DECISION MAKING FOR CAPACITY PLANNING IN A MAKE-TO-ORDER COMPANY USING MIXED INTEGER PROGRAMMING

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To my beloved family.

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ABSTRACT

The objective of this study is to propose a mixed integer model which can help Company T, a Make-to-Order (MTO) Company to make proper decision in accepting or rejecting the customers' orders. The proposed model can solve small capacity planning problem with the objective function of maximizing the profit with the condition that the orders must be delivered on time. If the company accepts the orders, three decisions can be made within the planning horizon, which are to do the job by normal time, overtime or to outsource it. A small case study was conducted at Company T and the proposed model was solved by using ILOG Optimization Programming Language (OPL). The reasonableness of the optimum solution shows the model is applicable to Company T. Besides that, sensitivity analysis of the model was done as well by using trial and error method.

ABSTRAK

Tujuan kajian ini adalah untuk mencadangkan satu model *mixed integer* yang dapat membantu Syarikat T, satu *Make-to-Order (MTO)* Syarikat untuk membuat keputusan yang betul DALAM menerima atau menolak tempahan daripada pelanggan. Model yang dicadang boleh diguna untuk menyelesaikan masalah perancangan kapasiti kecil dengan fungsi objektif yang memaksimumkan keuntungan dengan keadaan bahawa tempahan mesti diberi kepada pelanggan tepat pada waktunya. Jika syarikat menerima tempahan, tiga cara boleh dilakukan dalam masa perancangan, iaitu syarikat boleh melakukan pekerjaan dengan masa yang biasa, pekerjaan lebih masa atau sub-kontrak. Sebuah kajian kes kecil telah dijalankan di Syarikat T dan model yang dicadang telah diselesaikan dengan menggunakan *ILOG Optimization Programming Language (OPL)*. Kewajaran penyelesaian optimum menunjukkan model yang dicadang boleh diguna dalam Syarikat T. Selain itu, analisis sensitiviti untuk model juga dijalan dengan menggunakan kaedah cuba-cuba.

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LIST OF ABBREVIATIONS

CNC	-	Computerized Numerical Control
EDM	-	Electrical Discharge Machining
MTO	-	Make-to-order
MTS	-	Make-to-stock
OPL	-	Optimization Programming Language
WIP	-	work-in-process

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Manufacturing companies have various kinds of policies such as make-to-stock (MTS) and make-to-order (MTO). For the MTS companies, the companies' policies are forecasting the demand first and followed by the production. It is different with the MTO companies in which they will start to do the job after the customers' orders.

The capacity such as the high skilled labours and machines in the MTO companies are the most important resources to the companies. It is very costly to have many skilled labours and machines in the companies, therefore, proper capacity planning is needed in order to minimize the cost.

Company T is a small-sized MTO company, the company is always unable to make a proper decision which can maximize the company's profit because of lack of suitable technique. This study is focused in helping Company T to make a proper decision in short term capacity planning. A mathematical model is built so that Company T can use this model in order to make a proper decision which can maximize the company profit. Commercial software which is more reliable will be used to verify the model, as a proof that the model can be applied in the Company T.

1.2 Problem Statement

Company T is a company which specialized in manufacturing high precision moulds and dies. The capacity of the company is limited, this has caused the company to face the dilemma, whether to do the overtime or outsourcing, in order to deliver the products on time. However, outsourcing and doing overtime will increase the cost, which may result Company T suffer the loss.

Company T usually unable to make a proper decision because lack of suitable technique. Besides that, the company does not take into account their capacity when accept the customers' orders. The decision making for accepting the customers' orders are only based on the estimation of the processing cost.

As a result, almost 90% of the workers at Company T are working overtime for more than 70 hours per month. Besides that, there is about 30% of the products are not able to deliver on time. Basically, the late delivery will cause the customer dissatisfaction, as a result losing the customer. Therefore, a proper decision making tool is needed to Company T.

1.3 Objective of the Study

- To formulate a mixed integer programming model for capacity planning strategy.
- To determine the optimum solution using ILOG Optimization Programming Language.

1.4 Scope of the Study

The mixed integer model which is formulated in this project can help to make the decision in accepting the order, rejecting the order, doing the overtime or

outsourcing. Since the model has many constraints and decision variables, therefore a high-performance optimization software, IBM ILOG OPL-CPLEX Analyst Studio Teaching Edition 6.3 was used to solve the model.

There are many departments in Company T such as Milling Department, Grinding Department, Turning Department, CNC Milling Department, Wire-Cut Department and EDM Department. The software used is a trial version, which limits the decision variables and constraints to the size of 500. Therefore, the case study which was used to verify the model will focus on Milling Department, Grinding Department and EDM Department only.

Due to the time constraint and the limitation of the software, 1 week data were collected at Company T in order to conduct the case study. The validation of the model can be proven by the reasonableness of the optimum solution. Besides that, sensitivity analysis was investigated as well. Since the software was unable to provide the sensitivity report of the mixed integer model, trial and error method was used in order to get the sensitivity range.

1.5 Significance of the Study

The model formulated can be applied in Company T in order to make the decision which can maximize the profit. It is because the model is built based on the operation system in Company T and the problem faced by Company T. It is different with many other previous studies which are mainly focused on maximizing the utilization of the capacity or minimizing the cost. This model is used to maximize the profit, in which the most important element is the selling price.

In fact, this model not only can help to make proper decision, it also can help Company T to bid for the higher selling price based on their capacity. Originally,

Company T just bid for the higher price based on the processing cost only. This may cause the company suffer the loss at last when doing the overtime or outsourcing. In short, this model can help the company to avoid the unforeseen loss and maximize the profit.

Besides that, many previous studies did not investigate the sensitivity analysis and real case study. In this project, a real case study was conducted to verify the model and the sensitivity range of the model was investigated as well.

1.6 Arrangement of the Report

This report consists of seven chapters, as summarized below:

- **Chapter 1 Introduction**

  Chapter 1 gives a brief introduction to the study.

- **Chapter 2 Literature Review**

  Chapter 2 discusses on several topics related to this study. Topics reviewed include capacity planning, MTO companies, mixed integer programming, sensitivity analysis and optimization programming language. This chapter also discussed some previous researchers' works which are related to this study.

- **Chapter 3 Research Methodology and Company Profile**

  Chapter 3 discusses the methodology to conduct the project. Besides that, the company profile and the problem faced by the company are identified in this chapter.

- **Chapter 4 Model Formulation and Case Study**

  Chapter 4 discusses about the mixed integer model which can be applied to the company. This chapter also explains the method of modelling the case study by using ILOG OPL.

- **Chapter 5 Results and Discussions**

Chapter 5 explains the optimum solution of the case study. The sensitivity range of the selling price, processing cost and processing time are also given.

- **Chapter 6 Conclusions and Recommendations**

  The last chapter of the report is actually a summary of the study. Some recommendations for future studies are addressed.

1.7 Conclusion

This chapter has given a general idea of this project. By the problem identification at Company T, proper objectives and scopes have well defined. This has given a clear direction throughout this project. Besides that, the significant of the project is also discussed in this chapter. It is believed that this project will bring benefit to Company T, which can make a proper decision in order to maximize the profit.