CAPACITY PLANNING OF A DRINKING WATER MANUFACTURER

by

Mr. Mongkol Anusornteerakul

A Final Report of the Three - Credit Course
CE 6998 Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
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Project Title	Capacity Planning of a Drinking Water Manufacturer
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The Graduate School of Assumption University has approved this final report of the three-credit course. CE 6998 PROJECT, submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer and Engineering Management.

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ABSTRACT

This project concerns the development of capacity planning for drinking water manufacturer. The solution procedure for this study is divided into 3 parts.

In the production planning part, it is a multi-period and multi-period with fixed workforce and available overtime problem. The objective is to select production quantities, inventory levels and overtime requirement which minimize the total cost of inventory holding and overtime.

In the forecasting part, because the manufacturer has launched the drinking water products into the market, the historical data is not sufficient to predict mathematically. Therefore, qualitative method is suitable for prediction as this method uses the information from sales, executive management and Delphi method to make the decision for demand forecasting.

Eventually, both the production process and the capacity planning need to be improved. The new automatic machines should be added to the production process and the capacity planning is improved to cope with future demand. The improvement could reduce manpower and cost in the future. The implementation of the proposed method is made and applied in the production system.

ACKNOWLEDGEMENTS

The author would like to express his sincere appreciation to his advisor, Dr. Chamnong Jungthirapanich, for his excellent guidance and continuous encouragement throughout the course of this project.

Furthermore, he is grateful to the management and the staff of C.S. Union Group Company for providing the necessary data and information to carry out this project.

Eventually, he wants to thank his family and his friend for their endless support of all his endeavors, which enables him to have an enjoyable life in ABAC.

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I. INTRODUCTION

1.1 General Background

At present, a manufacturing company will be able to survive in a highly competitive environment if it can produce products and services to meet customer requirements in quality, time, quantity and price with the limited resources of labor, material and facility. For progressive companies, managers must effectively manage many functions of production such as, forecasting, planning, quality, inventory and make decisions in seeking solution to satisfy customer needs with resource constraints. The success of manufacturing management can be measured by inventory investment, labor cost, manufacturing cycle time, equipment utilization and due date.

Typically, the procedure of manufacturing companies is concerned with the prediction of sales demand to allow better purchasing material, production planning and scheduling of manufacturing facilities over future time periods. Production planning and scheduling cover the selection of inventory and workforce to meet fluctuating demand, the selection of the material, decision-making as to which product and component should come out first, the selection of the production facilities required to convert the materials into their finished form and the selection of the sequence of work tasks or route in which material is converted into the form required in the finished product.

There are many available options to support demand fluctuation for production planning. One option is to produce more than a required amount during low demand periods and holds the surplus until a later period. This approach uses higher inventory costs for a more constant production rate. The opposite approach is to hire and layoff workers for producing exact demand in each period. This approach has low inventory costs but costs of hiring, training, and unemployment are high. Overtime is an option to produce during high demand periods but companies must accept the associated increases in the cost. Finally, some combination of these options are used depending on the policy of each company. All of these have costs and non quantitative factors which relate in a complex manner so that the optimum set of decisions is frequently difficult to determine.

In the drinking water manufacturing, the planners have the responsibility to determine the same problem but it is difficult to provide the optimal production schedule for serving demand fluctuation because of inaccuracy of demand forecast, the limit of capacities, the variety of product types and the complexity of production constraints. The existing planning procedure is made manually and intuitively so that it is unable to achieve the efficient production plan.

1.2 Existing Planning Procedure

The monthly demand forecast of each product for covering the period of one year is prepared by the marketing department based on the past sale figures and the market research. According to these forecasting demand and other constraints such as available raw material, ready equipment and product line capacity, the monthly production planning and scheduling is manually and intuitively determined by the production planning department for three months.

1.3 Statement of Problem

The existing production planning procedure is not based on any theoretical method but based on the intuitive judgement and experience, so the following problems occur:

(1) <u>No accurate sales forecast:</u> The marketing department uses the past sales and experience to estimate sale forecast which is not based on any theoretical method. Therefore, the sale forecasts have much deviation from actual demand. This results in the shortage of raw material and the inaccurate production planning and scheduling.

(2) No efficient production planning and scheduling systems: Because of the multiple production processes, the multiple product type and the different process capacities, it is difficult to determine the efficient production quantities and inventory levels of each product for each process station during each period. Currently, the planners do not consider the inventory holding cost in production planning. Thus, the existing production plan is not optimal. Moreover, the production schedule is difficult to be revised when the demand is adjusted.

1.4 Objectives of the Study

The existing production planning procedure is performed by intuitive judgements based on past experience, which is not a systematic and accurate method to establish an efficient production plan. Hence, the objective of this study is to improve the demand forecasting, production planning and scheduling of this factory by developing an effective method. To achieve these objectives, the specific objectives are:

(1) To develop a forecasting model which is more accurate than the existing method.

(2) To develop a mathematical model for production planning and a methodology for production scheduling which are systematic and effective.

1.5 Scope of the Study

This study concentrates on developing a method for demand forecasting, production planning in a specific drinking water manufacturing.

This study does not consider the aspect of raw material planning and production loss. Thus raw materials are assumed to be always available and no provision is made for scrap or rework.

Since the present production data from the company is not available and the demand forecasting from the proposed model is taken as the input of planning model, the comparison of the result with the existing production planning is not performed.

II. LITERATURE REVIEW

This research concentrates on problems concerning the improved capacity planning which consist of 3 parts consists of process design, capacity planning and demand forecasting.

The capacity planning problems involve the selection of demand forecasting technique and effected process design developing.

The demand forecasting technique consists of quality technique and quantitative technique, which can be useful depending on several factors such as historical data, time, experience, etc.

The process design problems involve the factor of facet of process design, process analysis and the regular of government.

2.1 Process Design

Process design is the selection of inputs, operation, work flows and method for producing goods and services. Input selection includes choosing the mix of human skills, raw material and equipment consistent with an organization's positioning strategy and its ability to obtain these resources. Krajew/Ritzman (1975) noted that: Process design or redesign decisions must be made when:

(1) A new or substantially modified product or service is being offered.

(2) Competitive priorities have changed.

(3) Demand volume for products or services is changing.

(4) Current performance is inadequate.

(5) Competitors are gaining by using a new process or technology.

(6) The cost or availability or input has changed.

2.1.1 Facet of Process Design

Definition and consideration of 4 facets of process design.

(1) Capital Intensity is the mix of equipment and human skills in production process; the greater the relative cost of equipment, the greater the capital intensity.

(2) Resource Flexibility is the ease with which equipment and employees can handle a wide variety of products, output levels, duties and function.

(3) Vertical Integration is the degree to which a firm's production system handles the supply chain from raw material to final consumer.

(4) Customer Involvement reflects how much and in what ways the customer becomes a part of the production process.

2.1.2 Process Analysis

The four facets of process design represent broad, strategic issues. There is another more tactical side to process design: the careful, detailed analysis of each process. Process analysis, sometimes called methods study or work simplification, is the systematic study of the activities and flows of each process to improve it.

In this section, to present two basic techniques for analyzing activities and flows within processes, flow diagram and process chart are needed. These techniques can be used systematically to question the process itself and the details of each technique. The operation can highlight tasks that can be simplified or indicate where productivity can otherwise be improved. However, the greatest payoff is likely to come from applying them in operations having one or more of the following characteristics:

(1) The process involves disagreeable or dangerous working conditions.

(2) The process results in pollution or large amount of waste material.

(3) The process is a bottleneck.

(4) The process consumes a great amount of time.

(5) The process requires a great deal of physical movement.

Flow Diagram

When an operation involves considerable movement of material or people, a flow diagram is a useful analytical tool. A flow diagram traces the people, equipment or material through a process. To make a flow diagram the analyst makes a rough sketch of the area in which the process is performed. On a grid the analyst plots the path followed by the person, material or equipment, using arrow to indicate the direction of movement or the direction of flow.

2.2 Capacity Planning

2.2.1 Strategies for Production Planning

There are many available methods to manage inventory, production rate, manpower needs, capacity and other variables such as:

(1) Changing inventory levels. Inventories can be accumulated during stock periods of demand and can be depleted during periods of peak demand but the working capital and costs associated with obsolescence, storage, insurance and handling will increase. Otherwise, backlogs can increase during periods of peak demand and decrease during periods of slack demand but the poor customer service, long lead time and possible lost sale may occur.

(2) Changing workforce levels. The size of workforce can be changed by hiring and laying off production employees to match the production rate for meeting exact demand but laying off is a cause of lower worker morale and lower productivity.

(3) Changing working hours. Production rate can be varied by overtime or idle time from regular workforce but the increment costs associated with overtime and idle time will occur.

(4) Subcontracting. The company can subcontract some work during peak demand periods and increase the capacity to satisfy demand but it may open the chances for competition and it is also hard to find a reliable supplier who delivers on time.

(5) Mixed strategies. All above strategies may combine to arrive at a feasible production plan depending on the company policy.

2.2.2 Costs of Production Planning

The objective of capacity planning is to determine the plan that minimizes the sum of these costs.

(1) Basic production cost. The cost is concerned with material costs, direct labor costs and overhead costs. It is normally divided into variable and fixed costs.

(2) Cost of changing the production rate. This cost can be attributed to change in the workforce including regular time, overtime, under time, hiring and laid off costs.

(3) Inventory related costs. Inventory holding costs are the cost capital tied up in inventory, storing, insurance, taxes and during slack period. Conversely, shortage and backorder costs are the costs of lost sales, expediting orders and loss of goodwill.

(4) Subcontracting costs. For some companies, the outside subcontracting is a way of handling peak demand periods. The costs will be the price paid to the supplier plus the freight costs.

2.2.3 Methods of Production Planning

(1) Management coefficient model

Bowman develops the management coefficient model on the assumption that management's past decision can be incorporated into a system for improving present decisions. The production rate for any period will be set by the following very general decision rule

(2) Transportation model

Bowman formulates the model which is a special case of a linear programming model. The transportation method can be used to analyze the effects of holding inventories or backordering, overtime and subcontracting. The transportation model is easy to solve using the simplex method but when more factors are introduced., such as hiring and layoffs or the costs of changing production level, the more flexible simplex method of linear programming must be used. This model does not allow the additional constraints, such as limits on the site of the inventory which can be provided by using the simplex model.

(3) Linear decision rules model

Holt, Modigliani, Muth and Simon present the model which minimizes a quadratic cost function. The major difference between the LDR model and linear programming model is the approach to cost input data in which the costs can be approximated by quadratic functions. The four cost elements in LDR are regular payroll cost, hire and fire cost, overtime and under time cost and inventory and backlog cost. The regular payroll cost is assumed as a linear related to the size of the workforce. For the other three cost elements, they are assumed to take a quadratic form.

(4) Linear programming method

Linear programming is a popular mathematical technique. This technique is used to find the lowest cost plan which is subject to linear constraints in nonnegative variables. For the use of this model, the cost of variables is assumed to be linear and the variables can take on any real number.

Ahrslob and Svedunger develop the production planning system for the chemical division of the Boliden company Ltd., Sweden. The major elements of the production planning system are a linear programming method, a cost model, a scheduling program and program to forecast the economic outcome. The primary aim of the new system is to make optimal utility of the production resources so that the economic outcome of the firm would be maximized when adapting production to satisfy the market situation. A special organization is established to implement the plans.

(5) Production parametric planning model

John develops the method concerning with a set of decision rules which take current status information, such as inventory levels, workforce levels, production rate and a forecast of requirements over the lead time and computes change to be made in workforce size and production rate. These rules are a function of a few parameter whose optimal values are determined through a search procedure involving simulation against historical demand and use of the actual cost structure of the organization. The resulting rules are used each period on a moving horizon basis to plan production and workforce.

(6) Hierarchical production planning model

Bitran, Haas and Hax present a hierarchical approach to plan and schedule production in a manufacturing environment that can be modeled as a single stage process. Firstly, The basis tradeoffs inherent to production planning decisions are represented by an aggregate model solved on a rolling horizon basis. Subsequently, the solution of the plan is disaggregated, considering additional cost objectives and detailed demand constraints.

A job measurement determines an estimated time required to finishing a job

(a) Time study is a statistical technique that is accurate and appropriate for jobs comprising highly repetitive task.

Normal time is the elemental average time multiplied by the performance rating factor.

Normal time(Nt)=(elemental average time) (performance rating factor)

$$= t \times PR$$

Normal cycle time (NT) is the summation of normal times.

$$NT = Nt$$

A standard time is the time spent by an average worker to complete a lob under normal environment and conditions.

Standard time (ST) = (normal cycle time) (1+ allowance factor)

$$= NT \times (1+AF)$$

Assume that the distribution of sample times is normally distributed. The number of cycle or the sample size of the time study can be computed as follows:

$$n = \frac{zs}{Et}^{2}$$

Where

z = the number of standard deviations from the mean in the normal distribution reflecting a level of confidence.

s = sample standard deviation.

T= the average job cycle time.

e = the degree of error from the true mean of the distribution.

The hierarchical production planning is the most appropriate for this research because the data are available and the problems under study should be concentrated on the relationship between workstations to increasing the capacity requirements.

2.3 Demand Forecasting

Forecasting technique can be classified into 2 types, qualitative and quantitative. The qualitative techniques are the prediction of characteristic sale based on customer preference information from market research team. The accuracy of qualitative forecast is usually based on the belief that the data sources are representative and unbiased. Another technique is the quantitative technique oriented to forecast cases, in which the future value is assumed to follow historical data trends. Forecasting techniques using historical data are referred to as time series analysis.

Sometimes, adequate historical data are lacking, such as when a new product is introduced or there is a need to forecast long-term technological change. Qualitative techniques, which are designed for these situations, rely on managerial judgement and experience and other forms of qualitative information to generate forecasts. In this section, we discuss four of the more successful qualitative techniques currently in use:

(1) Sales force estimates

Sometimes the best information about future demand comes from the person closet to the customers. Sales force estimates is a method of compiling a forecast based on periodic personal estimates of future demands made by members of the sales force.

Needs of a Sales Forecast

Strategic corporate planning operates in an environment of uncertainty. Sales forecasting attempts to reduce some of this uncertainty by predicting what will be sold to whom and when. This information regarding what (products and services), whom (market segment) and when (time patterns) is necessary input for planning in all functional areas of the firm. It is useful to classify these needs as long-run and short-run needs for sales forecasts.

Long-run need is a forecast needed for organizational changes such as divisional decentralization, changing the sales force organization, open new territories, acquiring new companies, developing new channels and changing advertising agencies. Adding new product, product line extensions and dropping old product require long-run sales forecast. The capital budgeting process and changes in the production facilities will require a long-run sales forecast.

Short-run need is a forecast needed for each of the elements in the marketing mix. Product planning requires a forecast for estimating inventories that will be required at various times throughout the year and at geographic locations. Timing price changes, channel discounts and promotional deals require good sales forecasts. The sales forecast is needed for planning the production of a product. Inventory planning, purchasing raw material, hiring and training personnel, and estimating overhead charges require estimates of the timing and magnitudes of company sales.

What Should We Forecast?

Because the term sales can have different meanings, there can be many different kinds of sales forecasts. To prevent confusion, the term market capacity, market potential, company potential, company forecast, sales goals and sales quotas will be defined in this section.

Market capacity is the number of units of a product or service that could be absorbed by a market at a given time irrespective of prices of products and the marketing strategies of suppliers. Market capacity could be expressed in terms of the total market or disaggregated segments of the market that have similar needs or buying styles.

Market potential is the sales, expressed in the number of products and the dollar volume, that an entire industry expects to sell, given a known mix of products, prices and market strategies.

Company potential is the maximum that a company could sell at a given price, irrespective of the capacities of its production and marketing facilities. This measure of company potential would be used to decide whether to add production and marketing capacities, whether to subcontract for production and perhaps marketing capacities or whether to let some of the market go to competitors.

Company forecast is a company's estimated sales, in units and dollars, for a brand, given a price and a marketing strategy. The forecast will reflect the capacity limitations of the firm, so generally it will be lower than the company potential.

Sales goals are a hoped for sales level for a company, a division or a product. They are generally higher than a forecast to provide motivation, especially for the sales force. Goals must be within reach, however, or they will be discouraging and therefore motivating.

Sales quota is a goal that has been broken down into smaller units, such as a region, a district or a specific representative's territory to provide a management objective. The quota is generally part of a motivation plan that is linked to compensation plans for sales managers and representatives.

(2) Executive judgement

When a new product or service is contemplated, Sales force estimates may not be accurate enough. Executive judgement is a forecasting method that summarizes the opinions of a group of executives to arrive at a single forecast. The opinions are based on the executive's experience with similar products or services. Sometimes executive judgement is used to modify an existing sales forecast to account for unusual circumstances, such as a new sales promotion or unexpected international events.

(3) Market research

Suppose that you are planning a new business that would allow consumers to shop for groceries by using a personal computer in their homes. One way to determine consumer interest is to do market research. Market research is a systematic approach to creating and testing hypotheses about the market. Data usually are gathered by survey methods.

Designing and conducting a market research study includes the following activities. First, you need to design a questionnaire that requests the needed economic and demographic information from each person interviewed. As part of the questionnaire, you need to ask whether the interviewee would be interested in using your service. Second, in conjunction with the design of the questionnaire, you need to decide how to administer it. You have three choices: telephone polling, mailing and personal interviews. Third, you need to select a representative sample of households to survey. The sample should include a random selection within the market area of your proposed service. Finally, after collecting the information, you must analyze it. Analysis requires that you must exercise a considerable amount of judgement in interpreting the responses, determining their adequacy and making allowance for economic or competition factors not included in the questionnaire. Moreover, the response rate on mailed questionnaire is typically poor and you must weigh the possibility that the respondents are a typical group that no longer represents a random sample of your potential market.

Market research can be used to forecast demand for the short, medium and long term. Accuracy is excellent for the short term, good for the medium term and only fair for the long term. Although market research yields many benefits, it has some shortcoming. One shortcoming is the numerous qualifications and hedges typically included in the finding.

(4) Delphi method

The Delphi method is a process of gaining consensus from a group of experts while maintaining their anonymity. This form is useful when there are no historical data from which to develop statistical models when judgement or opinion, based on experience and study of the markets, industry or scientific developments are the only bases for marketing informed projections. The process involves a coordinator who sends questions to each member of the groups, who may not even know who else is participating. The experts respond to the questions and argue in support of their responses. The coordinator pools the responses and prepares a report consisting of statistical summary of the responses as well as a summary of arguments for particular responses. The coordinator then sends the report to the same group for another round. The participants can repeat or modify their previous responses. Some forms of consensus are usually obtained in two to four rounds. The Delphi method can be used to develop long-range forecasts of product demand and new product sales projections.

One of the more useful applications for the Delphi method is that of technological forecasting. The rate of technological change is increasing much more rapidly than ever before. Computer science is just one field experiencing explosive technological change; computer becomes obsolete soon after they are produced.

The Delphi method has a number of shortcomings, including the following major ones:

(a) The process can take a long time.

(b) Because the process preserves the anonymity of the experts, there is risk that their responses will be less meaningful than if they were accountable for them.

(c) There is little evidence to show that Delphi forecasts achieve high degree of accuracy. However, they are known to be fair or good in identifying turning points in new product demand.

(d) Poorly designed questionnaires will result in ambiguous or false conclusion.

The sales force estimated method is the most appropriate for this manufacturer because the company has just launched to the market. Therefore, the information from sales is so important because they have many competitors in their areas, who compete both quality and price.

III. THE EXISTING CAPACITY PLANNING

The study is carried out at the production process of C.S. Union Group, Ltd.,Thailand. This chapter highlights the background of this enterprise, production flow process and existing capacity planning are highlight here.

3.1 Background of the Enterprise

C.S. Union Group has been established since 1959. It started with interior design &housing and real estate business. Hardware shop and restaurant businesses were later extended. The Drinking water business has been running since 1998.

3.1.1 Introduction of Drinking Water Business

The top executive of the enterprise is the director, and the head office of drinking water manufacturer is located on Sukhumvit road, Bangkok, Thailand. The production plant is located behind the head office on the other side which consists of the followings:

(1) Mechanical workshop consists of different kinds of machine tools and necessary equipment to carry out all type mechanical work.

(2) Packaging workshop.

(3) Warehouses.

(4) Office area.

The quality of drinking water of this manufacturer gains the recommendation of the health ministry, which controls the quality of drinking water. (Appendices A & B)

3.1.2 Types of the Product

The company runs the business of drinking water contained in PET plastic bottles (clear bottle) and plastic bottles. And now, there are 6 sizes of drinking water in PET plastic bottles: 500cc, 750 cc, 950cc, and 1,500cc, 5 1 and 20 1.. The company uses the

PET bottle which is clear bottle for containing the drinking water of Reverse Osmosis (R.0), ozone, and ultra violet system. Automatic machines can produce a variety of bottle sizes.

3.2 The Production Flow Process

The production process of the existing flow process consists of 4 sections.

Firstly, it starts at the raw water tank which contains the raw water passed through the softener system (magnetic dioxide, activated carbon, water softener), filter (1 micron and 5 micron ceramic) and reverse osmosis system before being stored into R.O. tank. Secondly, the raw water from R.O. tank passes through the system of ultra violet (U.V.) and ozone system before moving into the filling section. Thirdly, the filling and capping is performed into the cleaned bottles (manual). Fourthly, packaging by wrapping (manual) and storing in the warehouse is performed.

Selecting and installing a reverse osmosis unit to produce high-purity water is now faster, simpler and more convenient than ever.

For the ozone water treatment system, the system consists of 3 major components: ozone generator, in-line mixer and filter module. The ozone generator either plugs into a standard receptacle or is hardwired (230 V). It has an air pump which provides compressed air to an ultraviolet ozone producing lamp, thus producing compressed ozone.

The mixer equipment installs into the well pump water feed pipe to the holding tank. The ozone gas is routed from the ozone generator, through the mixer, to the filter module within the holding tank. When the well pump turns on to provide water to the tank, the mixer automatically diverts and mixes the ozone gas into the incoming well water before the water enters the tank. The ozone gas from the mixer is fed to the filter

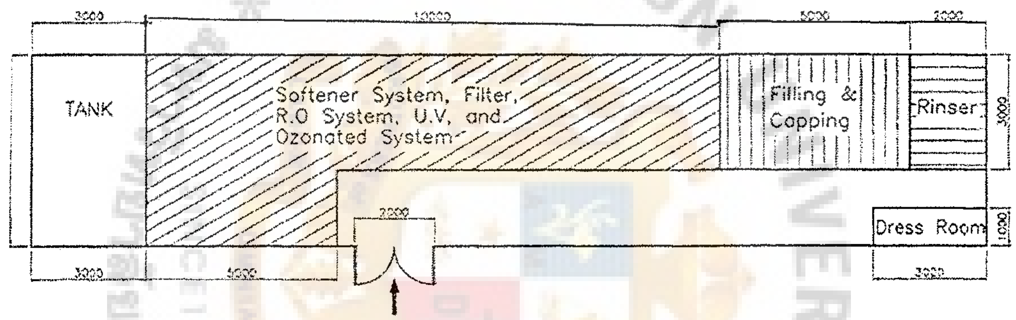
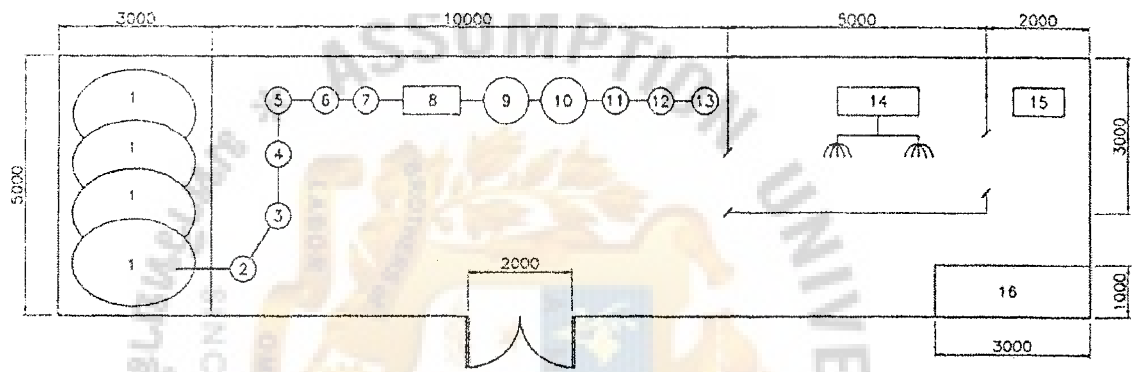


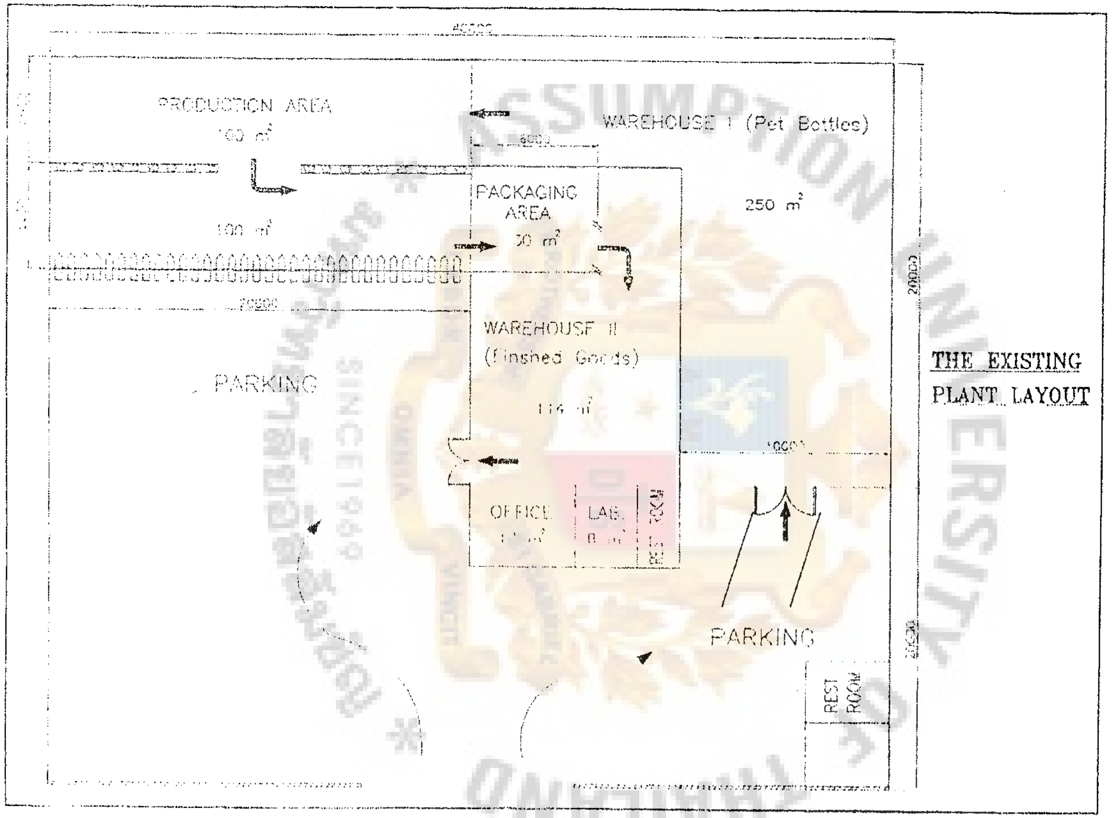
Fig 1. The Existing Production. Area.

PRODUCTION PROCESS

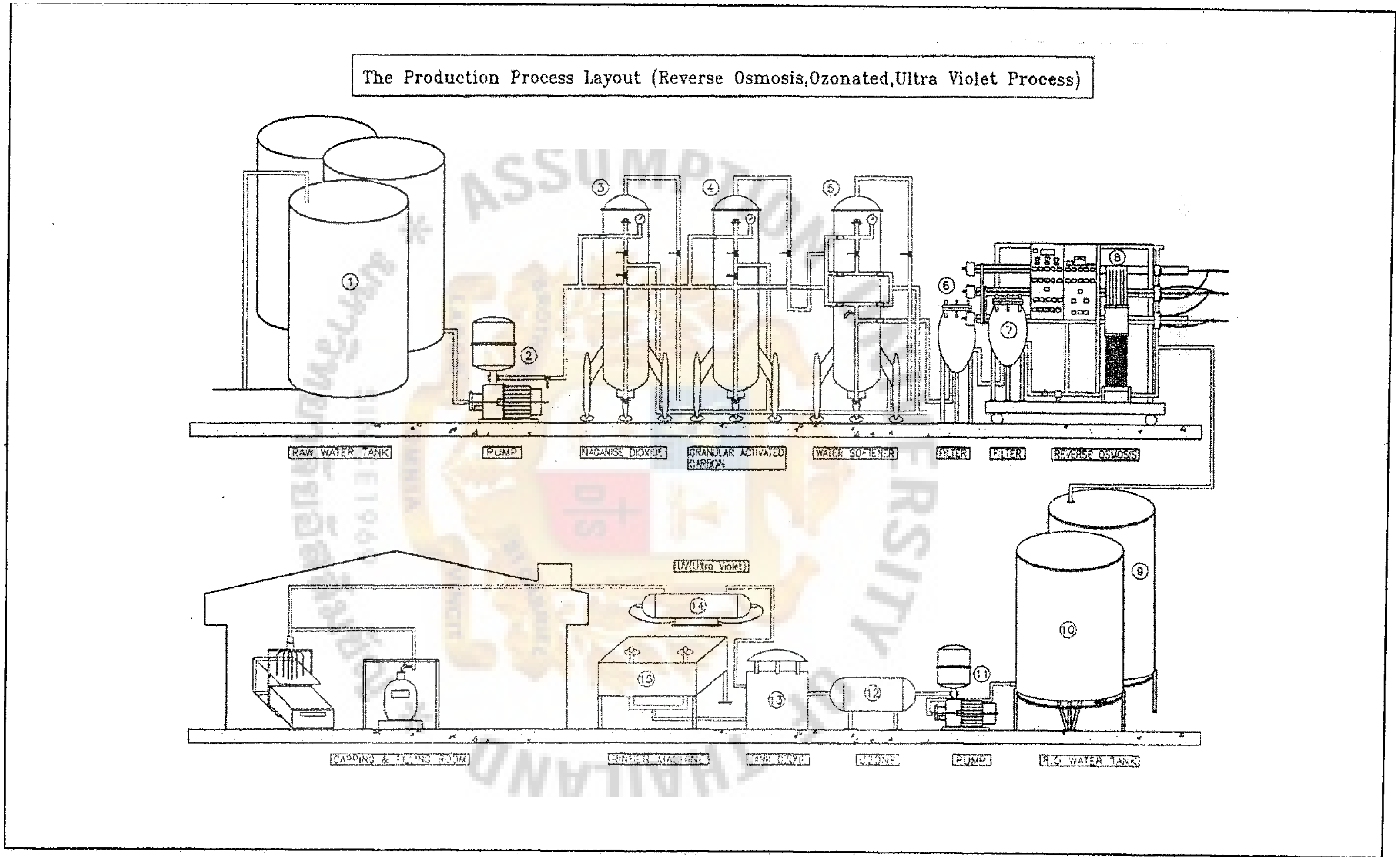


(1) = Row Water Tank
(2) = Pump
(3) = Manganise Dioxide
(4) = Granular Activated Carbon
(5) = Water softener
(6), (7) = Filter(5 μ, 1 μ, Ceramic)
(8) = Reverse Osmosis
(9), (10) = R.O Water Tank
(11) = Pump
(12) = Ultra Violet Machine
(13) = Ozone
(14) = Filling
(15) = Rinser Machine
(16) = Dress Changing Room

The Production Process.



The Existing Process Layout.



The Existing Plant Layout.

module diffuser, which makes millions of tiny ozone saturate bubbles that rise up the filter.

3.3 The Existing Capacity Planning

The existing capacity planning is shown in enclosed drawings (Figures 3.2 and 3.3) which have several machines in process and all machines specifications are described as follows.

The size of the product are 500, 750, 950, 1500 cc and 5 1., 201, of which 950 cc, 5 1. and 20 1. are packaged in PE bottle and size 500, 750, 1500 cc are packaged in PET bottle.

3.3.1 The Specification of Machine in the Process

The process has 9 machines; its detailed are as follows:

(1) Water tank

Capacity 2,8001.		2 units.
	1,000 1.	2 units.

(2) Water pump

Model: Grundfos CR 2-40 PT

Flow rate 3,000 1/hr.

(3) Softener tank

Media:	Anthracite	1 unit
	Activated carbon	1 unit
	Cation exchange resin	1 unit

(4) Filter tank 3 units

Flow rate 4,000 1/hr.

(5) Reverse osmosis machine 1 unit

Flow rate 3,900 1/hr.

(6) Ultra violet purifier 1 unit

Flow rate 2,000-2,7001/hr.

(7) Ozonator 1 unit

Flow rate 4,000 1/hr.

(8) Semi automatic contained machine 1 unit

Capacity at a time 24 and 12 bottles/time

(9) Rinsing machine 1 unit

Capacity at a time 12 bottles/time

(10) Packaging equipment (heat gun) 2 units

3.3.2 The Historical Data of the Sales Volume

The manufacturer gathered the data of sales volume from Oct 1998 until Dec 1999 which are shown as follows:

Table 3.1. The Historical Data of the Sales Volume.

Size Time	500 cc 1.	750 cc 1.	950 cc 1.	1500 cc 1.	5 1. 1.	201. 1.	Total 1.
Oct 98	12,000	2,700	20,520	10,800	200	400	46,620
Nov 98	9,000	900	22,800	1,800	200	600	35,300
Dec 98	21,000	9,000	22,800	2,700	300	600	56,400
Jan 99	18,000	7,200	22,800	19,800	200	800	68,800
Feb 99	12,000	3,600	26,220	16,200	200	800	59,020
Mar 99	24,000	2,700	26,220	21,600	200	800	75,520
April 99	39,000	6,300	22,800	27,000	400	1,000	96,500

Table 3.1. The Historical Data of the Sales Volume. (continued)

Size Tim	500 cc 1.	750 cc 1.	950 cc 1.	1500 cc 1.	5 1. 1.	20 1. 1.	Total 1.
May 99	54,000	4,500	22,800	36,000	400	1,000	118,700
June 99	66,000	7,200	28,500	39,600	400	800	142,500
July 99	72,000	9,000	28,500	39,600	300	800	150,200
Aug 99	72,000	9,000	28,500	36,000	300	800	146,600
Sep 99	96,000	13,500	22,800	41,400	400	1,000	175,100
Oct 99	102,000	16,200	22,800	41,400	400	800	183,600
Nov 99	108,000	15,300	22,800	39,600	300	1,000	187,000
Dec 99	108,000	18,000	22,800	45,000	400	1,200	195,400

From the above data, size 500 cc has the highest sales volume because the factory has several distribution channels to sell and can get more profits than other. For size 950 cc, the management team does not produce a lot because this size does not bring about much profit.

The manufacturer will plan the capacity planning by using the above data as the next item.

3.3.3 The Existing Capacity Planning

The manufacturer must calculate the existing capacity that can be produced by using the data from Table 3.1 and specification of machine.

Typically, this factory has to operate in a shift (8 hrs.) for 6 days a week.

Since the policy of this company is to hire the workforce with fixed manpower, overtime is allowed to operate during some overloads period in which overtime cost is exactly higher than regular time cost.

The setup time for each product on every machine in each process is almost equal and much less than the production time required for the monthly demands. Thus, the setup cost can be ignored in this study but the processing time in each stage is recorded including setup time.

The production cost of each product is assumed to be constant and all demands should be produced, then, cost of production can be neglected from the formulation.

The ending inventory of each product is allowed because the capacity planning under consideration is performed in 6 size standard products which can produce foe stock.

For the capacity planning of the past, the manufacturer must know the maximum capacity that the process can produce after bringing these data to plan the capacity planning.

To divide the process into 5 stations.

To calculate the standard time in each station.

To calculate the maximum capacity.

To plan the capacity planning.

Figure 3.4. The Capacity Planning Model.

The procedure to calculate the existing maximum capacity shown in Figure 3.4 is done by the followings;

Stepl: To divide the process into 5 stations.

Stationl : From raw material tank to semi containing machine.

Station2: The containing station.

Station3: The screw capping station.

Station4: The packaging station.

Station5: The rinsing station.

This reason for the division is to mark which machine is run automatically, which by staff.

For capacity at a time at each station is shown as follows;

Station2: It has 2 machines, one for size 5, 20 1. which contains 1 bottle at a time and another machine which contains remaining sizes (24 bottles at a time for 500' 750 cc and 12 bottles at a time for 950, 1500 cc).

Station4: It has 2 heat guns for packaging the product in each size as follows;

Size 500 cc. can be packaged 12 bottles / time.

Size 750, 950, 1500 cc. can be packaged 6 bottles / time.

Size 5, 20 1. can be packaged 1 bottles / time.

Station5: The rinsing machine can clean 12 bottles at a time.

Step2: To calculate the standard time in each station.

Stationl: The real time (working time) of all size of production is equal because this station is an automatic station. Therefore, the standard time is equal the real time, which is equal 0.833 1/s.

Station2: To contain the water in the bottle by using the machine after that record time for all sizes, the standard times are shown below:

Station3: To cap the bottle by using the staffs after that record time for all sizes, the standard times are shown below:

Station4: To package the bottle by using the machine after that record time for all sizes, the standard times are shown below:

Station5: To rinse the bottle by using the machine after that record time for all sizes, the standard times are shown below:

Table 3.2. The Existing Standard Time of Station 2.

Size	Containing at a		Record	The real	Allowance	The standard
	Bottle(s)	Liter	Time	Time (1/s)		Time (s)
500 cc	24	12	15	0.8	1.2	0.667
750 cc	24	18	18	1.0	1.2	0.833
950 cc	12	11.4	18	0.633	1.2	0.528
1500 cc	12	18	20	0.9	1.2	0.750
51	1	5	30	0.167	1.2	0.139
20 1	1	20	45	0.444	1.2	0.370

Table 3.3. The Existing Standard Time of Station 3.

Size	Capping at a time		Record Time	The real Time (Us)	Allowance	The standard Time (s)
	Bottle(s)	Liter				
500 cc	24	12	60	0.200	1.2	0.167
750 cc	24	18	60	0.300	1.2	0.250
950 cc	12	11.4	35	0.326	1.2	0.272
1500 cc	12	18	40	0.450	1.2	0.375
51	1	5	15	0.333	1.2	0.278
20 1	1	20	20	1.000	1.2	0.833

Table 3.4. The Existing Standard Time of Station 4.

Size	Packaging at a time		Record Time	The real Time (Fs)	Allowance	The standard Time (s)
	Bottle(s)	Liter				
500 cc	12	6	50	0.120	1.2	0.200
750 cc	6	4.5	35	0.129	1.2	0.216
950 cc	6	5.7	15	0.380	1.2	0.634
1500 cc	6	9	45	0.200	1.2	0.334
51	1	5	15	0.333	1.2	0.556
201	1	20	20	1.000	1.2	1.667

Table 3.5. The Existing Standard Time of Station 5.

Size	Rinsing at a time		Record Time	The real Time (Us)	Allowance	The standard Time (s)
	Bottle(s)	Liter				
500 cc	12	6	25	0.240	1.2	0.200
750 cc	12	9	25	0.360	1.2	0.300
950 cc	12	11.4	25	0.456	1.2	0.380
1500 cc	12	18	30	0.600	1.2	0.500
51	1	5	15	0.333	1.2	0.278
201	1	20	30	0.336	1.2	0.556

From all previous Table can be summarized as follows:

Table 3.6. The Summary of the Existing Standard Time of Each Station.

Size	The standard time in station Ws)					The standard time Selected (s)
	Station	Station 2	Station 3	Station 4	Station 5	
500 cc	0.833	0.667	0.167	0.200	0.200	0.167
750 cc	0.833	0.833	0.25	0.216	0.300	0.216
950 cc	0.833	0.528	0.272	0.634	0.380	0.272
1500cc	0.833	0.75	0.375	0.334	0.500	0.334
51	0.833	0.139	0.278	0.556	0.278	0.278
201	0.833	0.370	0.833	1.667	0.556	0.833

Step3: To select the least standard time from Table 3.6. For example in each size 500 cc.

Standard time of station 1 is 0.833 1/s.

Standard time of station 2 is 0.667 1/s.

Standard time of station 3 is 0.167 1/s.

Standard time of station 4 is 0.200 1/s.

Standard time of station 5 is 0.2001/s.

The data above means that the raw water flows into station 1 with flow rate 0.833 1/s. After that it flows into station 2 which can produce 0.667 1/s. Therefore, the output flow rate from station 2 is equal to 0.667 1/s. After that it flows into station 3 which can produce 0.167 1/s. Therefore, the output flow rate from station 2 is equal to 0.167 1/s. After that it flows into station 4 which can produce 0.200 1/s. Therefore, the output flow rate from station 2 is equal to 0.167 1/s. After that it flows into station 5 which can produce 0.200 1/s. Therefore, the output flow rate from station 2 is equal to 0.167 1/s. Other sizes have similar procedures.

Step4: To calculate the maximum capacity.

Step 2 shows the standard time selected, to bring these values to calculate the maximum capacity as in Table 3.7.

Steps: To plan the capacity planning

Capacity planning from Oct 1998 to Dec 1999. The manufacturer does not have problem during Oct 1998 to Aug 1999 because the sales volume is less than the maximum capacity. For example, to calculate the working time in July 1999 can be calculated as follows.

Table 3.7. The Existing Maximum Capacity.

Size	The standard time (Us)	The maximum capacity	
		Liter/day	Liter/month
500 cc	0.167	4,809.6	120,240
750 cc	0.216	6,220.8	155,520
950 cc	0.272	7,833.6	195,840
1500 cc	0.334	9,619.2	240,480
5 1	0.278	8,006.4	200,160
20 1	0.833	23,990.4	599,760

From the Table 3.8, the production time (24.6 days) is less than working time per month (25 days). Therefore, the capacity planning does not have problem.

The data from Sep 1999 to Dec 1999 is shown in Table 3.9, when the capacity time is more than working time per month 8.1 days. Therefore, the manufacturer must be paid for overtime to produce the product to cope with the demand.

From Sep 1999 to Dec 1999, the capacity planning has problem because the capacity time is more than working time. Management team solve this problem by working overtime for short term and long term (next 3 yrs.). It will be explained in next chapter.

Table 3.8. The Capacity of July 1999.

Size	Capacity time (days)			Working time Per month (day)
	Demand(1)	Max.cap./day	Capacity time(days)	
500 cc	72,000	4,809.6	15	25
750 cc	9,000	6,220.8	15	
950 cc	28,500	7,833.6	3.7	
1500 cc	39,600	9,619.2	4.2	
51	200	8,006.4	0.03	
20 1	800	23,990.4	0.03	
TOTAL			24.46	

Table 3.9. The Capacity of Dec 1999.

Size	Capacity time (days)			Working time Per month (day)
	Demand(1)	Max.cap./day	Capacity time(days)	
500 cc	108,000	4,809.6	22.5	25
750 cc	18,000	6,220.8	2.9	
950 cc	22,800	7,833.6	2.9	
1500 cc	45,000	9,619.2	4.7	
51	400	8,006.4	0.05	
20 1	1,200	23,990.4	0.05	
TOTAL			33.1	

IV. DEMAND FORECASTING

A forecast is a prediction of future events and sometimes it may be needed for prices, costs, events (such as new laws or regulations, entry of competitors, or the shortage of critical resources), or the advent of new technologies.

The procedures to forecasting demand are as follows:

(1) Selecting the required technique.

(2) Gathering the forecast information.

(3) The estimating of demand forecasting.

Before developing the forecasting model, we should briefly present the procedure for solving the problem in this study, which consists of the following steps:

Step 1: Group forecasting of demands

Objective: To determine the suitable demand forecasts for the production planning

Step2: Capacity planning

Objective: To determine the optimal production quantities of each product type in each process station for minimizing inventory holding and overtime cost.

For the efficiency of demand forecasting, capacity planning, the supplementary products which have both the inconsistent orders and the low level of demands are not considered in this study. These products are not necessary to produce for stock but can be produced in the periods having an under load conditions. Thus, the demand forecasting and capacity planning under consideration are carried out in six standard products which are the majority of total demands.

4.1 Group of Products in Forecasting

In the part of forecasting, it is hard to forecast individual products because of time consumption. Then, the six products are assigned into two groups depending on the customers. The group of products are shown in Table 4.1.

Table 4.1. Group of Product.

<table>
<tr><th>Group</th><th>Size</th><th>Customer</th></tr>
<tr><td rowspan="4">1</td><td>500 cc</td><td rowspan="4">Restaurants, Hotel
Dealer
Special Occasion e.g. King Cup, etc.
Gas Stations.</td></tr>
<tr><td>750 cc</td></tr>
<tr><td>950 cc</td></tr>
<tr><td>1500 cc</td></tr>
<tr><td rowspan="2">2</td><td>5 1.</td><td rowspan="2">Village</td></tr>
<tr><td>20 1.</td></tr>
</table>

4.2 Forecasting Model

There are several methods to forecast the demand. The selection of forecasting methods depends on the accuracy of forecasting, cost of forecasting and availability of data because this company has inadequate historical data. Thus, the sales force estimates are more suitable to predict the future demand than the others technique.

Sales department has many ways to collect information for forecasting such as following:

(1) Customers.

(2) Some data comes from Thai Farmer Center Co., Ltd. (Appendix C)

(3) Advertising.

To collect the information from sales department.

Choosing the quality information and analyzing its.

Checking company potential.

Setting the demand forecasting for next 3 years, sales goals and sales quotas.

Figure 4.1. Demand Forecasting Model.

Sales department informed that at present, all of the existing customers are pleased with quality, price and delivery time and they will expect at least 20% expansion in the next 3 years. For the new customers, they informed about the expansion in each region.

In the year 2000, expansion continued to remaining areas in Bangkok and the middle of Thailand because many customers called to the company to sell the product to them, with a suitable price. For this year, they will expect 20% expansion.

In 2001, expanding to the existing areas and east of Thailand are expanded because transportation cost is not expensive and some dealers of the competitors are interested in company's products. For this year, they will expect 20% expansion.

In 2002, the existing areas and west of Thailand will be expanded because transportation cost is not expansive and some dealers of the competitors are interested in company products. For this year, they will expect 25% expansion.

For company potential, the company has higher potential to expand the sales volumes because the price of product is reasonable and they have a fund to invest for improving the production are logistic and hire more staffs.

4.3 The Demand Forecasting Results

From the information of sales department and checking company potential, Demand forecasting are shown in Table 4.2. The manufacturer will concentrate on capacity planning, which will be explained in next chapter.

Table 4.2. The Demand Forecasting for Next 3 Years.

Size	Year 2000 (liter / month)	Year 2001 (liter / month)	Year 2002 (liter / month)
500 cc.	120,000	144,000	180,000
750 cc.	18,000	24,000	30,000
950 cc.	22,800	22,800	22,800
1500 cc.	45,000	54,000	72,000
5 1.	500	1,000	1,500
20 1.	1,000	1,500	2,000
TOTAL	**207,300**	**247,300**	**308,300**

V. THE CAPACITY PLANNING IMPROVEMENT

In this part of the study, how to improve capacity planning to cope with future situations will be discussed.

Capacity planning decisions normally involve these activities:

(1) An assessment of existing capacity.

(2) Estimates of future capacity needs (product, human, technological).

(3) Identification of alternative ways to modify capacity.

(4) Selection of a capacity alternative.

5.1 Identification of Problem in the Existing Capacity Planning

In majority of this study application, the problem of capacity planning is the flow rate of each section is equal especially at packaging and screw capping station which is the bottleneck of the process.

From the previous chapter, the data shows that increasing demand is increasing by about 10 % each year while the present maximum capacity is less than the present orders. Therefore, in three years from now it will face a more serious problem than at the present.

5.2 Methods to Solve the Problem

Now, the factory has the problem with the existing maximum capacity, which is not sufficient to sales volume demand. For this problem, the manager makes decision to buy new machine because this method is more suitable than hiring subcontractors, which is good for solving short-term problem only.

In chapter 3, the bottleneck points such as containing station, capping station and packaging station have been discussed. Therefore, these points should change the machine for increasing the capacity and change the rinsing machine to operate automatically.

5.3 Adding Machines Required

As mentioned before, the company expects higher growth in the next three years. Therefore, the capacity is not enough and some automatic machines should be determined.

The following figures are about the data of the machines required for increasing output by using the fully automatic in-line drinking water filling and packaging line. Decision points for the selection of the machine.

(1) Capacity of machine is enough for the future demand.

(2) Good quality and easy to maintenance.

(3) Appropriate price.

Table 5.1. The Machines Requirement for Capacity Expansion.

The machines required for improving the capacity output
Automatic rinsing machine 10 nozzles, 48 bottles/minute 1
Automatic filling machine 6 nozzles, 40 bottles/minute 1
Automatic capping machine 3 nozzles, 50 bottles/minute 1
Automatic shrink film machine 3 nozzles, 50 bottles/minute 1

5.1 The Automatic Rinsing Machine

Automatic Rinsing Machine 10 nozzles, the bottles will be placed on the conveyor where they will be delivered into the feeding perform. The bottle will be moved to the nozzles and will then be automatically aligned up. It will send the bottle to pass the streaming water jets. The bottles will slowly turn upside down. The water that has been used will be kept in a reserving tank for recycle. After a bottle has been completed in the process, it will be released from the grip and will be delivered into the process of containing.

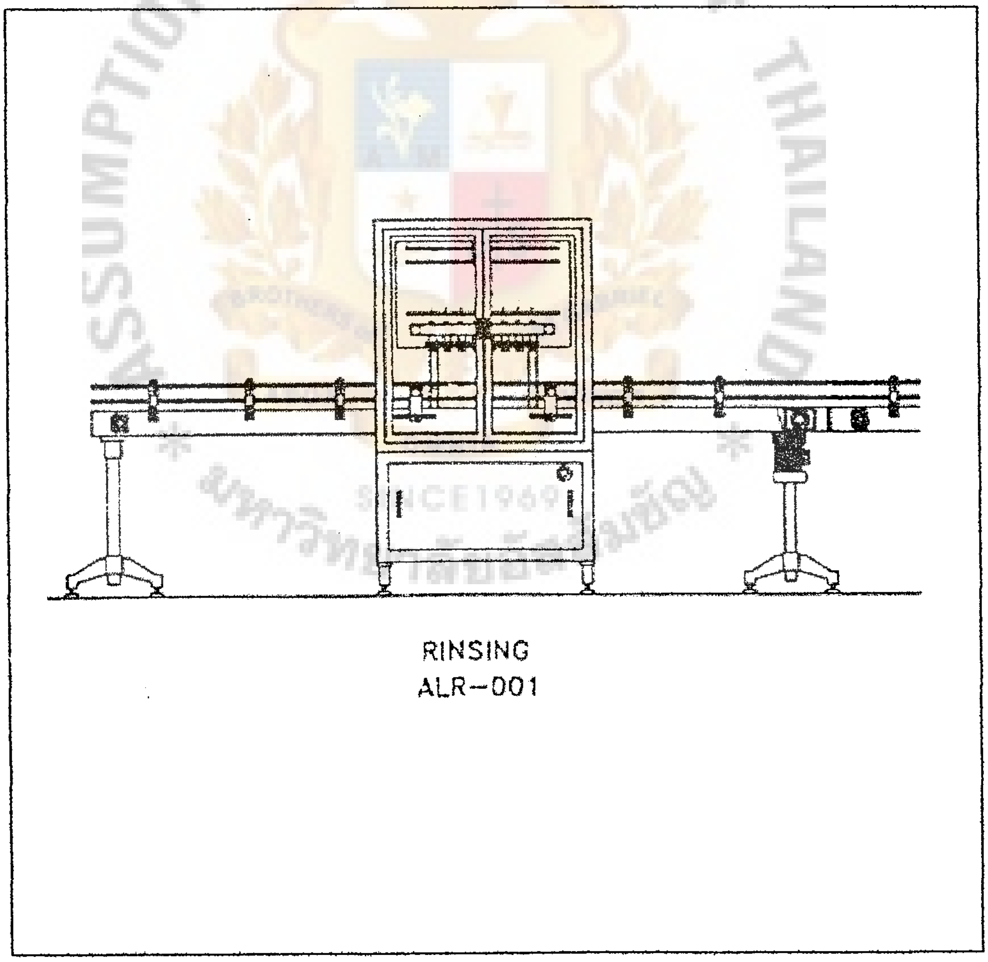


Figure 5.1. The automatic Rinsing Machine.

5.2 The Automatic Filling Machine

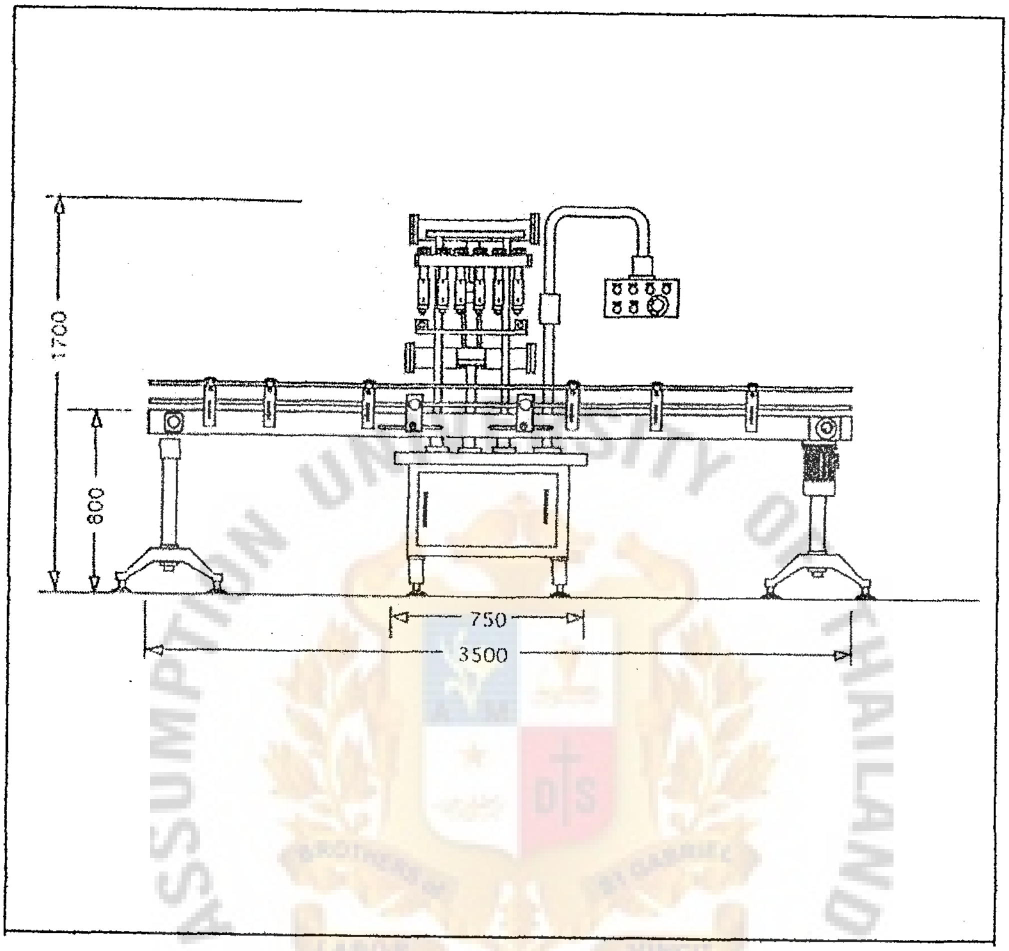


Figure 5.2. The Automatic Filling Machine.

This is in-line, fully automatic of 6 nozzles filling machine for drinking water. It is capable of utilizing both glass and rigid plastic bottle of various sizes, with especially designed pumping action to keep the amount of form forming at the minimum level. During the process, bottles travel along a delivery conveyor and are positioned under the filling nozzles. The machine can detect the presence of the bottle, therefore performing its task on the basis of no bottles-no fill. The level of the filling nozzle can be adjusted easily by a hand operation knob, allowing the operator to easily cope with multiple types of job in a short period of time. The frame of the machine is made of stainless steel, carefully assembled to deliver a 100% water proof standard, protecting its electrical compartment from water getting in. The complete filling machine may be dismantled for cleaning and maintenance.

5.3 The Automatic Capping Machine

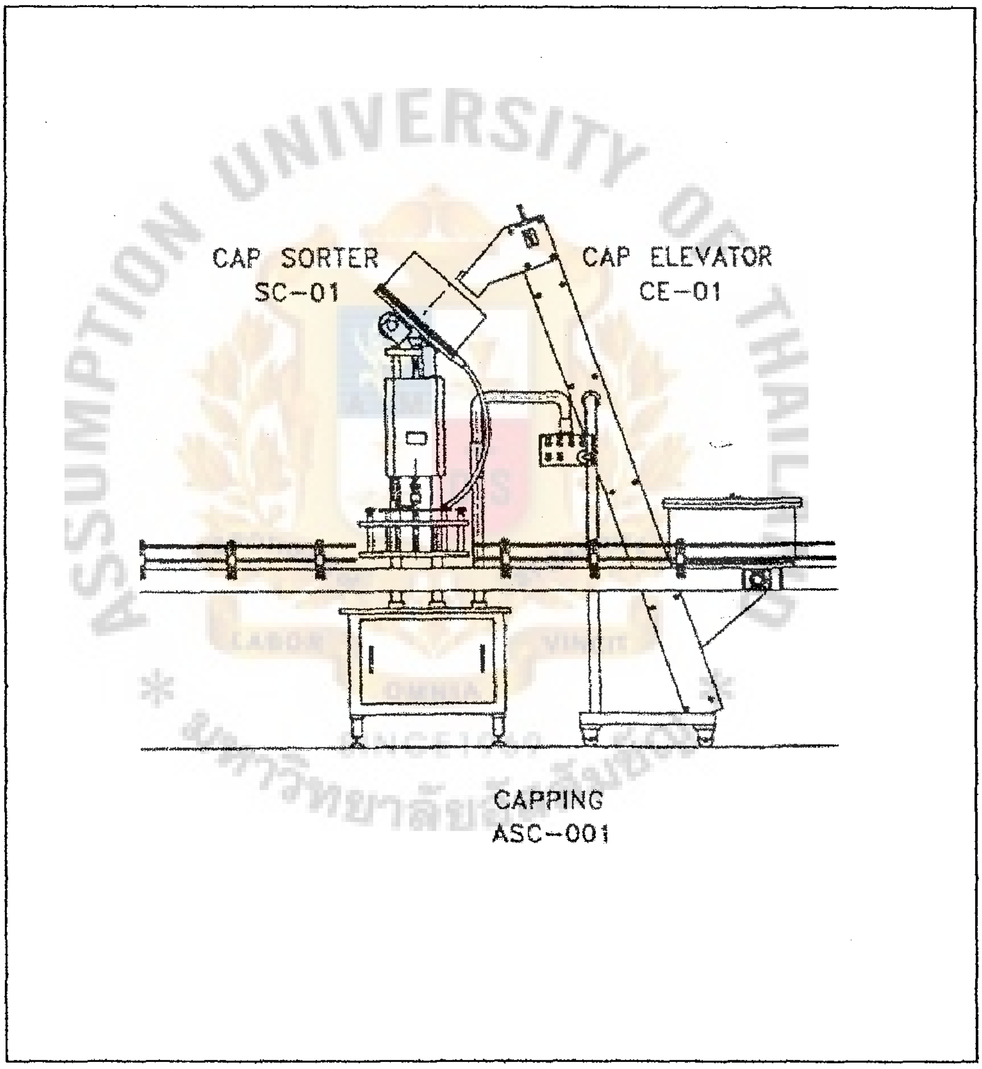


Figure 5.3. The Automatic Capping Machine.

5.4 The Automatic Shrinking Film Wrapping Machine

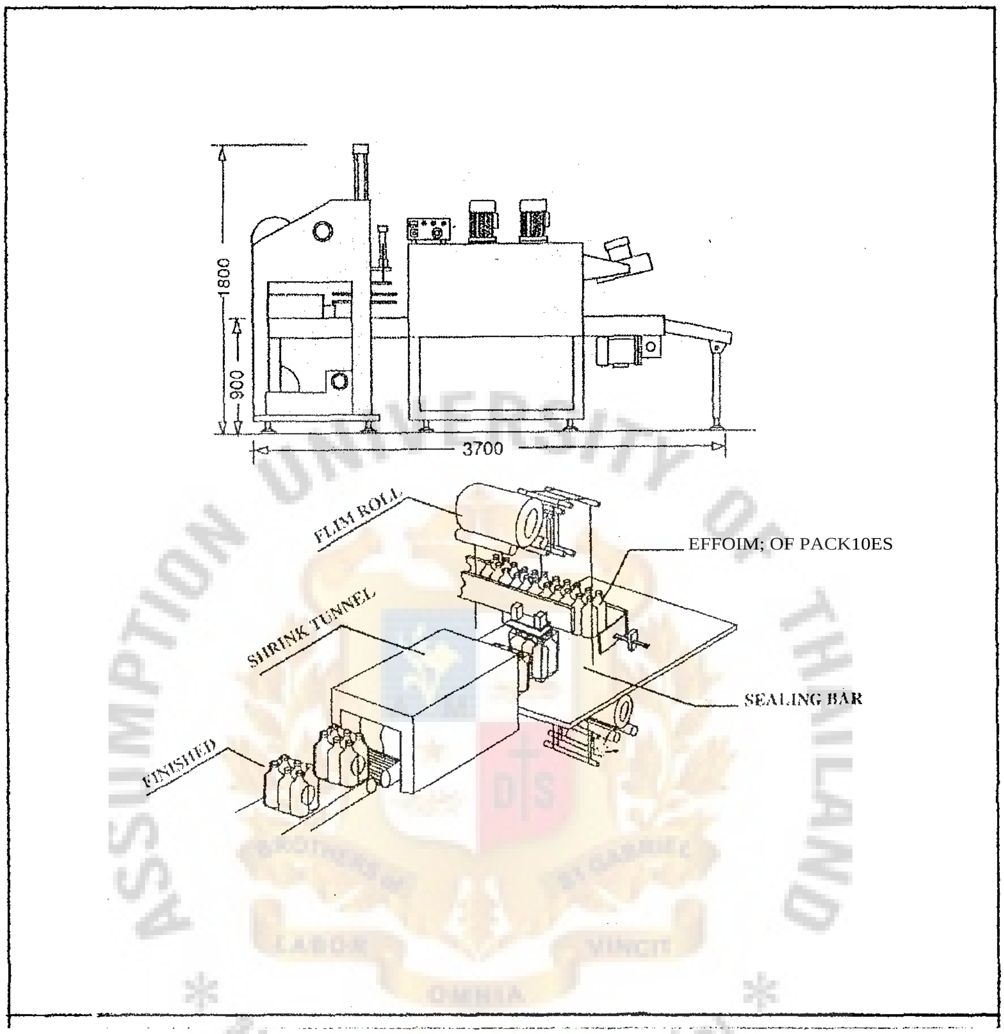


Figure 5.4. The Automatic Shrinking Film Wrapping Machine.

The film wrapping machine is used for packaging the products so as to be convenient for transportation. The machine is separated into two parts. The first part locates the film wrapping the bottle and cutting down thew film. The second part is the heating tunnel to shrink the film. Both parts of the machine will work relatively throughout the process. The temperature and heating can be set at any level up to desire in order to get along well with the speed and thickness of the film.

5.4 Process Design

After buying the new machine, process should be redesigned for ease to control and the production process chart will be as follows:

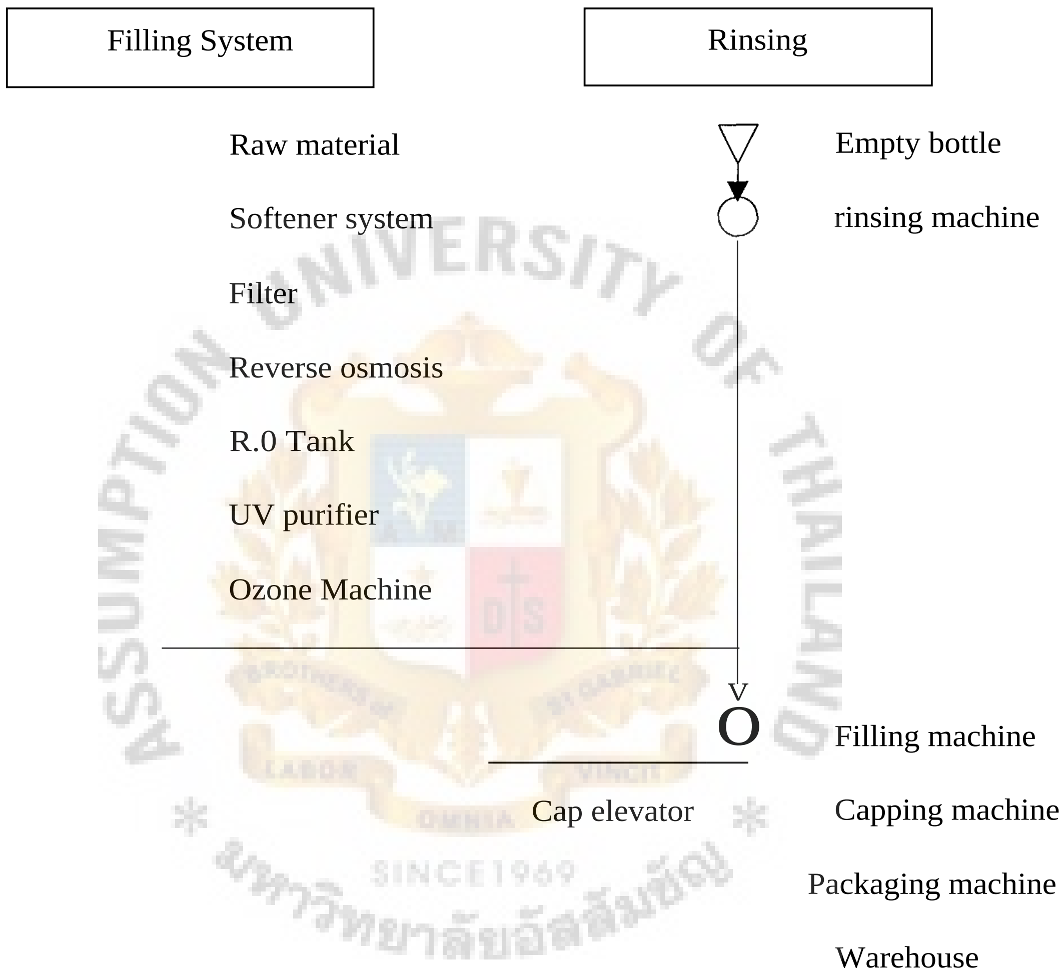
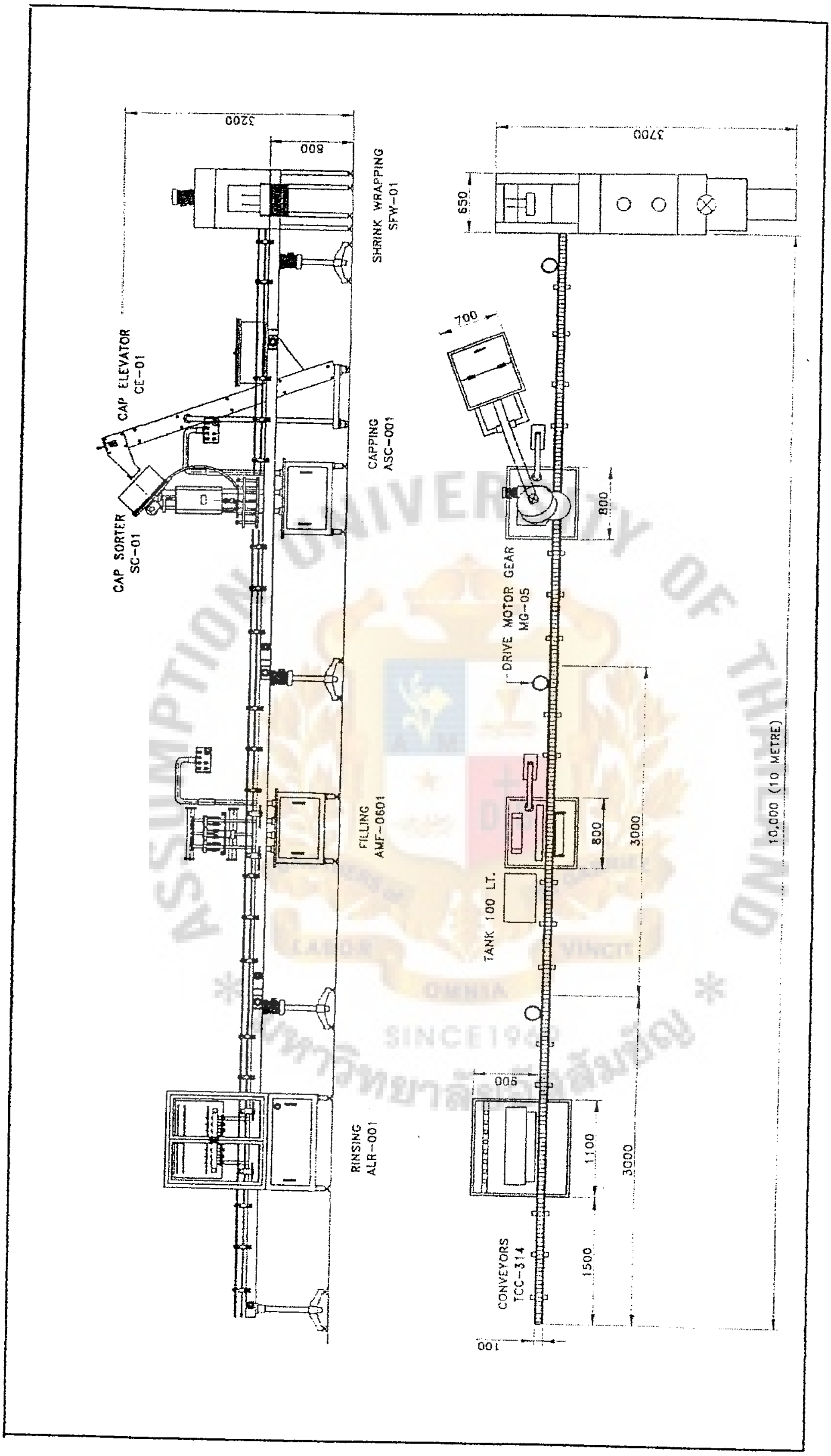


Figure 5.5. The New Process Design.



SHRINK WRAPPING SFW-01
CAP ELEVATOR CE-01
CAPPING ASC-001
CAP SORTER SC-01
FILLING AMF-0601
RINSING ALR-001
DRIVE MOTOR GEAR MG-05
TANK 100 LT.
CONVEYORS TCC-314
10,000 (10 METRE)
3200
600
3700
650
700
800
3000
900
1100
1500
100

5.5 Comparing the Improving Capacity and the Forecast Demand

Presently, the forecast demand is shown in Table 4.2, chapter 4. Therefore, this section will calculate the maximum capacity for comparing the forecast demand by using calculated the maximum capacity model below:

Stepl: To divide the process into 5 stations.

Step2: To calculate the standard time in each station.

Step3: To select the std. time from step 2 to using for calculated the maximum capacity.

Step4: To calculate the maximum capacity.

Step5: Comparing the improving capacity and the forecast demand.

Figure 5.7. Calculated the Maximum Capacity Model.

The procedure to calculate the maximum capacity shown in Figure 5.7 is done by the following:

<u>Stepl:</u> To divide the process into 5 stations as follows:

Stationl: The raw water to ozone machine.

Station2: The empty bottle to the rinsing machine.

Station3: The filling machine.

Station4: The capping machine.

Station5: The packaging machine.

Step2: To calculate the standard time in each station.

This step will calculate the standard time in each station as follows:

Stationl: From the specification of machine in this automatic station, the standard time is equal to 0.833 1/s., assumed the allowance value = 1, as this station is the automatic station the working is certainly smooth.

Station2: The rinsing machine, from the specification of machine, the standard time is shown below:

Table 5.2. The Standard Time of Station 2.

Size	Rinsing at a time		Record time (s)	Real time (1/s)	Allowance	The std. time (1/s)
	Bottle (s)	liters				
500 cc	12	6	48	0.5	1.1	0.454
750 cc	12	9	54	0.667	1.1	0.606
950 cc	12	11.4	55	0.829	1.1	0.754
1500 cc	12	18	60	1.200	1.1	1.090
51.	1	5	60	0.333	1.1	0.303
20 1.	1	20	60	0.667	1.1	0.606

The allowance factor value=1.1 is because the staffs to do the jobs have more experiences. The idle time, therefore, is less.

Station3: The filling machine, from the specification of machine, the standard time is as follows:

The allowance of this station-1 because this station is an automatic station.

Table 5.3. The Standard Time of Station 3.

Size	Filling at a time		Record time (s)	Real time (1/s)	Allowance	The std. time (1/s)
	Bottle (s)	liters				
500 cc	20	10	12	0.833	1	0.833
750 cc	20	15	18	0.833	1	0.833
950 cc	20	29	23	0.826	1	0.826
1500 cc	20	30	30	1	1	1.000
5 1.	1	5	30	0.167	1	0.167
20 1.	1	20	60	0.444	1	0.444

Station4: The capping machine, from the specification, the standard time is as follows:

For the size of 500, 750, 950, 1500 cc., the allowance-1 because this station is an automatic station.

For the size of 5, 20 1., the allowance-1.2 because this size has the staffs to do the jobs and this job is more difficult than station 2 so allowance value is higher than station 2 also.

Table 5.4. The Standard Time of Station 4.

Size	Capping at a time		Record time (s)	Real time (1/s)	Allowance	The std. Time (1/s)
	Bottle (s)	liters				
500 cc	3	1.5	4	0.375	1	0.375
750 cc	3	2.25	4	0.563	1	0.563
950 cc	3	2.85	4	0.713	1	0.713
1500 cc	3	4.5	4	1.125	1	1.125
5 1.	1	5	15	0.333	1.2	0.278
20 1.	1	20	20	1.000	1.2	0.833

Station5: The packaging machine, from the specification, the standard time show as follow:

Table 5.5. The Standard Time of Station 5.

Size	Packaging at a time		Record time (s)	Real time (1/s)	Allowance	The std. Time (1/s)
	Bottle (s)	Liters				
500 cc	12	6	8	0.750	1	0.750
750 cc	6	4.5	8	0.563	1	0.563
950 cc	6	5.7	8	0.713	1	0.713
1500 cc	6	9	8	1.125	1	1.125
5 1.	1	5	15	0.333	1.2	0.278
201.	1	20	20	1.000	1.2	0.833

For the size of 500, 750, 950, 1500 cc., the allowance=1 because this station is an automatic station.

For the size of 5, 20 1., the allowance=1.2 because this size has the staffs to do the jobs and this job is more difficult than station 2 so allowance value is higher than station 2 also.

Step3: To select the standard time for calculating the max, capacity by using the data from step 2. The data of step 2 can be summarized in table below:

The reasons to selecting the standard time for calculating the max, capacity is similar to explaining in Chapter 3.

Table 5.6. The Summary of the Standard Time of Each Station.

Size	The standard time of each station (lis)					The std. time selected (Us)
	Station 1	Station 2	Station 3	Station 4	Station 5	
500 cc	0.833	0.454	0.800	0.375	0.750	0.375
750 cc	0.833	0.606	0.833	0.563	0.563	0.563
950 cc	0.833	0.754	0.826	0.713	0.713	0.713
1500 cc	0.833	1.09	1.000	1.125	1.125	1.000
5 1.	0.833	0.303	0.167	0.278	0.278	0.167
20 1.	0.833	0.606	0.444	0.833	0.833	0.444

Step 4: To calculate the maximum capacity by bringing the data from Table 5.5 to calculate in table form as follows:

Step 5: Comparing the improving capacity and the forecast demand, this step is the latest step for capacity model. Comparison by using the data of step 4 and the data of the demand forecasting from Chapter 4 is shown below:

Table 5.7. The Maximum Capacity.

Size	The standard time (Us)	The max. cap. / day (1)	The max. cap. / month (1)
500 cc	0.375	10,800.0	270,000.0
750 cc	0.563	16,214.4	405,360.0
950 cc	0.713	20,534.4	513,360.0
1500 cc	1.000	28,800.0	720,000.0
5 1.	0.167	4,809.6	120,240.0
20 1.	0.444	12,787.2	319,680.0

Table 5.8. Comparing the Improving Capacity and the Demand Forecasting.

Size	The max. capacity/month (1)	The demand forecasting/month (1)		
		Year 2000	Year 2001	Year 2002
500 cc	270,000	120,000	144,000	180,000
750 cc	405,360	18,000	24,000	20,000
950 cc	513,360	22,800	22,800	22,800
1500 cc	720,000	45,000	54,000	60,000
5 1.	120,240	500	1,000	1,500
201.	319,680	1,000	1,500	2,000

From the data shown above, the improving capacity is enough for future demand next 3 years.

For checking the maximum capacity is required to calculate the future demand. For the year 2002, this year data is selected because the demand is the highest. To compare the maximum capacity and the highest future demand, comparison of the working time per month and the production time to produce the product of each size per month is shown below:

The working time size 500 cc takes to produce	16.67 days.
The working time size 750 cc takes to produce	1.23 days.
The working time size 950 cc takes to produce	1.11 days.
The working time size 1500 cc takes to produce	2.09 days.
The working time size 5 1 takes to produce	0.31 days.
The working time size 20 1 takes to produce	0.16 days.
Total working time to produce	**21.57 days.**

The working time to produce (21.57 days) is less than the working time per month (25 days). Therefore, this improving capacity planning is effective.

5.6 Implementation of Models

The methods for forecasting and capacity planning of the manufacturer are already developed. The system for implementing these methods is applied to periodically generate the required plans. The monthly drinking water implementation of models is shown in Figure 5.8 and done by the followings:

(1) Adding the past demand and forecast the effective demand by sales force estimate technique.

(2) To bring the data to make the demand forecasting.

(3) To compare the existing capacity planning and the demand forecasting if the existing capacity planning is sufficient to the future demand, the existing capacity planning is effective if the existing capacity planning is not sufficient for the future, the capacity planning improvement is done.

(4) Determine the safety stock of each product while improving the capacity planning in order not to lose the customer.

(5) Update the essential parameter for improving capacity planning, forecast demand, safety stock, inventory, storage, overtime and regular time.

(6) To create the capacity planning improvement to cope with the future demands.

(7) To compare the improving capacity planning and the demand forecasting if the improving can be coped with the future demand, the capacity planning improvement is effective.

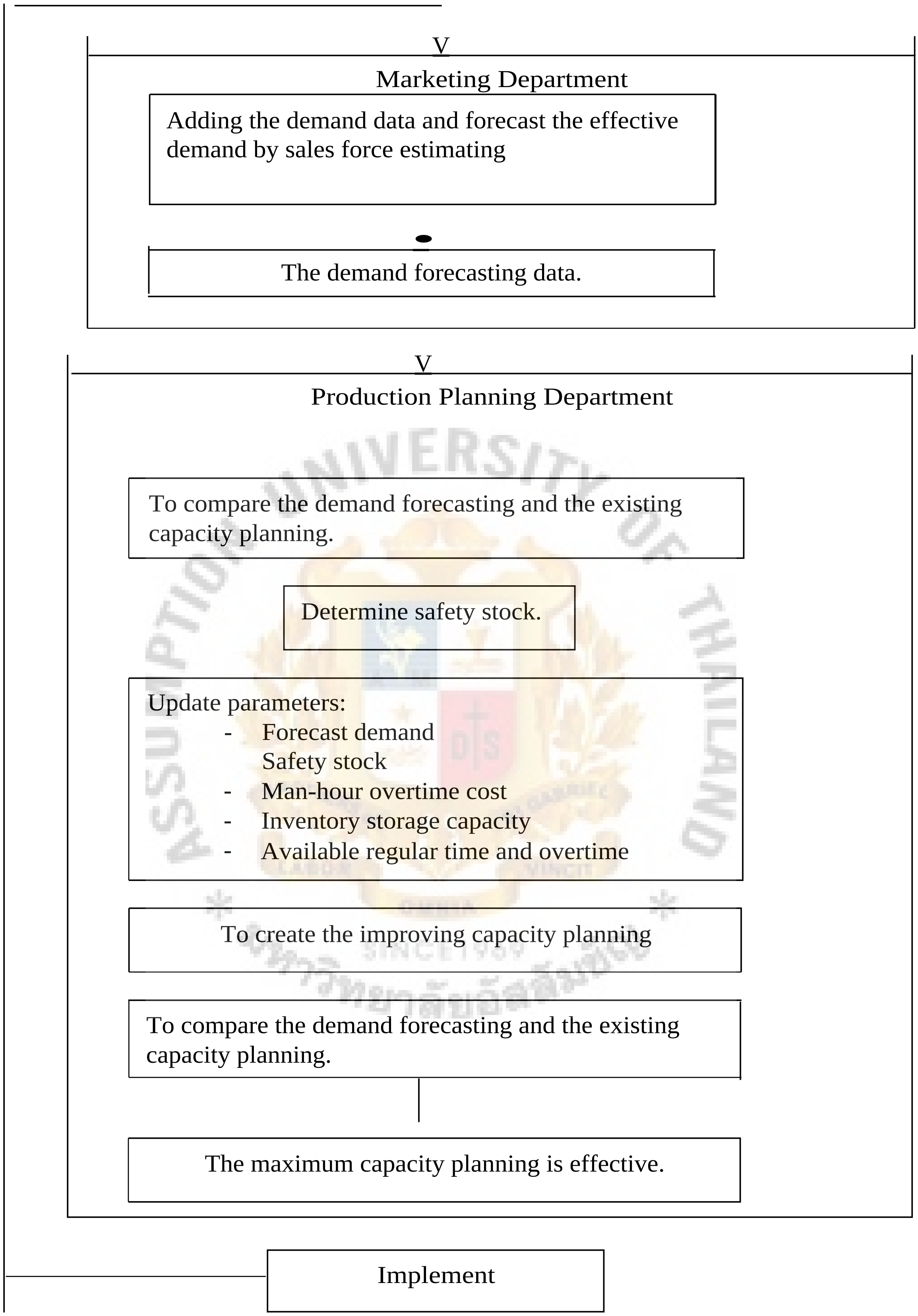


Figure 5.8. Flow Chart for Monthly Drinking Water Implementation of Proposed Method.

VI. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The objective of this study is to provide an appropriate methodology for forecasting and planning in a real case of drinking water manufacturer. To achieve this purpose, the procedure for solving the problem consists of two parts.

6.1.1 Production Planning

The individual forecast demand from forecasting model input for capacity planning. Instead of the existing practice, the planning horizon is extended to three years.

The basic planning problem is a multi-period and multi-product with fixed workforce and available overtime problem. The process which has not too much different capacity is aggregated into one stage because work-in-process between each station is quite low. The setup cost is negligible because the setup time for the product is much less than production time but the processing time of the machine in each station is recorded including setup time. The safety stock levels of individual product are considered in term of forecasting errors and product mix.

In this study, The hierarchical production planning model is used for capacity planning because the data are available and the problem should be concentrated on the relationship between workstations to increase the capacity requirements. The normal time and the standard time are the highlighted.

The capacity planning improvement has several factors to realize for improvement as follows:

(1) The existing capacity planning should be compared with demand forecasting. If demand forecasting is more than the existing maximum capacity, the improvement is obtained.

(2) The demand forecasting is used for the sales estimate method.

(3) The adding machine is selected based on demand forecasting.

(4) Company potential is the maximum that a company could sell at a given price, irrespective of the capacities of its production and marketing facilities.

(5) Market potential is the sales, expressed in number of product and the bath volume, rather than an entire industry expects to sell, given a known mix of products, price and marketing strategies.

Thus, an improved capacity planning is developed to provide an optimal capacity planning and cope with the market 3 years later.

6.1.2 Forecasting

The manufacturer has launched product into the market so it is difficult to forecast the demand which can be from several factors such as lack of historical data, competitors information, experience of the management team, etc. but the demand forecasting is important and management team must be considered and make decision to forecast the demand.

For this company which lacks historical data, it can use the qualitative model to solve this problem and sales force estimate method is selected because of the lack of historical data. So the decision data must come from sales department.

6.2 Recommendations

6.2.1 Recommendations for the Company

The following recommendations are made to the management of the company under study for policy implementation.

(1) The demand forecasting is an important part in capacity planning because the more accurate the forecast demand, the more precise the result obtained from the capacity planning will be.

Moreover, the company should attempts to continuously minimize the forecasting errors for more accuracy of capacity planning due to the company's lack of historical data and limited time. Therefore, the sales force estimate is now appropriate and should be updated when more data are obtained.

(2) Since the management team can make decision efficiently from the solutions of the planning model, the company should collect and adjust the costs and parameters to ensure the correct and accurate result.

(3) The policy of raw material planning and supplementary production planning should be managed by considering the results of planning model.

(4) If the pattern of demand is not uncommonly deviated, it should be compared with the actual situation for appropriate adjustment.

(5) Currently, the company gets customers only trough salespeople. Therefore, magazine advertising should be considered.

(6) Most of the company's products are 500, 750, 950, 1500 cc. which do not make much profits and take a long time to break even point. The majority customers are now gas stations and dealers. Therefore, the company should

be more concentrated on the product 20 1., 5 1. bottle which yields more profits.

(7) Demand forecasting results maybe incorrect because the management team has inadequate historical data and untrustworthy data from sales and marketing department. Therefore, the management team should focus the customers and recheck every quarter the data from sales and marketing department and obtain the quality data into the data collecting system.

(8) The fully automatic drinking water production line facilitates production and control the product but it has problems when the machine breaks down and needs repair. The production come to a stop in this case so the company should be prepared to cope with this situation by adding the backup process by using the existing machine.

6.2.2 Recommendations for Further Study

(1) The study could be extended to cover raw material planning, especially, the PET bottles which are the main raw material.

(2) The capacity planning model for every process station would be an interesting area for further study.

(3) The logistic management for distribution to customer with minimized cost.

(4) The study could be extended to the feasibility study for investment of this improvement.

APPENDIX A

RECOMMENDATION OF HEALTH MINISTRY FOR WATER QUALITY

RECOMMENDATION OF HEALTH MINISTRY FOR WATER QUALITY

Government attempt to control the quality of drinking water by issuing the recommendation as following;

(A) Drinking Water Specification

(a) Physical Specification

(1) The color less than 20 hazen unique.

(2) The product must not have smell (exception of chlorine smell).

(3) Level of acid — base between 6.5-8.5 PH.

(b) Chemical Specification

(1) Solid less than 500 mg. per water 1 1.

(2) Calcium carbonate less than 100 mg. per water 1 1.

(3) Arsenic less than 0.05 mg. per water 1 1.

(4) Barium less than 1 mg. per water 1 1.

(5) Cadmium less than 0.01 mg. per water 1 1.

(6) Chlorine less than 250 mg. per water 1 1.

(7) Chromium less than 0.05 mg. per water 1 1.

(8) Copper less than 1 mg. per water 1 1.

(9) Iron less than 0.3 mg. per water 1 1.

(10) Lead less than 0.05 mg. per water 1 1.

(11) Manganese less than 0.05 mg. per water 1 1.

(12) Nitrate less than 0.05 mg. per water 1 1.

(13) Mercury less than 0.02 mg. per water 1 1.

(14) Phenol less than 0.001 mg. per water 1 1.

(15) Selenium less than 0.01 mg. per water 1 1.

(16) Silver less than 0.05 mg. per water 1 1.

(17) Sulphate less than 250 mg. per water 1 1.

(18) Zinc less than 5 mg. per water 1 1.

(19) Fluoride less than 1.5 mg. per water 1 1.

(20) Aluminium less than 0.2 mg. per water 1 1.

(21) Siyanide less than 0.1 mg. per water 1 1.

(22) Alky benzene sulfonate less than 0.2 mg. per water 1 1.

(c) Bacteria Specification

(1) Coliform bacteria less than 100 mg. per water 1 1.

(2) None of E. coli bacteria.

(3) None of bacteria which issued the disease.

(B) Standard Process

(a) Small Industry: The production is not complex.

(1) The local water flows into sand filter.

(2) Flow into the base exchanger, which contains resin to decrease the hard of water.

(3) Flow into the activate carbon filter, which is used for eliminating the smell, color.

(4) Flow into the bacteria filter, which has ceramic filtration.

(5) Flow into the ultraviolet purifier for eliminating virus.

(6) Containing and packaging.

(b) Large Industry

(1) To suck the raw water from underground under at least 150 m.

(2) To bring raw water action with air for producing mineral.

(3) To fill the chlorine for eliminating virus, bacteria.

(4) To suck the water into the sand filter, the carbon filter, the softener.

(5) The water flows into reserve tank after that filling the chloride into the water.

(6) Flow into the carbon filter for eliminating chloride, smell, color.

(7) Flow into the other reserve tank for filling ozone to eliminate virus.

(8) Containing and packaging.

APPENDIX B

RESULT OF DRINKING WATER QUALITY REPORT

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E4iii (SO_2)	12	-	-
880138 (C1)	12	250	500
88(148 (SO_4)	22	200	250
f6llUDH141 (CO_3)	0	-	-
lufillut mfIC0₃)	94	-	-
lulem No₂)	0.005	-	-
luinm NO_3)	0.6	45	45
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Figure B.1. The Raw Water Quality Report of the Company.

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t1111111114 (Mn)	0.00	0.00	0.00	0.00	0.02	0.3	0.5	0.3	0.5
1104UG4 (CO	0.00	0.00	0.00	0.00	0.00	1.0	1.5	1.0	1.5
fisina (Zn)	–	–	–	–	–	5	15	5	15
maelli· (CI)	53	8.0	12	4.6	58	200	600	200	600
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Figure B.2. The Drinking Water Quality Report of the Cor - itors.

APPENDIX C

PEOPLE'S BEHAVIOR WITH THE BOTTLED WATER

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APPENDIX D

DRINKING WATER PRODUCTION

DRINKING WATER PRODUCTION

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APPENDIX E

THE AUTOCAD INTERFACE

THE AUTOCAD INTERFACE

The graphics window is where AutoCAD displays your drawing and where you work on your drawing. The text window display a history of commands and options you have entered.

The crosshairs are controlled by your pointing device (usually a mouse) and are used to locate points and select objects in your drawing. The status bar displays the coordinate location of your crosshairs and the current setting of grid, snap and other drawing aids.

When you start the AutoCAD, it creates a new unnamed drawing for you. You can either start drawing objects in this blank drawing or open an existing drawing.

If you open an existing drawing, all of command and system variable settings last used on that drawing and restored because this information is saved in the drawing file.

When you start a new drawing, there are a few settings you will want to establish to assist you during the drawing process. The setup Wizard will assist you automatically, however, you can change these basic settings at any time.

(1) Units determines the measuring units you will use to draw objects: feet and inches, millimeters, miles, furlongs and so on.

(2) Scale determine the size of a unit when plotted on the paper. In AutoCAD, you draw everything full scale in the units you set up, so you do not have to worry about scale unit you are ready to plot your drawing.

(3) To help you visualize units, you can display an array of dots, called a grid, on your screen. The grid helps you visualize the size of units on your screen if you increase or decrease the magnification (zoom in or out) of your drawing.

(4) Limits indicate to AutoCAD where in drawing area's infinite space you intend to draw. AutoCAD displays the grid only within these limits also control some viewing options.

(5) Snap enables you to locate and position points exactly on the grid or some subdivision of it. For example, you could display a grid with intervals of 4 millimeters but have points snap to exactly 1 millimeter, this making it easier and faster to draw objects accurately.

Once you have established these basic settings, you may want to use them for subsequent new drawings. You can do this by saving the drawing as a template drawing. A template drawing is typically a black drawing with preset settings that you use to start a new drawing.

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