



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DEVELOPMENT OF AGGREGATE PLANNING USING
LINEAR PROGRAMMING TECHNIQUE IN CASTING
INDUSTRY**

This report submitted in accordance with requirement of the Universiti
Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of
Manufacturing Engineering (Manufacturing Design) with Honours.

by

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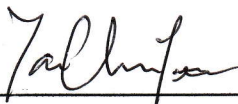
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ABSTRACT

To purpose of this project is to develop a manufacturing planning by using the aggregate planning method. The target of this project is a casting company – ABC Company. This project will analyze the current planning system and indentified the problems and develop an aggregate plan for improving the company production efficiency. The aggregate planning procedure start by having data collection at the target company, the data collection including the determination of demand period, the unit cost for regular time, overtime, subcontracting, holding inventories, back orders, layoffs, company policies, and company capacities. Once the data collected, then it is arranged in an orderly form according to their types of data and necessary assumptions are to be made. It is later then used as the input to construct out the appropriate aggregate plan. A few alternatives plan will be generated. A linear programming approach is used to develop alternative plan. The generated plans will be evaluated and the alternatives plan will be selected based on the most that satisfies the objectives of the study. At the end of the project, the alternative plan was suggested and the expected improvement was list out by comparing to the current layout. As conclusion, the generated alternative plan provides improvement in term of productivity of the section and at the same time ensures the company does make profit out of the plan.

ABSTRAK

Projek bertujuan untuk menghasilkan satu rancangan pembuatan dengan menggunakan cara “Aggregate Planning“. Sasaran projek ini adalah dibuat dalam kilang penuangan - ABC Company. Project ini dimulakan dengan menentukan masalah yang dihadapi dan daripada itu, skop and objektif projet ditentukan. Selepas itu, maklumat-maklumat berkenaan dengan ciri-ciri serta cara-cara merancang satu rancangan pengumpulan dikumpulkan and difahamkan. Selepas itu, ia bertumpu kepada penjanaaan rancangan pengumpulan yang alternatif. Ianya dimulakan dengan pengumpulan maklumat di sasaran, maklumat yang dikumpulkan itu termasuk penentuan jangka masa untuk satu tempoh, kos unit untuk masa tetap, bayaran lebih masa, pegangan inventori, polisi syarikat dan kapasiti syarikat. Selain itu, perkara yang menimbulkan masalah dalam rancangan pengumpulan dikenalpasti dan andaian yang berkaitan perlu dibuat. Setelah maklumat yang secukupnya dikumpulkan, beberapa langkah yang terkandung dalam “Aggregate Planning“ dijalankan untuk merancang rancangan pengumpulan. Beberapa rancangan alternatif akan dihasilkan. Rancangan yang telah dihasilkan akan dinilai dan rancangan altenatif yang mana dapat memenuhi objektif penyelidikan ini akan dipilih. Daripada keputusan “Aggregate Planning“, pelan alternatif dimana akan menyumbang kebaikan yang paling ketara akan dipilih. Selain itu, pembaikan yang akan dicapai oleh pelan alternatif baru itu juga disenaraikan untuk dibandingkan dengan pelan semasa. Pelan baru ini, bukan sahaja meningkatkan daya pengeluaran, tetapi ianya juga meningkatkan keuntungan syarikat.

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CHAPTER 1

INTRODUCTION

1.1 Background

Manufacturing planning is crucial in order to lead to a smooth production line. This is where the aggregate planning comes in. Aggregate planning is one of the most vital of all in the manufacturing planning. It is like the backbone of the manufacturing planning. Aggregate planning is the process of developing, analyzing and maintaining groundwork, approximate schedule of the overall operations of an organization. The goal of having aggregate planning is that to achieve a production plan which will effectively use the organization's resources to satisfy expected demand at a minimum cost.

Aggregate planning is importantly a big-picture approach to planning. Planners generally try to avoid focusing on individual products or services unless the company has only one major product or service. Instead, they concentrate on overall capacity. Aggregate planning in actual is very closely related to budgeting of a company. Most budgets are based on assumptions about aggregate output, personnel levels, inventory levels, and purchasing levels. An aggregate plan should thus be the basic for initial budget development and for budget revisions.

The operation plan is driven by customers' firm orders, or forecasts demand and then developed from three component plans: the aggregate plan, where short term capacity adjustments are made, the master production schedule and the material requirements plan.

This thesis is regarding the development of a framework for manufacturing planning based on the aggregate planning. For this research, ABC Company was selected to perform the study. This company general produce casting product. The material used to produce casting product is aluminum. The casting methods that used to produce the products are pressure die casting and gravity die casting.

1.2 Problem Statement

In manufacturing industry, the company which applies line production and continuous processing production had implemented the push system as their manufacturing strategy so that they could be competitive in the market. Improper manufacturing strategy and process choice may cause much longer lead time, low productivity and poor on time delivery. This would indirectly affect the company's competitiveness in the market and their reputation. Furthermore, the company may suffer huge loss in their business if the process planning is not implemented properly.

Moreover, industrial and service enterprise face increase pressure to minimizing the time it takes to service customer and fulfill demand. Today, customers tend to set high expectation on the product and service quality with custom features at affordable prices. This situation has put tremendous pressure on business manager to maximize profits while minimizing the risks.

However, due to meet the customer demand that varies from a period to a period, it makes it difficult for the company to plan their production schedule. This is especially when the company had a variety of products. Due to the fluctuation demand of the customer, the company had to make a lot of changes to their production line and workforce arrangement. Things go bad when there is a sudden change of quantity or products from the customer. This gives difficulty and challenge to the company which resulting the production line and inventory level to be in chaos.

Moreover, the company will also suffer losses that are unknown too. Material and other consumable items that are used to produce the products might be over used and wasted in order to meet the customer demands so that the delivery could be makes on time. As such, this gives another obscurity for the company.

1.3 Objectives

The objectives of this project are:

- a) To recognize the constraints and objective of problem in developing aggregate planning.
- b) To formulate the aggregate planning in linear programming.
- c) To generate alternative solutions using a spreadsheet and select the best planning based on company's requirement.

1.4 Scope of Study

This project will be mainly focus on manufacturing planning where the production planning system will be generated. Demands from the customers will be leveled in the production plan schedule. This gives means to that the demand from the customer throughout the year will be aggregated. In this project, the aggregate process will focus on 12 months of period time in order to fulfill the delivery date dateline of each period.

The aggregate plan will be planned by using the linear programming technique. The current manufacturing system of the company will be studied in order to get a better understanding of the current problem facing by the company. The input and output data that is needed in programming out the aggregate plan will be identified and hence collect the input data that is needed. The input data are as such the unit production cost, unit holding inventory cost, product quantity of customer demand, the working hour of the workers, maximum storage capacity and so on.

These input data will then be used in programming out the linear programming model. Output data will be the result generated out by the linear programming model. In this study, the output data will be focus on the production level that is going to be run in that particular period, inventory level for that particular period, number of workers needed, the number of workers need to be hired or fired and so on.

1.5 Organization of The Study

This study will be categorized into six chapters, which are Introduction, Literature Review, Methodology, Results, Discussion, and Conclusion.

a) Chapter 1 : Introduction

This chapter contains the background of the problem statement, the objectives and the scope of the study. In this chapter, it summarizes the progress of the study and describes the plan to accomplish the study.

b) Chapter 2: Literature Review

In this chapter, the information and theory which is related to the research is studied and summarized. The source of the information is from journals, books, internet, articles and etc.

c) Chapter 3 : Methodology

It describes overview of the research methods and how to conduct the research methods. The steps to perform aggregate planning method will be included in this part.

d) Chapter 4 : Results

In this chapter, a full detail on how to develop the linear programming model will be included in this chapter. The result of developing the aggregate planning will be presented out in this chapter as well.

e) Chapter 5: Discussion

The outcome of the results will be discussed more in detail. The discussion includes the alternative solutions that are proposed for the company with the scenario that is almost in accordance with the problem faced by the company. The best alternative solution will be proposed in order to enhance the company's manufacturing performance. The objective achievement of this study will be discussed in this chapter as well.

f) Chapter 6 : Conclusion and Recommendations

It summarizes the main findings and how the scope is covered fully and brief recommendation for further studies. Hence, alternative ways or suggestions will be recommended to improve the study in future.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Aggregate Planning

Aggregation refers to the combining of products into groups or families for planning purpose (Vonderembse and White, 2004). In aggregate planning, it concerns with the overall operations of an organization over a specified time horizon. It determines the efficient way of responding which allocating resources to market conditions. On top of that, it effectively allocates system capacity which consists of plant, equipment, and manpower over a designated period.

Aggregate planning is an intermediate-range capacity planning that typically covers a time horizon of 2 to 12 months (Stevenson, 2005). It is a medium range tactical problem of establishing aggregate production rates, work force sizes, inventory levels and changes, back orders and subcontracting in or out. This planning comes to usefulness for organizations that experience seasonal or other fluctuations in demand or capacity.

Aggregate planning decisions are strategic decisions that define the framework within which operating decisions will be made. They are the starting point for scheduling and production control systems. They provide input for financial plans; they involve forecasting input and demand management and they may require changes in employment levels. The aggregate plan will guide the more detailed plan planning that eventually leads to a master schedule. The figure below illustrates the planning sequence.

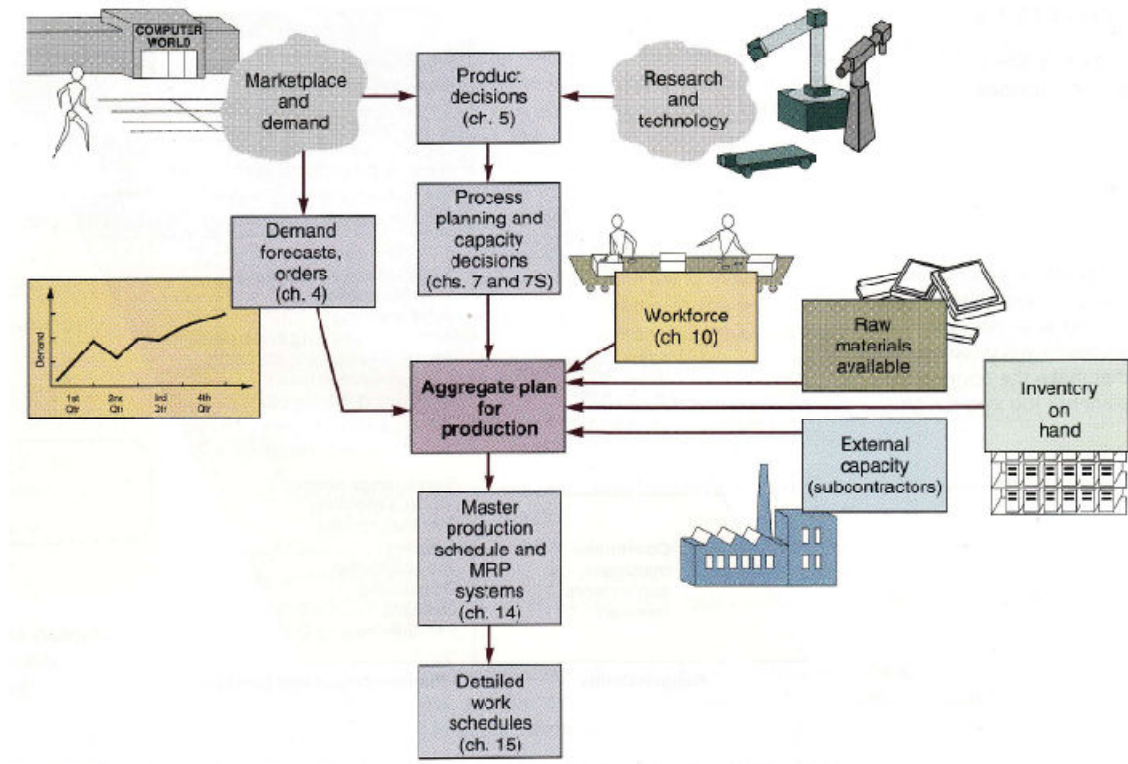


Figure 2.1: Relationships of the aggregate plan

Source: Heizer and Render (2006)

Aggregate planning methodology is designed to translate demand forecasts into a blueprint for planning staffing and production levels for the firm over a predetermined planning horizon. Aggregate planning horizon is not limited to top level planning. Although generally considered to be a macro planning tool for determining overall workforce and production levels, large companies may find aggregate planning useful at the plant level as well. Production planning may be viewed as a hierarchical process in which purchasing, production, and staffing decisions must be made at several levels in the firm. Aggregate planning methods may be applied at almost any level, although the concept is one of managing groups of items rather than single items (Nahmias, 2005).

Aggregate planning is important to many organizations no matter to large or small organizations as according to Stevenson (2005), aggregate planning is connected to the budgeting process. Most organizations plan their financial requirements annually on a department-by-department basis. Moreover, aggregate planning is important as

it is not possible to predict with any degree of accuracy the timing and volume of demand for individual items. So if an organization were to concentrate on individual items, it would lose the flexibility to respond to the market. Furthermore, aggregate planning is important because it can help synchronize flow throughout the supply chain: it affects costs, equipment utilization, employment levels, and customer satisfaction (Stevenson, 2005).

An effective aggregate planning requires good information or inputs in order to produce a valuable output. It requires information of the available resources over the planning period must be known. Then a forecast of expected demand must be available. Finally, planners must take into account any policies regarding changes such as employment levels as some organizations view layoffs as extremely undesirable, so they would use that only as last resort (Stevenson, 2005). A good production plan should be consistent with organizational policy, meet demand requirement, be within capacity constraints, and minimizes cost. The production plan links the strategic goals to production and is coordinated with sales objectives, resource availabilities, and financial budgets.

Table 2.1: Aggregate Planning Inputs and Outputs

Source: Stevenson (2005)

Inputs	Outputs
<ul style="list-style-type: none"> • Resources <ul style="list-style-type: none"> a) Workforce/production rates b) Facilities and equipment 	<ul style="list-style-type: none"> • Total cost of a plan
<ul style="list-style-type: none"> • Demand forecast 	<ul style="list-style-type: none"> • Projected levels of <ul style="list-style-type: none"> a) Inventory b) Output c) Employment d) Subcontracting e) Backordering
<ul style="list-style-type: none"> • Policies in workforce changes 	
<ul style="list-style-type: none"> • Subcontracting 	
<ul style="list-style-type: none"> • Overtime 	
<ul style="list-style-type: none"> • Inventory levels/changes 	
<ul style="list-style-type: none"> • Backorders 	
<ul style="list-style-type: none"> • Costs <ul style="list-style-type: none"> a) Inventory carrying cost b) Backorders c) Hiring/firing d) Overtime e) Inventory changes f) Subcontracting 	

2.2 Aggregate Planning Strategies

Aggregate planning strategies can be described as proactive, reactive, or mixed. Proactive strategies involve demand options; they attempt to alter demand so that it matches capacity. Reactive strategies involve capacity options. They attempt to alter capacity so that it matches demand. Mixed strategies involve an element of each of these approaches.

Steps taken to produce an aggregate plan begin with the determination of demand and the determination of current capacity. Capacity is expressed as total number of units per time period that can be produced (this requires that an average number of units be computed since the total may include a product mix utilizing distinctly different production times). Demand is expressed as total number of units needed. If the two are not in balance (equal), the firm must decide whether to increase or decrease capacity to meet demand or increase or decrease demand to meet capacity. In order to accomplish this, a number of options are available.

Options for situations in which demand needs to be increased in order to match capacity include:

- a) **Influencing demand.** When demand is low, a company will try to increase demand through advertising, promotion, personal selling, and price cuts (Jacobs *et al*, 2006). Pricing differentials are commonly used to shift demand from peak periods to off-peak periods. An important factor to consider is the degree of price of elasticity for the product or service; the more elasticity, the more effective pricing will be in influencing demand patterns. Unlike pricing policy, promotion had much less control over the timing of demand. Thus there is the risk that promotion can worsen the condition it was intended to improve (Stevenson, 2005).
- b) **Back ordering.** By postponing delivery on current orders demand is shifted to period when capacity is not fully utilized. This is really just a form of smoothing demand. Service industries are able to smooth demand by taking

reservations or by making appointments in an attempt to avoid walk-in customers. Some refer to this as "partitioning" demand. According to Stevenson (2005), the success of this approach depends on how willing customers are to wait for delivery. Moreover, the costs associated with back orders can be difficult to pin down since it would include lost sales, annoyed or disappointed customers, and perhaps additional paperwork.

- c) **New demand creation and counterseasonal product.** It is a widely used active smoothing technique among manufacturers in order to develop a new product or counterseasonal items (Jacob *et al*, 2006). A new, but complementary demand is created for a product or service. Many organizations are faced with the problem of having to provide products or services for peak demand in situations where demand is very uneven. Manufacturing firms that experience seasonal demand for certain products are sometimes able to develop a demand for a complementary product that makes use of the same production processes. They thereby achieve a more consistent use of labor, equipment, and facilities (Stevenson, 2005).

Options which can be used to increase or decrease capacity to match current demand include:

- a) **Hire/lay off.** In order to meet demand, one of the ways is to hire or lay off production workers to match production rates. It is often that new employees needed to be train, and as such it makes the average productivity of a company drops temporarily (Heizer and Render, 2006). According to Stevenson (2005), laying off can present serious problems for workers. Layoffs or firings will lower the morale of all workers and can lead to lower productivity (Heizer and Render, 2006). There are some firms have policies that either prohibit or limit downward adjustments to a workforce in order to maintain the image of the company and the company productivity.
- b) **Overtime.** The use of overtime can be especially attractive in dealing with seasonal demand peaks by reducing the need of hire and train people who will take to be laid off during the off-season. The option of overtime is a less

severe method for changing capacity than hiring and laying off workers (Stevenson, 2005). It is to be known that overtime requires more pay to the workers and too much overtime will wear the workers down to the point that overall productivity drops off. On top of that, overtime will also affect the increment of overhead cost as the need to keep the facility open (Heizer and Render, 2006)

- c) **Part-time or casual labor.** The use of part time workers is a feasible option. It depends very much on the nature of work, training and skills is needed. Seasonal work require low-to-moderate job skills will usually in need of part-time workers who generally cost less than regular workers in hourly wages and fringe benefits. In order to be successful, these organizations must be able to hire part-time employees when they are needed. In addition to having different pay scales and no benefits, they can be hire or layoff from the workforce without difficulty than regular workers. This gives the companies great flexibility in adjusting the size of the workforce (Stevenson, 2005).

- d) **Inventory.** Managers can increase inventory during periods of low demand to meet high demand in future periods. According to Heizer and Render (2006), if this strategy is selected, costs associated with storage, insurance, handling, obsolescence, pilferage, and capital invested will increase. (These costs typically range from 15% to 40% of the value of an item annually). On the other hand, if the firm experienced an increasing demand, shortages can result in lost sales due to personality longer lead times and poorer customer service. In essences, inventories can be built up during periods when production capacity exceeds demand and drawn down in periods when demand exceeds production capacity (Stevenson, 2005).

- e) **Subcontracting.** A firm can acquire temporary capacity by subcontracting work during peak demand periods. By subcontracting work to an alternative source, additional capacity is temporarily obtained. It enables planners to acquire temporary capacity although having less control over the output and

may lead to higher costs and quality problems (Stevenson, 2005). Subcontracting however has its disadvantages. First, it may be costly, second it risks opening the client's door to a competitor. Third, it is often hard to find the perfect subcontract supplier, one who always delivers the quality product on time (Heizer and Render, 2006).

Table 2.2: Aggregate Planning Options: Advantages and Disadvantages

Source: Heizer and Render (2006)

Option	Advantages	Disadvantages	Comments
Influencing demand	<ul style="list-style-type: none"> • Tries to use excess capacity • Discounts draw new customers 	<ul style="list-style-type: none"> • Uncertainty in demand • Hard to match demand to supply exactly 	<ul style="list-style-type: none"> • Creates marketing ideas • Overbooking used in some business
Backordering	<ul style="list-style-type: none"> • May avoid overtime • Keeps capacity constant 	<ul style="list-style-type: none"> • Customer must be willing to wait, but goodwill is lost 	<ul style="list-style-type: none"> • Many companies back orders
New demand creation and counterseasonal items.	<ul style="list-style-type: none"> • Fully utilizes resources • Allows stable workforce 	<ul style="list-style-type: none"> • May require skills or equipment outside firm's areas of expertise 	<ul style="list-style-type: none"> • Risky finding products or services with opposite demand patterns
Varying workforce level by hire and layoffs	<ul style="list-style-type: none"> • Avoids the cost of other alternatives 	<ul style="list-style-type: none"> • Hiring, layoff and training costs may be significant 	<ul style="list-style-type: none"> • Used where size of labor pool is large
Varying production rates through overtime	<ul style="list-style-type: none"> • Matches seasonal fluctuations without hiring/training costs 	<ul style="list-style-type: none"> • Overtime premiums • Tired workers • May not meet demand 	<ul style="list-style-type: none"> • Allows flexibility within the aggregate plan
Using part time workers	<ul style="list-style-type: none"> • Less costly and more flexible than full time workers 	<ul style="list-style-type: none"> • High turnovers/training costs • Quality suffers • Scheduling difficult 	<ul style="list-style-type: none"> • Good for unskilled jobs in areas with large temporary labor pools
Changing inventory levels	<ul style="list-style-type: none"> • Changes in human resources are gradual or none • No abrupt production changes 	<ul style="list-style-type: none"> • Inventory holding costs may increase • Shortages may result in lost sales 	<ul style="list-style-type: none"> • Applies mainly to production