖNEMDEKİ ÜRETİM PLANLAMASI "ÖRNEK ÇALISMA"**

**HAZIRLAYAN**

**Burak SÜER**

**ISLETME YÜKSEK LISANS TEZİ**

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**EYLÜL, 1994**

**Denetleyen: Yar. Doç. Dr. Murat Mercan**

Bu çalısmada, 1994 yılında üretimde doğabilecek sorunları önceden fark edebilmek için bir analiz yapılmıştır. Tacer firmasının yıllık satış hacimlerine göre bir ürün sınıflandırılması yapılmıştır. Bunların 1994 yılındaki tahmini satış miktarları belirlenmiş ve buna uygun olarak bir imalat programı çıkarılmıştır. Yapılan programın uygunluğunun tesbiti amacıyla bazı kapasite ve maliyet analizleri kullanılmıştır. Bunların sonucunda kapasitede bazı yetersizlikler ortaya çıkmıştır. Bu sorunların çözülebilmesi için gerekli çözümler önerilmiştir.

## **ACKNOWLEDGMENTS**

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# **CHAPTER ONE**

## **INTRODUCTION**

### **1.1. Inventory Management**

Production and inventory management can be defined as the design, operation, and control of systems for the manufacture and distribution of products. Certain planning functions must be performed for all companies from a production and inventory management point of view.

#### **1.1.1. Inventory**

Inventories are those materials and supplies carried on hand by a business or institution either for sale or to provide inputs or supplies to the production process. Inventories must be considered at each of the planning levels and are thus part of production planning, master production scheduling, and material requirements planning

#### **1.1.2. Planning**

Planning is the first step in management. It consists of selecting measurable objectives and deciding how to achieve them. Planning is a prerequisite for execution and control. Without plans there is no basis for action and no basis for

evaluating the results achieved. Planning not only provides the path for action, it also enables management to evaluate the probability of successfully completing the journey [Fogarty, 14].

### **1.1.3. Competitive Strength**

Firms were able to sell their products to the customers in the past. Companies produced items and consumers bought the products. Consumers had no chance to choose because there were no alternatives.

Today, there are lots of companies producing the same type of products. Consumers have a chance to choose between alternatives. Small differences between the products or services effect the decision of buyer's behavior. Thus, an organization may stress quality, price, product variations and options, quick delivery, service after the sale, or some combination.

## **1.2. Case Study**

"Tacer" company is settled in Ankara in 1985. Its working capital is 1.000.000.000 TL. There are two partners who own the company with the shares, 60 % and 40 % respectively. Total number of people who are working for the company is fifty. Fifteen of these people are working in production, five of them are working in administration, and rest is assigned for structuring.

There are seven main firms buying products from the company and selling them to the market. They are located in Istanbul, Izmir, Antalya, Gaziantep, Samsun, Trabzon, and Erzurum. Some of them construct the products by

themselves but some of them want worker support from the company. There are direct sales to places different from these seven cities. Sales are increasing rapidly from 465.0000\$ to 1.007.518\$.

"Tacer" company is producing decorative elements to the buildings. These elements are mostly used in ceilings and walls of the buildings. They are mostly used in government buildings, business centers, hospitals, factories, houses, airports, railway stations, banks, and gas stations.

Aluminium suspended ceiling is introduced to the market by "Tacer" company in 1985. Consumer needs brought "Ikiz panel" which is another type of ceiling, to this market. Then other types of ceilings have come which were "Rockwool-Tasyünü and Gypsum boards-Alcipan". The main items used in production of tasyunu and alcipan are bought from other companies. Sub-items of them (construction profiles) are produced in the company.

There are various competitors in the market but "Tacer" company is the only one that produces the sub-items of aluminium, tasyunu and gypsum. Other companies deal with only one type of product whereas "Tacer" company produces different types of ceilings and walls.

The main items used in production are bought from different places. Aluminium is taken from Seydisehir Aluminium (KONYA), paint from Akzo-Kemipol (IZMIR), Tasyunu from Aspen (ISTANBUL), and Alcipan from Bildepe (ANKARA). They are transported to the company's warehouse that is settled in Ankara.

It is more economical to buy raw materials in lots than to buy separately. The discount rate for each product varies according to the lot size. Prices also depend on the size of the seller. Small sellers have prices that are 1.3 times more than local big sellers.

Materials are either constructed by company's workers or consumers buy the main items for construction. Workers are specialized in construction and they work in only one type of fitting. Production workers have no specialization so they are able to work in any machine.

There are different work centers in production. Assembly lines for products are different. For most of the items, there are two main assembly lines whose functions are stated below:

- Cut into pieces - Shape the items - Paint the items - Heat the items - Paint the items - Heat the items - Package the items
- Press the items - Paint the items - Heat the items - Paint the items - Heat the items - Package the items

The capacity is designed for the needs of the market demand in 1985. The idea of producing different types of products using the same machines was taken into consideration in 1989. Company's strategy is to produce end products and to buy raw materials from outside vendors.

Prices are defined according to raw materials. When prices of aluminium and paint increase, costs of the products change. These raw materials prices are indexed to foreign currency.

"Tacer" company produces medium priced high quality products. Mostly, customers want the products immediately. Also customers pay money when they get the products. Sales price should stay constant when the order is given to the company whereas prices of raw materials are continuously increasing in this inflationary system. Companies can lose lots of money because of this problem. In order to decrease the risk of losing money, it is very important to distribute the product in a short time. It is known that "Tacer" company produces and distributes the products in a very short time. This is one of the competitive strength of the company. The company's strategy is to increase the product types but this will effect the production organization and distribution times.

Company is looking for new markets because of the crisis in construction sector in Türkiye. Long term goal of the company is to export products to Russian and Arabian markets.

### **1.3. Thesis Outline**

A planning model is structured to satisfy production strategies of "Tacer" company in this thesis. All of the relevant data for production and capacity control is analyzed. Some reasonable assumptions are made for developing the production, capacity and financial modeling.

Some important subjects and techniques are introduced within the scope of some authors in chapter II. The steps for ABC classification, forecasting, production planning and capacity planning are briefly explained.

In Chapter III, ABC classification is done for all items. Class A items are chosen and forecasted for production planning and capacity planning. In capacity planning, some expected problems have appeared. In the light of these results, feasible solutions are advised. In section 3.8. all items are considered and financial power of the company is basically tested.

In Chapter IV, a review is done for the analysis part. Results of the applications are summarized. Some solutions are proposed to the executives for



the problems in capacity planning. Some recommendations are made to achieve better production and capacity planning. Financial power of the company is considered in doing this.

Finally, tables for the analysis are reported in appendices.

The subject of this thesis is important because it shows a planning procedure for small companies. Future plans define the target of the company. Analysis of these future plans give some clues which help the company achieve its goals easier. This will increase the competitive strength of the company by empowering its market place.

# CHAPTER TWO

## LITERATURE SURVEY

### 2.1. ABC Inventory Control

In order to classify the items on the basis of relative importance, ABC analysis is a safe and an easy method. Vilfredo Pareto was the first to document the Management Principle of Materiality, which is the basis of ABC classification. The idea is very easy that many situations dominated by a relatively few elements in the situation. So controlling these dominant few items can also be a control for the whole system [Arnold, 150].

Applying ABC principle to inventory management involves:

1. Inventory items are classified according to their relative importance.
2. Different management control policies are applied to different classified inventory items.

This is a very useful concept in business since it can be applied to inventory control, production control, quality control and many other management problems. ABC letters show the rank of the inventory items from the most important to the least important. Mostly the classification is made according to the annual dollar usage volume but there can be other criteria for classifying the items in ABC classification [Fogarty, 177]. These can be:

1. Unit cost
2. Annual dollar transaction volume for an item
3. Lead time
4. Cost of stockout
5. Storage requirements
6. Shelf life or other critical attributes
7. Availability of resources or facilities to produce an item
8. Scarcity of material used in producing an item
9. Engineering design

### **2.1.1. Evaluating ABC Classification**

According to the annual dollar usage, ABC classification procedure is as follows:

**A) Determination of annual dollar usage.**

- The cost of each item is multiplied with the annual usage.
- The total annual dollar expenditure is obtained by summing up

annual dollar usage of each item.

**B) Annual dollar usage percent for each item is found by dividing the annual dollar usage to total annual dollar usage.**

**C) According to their percentage volume the items are listed in descending order.**

**D) Items are grouped on the basis of percentage of annual dollar usage.**

ABC classification is generally based on the annual dollar volume. A-B-C items are classified according to the following criteria:

**Class A Items:** High value-Those relatively few items whose value accounts for 80% of the whole annual usage make up 15-20% of the items.

**Class B Items:** Medium value-A larger number in the middle of the list is usually about 30-40% of those, whose total value accounts for 15-20% of the whole annual usage.

**Class C Items:** Low value-50% of the items whose total inventory value has negligible cost for 5% of the whole annual usage [Coyle,209].

### 2.1.2. Control Techniques for ABC Classes:

Different controls are made for different classifications:

#### **Class A Items:**

Frequent forecasting and frequent control must be done on these items.

Lead time of class A items are tried to be reduced.

Frequent review of demand requirements must be done. Demand control, safety stock control are some control techniques to prevent the lack of material for class A items.

Records must be daily updated for sudden changes.

Items must be closely followed and cycle counting procedure must be done with tight tolerances.

#### **Class B Items:**

These items are less important than Class A items. The same control techniques are enough for class B items when they are applied less frequently.

#### **Class C:**

There is no need to take records or periodic controls.

It is enough to order large quantities considering a safety stock.

Storage areas should be easily accessed. This is important for fast production.

It is enough to count items infrequently (annual or semiannual) with scale accuracy (weighting rather than counting)

Application of the ABC analysis does not require the use of only three classifications or even that the classifications be designated A, B, C. There can be more than three categories. These categories can be related to any functional use of the items [Coyle,210] .

ABC classification is not used for only final products. There can be other items like purchased items, manufactured items, assemblies, subassemblies, independent demand items, dependent demand items those can be classified by ABC analysis.

The analysis should not ignore the trends in demand. Product life cycles, marketing, redesign of the component must be considered. Historical data can be misleading if followed blindly.

## **2.2. Forecasting**

Future demand must be forecasted to plan inventory management activities. Customers should not wait too much for their orders. Manufacturers should anticipate future demand for products or services. By this way they can make plans to provide the capacity and resources to meet the demand.

There are five essential steps in forecasting:

1. Defining the purposes.

2. Preparing data.
3. Selecting the techniques.
4. Making the forecasts and estimating the forecast errors.
5. Tracking the forecasts.

Future demand relates to the past in some way. This does not mean that it is just the same but there are some relationships between the future and the past. There are two types of time series data. They are intrinsic and extrinsic. Intrinsic time series data are data concerning past sales of the product to be forecasted. Extrinsic time series data are data those are external but are related to sales of the product [Fogarty,79].

The forecast horizon must be longer than the product's total lead time. If the forecast is shorter, then the earliest production activities, such as placing purchase orders for long lead time components, are performed with insufficient information. The forecasts' horizon can be as long as possible until it is valid in an error percentage. Forecasts should be updated frequently for high dollar volume items, less frequently for low dollar volume items.

### **2.2.1. Quantitative and Qualitative Forecasting Techniques:**

There are two main forecasting techniques: *quantitative and qualitative*.

Qualitative techniques rely on judgment, intuition, and subjective evaluation. Major techniques within this category are market research, historical analogy and management estimation. These techniques are depended on good theory and can yield valuable information for marketing decisions. They are not intended to

support inventory decisions. Rather they are intended to support product development and promotion strategies. Some methods like Delphi or panel consensus may be useful in technological forecasting [Anderson,721].

Quantitative technique can be divided into two main types: intrinsic and extrinsic. Intrinsic technique involves mathematical manipulation of demand history for an item. Extrinsic methods create a forecast by attempting to relate demand for an item to data about another item or group of items.

Intrinsic method involves with time series and it consists of four components:

- **Cyclical:** This can be very important for long-range planning. It refers to the business cycle and trends in the economy. However it is not effective in forecasting demand for individual products those rarely have sufficient data to permit a distinction between the effect of the business cycle and the effect of the product life cycle [Hanke,92].
- **Trend:** It is generally modeled as a line and it shows the rate of growth or decline of a series over time that expresses with its slope [Hanke,92].
- **Seasonality:** The demand can change according to some special effects in time like holidays,weather,seasons or special events that take place on a seasonal basis [Hanke,92].
- **Random:** It is mostly referred as unexpected patterns. Strikes, wars, earthquakes can be the effects of the random variations. In all series it is present and an averaging process will help to decrease its error effect [Hanke,92].

### 2.2.1.1. Forecasting Techniques From Intrinsic Time Series

- **Moving averages:** The simplest of all time series forecasting technique is a moving average. The forecast of the next period is found from the average of actual past demand for the required period.

For a 3 period of moving average it can be seen that:

$$\frac{D_{i-3}+D_{i-2}+D_{i-1}}{3}=F_i$$

$D_i$  = actual demand in period  $i$

$F_i$  = forecast demand in period  $i$

The number of periods to use in computing the average may be anything from 2 to 12 or more, with 3 or 4 periods being common. Moving average is not a satisfactory method if there is any seasonal or trend effect. Moving averages lag behind any trends [Arnold, 128].

- **Weighted Moving Averages:** Sometimes the recent data can be more important than the older data. For the forecasted period each period which is computed is multiplied with a weighted factor. In weighted moving average more importance is weighted on the recent data. A weighting factor is given to the data.

$$F_i = \frac{2D_{i-3}+4D_{i-2}+5D_{i-1}}{2+4+5}$$

$D_i$  = actual demand in period  $i$

$F_i$  = forecast demand in period  $i$



Weighted factors can be any values. A simple moving average is undesirable because of its tendency to lag behind a trend. The moving average solves this problem a little bit by giving more importance on the recent data but it still lies behind the trend [Fogarty,91].

- **Exponential Smoothing:** It is the most popular forecasting method which is based on forecasting errors. It is equivalent to the weighted moving average but it requires fewer data and calculations. The forecast can be based on the old data and the new data [Hanke,140]. It is a good method for short-range forecasting and for stable items.

$$\text{New forecast} = (@)(\text{latest sales}) + (1-@)(\text{previous forecast})$$

$$@ = \text{exponential smoothing factor} \quad 0 \leq @ < 1$$

Another advantage is that the data required are only the last forecast, the last actual demand, and the value of @. Computation is reduced to two multiplication operations and one addition for each forecast. Large values of @ place heavier weight on the most recent actual data and less weight on the historical values [Arnold,130].

- **Seasonality:** Many products have seasonal demand. According to the season (for example: skis in winter, bathing suits in summer) the demand for the products can increase or decrease. It is best reflected with the seasonal index factor.

- **Seasonal Index:** It reflects the seasonal effects on the forecast. Seasonal index shows how much the seasonal period effects the demand. Period can change according to the seasonality of sales. It can be days, weeks or months [Kress,51].

$$\text{Seasonal index} = \frac{\text{period sales}}{\text{average period sales}}$$

### 2.2.2. Forecasting Errors

Forecasts are never perfect and true. The important thing is to minimize the errors. We have to measure the forecast errors and try to have better plans for the next time. We need to track the forecast. Tracking the forecast is the process of comparing actual demand with the forecast.

The difference between the actual demand and the forecasted demand is the forecast error. Error can be in two ways, bias and random variation.

- **Bias:** Forecasts can differ from the actual sales. Forecasts can be greater or less than the actual so the sum of the errors shows that forecasting is made positively or negatively and bias shows this direction. The main purpose of tracking the forecast is to be able to react to the forecast error by planning around it or trying to reduce it. If a large variation is observed, the reasons lying under this must be investigated. These can be machine breakdowns, strikes, customer shutdown or other effects that really effect the demand or production. Also timing errors in forecasting can cause large bias numbers.

- **Random Variation:** The difference between the forecasts and the actual shows how our forecasts vary positively or negatively from the actual demand. The variability will depend upon the demand pattern of the product. If the demand is stable variation will be small. Unstable demand shows large variations.

- **Mean Absolute Deviation:** In order to modify the forecasting techniques we have to measure the error. One way is MAD. It considers the difference of the forecast and the actual demand and takes the absolute value of them and sums them up then take its average.

$$\text{MAD} = \frac{\text{Sum of absolute deviations}}{\text{number of observations}}$$

The MAD is the most common measure of forecast error and usually forms the basis for actions taken to offset forecast error. The mean square error (MSE) is found by averaging the squared deviations, places more weight on the large errors than on the small ones. The mean square error is not on the same scale as the MAD or the average error, as the mean squared error deals with squared data. The MSE is preferable if one wishes to determine which of a set of forecasting techniques produces the most desired results [Jarret,23].

### 2.3. Production Planning

From a production and inventory management viewpoint, all companies must perform certain necessary planning functions. All must forecast demand for their products. All must determine when to increase facility size, how to staff the

facilities, when to make or buy the items, and how many to make or buy. In this thesis we will discuss the planning cycle and deal with the concepts by analyzing a company.

First step in management is planning. It consists of selecting measurable objectives and deciding how to achieve them. Without planning we can not exactly know what to do and we can not control-compare the results.

Plans can be long range, medium range, short range depending on the time required to complete the execution. The long range planning horizon should exceed the time required to acquire new facilities and equipment. It can be 18 months short or 10 years long. Medium range planning is the development of the aggregate production rates and aggregate levels of inventory for product groups within the constraints of a given facility. In the medium range planning expansion of capacity is limited to increase personnel, schedule overtime, more efficient tooling, or adding some types of equipment. Medium range planning usually covers a period of beginning 1-2 months and ending 12-18 months in the future. Although there is not a precise range for short term planning it may take place over a number of weeks. Detailed schedules and assignments of men and machines do not occur until well within the short range period [Aft,5].

### **2.3.1. Medium Range Planning**

Medium range planning deals with the following main topics:

- **Distribution Requirements Planning (DRP):** Time and place have value. The main objective of the distribution inventory management is to have inventory

in the right place at the right time at reasonable cost. In a branch warehouse environment the DRP provides a solid link between distribution and manufacturing by providing a record of the quantity and timing of likely orders. In this thesis we will not deal with the distribution requirements planning because the factory and the warehouse are in the same place so there is no need to deal with it.

- **Demand Management:** In order to make a plan for the future it is important to know the aggregate demand in the future. This determination reflects forecasts and includes customer orders received, branch warehouse orders, interplant orders, special promotions, safety stock requirements, service parts, and building inventory for later high volume demand periods. Forecasting is the starting part of planning. Minimum errors for forecasting make our plans more reliable. In this thesis 12 month forecasting is done for future demand [Fogarty,19].

- **Master Production Schedule (MPS):** The MPS is a time-phased plan of the items and the quantity of each that the organization intends to build. It must be approved by purchasing, marketing, and the top management. The MPS covers anything from the present to 1 to 18 months. It is used both a short range and medium range planning device. In this thesis 12 months MPS is done.

- **Rough Cut Capacity Planning (RCCP):** In order to verify the production plan or MPS the ability of the organization must be controlled. Rough cut capacity includes the following:

1. Determination of sufficient working capital that will be available to meet the cash flow requirements.
2. Verification of production facilities and adequacy of equipment capacity.
3. Commitment of third party vendors to obtain required production capacity.

- **Material Requirements Planning (MRP):** It starts with the items listed on the MPS. It also determines the quantity of all components and materials required to fabricate those items. Time phased MRP is accomplished by exploding the bill of materials and offsetting requirements by the appropriate lead times.

- **Capacity Requirements Planning:** Requirements that are obtained from MRP are used in conjunction with other data to determine the capacity for manufacturing the number of elements in MRP. These capacity requirements are compared to available capacity. If something is wrong with the capacity, corrective actions are taken. These can be overtime working, subcontracting, rerouting production etc. Again if the capacity is not available, some revisions in the MPS and MRP must be done [Aft,9].

### 2.3.2. Developing a Production Plan

There are three basic strategies for developing a production plan:

1. **Demand Matching:** Some industries have the chance to manufacture equal to the demand. Sometimes the equipment can stay idle or hiring people can be needed. In this system there is no inventory stock problem. Inventory holding cost is minimum. But the capacity must be enough to tolerate the maximum peak demand.

2. **Production Leveling:** In this system an average demand is chosen and the production stays equal to that average demand. As the production stays constant the change cost for the production level will be small. There is constant production

so there is no need to work overtime or subcontract with other companies. But there can be large amounts of inventory on hand in low demand cases so inventory holding can be costly.

**3. Subcontracting:** In some cases, subcontracting with other companies and minimizing production is profitable for companies. Subcontracted companies must hold the inventory on hand and there is no cost for changing the production levels. The items can be costly to purchase and there can be transportation or production problems within the subcontracted companies.

#### **2.4. Master Production Schedule (MPS):**

Master Schedule is a presentation of the demand including the forecast. After production planning production must be scheduled in some way. This is done by preparing a master production schedule (MPS). Master production schedule is the primary output of the master scheduling process. End items that the organization anticipates for each period are specified by MPS. It is the plan for providing the supply to meet the demand. MPS is not a sales forecast, it states the production to meet the demand. Also MPS is not an assembly or packaging schedule [Gessner,25].

MPS is built from actual demands and forecasts for individual end item. It is a plan for items to meet the expected demand by determining the items and the quantities.

There are many factors in developing the MPS. These inputs are:

1. Customer service goals
2. Service part policies

3. Safety stock levels
4. Whether products are stocked, built-to-order or a combination of both
5. Make versus buy policies
6. Number and location of warehousing and production facilities
7. Interplant transfer of components
8. Customer orders and demand forecasts
9. Policies on stability of employment and demand plant utilization
10. Product structure as defined by bill of materials [Plossl,175]

The competitive strategy of the company can be any of the following:

**A) Make-to-Stock:** This competitive strategy depends on the immediate delivery of the standard items. In this environment MPS is the schedule of the items required to maintain the finished goods at the desired level. Quantities on the schedule are based on manufacturing economics and the forecast demand as well as desired safety stock levels. Items may be produced either on a mass production line or batch production. MPS is the same as final assembly schedule [Fogarty,125].

**B) Assemble, Finish, Package to Order:** Items are produced in sub-assemblies or components in this competitive strategy. From standard parts a large variety of final products are produced within a relatively short lead time. This environment requires a forecast of options as well as of total demand. Thus there is an MPS both for the options, accessories, common components and final assembly schedule as well. There is an advantage that many final products can be produced from relatively few subassemblies [Fogarty,125].



**C) Custom Design and Make-to-Order:** The final product is usually a combination of standard items and items' custom designed to meet the special needs of the customer. In many situations the final design of an item is part of what is purchased. There is one MPS for the raw material and the standard items that are purchased, fabricated, or built to stock and another MPS for the custom engineering, fabrication and final assembly [Fogarty,125].

Final products are made from subassemblies and components. The bill of material (BOM) is created as part of the design process and is used by manufacturing department to determine which items should be purchased and which items should be manufactured. Inventory planning uses BOM to determine the purchase requisitions and production orders.

#### **2.4.1. Bill of Material**

The final product includes many subassemblies. The list is called bill of material (BOM). Its use can be in different ways. For manufacturing engineers it helps to determine which items should be produced, which items should be purchased. It is used with the MPS to determine which items should be released in order to satisfy the required production. Accounting uses it to price the product.

In designing the BOM it is easy to see the production assembly and the quantity of each sub-component for the final product. It forms the connection between the production planning and what is actually produced. To determine the capacity and the resources that are needed MPS is the main source, also it determines the basis for material requirements planning . It is the priority plan for manufacturing [Aft,227].

#### **2.4.2. Designing the MPS**

Designing the MPS includes the following steps:

1. Selecting the items both in the components and final assemblies
2. Organizing the MPS by product groups
3. Determining the planning horizon, the time fences, and the related operational guides

#### **2.4.3. Creating the MPS**

Creating the MPS includes the following steps:

1. Obtaining the necessary informational inputs, including the forecast, the backlog (customer commitments), and the inventory on hand
2. Preparing the initial draft of the MPS
3. Developing a rough cut capacity requirements plan
4. If required, increase capacity or revise the initial draft to obtain a feasible schedule [Arnold,35]

#### **2.4.4. Controlling the MPS**

Controlling the MPS includes the following steps:

1. Controlling the actual production and the planned production if it is met or not.
2. Calculating the available to promise to determine whether an incoming order can be promised in a specific period.

3. Calculating the project on hand if planned production is sufficient to fill expected future orders.
4. With the help of the first three steps determining if the MPS or the capacity should be revised.

#### **2.4.5. Uses of MPS**

MPS is one of the set of data under management control. Some of the uses of MPS is as follows:

- It interlocks the higher level production plan and day-to-day schedules
- It drives the several detailed plans including the Material Requirements and Capacity Requirements. These establish the proper timing and quantities of materials, people, machinery, tooling, supplies, testing and other equipment needed to produce the end items in the MPS.
- It drives the financial plans leading to budgets for stock components, work-in-process inventories, direct labor, cost of goods sold.
- It makes customer delivery promises on make-to-order products. Developing promises is easier and much higher levels of on-time delivery can be attained.
- It monitors the performance of marketing, sales, engineering, planning, By this the causes of fall downs are made clear and performance is improved.
- It coordinates the managers' activities.
- MPS is satisfactory because it tells the plant when to start and stop production for individual items and the capacity is consistent with the production plan.
- By maintaining finished-goods inventory levels or by scheduling to meet customer delivery requirements the desired level of customer service can be done.
- To make the best use labor, material and equipment.
- Maintaining inventory investment at the required levels [Plossl, 188].

#### **2.4.6. Problems with MPS**

Five major facts destroy the effectiveness of the MPS. These are:

1. Overloading: The net effect of overloading is poor customer service, excessive costs and high inventories.

2. Excessive nervousness: An excessive number of action notices to change priorities or capacities and conflicting signals can destroy the abilities and morale of the successful people.

3. Invalid data: Invalid data used in developing inputs to the MPS include poor forecasts, wrong finished goods' inventories, incorrect customer orders and mistakes in shipments [Plossl, 187].

#### **2.5. Rough Cut Capacity Planning**

End items' production schedule related to the forecasted data is defined in MPS. The quantity of material and timing of that material is defined in MRP by using the output of MPS. In both cases it is assumed that sufficient capacity is available to produce components when they are needed.

There are four time horizons considered. In an MRP system the typical sequence is creating an MPS and use rough cut capacity to verify the feasibility of MPS, perform an MRP chart and verify it with the capacity requirements planning.

If the capacity is not sufficient to produce the materials, there can appear some problems. The problems may result in increasing lead times (because of producing

more items), big errors in forecasting (because of the change in lead times) etc. Capacity must be controlled after MPS. If it is not enough, some precautions should be taken.

### 2.5.1. RCCP Techniques

There are three main techniques for Rough Cut Capacity Planning. All of them have the same purpose but they need different data and their computation complexity is different. If the capacity is not sufficient according to these techniques the company can increase the capacity or work overtime to tolerate the difference. If this method is expensive for the company a new version of the MPS is needed. The three techniques are capacity planning using overall factors, the bill of labor approach, and the resource profile approach [Fogarty,410].

**1. Capacity Planning Using Overall Factors:** This technique requires least detailed data and least computational method. MPS, total time for producing one typical part, historical proportion of total plant time required by each of the key resources are needed. If more than one product family exists, one typical part time is needed for each family. CPOF multiplies the typical time by the MPS quantity to obtain total time required in the entire plant to meet the MPS. This time is then prorated among the key resources by multiplying total plant time by the historical proportion of time used at a given work center [Fogarty,410].

**2. Bill of Labor Approach:** This technique uses detailed data on the time standards for each work station. For every product the time required on each work station is analyzed. The time standards for each product are very important and must be updated in case of efficiency, product method changes. By using the data

in MPS for each product the time required for each work station is found and they are summed up in order to find the total capacity [Fogarty,411].

**3. Resource Profile Approach:** This technique uses the time standards like BOL Approach. In addition to that lead times are required to perform certain tasks. The other two approaches do not require the time phase between the production period. All items can not build at the same time. For coming to the next work station a time must pass and at the same time the next work station must stay idle. This technique is the most detailed one but not as detailed as capacity requirements planning [Fogarty,411].

In the RCCP two factors must be considered. First one is the *utilization*. The production can not go on the same basis all the time. Sometimes the worker may be absent. The machines can breakdown. The material needed can not be available all the time. The utilization factor is a number among 0-1 that is equal to 1 minus the proportion of time typically lost due to machine, worker, tool, or material unavailability.

Second one is the *efficiency*. There must be an adjustment between the time standard average and the actual production rate of the department. Efficiency is formally defined to be the average of standard hours of production per clock hour actually worked. Efficiency is "1" if a time standard is exactly right. If the time that is required to perform the work is less than the standard, then efficiency is more than "1". If the time that is required to perform the work is more than the standard, then efficiency is less than "1" [Fogarty, 422].

Capacity that is available is found by multiplying available time by utilization and efficiency.

Capacity Available = Time Available x Utilization x Efficiency

### **2.5.2. Capacity Problems**

When capacity is inadequate there are four basic options to solve the problem. Overtime, subcontracting, alternate routing, adding personnel.

Overtime is the most popular solution for increasing the capacity. Workers appreciate to take more money but some of them would rather have the time off than the extra money. Also there are government limits to work overtime.

Also efficiency decreases because workers can get tired.

Subcontracting is the second way to increase the capacity. It is more expensive than building an item in house on regular working time but it can be cheaper than overtime working. Lead time increases and a decrease in quality can appear. Additional transportation costs and timing problems are present.

Alternate routing is the increasing capacity by adding an additional work center that has free time for excess work. Adding some changes to work center B we can increase the capacity in work center A. But the changes can be costly or we can need work center B for its own purpose. The quality in work center B can not be as good as in work center A.

Adding personnel can be another alternative. Hiring new personnel or shifting workers from one work station that has enough capacity to another station can be

possible but the machine capacity must be enough to compensate the new workers. It takes time for the new workers to learn their job. Efficiency can be low [Fogarty,424].

## **2.6. Material Requirements Planning (MRP)**

Material requirements planning is a computational technique that converts the master schedule for end products into a detailed schedule for raw materials and components used in the end products. The detailed schedule identifies the quantities of each raw material and component item. It also tells when each item must be ordered and delivered so as to meet the master schedule for the final products [Arnold, 48].

MRP is always considered to be a subset of inventory control. While it is an effective tool for minimizing unnecessary inventory investment, MRP is also useful in production scheduling and purchasing of materials.

The concept of the MRP is relatively straightforward. What complicates the application of the technique is the sheer magnitude of the data to be processed. The master schedule provides the overall production plan for final products in terms of month-by-month or week-by-week delivery requirements. Each of the products may contain hundreds of individual components. These components are produced out of raw materials, some of which are common among the components. The components are assembled into simple subassemblies. Then these assemblies are put together into more complex assemblies and so forth, until the final product is assembled together [Arnold, 56].



### **2.6.1. Basic MRP Concepts**

Material requirements planning is based on four main concepts. These are:

1. Independent versus dependent demand
2. Lumpy demand
3. Lead times
4. Common use items

#### **2.6.1.1. Independent versus dependent demand**

This distinction is fundamental to MRP. Independent demand means that demand for a product is unrelated to demand for other items. End products and spare parts are examples of items whose demand is independent. Independent demands must be forecasted.

Dependent demand means that the demand for the item is relatively related to the demand for some other product. The dependency usually derives from the fact that the item is a component of the other product. Not only component parts, but also raw materials and subassemblies, are examples of items that are subject to dependent demand.

Whereas demand for the firm's end products must often be forecasted, the raw materials and component parts should not be forecasted. Once the delivery schedule for the end products is established, the requirements for components and raw materials can be calculated directly.

MRP is the appropriate technique for determining quantities of dependent demand items. These items constitute the inventory of manufacturing: raw materials, work-in-process, component parts, and subassemblies. Accordingly, MRP is a very powerful tool in the planning and control of manufacturing [Groover,343].

#### **2.6.1.2. Lumpy demand**

In an order point system, the assumption is generally made that the demand for the item in inventory will occur at a gradual, continuous rate. In a manufacturing situation, demand for the raw materials and components of a product will occur in large increments rather than small, almost continuous units. The large increments correspond to the quantities needed to make a certain batch of the final product. When the demand occurs in large steps, it is referred to by the term "lumpy demand". MRP is the appropriate approach for dealing with inventory situations characterized by lumpy demand [Groover,343].

#### **2.6.1.3. Lead times**

In manufacturing there are two kinds of lead times: *ordering lead times* and *manufacturing lead times*. Ordering lead time is the time starting from the purchase requisition to the receipt from the seller. If the materials are in the stock of the seller, then the lead time should be short. If the materials are to be produced by the seller, the lead time is long. Manufacturing lead time is the time required to process a part through the sequence of machines [Groover, 344].

In MRP, lead times are used to determine starting dates for assembling final products and subassemblies, for producing component parts, and for ordering raw materials.

#### **2.6.1.4. Common use items**

In manufacturing, the basic raw materials are often used to produce more than one component type. Also a given component may be used on more than one final product. MRP collects these common use items from different products to effect economies in ordering the raw materials and manufacturing the components [Groover 344].

#### **2.6.2 Inputs to MRP**

Master production schedule is converted into a detailed raw materials and components by MRP. In order to organize the MRP system we must have Master Production Schedule, inventory records and bills of material.

The following data must be considered in order to deal with MRP process. These are:

**Lead Time:** It is the time to process the one unit of item in a period and it includes ordering time, delays, moving etc.

**Lot size:** Physical place of the items that is stored.

**On hand:** Starting inventory.

**Safety stock:** In order not to stockout or for customer satisfaction it is the safety level of inventory kept in hand.

**Allocated:** Inventories that are sold or placed before the starting of the period.

**Low level code:** It determines if the product is a sub-component of another product or it is the final product.

**Gross requirements:** The quantity that is obtained from MPS. The quantity of the product to satisfy the demand.

**Scheduled receipts:** Material that is already ordered and expected to arrive.

**Projected on hand:** It is the starting inventory taking care of the safety stock and allocated materials.

On hand-safety stock-allocated = Projected on hand

**Net requirements:** Exact number of production number taking care of the scheduled receipts and projected on hand.

Gross requirements - scheduled receipts - projected on hand = Net requirements

**Planned order receipts:** After lead time the amount of quantity that is arrived for net requirements.

**Planned order releases:** The size of the planned order that will arrive after the lead time [Tersine, 340].

### 2.6.3. MRP Process

The master schedule specifies a period-by-period list of final products produced. The bill of material defines what sub-materials or products are needed to produce the final products required. The inventory record file contains the data for the current and future status of each component. The MRP program computes how many of each component and raw material are needed by "exploding" the end-product requirements into successively lower levels in the product structure [Magad, 204].

There are several factors that must be considered in the MRP parts and materials explosion. First, the component and the subassembly quantities given are gross requirements. Quantities of some of the components and subassemblies may already be in stock or on order. Hence the quantities that are in inventory or scheduled for delivery in the near future must be subtracted from gross requirements to determine net requirements for meeting the master schedule.

Secondly the lead times must be considered. The MRP processor must determine when to start assembling the subassemblies considering the manufacturing lead times. Similarly the raw materials for the components must be offset by their respective ordering lead times.

Thirdly the common use items must be considered. The MRP processor must collect these common use items during the parts' explosion. The total quantities for each common use item are then combined into a single net requirement for the item.

Finally MPS provides time-phased delivery requirements for the end products, and this time phasing must be carried through the calculations of the individual component and raw material requirements [Aft, 234].

#### **2.6.4. Benefits Of MRP**

MRP generates a variety of outputs that can be used in the planning and management of plant operations. These benefits are as follows:

- MRP mainly affects raw materials, purchased components, and work-in-process inventories. Users claim a 30 to 50% reduction in work-in-process.
- Some MRP proponents claim that late orders are reduced 90%.
- Quicker response to changes in demand and in the master schedule.
- Productivity can be increased by 5 to 30% through MRP. Labor requirements are reduced correspondingly.
- Reduced setup and product changeover costs.
- Better machine utilization.
- Increased sales and reduction in sales price.

MRP is not a system. It is simply one technique in a system. The success in its use depends on many factors defined before [Groover, 351]. The following contribute to the reasons for the lack of success in the use of MRP:

1. It is part of an incomplete system
2. It is driven by an invalid or mismanaged MPS
3. Data are inaccurate
4. Bills of material are structured improperly
5. Users are under qualified

## 2.7. Capacity Requirements Planning

Capacity planning defines the number of workers, machines and other resources to satisfy the planned production. The planned capacity must be translated to a common measure that is common to the mix of products encountered.

There are many factors that affect capacity. Some factors are completely under management control, while others are not. The management controlled factors include [Tersine,367]:

1. land
2. labor
3. facilities
4. machines
5. tooling
6. shifts worked per day
7. days worked per week
8. overtime
9. subcontracting
10. preventive maintenance

Other less controllable factors include:

1. absenteeism
2. personnel turnover
3. labor performance
4. equipment breakdown
5. scrap and rework

Capacity can be affected in any of the factors above.

In Rough Cut Capacity Planning the capacity control for the plant is done with the help of the Master Production Schedule. If the capacity is enough then a Material Requirements Plan is done. Open shop orders and planned orders in the MRP system are input to the CRP which translates these orders into hours of work by work center by time period [Fogarty,430].

Capacity Requirements Planning is a detailed comparison of the capacity required by the material requirements plan and by orders currently in progress versus available capacity. CRP verifies that there is sufficient capacity to process all orders due to be released within the planning horizon. If the MPS is accepted after the control of RCCP, CRP defines the load that is expected at each working center during each time period.

Capacity planning is the most detailed, complete, and accurate of the capacity planning technique. This accuracy is most important in the immediate time periods. Because of the detail, the data and the computation required are great.

### **2.7.1. Inputs to CRP**

The inputs to the CRP are open-shop orders, planned order releases, routings, time standards, lead times, and work center capacities. The information can be obtained by:



**Open order file:** An open shop order appears as a scheduled receipt on the MRP. It is a released order for quantity of a part to be manufactured and completed on a specific date. It shows all information such as quantities, due dates, and operations [Arnold, 80].

**Planned order releases:** Planned orders are determined by the computer's MRP logic based upon the gross requirements for a particular part. They are inputs to the CRP process in determining the total capacity required in future time periods [Arnold, 80].

**Routing file:** A routing is the path that work follows from work center to work center as it is completed. Routing is specified on a route sheet or, in a computer-based system, in a route file. One should exist for every component manufactured and contain the following information [Arnold, 80]:

- Operations to be performed
- Sequence of operations
- Work centers to be used
- Possible alternate work centers
- Tooling needed at each operation
- Setup times and run times per piece

**Work center file:** A work center is a particular production facility of one or more machines and/or people each of which performs the same functions and has the same capacity. A work center file contains information on the capacity and moves, wait, and queue associated with the center.

The move time is the time normally taken to move material from one work station to another. The wait time is the time a job is at a work center after completion and before being moved. The queue time is the time a job waits at a work center before being worked on. Lead time is the sum of queue, setup, run, wait, and move times [Arnold, 81].

### 2.7.2. Use of CRP

It is very easy to make a Capacity requirements plan. Planned order releases are taken from the MRP and a deterministic simulation that uses lead time offsets to find out real time passed through each work station is done.

First of all the work centers for each production type must be defined in turn. The availability, utilization, efficiency for each work station must be known. The important two things are the "Setup Time per Lot" and "Run Time per Piece".

**Setup Time/Lot:** It defines the setup time for the machinery, place, equipment, workers etc. All of the lot is processed after the setup. This setup time is not exactly considered in Rough Cut Capacity Planning.

**Run Time/Piece:** This is the time for producing one unit of item in one work center.

Capacity Requirements computation requires calculation of the setup time and run time separately. The setup time matrices are directly calculated from the planned order releases in MRP [Fogarty, 435]. When an order is released the standard setup time is written for that work station. Also the lead times make a shift for the next working station. The same calculation is done for the run time but the number of pieces are multiplied with the run time/piece. For each period the sum of each working station's capacity is taken. In order to have an exact calculation we

must take care of the capacity required by released orders. If there is a scheduled receipt for any product the setup and run time calculations must be done. Total sums of the three calculations give the capacity requirements of each work station for a given period.

### **2.7.3. Forward and Backward Scheduling**

Forward and backward scheduling are the two terms frequently associated with the capacity requirements planning. In *forward scheduling* activities start at the planned released date and move forward in time. In *backward scheduling*, activities start at the planned receipt date and move backward in time.

If operation lead times add to the job lead time and operation time is assumed to occur at the end of the operation lead time, then forward scheduling and backward scheduling yield the same result. Some commercial and CRP systems use forward scheduling, others use backward scheduling. As long as the concepts are applied properly, the choice is not significant [Fogarty,439].

# CHAPTER THREE

## ANALYSIS

### 3.1. ABC Analysis

In order to make an inventory management, materials must be classified. ABC analysis is done for the company called "Tacer" according to the annual dollar volume of the transactions. ABC classification is done considering years "1991, 1992, 1993".

#### 3.1.1 Procedure for ABC Classification

First of all, daily sales records are organized and they are put into monthly sales. Unit cost of all items those are sold in July is converted to US dollars by dividing the prices to the number "30,800" ( 1\$ is assumed to be 30800 TL in July) to have a constant unit price. It is assumed that the inflation rate in US dollar is negligible. The annual dollar sales of each item is found by multiplying the unit cost with the annual usage. The percentage effect of each item is found by dividing the annual dollar sales of each item to the total annual dollar sales. The items are listed from ascending to descending order and 20-30-50 percent criteria is accepted for classifying the class A-B-C items accordingly (see Table 1 of App.). The following results are obtained for each year according to the percentage in annual sales.

### 3.1.1.1. ABC Classes in 1991

#### **Class A items:**

- Panel
- 1x40Watt
- Cita

They turned out to be the Class A items. 20 percent of the total items cost 77 percent of the total usage.

#### **Class B items:**

- Ikiz panel
- U Profil
- Tas-U
- Tel
- Yay

They turned out to be the Class B items. 30 percent of the total items cost 20 percent of the total usage.

#### **Class C items:**

- 2x40Watt
- Dubel 6
- Halojen
- Kulak
- 1x20Watt
- 2x20Watt
- Piton
- Vida 20x35

They turned out to be Class C items. 50 percent of the total items cost 3 percent of the total usage.

### 3.1.1.2 ABC Classes in 1992

#### **In 1992:**

#### **Class A items:**

- Panel
- Cita

- 1x40Watt
- İkiz Panel

They turned out to be the Class A items. 20 percent of the total items cost 76 percent of the total usage.

**Class B items:**

- Kenar U
- Ara Kayit
- Ana Tasiyici
- 1x20Watt
- Tavan C
- Tas U

They turned out to be the Class B items. 30 percent of the total items cost 18 percent of the total usage.

**Class C items:**

- Tavan U
- L Profil
- Tel
- T sürgüsü
- Halojen
- Kulak
- Yay
- Vida
- 20x35
- Dubel 6
- Piton

They turned out to be Class C items. 50 percent of the total items cost 6 percent of the total usage.

### 3.1.1.3. ABC Classes in 1993

**In 1993:**

**Class A items:**

- Panel
- 1x40Watt
- Cita
- İkiz Panel
- Kenar U
- Tasyunu
- Tas U
- Alcipan

They turned out to be the Class A items. 20 percent of the total items cost 79 percent of the total usage.

**Class B items:**

- Trapez 0.70
- Delikli pano
- Ara kayıt
- Tavan C
- L profil
- C75
- Patlatma
- Yay
- Ana tasiyici
- Tavan U
- U75
- Tel
- 1\*20 watt

They turned out to be the Class A items. 30 percent of the total items cost 17 percent of the total usage.

**Class C items:**

- Pul
- Ek parcasi
- T surgusu
- Vida 22\*45
- Borazan 35
- Dubel 8
- Piton
- Izocam
- 2\*20 watt
- Halojen
- Klips
- Kulak
- Fuga gibis
- Vida 20\*35
- Borazan 25
- Dubel 6
- Agraf
- Derz bandi
- Kanca takimi
- 4\*20 watt
- Masa

They turned out to be the Class C items. 50 percent of the total items cost 4 percent of the total usage.

### **3.1.2. Evaluation of ABC Analysis**

The number of items used in the firm's inventory increased over the years from "16" to "21" then to "43" . The reason for this is adding new products to the product line. "Alcipan" and "Tasyunu" that are introduced with their related sub items to the market in 1993 has increased the product number. The item called "Ikiz panel" which was class B in 1991 became a class A item in years 1992 and 1993. This product was introduced to the market in 1990. As "Ikiz panel" was not known well in the market, its sales were not so high for the first two years. Increasing demand for "Ikiz panel" turned it out to be a class A item for 1992-1993.

Items "Panel, Cita, 1x40 Watt" are always in Class A items. These products are first introduced in 1985 to the market but they have not reached to the maturity or decline yet . Demand for these items are still increasing.

Increasing the number of materials shows that a classification must be done to control the inventory easily and correctly. It is not in the program to add new items to the product line for 1994. It is assumed that Class A items will be in the same class for the year 1994 because they are the main products and none of the product life cycles are reached to maturity. So we will deal with Class A items in 1993 and try to control them.

### **3.2. Forecasting for 1994**

In order to plan future, we must have some data at hand. This can be done by forecasting. The demand graphs of 3 years (1991-1992-1993) of Class A items



Panel, Cita, 1x40Watt, Ikiz Panel, Kenar U, Tasyunu, U Tasiyici, Alcipan are analyzed accordingly . In order to forecast the year 1994 month by month, the best forecasting technique is tested for the year 1993.

### 3.2.1. Forecasting Techniques for 1994

We have the demand data of the products for 1991-1992-1993. The data of 1991-1992 are used to find a forecasting technique for 1993. Then the forecasts and actual demands of 1993 are analyzed. The minimum MAD value is accepted the best forecasting technique for 1994.

Seasonal indexes are found by finding the ratio of each month to the total demand. For each product the monthly demand of 1991-1992-1993 are summed up and divided to the sum of the three years.

$$\text{Seasonal index of month (i)} = \frac{1991(\text{month}(i)) + 1992(\text{month}(i)) + 1993(\text{month}(i))}{1991(\sum_{i=1}^{12} \text{month}(i)) + 1992(\sum_{i=1}^{12} \text{month}(i)) + 1993(\sum_{i=1}^{12} \text{month}(i))}$$

i = 1 to 12 where 1 is January, 12 is December

Then three month and six month moving averages are taken for each item. To decrease the error in forecasts the exponential smoothing factors and seasonality indexes are added to the calculation of the moving averages. In order to find the best exponential smoothing factor for each item, numbers starting from 0 and increasing 0.1 steps up to 1 is tried one by one. When the MAD has reached to a minimum number the @ (exponential smoothing factor) at that time is accepted the best exponential smoothing factor for that item. Also the bias and the random variation are found for each month. Adding the best exponential factor to the moving averages it is tried to minimize MAD by calculating with the seasonal

indexes for three and six month moving averages. The MAD of both results are compared and the minimum MAD result is accepted as the best forecasting technique for that product. The same forecasting method is accepted for the year 1994.

Every item's forecasting technique is different from the other. For example for "item A" 3 month moving average having 0.5 exponential smoothing factor and multiplying its seasonal factor for each month; For "item B" 6 month moving average having 0.8 exponential smoothing factor and different seasonal factors for each month are accepted the forecasting method for 1994. For example the item IKIZ forecasting technique is found to be like:

3 month moving averages having an exponential factor of 0.7 and seasonality factors for each month and a MAD of 1226.3 .

### 3.2.2. Forecasting of 1994

In order to forecast the year 1994 month by month, the minimum MAD calculation method is taken. The same seasonality and exponential factors which are found for the forecast of 1993 are accepted (see Table 8).

TABLE 8 MAD AND @ VALUES OF ITEMS

	UTAS	PANEL	1X40	IKIZ	CITA	U-PROF
<b>6 M.MOVING AVERAGES(MAD)</b>	1405	7792	174	1357	5267	956
<b>6 M.MOVING AVERAGES(@)</b>	0.3	0.7	0.7	0.7	0.2	0.3
<b>3 M.MOVING AVERAGES(MAD)</b>	1350	8577	172	1226	5452	1004
<b>3 M.MOVING AVERAGES(@)</b>	0.4	0.6	0.7	0.7	0.7	0.3
M relates to month						

The forecast of 1994 is done for the whole year. Because of this we don't have actual demand data for calculating moving averages. Last forecast value is accepted the actual value for the next month moving average technique.

$$F_i = \frac{D_{i-3} + F_{i-2} + F_{i-1}}{3}$$

$D_i$  = actual demand

$F_i$  = forecasted demand

$i = 1$  to 12 where 1 is January, 12 is December

We do not have data for the years' 1991-1992 because alcipan and tasyunu are new products. Seasonal indexes are found from the data of 1993. The exponential smoothing factor is accepted as 0.7 ( the most used exponential smoothing factor in other products' forecasts) (see Table 2 of App.).

The forecasting for the year 1994 is made for finding out the Master Production Schedule and Material Requirements Planning.

### **3.3. Production Planning for 1994**

Demand strategy is a good production way if there is sufficient capacity but good customer service is important. Customers want to get the products in a short time. They can prefer other companies because of long production lead times. Also in an inflationary system selling a product if it is not present on hand can cause big losses for the company. Because of these reasons it is not a good way to use the "demand strategy".

It is very useful for the company to have a constant production rate because it minimizes the cost of inventory and cost of production. But having a constant

production rate is not so easy as the demand is not constant in each period. So efforts must be spent on controlling the inventory to decrease the cost of production.

It can be useful to subcontract with third party companies for some items. If these companies are big enough to stock every necessary item, then there is small probability for stocking out. Items can be supplied from these companies whenever they are necessary without an inventory holding cost. The disadvantage for this may be the high purchase prices. The company should make the judgement to sell the lowest possible price. This judgement is based on comparing the cost of inventory and the purchase price.

### **3.4. Master Production Schedule for 1994**

First of all forecasts of 1994 is taken in order to determine the MPS for the Class A items in 1994. In order to determine the quantities and components of the final products, multilevel tree structures of items are determined. The starting inventories for each item of the year 1994 is taken from the company's records (POH).

#### **3.4.1. MPS Calculations for 1994**

Two MPS calculations are done. They are explained in the next two sections.

##### **3.4.1.1. 1994 MPS Calculations**

Firstly the production is kept to zero and the required production for the whole year is observed. For planning the first MPS, it is assumed that the product is made

to stock ( a limited number of items are assembled from many components), an inventory is kept, and the product is made in lots or batches (see Table 3 of App.). 61000 mt. for panel, 1500 pieces for 1x40, 40000 mt for cita, 15000 mt for ikiz, 2500 mt for utas, 8000 mt for kenar u, 4000m<sup>2</sup> for tasyunu, 10000m<sup>2</sup> for alcipan are accepted the lots for the class A items. As the tasyunu and alcipan are not produced but bought from vendors just the order points of those items are defined in the MPS (See Table 3 of App.).

#### **3.4.1.1.1. MPS for Alcipan and Tasyunu**

The items Tasyunu and Alcipan are readily bought from the vendors. The lead time to get the product is very short. These items need a large place to stock. Vendors have the ability to hold the products and when it is needed they are able to send them quickly. In order to get a big discount from the sales prices Tasyunu must be ordered minimum 4000 m<sup>2</sup>. The same condition is true for Alcipan for 5000 m<sup>2</sup>. In these conditions it is tried to minimize the holding cost by zero inventories on hand ( See Table 3 of App.).

#### **3.4.1.2. 1994 Revised MPS Calculations (Panel-Kenar U-1x40Watt-Cita-Ikiz-Utas)**

It is seen that the production must be heavily done in some months and the workers must stay idle for the following months ( see Table 3 of App.). In order to decrease the shortfall for each month it is tried to shift some part of the schedule to

the next month. The starting inventories (POH) are high for some items. The inventory holding cost can be costly for those items so it is decided that the ending inventory for each item will decrease to a number.

### **3.4.2. Safety Stocks and Ending Inventories**

The starting inventories are decreased to 43750 to 11000 meters for Panel, 350 to 300 pieces for 1x40, 26000 to 10000 meters for Cita, 12500 to 1000 meters for Uprof, 3800 to 1000 meters for Utas. A safety stock of 11000 meters for Panel, 300 pieces for 1x40, 1800 meters for Cita, 1000 meters for Kenar U, 200 meters for Utas are defined. Just for the Ikiz panel the ending inventory is increased from 750 meters to 4000 meters because there is an increase in demand for that item for the next year ( Ikiz panel is used in gas stations and Petrol Ofisi had decided to modern its stations in 1995 ) (see Table 3 of App.).

### **3.5. Rough Cut Capacity Planning for 1994**

After the MPS, the capacity must be controlled if it is feasible or not. If the capacity is not feasible the Master Production Schedule must be revised or some precautions must put into the system to hold the production enough. The capacity control for MPS is done by Rough Cut Capacity Planning (RCCP).

#### **3.5.1. Developing a RCCP Schedule**

In order to make a RCCP the bill of labor for each product must be determined. The production schedule is defined for each item. The following work centers are used for each item as follows:

**PANEL:** DILME - BUKME - ASTARLAMA - BOYAMA - KURUMA-  
PAKETLEME

**CITA:** BUKME - ASTARLAMA - BOYAMA - KURUMA - PAKETLEME

**1X40:** ELOKSAL - KESME - PRES - MONTAJ - PAKETLEME

**IKIZ:** BUKME - ASTARLAMA - BOYAMA - KURUMA- PAKETLEME

**KENAR U:** ASTARLAMA - BOYAMA - KURUMA- PAKETLEME

**U-TAS:** PRES - ASTARLAMA - BOYAMA - KURUMA- PAKETLEME

The unit production time for one unit item is defined for each product ( see Table 4 of App.). The unit production time is calculated by measuring the work centers during production. The measurement is done for two weeks and the average time is accepted for the unit production time.

### **3.5.2. RCCP Techniques**

Bill of Labor method is used in the case study. Lead times are maximum one - two weeks (see Table 4 of App.). MPS periods are accepted as months. So we can not analyze the lead times in Resource Profile Approach method. Also time standard for each work station is known so we can get more precise answers from the BOL Approach. The Bill of Labor for each product in each work station is taken out by observation. The efficiency and utilization factors are thought to be 100 percent. In the past 5 years experience there was not big machine or production problems (maximum 1-2 hours during whole month). The measurements are done taking care of the utilization and efficiency. In case of changing the production method or product types the time standards will be revised in the future.

### **3.5.2.1. RCCP Using Bill of Labor Approach**

In Bill of Labor Approach the MPS outputs are multiplied by the standard production unit times of each item. Then the separate working center capacity requirements are summed up to find a total capacity for each work center. All calculations are done in minutes. Then they are adapted to days by dividing the results to 60 minutes and 8 hours ( There is 8 hour working time in one day). For each month the results are compared to 24 work days. If the results are greater than 24 there seems to be a capacity problem in that work center.

### **3.5.3. RCCP Decisions**

In this section we discuss how to determine the capacity problems and the solutions for them.

#### **3.5.3.1. Determining the capacity problems**

When we look capacity for each work center there is big problem in painting work station and there can be some small problems in bükme work station.

The capacity is two times bigger than the work station capacity for 8 hours (accepted work hour in one day) in painting work station (see Table 9). Efficiency and the utilization factors for that work station must also be considered. We have accepted the efficiency factor is 1. Machine break downs or absent workers may cause a problem in utilization. There are 3 (one working, two unused painting machines) on hand so there is no problem with the machines. Also all the workers are capable of working in the painting section because all of them are working turn by turn in order to learn to use all the machines in production.



In bükme work station the capacity is not enough in May and July (see Table 9). Efficiency and utilization factors are accepted as one. There are 2 "bükme machines" and all workers are capable of working in this station.

TABLE 9 RCCP PROBLEM IN 1994

(DAYS)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DILME	5.5	6.8	7.8	8.1	4.9	5.8	6.6	9.3	9	8.9	3	9.8
BUKME	13.7	16	21	19.9	24	14.1	25.3	17.2	16.7	16.5	22.1	18.2
ELOKSAL	3.8	3.8	2.5	2.5	5	5	0	3.8	3.8	1	0.9	3.7
PRES	0.7	0.7	1.5	2.1	1	1	2.6	0.7	0.7	1.8	2	0.7
MONTAJ	6.8	6.8	4.5	4.5	9	9	0	6.8	6.8	1.8	1.6	6.7
BOY+ASTAR	34.8	44.5	53.4	50.8	59.1	35.9	65.3	45.7	49.6	50.3	49.7	50.8
KURUMA	7	8.9	11.1	10.5	13.1	7.2	14.1	8.9	9.5	9.6	11.4	9.8
PAKETLEME	7.8	9.3	10.4	10.1	10.7	8.1	11.6	9.9	10.5	10.4	9	10.9
KESME	0.3	0.3	0.2	0.2	0.4	0.4	0	0.3	0.3	0.1	0.1	0.3

### 3.5.3.2. Solutions for Capacity Problems in RCCP

The solutions for the capacity problems for painting station can be as follows:

If the capacity is not feasible for the present MPS, the MPS can be revised for the second time. In this case the production is nearly twice of the capacity so shifting the production schedule can never be a solution (see Table 9).

The need for the capacity increase in painting work center is two times larger than the present so overtime working with the same workers is not feasible.

There is not another painting station for increasing the capacity. Building a new painting station can be a good solution but there is a space problem in the factory that it is impossible to build a new one.

The best way for increasing the capacity is adding new workers to the painting station. These new workers will work after the official work hours. Official work hour finishes at 5:00 o'clock P.M.. Second painting group must start at 5 P.M. and finish at 1 o'clock A.M. For some months (March, May, April, July, October, December) also subcontracting with another company is a solution for increasing capacity. The painting procedure is easy that the quality difference can not cause a big problem. It can just increase the cost of the material.

The solutions for the capacity problems for bükme station can be as follows:

The capacity and the production difference is very small for bükme work station. There seems to be a capacity increase in bükme work station in July (see Table 9). The easy way is overtime working. There is a need for 1.3 days. This can be done working 30 minutes more for one month or working two Sundays in July.

### **3.6. Material Requirements Planning for 1994**

If the RCCP analysis is feasible that means MPS is accepted. In Material requirements planning raw materials and components used in MPS end products are scheduled.

#### **3.6.1. Developing an MRP for 1994**

For making an MRP table we have to compute the lot size, lead time, on hand, safety stock, allocation, level code data for each item. Inventory on hand and the lot sizes are computed from the companies' records. Level code data is defined

from the bill of labor of each product (See Table 5 in App.). Allocation is zero for all the products. The safety stock is assumed to be zero because in MPS the products are scheduled by make to stock basis. Also the economy factor in forecasting is not calculated. The economy factor looks like to decrease in demand so the forecasts are overestimated. There seems to be an overestimated inventory on hand. The lead times are calculated by taking the average of the last years order lead times.

### 3.6.2. MRP Calculations

The bills of material for class A items are observed. The dependent demands of the sub items are calculated from the main products. For example for panel 0.16 kg of 110 mm. aluminium is needed. The requirement of 110 mm. aluminium is found by multiplying 0.16 kg with the requirement of panel at that period. Backward scheduling is done for planned order releases considering the lead times.

The common use items for all Class A products in their low level code are found as:

- Paint, Astar, Tiner are found to be the common use items for Panel-Cita-Kenar U-Ikiz-Tas U.
- U-Profile is found to be the common use item for Kenar U and Tas U

The common use items are calculated for all the items related with them and they are summed up. At first the MRP tables of Panel-Cita-Kenar U-Ikiz-Tas U are examined. After the calculations, with the help of the bill of material the need for

the paint, Astar, Tiner are examined. Also because of the correlation between Kenar U and Tas U, U profile is calculated later (see Table 5 in App.).

The lot sizes are kept constant for each item. The same calculations are done for 1x40 Watt also (see Table 5 in App.). Other items Alcipan and Tasyunu are not calculated because they are directly bought from outside sellers. Alcipan and Tasyunu are always in stock of the vendors so the order lead time is very short. For tasyunu the transportation time (also the lead time) is one day, for alcipan the transportation time (also the lead time) is 3 hours.

In MPS calculations, months are accepted for time periods but the lead times for the materials are shorter than a month. So 12 months are accepted to be 48 weeks and the production during each week is required to be 25% of each month.

### **3.7. Capacity Requirements Planning for 1994**

After the Material Requirements Planning the capacity is controlled again by Capacity Requirements Planning. The time requirement for each work center is examined more detailed than RCCP.

#### **3.7.1. Developing an MRP for 1994**

In order to define the setup time per lot and runtime per product values for each product an observation is done for a month. Everyday the setup and run times for work centers for each work center is calculated and the average of each work center is accepted for the setup time per lot. For panel, measurements are done in "dilme" work center as follows:

**Setup time/lot** = "Dilme" machine is connected to the electricity + Aluminium sheets are transported from the storehouse + Aluminium sheets are connected to the "dilme" machine + Some sensitive tests are done for correct process = 30 MIN.

**Run time/piece** = "Dilme" machine is starts to cut the aluminium sheets to pieces + Aluminium pieces are attached to a cylinder + "Dilme" machine stops + Aluminium pieces are taken out from the cylinder = 2 MIN.

Note that at the same time 10 meters of panel is processed so  $2/10 = 0.2$  MIN.

### 3.7.2. Calculating the CRP matrices

Using the MRP calculations the Setup Time matrices, Run Time matrices, capacity requirements of planned releases, capacity required by released orders, and CRP is done.

#### 3.7.2.1. Setup Time matrices

A matrice is defined after calculating the setup times for each product . The setup time is present when the planned order releases in MRP appear. In rows work centers, in columns weeks (periods) are defined in the matrice. The lead time for each process is one week. The process order is defined with setup and run time table (see Table 6 in App.). For the same product second work station set up time occurs one period later from the first work station because of the one week lead time. After these different setup times appearing in the same period, they are summed for a total setup time for each period. (see Table 6 in App.). For example for panel the setup time matrice occurs for dilme and bukme as follows (see Table 10).

TABLE 10 SETUP TIME MATRICE FOR PANEL (DILME&BUKME)

ITEM	WORK CENTER	SETUP TIME/LOT		RUN TIME/PIECE			
PANEL	DILME	30	MIN.	0.2	MIN.		
	BUKME	20	MIN.	0.15	MIN.		
W.C.	PART	WEEK1	WEEK2	WEEK3	WEEK4	WEEK5	WEEK6
PLAN.ORD.REL						7950mt.	9850mt.
DILME	PANEL	0	0	0	0	30 min.	30 min.
BUKME	PANEL	0	0	0	0	0	20 min.

3.7.2.2. Run Time matrice

The run time matrice periods and work centers are the same in the matrice but the quantity of the material in the MRP is multiplied with the run time per piece for each product. After the multiplications, the numbers are summed for the total run time matrice. For example for panel the run time matrice occurs for dilme and bukme as follows (see Table 11).

TABLE 11 RUN TIME MATRICE FOR PANEL (DILME&BUKME)

ITEM	WORK CENTER	SETUP TIME/LOT		RUN TIME/PIECE			
PANEL	DILME	30	MIN.	0.2	MIN.		
	BUKME	20	MIN.	0.15	MIN.		
W.C.	PART	WEEK1	WEEK2	WEEK3	WEEK4	WEEK5	WEEK6
DILME	PANEL					1590mt.	1970mt.
	TOTAL	0	0	0	0	1590mt.	1970mt.
BUKME	PANEL	0	0	0	0	0	1192mt.

### 3.7.2.3. Capacity Requirements by Released Orders

On the first time periods the scheduled receipts (they satisfy the demand on the first periods) appear as the planned order releases. For a better capacity planning the scheduled receipts must be calculated both for the run time and setup time. Just Ikiz panel has a scheduled receipt on the first week. The capacity is calculated as follows (see Table 12).

TABLE 12 RELEASED ORDER CAPACITY FOR IKIZ

RELEASED ORDER CAPACITY REQUIREMENTS						
WC	WEEK1	WEEK2	WEEK3	WEEK4	WEEK5	WEEK6
BUKME	400mt.	0	0	0	0	0
BOYAMA	0	390mt.	0	520mt.	0	0
KURUMA	0	0	50010mt.	0	150010mt.	0
PAKETLEME	0	0	0	0	62.5mt.	215mt.
ELOKSAL	42080mt.	0	0	0	0	0
KESME	0	77.5mt.	0	0	0	0
PRES	0	0	200mt.	0	0	0
MONTAJ	0	0	0	1540mt.	0	0

### 3.7.2.4. Capacity Requirements Plan

The capacity required by the planned order releases is now added to the capacity required by orders already released to the shop to produce the capacity requirements plan (see Table 6 in App.).

### **3.7.3. Capacity problems in CRP**

One week is taken for each period and 48 weeks are accepted for the working time. The final capacity requirements planning values are changed to days by dividing the minutes to 480. The numbers greater than 6 (working days in a week) have some capacity problems in their work centers. There seem to be some problems in the painting and shaping work centers. A similar result is also found in RCCP before.

### **3.7.4. Capacity Balancing**

There are two ways of balancing the available capacity and load. First one is shifting orders ahead or back so the load is leveled. It can easily be seen on the table that the capacity is not enough for the whole period for painting work station. Changing the capacity is the second solution and it is explained before in the RCCP. The best solution for painting station is adding personnel to the painting station and they work more eight hours. For some weeks (required capacity larger than 12 days) if the capacity is not enough subcontracting with another company is feasible. For the shaping work station shifting orders ahead or back can be a cheap solution (for the weeks 16,24-28).

## **3.8. Financial Analysis**

In order to have a complete plan for the future we must control the financial part of our plans. Everything can be perfect in production and capacity planning but the finance of the materials required in the system can be impossible.



When the materials or sub-items are required in a period the money for them must be in hand that the firm can get the number of materials at the exact time. If there is a finance problem (money turnover can be long) the expenses can not be paid. It can be impossible to buy inventories or to fix machines.

### **3.8.1. Evaluating the Financial Analysis**

Analyzing the financial power of the company is very easy and straight forward. All of the calculations before are done in US. dollars. The same thing is done for the financial analysis.

Firstly all the items in the inventory are listed one by one. Most of the items are sub-materials or correlated products with class A items. As we have the forecasts of 1994 for class A items, the correlation factors are multiplied with the forecasted class A items. For example a correlation factor of:

"1/0.37" is used for Ana Tasiyici that is correlated with Tasyunu. In order to construct 1 m<sup>2</sup> of "Tasyunu ceiling" ,1m<sup>2</sup> of tasyunu and 1/0.37 mt. Ana Tasiyici are needed (see Table 13).

"4" is used for Ara Kayit which is correlated with Tasyunu. In order to construct 1 m<sup>2</sup> of "Tasyunu ceiling" ,1m<sup>2</sup> of tasyunu and 4 pieces of Ara Kayit are needed. All of these correlation numbers are found from the "Malzeme Rayic Listeleri" book published by the government.

TABLE 13 FINANCIAL CALCULATIONS (DEPENDENT ITEMS)

		WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6
<b>Demand</b>	<b>TASYUNU</b>	250 m2	250 m2	250 m2	250 m2	250 m2	250 m2
<b>Demand</b>	<b>ANA TASIYICI</b>	676 mt.	676 mt.	676 mt.	676 mt.	676 mt.	676 mt.
<b>Cost</b>	<b>0.87/mt</b>	\$ 588	\$ 588	\$ 588	\$ 588	\$ 588	\$ 588
<b>Demand</b>	<b>ARA KAYIT</b>	1000 pcs.	1000 pcs.	1000 pcs.	1000 pcs.	1000 pcs.	1000 pcs.
<b>Cost</b>	<b>0.53/pcs</b>	\$ 530	\$ 530	\$ 530	\$ 530	\$ 530	\$ 530

Of course there are some products that are totally independent like Trapez 0.70mm. Independent items assumed to be the same like 1993. The analysis is done according to the 48 weeks because MRP is done for 48 weeks. The prices of each item are transferred to US. dollars (calculated before in ABC analysis).

Last years' records of "money collected" day by day is taken from the companies old records. Regarding the inflation all of the money is transferred to July of 1994. The ratios are taken from the *Consumer price index of 1993*. In our all calculations 1\$ is accepted as 30800 TL. (July price of dollar). The total Turkish liras are divided to 30800 to find the numbers in dollar basis. Also the trend factor is multiplied with all the "money collected from customers". The trend is calculated as:

Total annual dollar sales of 1994/Total annual dollar sales of 1993 = Trend factor

1.305.509\$/1.007.518\$ = 1.2957 Trend factor

Weekly money needed for buying the required materials is changed to months in order to compare with "money collected from customers". The differences between the months show that the money collected is enough to organize our production and capacity plans (see Table 7).

## CHAPTER 4

### SUMMARY, CONCLUSION AND RECOMMENDATIONS

#### 4.1. Summary

A company's inventory management is planned and controlled in the overall analysis . Important items are separated from the others by ABC inventory classification. Items are listed according to their annual sales. Class A items are taken for planning production, capacity, and finance for the year 1994.

Forecasts of class A items are calculated for twelve months. These forecasts are the inputs for Master Production Scheduling. After master scheduling a rough cut capacity technique called "Bill of Labor" is used to control the capacity. Some capacity problems appeared in rough cut capacity planning.

Material requirements planning is calculated for class A items. The output of MRP is used for a more detailed capacity control technique, called Capacity Requirements Planning. The same problems are seen in capacity requirements planning.

Financial costs of all inventory items are calculated after examining production and capacity plans of the company. Results of financial costs are compared with the financial power of the company.

#### **4.2. Conclusion**

After rough cut capacity planning and capacity requirements planning, some capacity problems were observed in "painting" and "bükme" work stations.

These work stations must be controlled more frequently in the future plans. Some solutions for the capacity problems are explained in analysis chapter.

In the financial analysis part, the companies purchase power is calculated and found sufficient for MPS and MRP.

#### **4.3. Recommendations**

In addition to previous work, there are some points to be recommended to achieve better solutions in the future. These points can be summarized as follows;

In order to classify the items, materials' annual sales are organized from 1991 to 1993. All the data are taken from the daily sales records. The records have not been organized until today . All the data are stored in the computer. In all future plans, "Tacer" company needs these fundamental data. The company must keep the records in an organized manner. A coding system should be developed and records should be kept in electronical environments.

All of the calculations are undertaken according to the class A items in 1993. It is assumed that product line will be the same for 1994. Construction sector is changing year by year. Every year, lots of new products are being introduced to the market. The life cycle of a product can be short. A new product that is cheap and more useful than the old one can hold the market in a very short time. Because of all these things, a detailed market research must be done. The ABC classification must be done for the new products. The company can produce the same products or add new products to its product line. ABC analysis must take the feedback from the market research.

All of the products' unit costs are converted to US. dollars to have a constant unit price in the case study. It is assumed that the inflation rate is negligible in US. dollar. In fact, exact annual sales can be find by multiplying items with daily prices. Inflation effect can also be calculated but records are not kept seriously so it is not possible to find the daily prices of the items.

ABC classification is performed according to the annual sales volume. Other criteria such as unit cost or scarcity of material can be used for ABC classification. Decisions must be taken according to the company's management policies.

Good forecasts are useful for correct planning . In this thesis, one year forecasting is undertaken. This is a long forecasting period. Moving average technique is used for calculations. Forecasted data are used as input to the moving averages.

$$F_i = \frac{D_{i-3} + F_{i-2} + F_{i-1}}{3}$$

$D_i$  = actual demand

$F_i$  = forecasted demand

$i = 1$  to 12 where 1 is January, 12 is December

This will increase the forecast errors for later months.

Forecasting should also be performed monthly. Each month, actual output must be calculated and it must be compared with the forecasted data. When the difference exceeds a measure of reasonableness error, an investigation should be made to discover the cause of the error. If there is no apparent cause of error, then the method of forecasting should be reviewed to see if there is a better way to forecast.

In MPS a safety stock is determined . It is tried to decrease the inventory at the end of 1994 except "Ikiz" item. Using this data an MRP table is determined and cost of each item is analyzed in financial analysis table. There can be other levels of production techniques. These techniques can increase the productivity of the system. Also the company can respond to the variable demand immediately.

*Just-in-Time Manufacturing* is a new approach for production. It is the elimination of waste. Waste is defined as anything other than the minimum amount of equipment, parts, space, material, and workers' time that is absolutely necessary to add value to the product. This means there should be no surplus, there should be no safety stocks, and lead times should be minimum [Arnold, 216].

Just-in-time manufacturing should be modeled to the system. The comparisons should be made according to capacity, cost and product availability. Demand is variable in "Tacer case" so a simulation should be done. Responses of the models should be observed one by one on each basis.

Capacity is controlled by rough-cut capacity planning and capacity requirements planning. In both analyses, capacity was not available to hold the required production. Especially in "Painting" work station, serious problems seem to appear. Present capacity of painting work station can totally effect our production plans.

Short term solutions are explained in Rough-cut capacity planning and in capacity requirements planning. Long term decisions require detailed data and research. A good way of solving the capacity problem is using another machine in painting work station.

In the present case, using a second machine with the same capacity is not feasible because of the space problem. Also capacity should be twice more than the present capacity. If we want to produce new products, capacity will not be enough for future plans.

There is a high technology new painting work station in the market. Its capacity is four times more than the present painting machine's capacity. It costs nearly \$140,000. Also the paint used in the system is different. Present paint costs \$2.75/kg and new paint costs \$3.05/kg. Opposite to this, paint loss during painting

is less than the present one. For painting 1 Mt. of "Panel" item 0.150 kg paint is needed in the present system. New machine uses 0.120 kg for painting 1 Mt. of "Panel" item.

The company must choose among three decisions:

1. Increase capacity by working 8 hours more.
2. Buy a new high technology painting work station.
3. Buy the same working station and invest for increasing space by building a new place.

The company should not only consider short range profitability. Final decisions must consider the future aspects of the company too. These can be entering to new markets and competing with foreign companies with high quality products.

In this thesis, basic financial analysis is performed to the materials required by the company. The lot sizes are accepted to be the present lot orders. Exact calculations can be undertaken by considering the transportation , holding , ordering costs. Lot sizes can be reorganized using the data of detailed financial analysis.

Especially, solving the capacity problem of "Painting" work station lies in financial power of the company. Cost over profitability analysis should immediately be done. For the three solutions given above, the competition power of the company on cost-selling price basis should be given.

As a final issue to summarize all of these recommendations, "Tacer" company must immediately start to use the tools of *Inventory Management*.



## REFERENCES

1. Coyle, C. John Joseph, Bardi J. Langley, The Management of Business Logistics, 5th edition, 1992.
2. Hanke, John, Reitsch, Arthur G., Business Forecasting, Allyn & Bacon, 4th edition, 1992.
3. Anderson, David R., Sweeney, Dennis J., Williams, Thomas A., An Introduction to Management Systems, 6th edition, 1991.
4. Kress, George, Practical Techniques of Business Forecasts, 2nd edition, 1985.
5. Jarrett, Jeffrey, Business Forecasting Methods, 3rd edition, 1987.
6. Gessner, Robert A., Master Production Schedule Planning, Wiley Productions, 3rd edition, 1986.
7. Aft, Lawrence S., Production and Inventory Control, Technology Publications, 4th edition, 1987.
8. Magad, Eugene L., Total Materials Management, Van Nostrand Reinhold , 1989.
9. Fofarty, Blackstone, Hoffmann, Production & Inventory Management, Thomson Information, 2nd edition, 1991.
10. Arnold, J.R. Tony, Introduction to Materials Management, Prentice Hall, 1st edition, 1991.
11. Plossl, George W., Production and Inventory Control, Prentice Hall, 2nd edition, 1985.
12. Groover, Mikell P., Computer-Aided Design and Manufacturing, Prentice Hall, 1st edition, 1984.
13. Tersine, Richard J., Principles of Inventory and Materials Management, North-Holland, 3rd edition, 1988.

14. Shapiro, Alan C., Modern Corporate Finance, Maxwell Editions, 1st edition, 1991.

## **APPENDIX**

TABLE 1

## ABC CLASSIFICATION (1993)

Item (unit)	Unit Cost	Unit Usage	Units	Annual Usg.	Cumul.Usg.	Class	Percentage
	in dollars			in dollars	in dollars		
Panel (mt.)	\$ 0,77	505095 mt.		\$ 388.923	\$ 388.923	A	0,3860
Cita (mt.)	\$ 0,45	221452 mt.		\$ 99.653	\$ 488.577	A	0,4849
1x40 Watt (pcs.)	\$ 11,97	6908 pcs.		\$ 82.689	\$ 571.265	A	0,5670
lkiz Panel (mt.)	\$ 2,03	36980 mt.		\$ 75.069	\$ 646.335	A	0,6415
U Profil (mt.)	\$ 0,84	59040 m2		\$ 49.594	\$ 695.928	A	0,6907
Tasyunu (m2)	\$ 6,56	7365 mt.		\$ 48.314	\$ 744.243	A	0,7387
U Tasiyici (mt.)	\$ 0,84	38332 m2		\$ 32.199	\$ 776.442	A	0,7706
Alcipan (m2)	\$ 1,67	12500 m2		\$ 20.875	\$ 797.317	A	0,7913
Delikli Pano (m2)	\$ 20,62	994 m2		\$ 20.496	\$ 817.813	B	0,8117
Tavan C (mt.)	\$ 0,74	26753 mt.		\$ 19.797	\$ 837.610	B	0,8313
Trapez 0.70 (m2)	\$ 3,55	5452 m2		\$ 19.355	\$ 856.965	B	0,8505
Ana tasiyici (mt.)	\$ 0,87	19741 mt.		\$ 17.175	\$ 874.139	B	0,8676
Ara Kayit (pcs.)	\$ 0,53	28492 pcs.		\$ 15.101	\$ 889.240	B	0,8826
1*20 Watt (pcs.)	\$ 11,00	1239 pcs.		\$ 13.629	\$ 902.869	B	0,8961
Yay (pcs.)	\$ 0,21	64857 pcs.		\$ 13.620	\$ 916.489	B	0,9096
C 75 (mt.)	\$ 1,03	12270 mt.		\$ 12.638	\$ 929.127	B	0,9222
Tel (mt.)	\$ 0,22	56036 mt.		\$ 12.328	\$ 941.455	B	0,9344
L Profil (mt.)	\$ 0,84	11170 mt.		\$ 9.383	\$ 950.838	B	0,9437
Tavan U (mt.)	\$ 0,64	13661 mt.		\$ 8.743	\$ 959.581	B	0,9524
U 75 (mt.)	\$ 0,91	8697 mt.		\$ 7.914	\$ 967.495	B	0,9602
Patlatma (mt.)	\$ 0,53	12835 mt.		\$ 6.803	\$ 974.298	B	0,9670
Halojen (pcs.)	\$ 10,67	523 pcs.		\$ 5.580	\$ 979.878	C	0,9725
4x20 Watt (pcs.)	\$ 53,39	103 pcs.		\$ 5.499	\$ 985.377	C	0,9780
Masa (pcs.)	\$ 0,25	12757 pcs.		\$ 3.189	\$ 988.567	C	0,9812
Borazan 25 (pcs.)	\$ 0,01	308695 pcs.		\$ 3.087	\$ 991.654	C	0,9842
Piton (pcs.)	\$ 0,04	58037 pcs.		\$ 2.321	\$ 993.975	C	0,9865
Derz Bandi (mt.)	\$ 9,54	197 mt.		\$ 1.879	\$ 995.854	C	0,9884
Kanca takimi (pcs.)	\$ 0,43	4200 pcs.		\$ 1.806	\$ 997.660	C	0,9902
Kulak (pcs.)	\$ 0,05	33122 pcs.		\$ 1.656	\$ 999.317	C	0,9918
Klips (pcs.)	\$ 0,04	38294 pcs.		\$ 1.532	\$ 1.000.848	C	0,9933
Vida 20*35 (pcs.)	\$ 0,03	50534 pcs.		\$ 1.516	\$ 1.002.364	C	0,9949
Vida 22*45 (pcs.)	\$ 0,04	34649 pcs.		\$ 1.386	\$ 1.003.750	C	0,9962
Dübel 6 (pcs.)	\$ 0,01	100693 pcs.		\$ 1.007	\$ 1.004.757	C	0,9972
Fugagips (kg.)	\$ 0,14	4300 kg.		\$ 602	\$ 1.005.359	C	0,9978
Ek parçası (pcs.)	\$ 0,05	11791 pcs.		\$ 566	\$ 1.005.925	C	0,9984
Dübel 8 (pcs.)	\$ 0,01	42508 pcs.		\$ 425	\$ 1.006.350	C	0,9988
T sürgüsü (pcs.)	\$ 0,05	5776 pcs.		\$ 289	\$ 1.006.639	C	0,9991
2*20 Watt (pcs.)	\$ 14,56	17 pcs.		\$ 248	\$ 1.006.887	C	0,9993
Borazan 35 (pcs.)	\$ 0,02	10130 pcs.		\$ 203	\$ 1.007.089	C	0,9995
Pul (pcs.)	\$ 0,01	18521 pcs.		\$ 185	\$ 1.007.274	C	0,9997
Agraf (pcs.)	\$ 0,24	730 pcs.		\$ 175	\$ 1.007.450	C	0,9999
Percin (pcs.)	\$ 0,01	6800 pcs.		\$ 68	\$ 1.007.518	C	1,0000

TABLE 2

FORECAST SALES OF CLASS A ITEMS (1994)

@ = Exponential smoothing factor

A = 3 month moving average method

B = 6 month moving average method

UNIT	ITEM NAME							
	Panel	Cita	Ikiz panel	1x40 Watt	Rockwool	Gypsum	U Profile	U Carrier
	mt.	mt.	mt.	pcs.	m2	m2	mt.	mt.
@	0,7	0	1	1	1	1	0	0
A			X	X				X
B	X	X			X	X	X	
JAN	46926	15899	1975	863	974	1276	4793	934
FEB	30403	13014	1141	290	713	995	3984	831
MAR	37608	15428	4375	641	947	1212	4441	841
APR	38428	18925	2122	686	897	1169	3387	899
MAY	42482	20166	858	767	946	1280	3976	1246
JUN	37513	8831	8313	280	848	1195	4029	980
JUL	53810	17613	7263	654	1163	1446	4497	1159
AUG	45352	7328	936	602	1028	1338	5048	1090
SEP	64480	15096	402	654	1472	1921	7297	554
OCT	31176	11867	3140	369	702	924	3675	994
NOV	38666	8951	2151	554	866	1144	3963	645
DEC	60280	19828	6837	810	1352	1779	5847	852

TABLE 3

MASTER PRODUCTION SCHEDULE (1994)

	ITEMS								
		PANEL	1X40	CITA	IKIZ	UPROF	UTAS	TASYUNU	ALCIPAN
	UNIT	mt.	pcs.	mt.	mt.	mt.	mt.	m2	m2
P	JAN	32000	750	0	10000	0	0	4000	5000
L	FEB	39400	750	5000	5000	6000	0	0	0
A	MAR	45000	500	20000	0	2000	1000	0	0
N	APR	46800	500	15000	0	0	1500	0	0
N	MAY	28500	1000	40000	5000	8000	0	4000	5000
E	JUN	33300	1000	0	10000	0	0	0	0
D	JUL	38000	0	40000	0	8000	2500	0	0
P	AUG	53500	750	0	0		0	0	0
R	SEP	52000	750	0	0	8000	0	4000	5000
O	OCT	51500	200	0	0	8000	1500	0	0
D	NOV	17500	175	36946	12763		1725	0	0
U	DEC	56875	745	0	0	3437	0	0	5000
C									
T									
I									
O									
N									

TABLE 4

ROUGH CUT CAPACITY USING BILL OF LABOR APPROACH

		WORK CENTERS								
		SIZING	SHAPING	ELOKSAL	PRES	FITTING	PAINTING	HEATING	PACKAGE	CUTTING
JAN.	days (*)	5,5	13,7	3,8	0,7	6,8	34,8	7,0	7,8	0,3
FEB.	days	6,8	16,0	3,8	0,7	6,8	44,5	8,9	9,3	0,3
MAR.	days	7,8	21,0	2,5	1,5	4,5	53,4	11,1	10,4	0,2
APR.	days	8,1	19,9	2,5	2,1	4,5	50,8	10,5	10,1	0,2
MAY	days	4,9	24,0	5,0	1,0	9,0	59,1	13,1	10,7	0,4
JUN.	days	5,8	14,1	5,0	1,0	9,0	35,9	7,2	8,1	0,4
JUL.	days	6,6	25,3	0,0	2,6	0,0	65,3	14,1	11,6	0,0
AUG.	days	9,3	17,2	3,8	0,7	6,8	45,7	8,9	9,9	0,3
SEP.	days	9,0	16,7	3,8	0,7	6,8	49,6	9,5	10,5	0,3
OCT.	days	8,9	16,5	1,0	1,8	1,8	50,3	9,6	10,4	0,1
NOV.	days	3,0	22,1	0,9	2,0	1,6	49,7	11,4	9,0	0,1
DEC.	days	9,8	18,2	3,7	0,7	6,7	50,8	9,8	10,9	0,3

CAPACITY PROBLEMS

(\*) 24 DAYS ARE ACCEPTED TO BE THE OFFICIAL WORKING PERIOD IN ONE MONTH

TABLE 5

MATERIAL REQUIREMENTS PLAN (1994)

L.L.C.: Low level code

ITEMS	UNITS	LOT SIZE	ON HAND	L.L.C.	LEAD TIME	REQUIRED MATERIALS DUE TO MONTHS											
						JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
PANEL	mt.	1	43750	0	1	0	38900	45450	53925	29700	34475	51375	53125	51875	43000	27343	42654
110MM ALUM.	kg.	5000	6080	1	2	0	5000	10000	10000	5000	5000	10000	5000	5000	5000	5000	5000
CITA	mt.	1	26000	0	1	0	0	2750	24000	30000	10000	40000	0	0	9236	36944	0
KENAR U	mt.	1	12500	0	1	0	0	0	0	0	2000	6000	2000	8000	8000	860	2580
IKIZ	mt.	1	750	0	1	8750	3750	0	1250	5000	10000	0	0	0	3190	9570	0
30MM AL	kg.	2000	1000	1	2	0	0	0	0	0	2000	0	0	0	2000	0	0
300MM AL	kg.	2000	500	1	2	4000	0	0	2000	2000	2000	0	0	0	2000	4000	0
U-PROF	mt.	4000	3000	1	3	0	0	0	4000	0	8000	0	8000	8000	4000	4000	0
TAS-U	mt.	1	3800	0	1	0	0	0	0	0	0	1400	0	375	1557	1296	0
PAINT	kg.	5000	1500	1	3	10000	5000	10000	5000	10000	10000	5000	10000	5000	15000	5000	0
ASTAR	kg.	2500	500	1	1	2500	2500	0	2500	2500	2500	2500	2500	2500	2500	2500	2500
WASH-PRIMER	kg.	2000	250	2	3	2000	2000	2000	4000	2000	2000	2000	2000	2000	4000	2000	0
TINER	kg.	10000	700	2	1	10000	10000	10000	10000	10000	0	10000	10000	0	10000	0	0
HARDNER	kg.	500	100	2	3	0	500	0	500	0	0	500	0	500	0	0	0
1X40 WATT	pcs.	1	350	0	1	914	689	500	625	1000	750	188	752	614	194	319	561
AL LAMP	kg.	500	1000	1	1	0	1000	500	500	1000	1000	0	500	1000	0	500	500
LAMP PR.	kg.	500	1000	2	3	0	500	500	1000	1000	0	500	1000	0	0	1000	0
ELOKSAL	kg.	500	0	2	1	500	1000	500	500	1000	1000	0	500	1000	0	500	500
1X40 BALAST	pcs.	500	200	1	2	500	1000	500	500	1000	500	500	0	500	500	500	0
STARTER	pcs.	1000	400	1	2	1000	2000	0	1000	1000	1000	0	1000	0	0	1000	0
SOKET	pcs.	1500	500	1	1	1500	1500	1500	1500	1500	1500	0	1500	1500	1500	0	1500
CABLE	mt.	3000	2000	1	1	3000	0	3000	0	3000	3000	0	0	3000	0	0	3000
SOMUN	pcs.	10000	5000	1	1	10000	0	0	10000	0	10000	0	0	20000	0	0	0
CIVATA	pcs.	10000	5000	1	1	10000	0	0	10000	0	10000	0	0	20000	0	0	0
KLEMENS	pcs.	1000	200	1	1	1000	1000	0	1000	1000	1000	0	1000	0	1000	0	0
LAMP SR	pcs.	5000	1500	1	1	5000	5000	0	0	5000	5000	0	5000	0	0	0	5000
SAC	kg.	20000	2000	2	2	0	0	0	0	0	0	20000	0	0	0	0	0
GALVANIZ	kg.	20000	0	2	3	0	0	0	0	0	0	0	20000	0	0	0	0



TABLE 6

CAPACITY REQUIREMENTS PLAN (1994)

		WORK CENTERS								
		SIZING	SHAPING	ELOKSAL	PRES	FITTING	PAINTING	HEATING	PACKAG	CUTTING
JAN.	days (*)	0,00	3,78	6,34	1,12	6,42	5,42	0,31	0,00	0,60
FEB.	days	16,46	10,09	3,46	1,13	7,03	10,63	1,67	2,29	0,44
MAR.	days	19,19	15,12	2,51	0,97	5,90	15,04	0,85	1,32	0,36
APR.	days	17,84	22,00	3,14	0,92	4,77	21,39	2,53	0,36	0,36
MAY	days	12,63	20,31	5,01	1,23	7,01	56,75	9,89	1,74	0,52
JUN.	days	14,61	17,06	3,76	1,33	9,25	47,28	12,52	8,28	0,47
JUL.	days	17,70	24,67	0,94	1,98	4,63	61,60	11,71	9,58	0,05
AUG.	days	22,39	16,89	3,77	0,85	3,51	45,55	11,25	12,50	0,44
SEP.	days	21,86	16,42	3,08	1,58	7,03	39,24	6,65	7,05	0,44
OCT.	days	18,17	20,23	0,98	2,65	4,56	43,97	7,85	6,63	0,27
NOV.	days	11,64	17,53	1,61	2,19	1,98	62,88	12,37	7,16	0,26
DEC.	days	17,96	17,90	2,82	0,88	4,36	52,54	13,47	14,09	0,39

CAPACITY PROBLEM

(\*) 24 DAYS ARE ACCEPTED TO BE THE OFFICIAL WORKING PERIOD IN ONE MONTH

TABLE 7

FINANCIAL ANALYSIS (1994)

A: ACCORDING TO THE JULY PRICES(TL) MONEY COLLECTED FROM THE CUSTOMERS

B: ADAPTING TO THE INCREASE IN DEMAND ACCORDING TO FORECASTS(TL)

C: ADAPTING TO US DOLLARS

D: FORECASTED \$ COLLECTED

E: FORECASTED \$ NEEDED

F(i): MONEY LEFT (E(i)-D(i)+F(i-1)) WHERE 1=JANUARY, 12=DECEMBER

CR.: CURRENCY

M.O.H.: MONEY ON HAND

CR. M.O.H.	A	B	C	D (*)	E	F
	TL.	TL.	TL.	\$	\$	\$
					80.000	
January	785.000.000	2.198.471.000	2.848.707.097	127.573	92.490	44.917
February	1.150.000.000	3.058.655.000	3.963.305.500	127.004	128.679	46.592
March	1.210.000.000	3.094.454.000	4.009.692.678	113.274	130.185	131.860
April	1.055.000.000	2.574.411.000	3.335.837.901	110.373	108.306	193.574
May	1.160.000.000	2.711.384.000	3.513.323.052	101.158	114.069	175.783
June	1.670.000.000	3.728.275.000	4.830.977.280	115.893	156.850	139.059
July	1.310.000.000	2.872.830.000	3.722.519.519	103.748	120.861	84.137
August	1.010.000.000	2.111.506.000	2.736.020.683	126.003	88.832	33.910
September	1.250.000.000	2.544.500.000	3.297.080.202	91.573	107.048	56.821
October	1.132.000.000	2.182.156.400	2.827.567.170	138.183	91.804	114.715
November	1.050.000.000	1.893.360.000	2.453.354.203	97.873	79.654	137.549
December	1.735.000.000	2.940.478.000	3.810.175.593	71.365	123.707	146.540

(\*) 1\$ is accepted to be 30,800TL.