SIMULATION OF SEQUENCING RULES IN A FIVE-SIMILAR-MACHINE JOB SHOP

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To my Beloved Mother and Father

LEE SIEW DUAN
ANG TECK YOKE

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ABSTRACT

Nowadays, simulation is essential when researching manufacturing process or designing production system. Line performance and equipment utilization are two major points of interest for every manufacturing company in order to increase competitiveness in the global market. The job shop scheduling is the allocation of a number of machines to perform a set of jobs. Job shop scheduling problem exists in most of the manufacturing systems in various form. Due to its high mix and low volume manufacturing environment, priority selecting among the jobs is challenging. This project is a real case study which involving a job shop with five similar CNC milling machines. A total of six jobs were performed and each of them consists of a different set of operation. The sequence of the six jobs to enter the system was determined by the sequencing rules including shortest setup time (SST), shortest processing time (SPT), shortest processing time + setup time (SPST), lowest volume (LV), least process (LP) and earliest due date (EDD). The setup time was taken into consideration to make the results more realistic. Due to the complexity of the model, WITNESS was used to simulate all the sequencing rules and the results are obtained. The best rules approach for the company in this study can be determined by comparing the results for each rule. By doing this, the company will be able to make faster and better decision about which job should be processed first instead of pick it randomly among the jobs. The results indicate that no single rule is excellent in all criteria. SPST rule was recommended to the company as it performed the best in terms of total completion time.

ABSTRAK

Pada masa kini, simulasi adalah penting ketika meneliti proses pembuatan atau merekabentuk sistem pengeluaran. Prestasi line pengeluaran dan pemanfaatan penggunaan peralatan adalah dua perkara penting yang menarik perhatian bagi setiap syarikat perkilangan untuk tujuan meningkatkan daya saing di pasaran global. Penjadualan dalam bengkel kerja bermaksud penetapan mesin-mesin yang sedia ada untuk melakukan serangkaian pekerjaan. Masalah penjadualan bengkel kerja yang terdapat dalam sistem manufaktur muncul dalam berbagai-bagai bentuk. Disebabkan oleh proces yang rumit dan volume yang rendah, pemilihan keutamaan antara pekerjaan adalah mencabar. Projek ini merupakan kajian kes benar yang melibatkan sebuah job shop yang mengandungi lima mesin penggilingan CNC yang serupa. Sebanyak enam pekerjaan akan dilakukan dan masing-masing terdiri daripada satu set operasi yang berbeza. Urutan dari enam pekerjaan untuk memasuki sistem ditentukan oleh peraturan urutan termasuk masa setup terpendek (SST), masa proses terpendek (SPT), masa setup + masa proces yang terpendek (SPST), volume terendah (LV), bilangan proses yang tersedikit (LP) dan tarikh tamat terawal (EDD). Masa setup telah dipertimbangkan untuk menjadikan keputusan lebih realistik. Disebabkan oleh kerumitan model ini, WITNESS telah digunakan untuk mensimulasikan semua peraturan urutan dan menghasilkan keputusan. Peraturan yang terbaik bagi syarikat dalam kajian ini dapat ditentukan dengan membandingkan keputusan untuk setiap aturan. Dengan ini, syarikat dapat membuat keputusan lebih cepat dan lebih baik tentang urutan pekerjaan yang harus diproses dahulu dan bukan memilih pekerjaan secara rawak. Keputusan kajian menunjukkan bahawa tidak ada peraturan tunggal yang sangat baik di semua kriteria. Peraturan SPST dicadangkan kepada syarikat kerana ia mencatat masa yang terpendek untuk menamatkan semua pekerjaan.

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LIST OF SYMBOLS/ ABBREVIATIONS

CR	-	Critical ratio
EDD	-	Earliest due date
FCFS	-	First come first serve
LP	-	Least process
LPT	-	Longest processing time
LV	-	Lowest volume
SPT	-	Shortest processing time
SPST	-	Shortest processing time + setup time
SST	-	Shortest setup time
T_E	-	The instant in the simulation when event E occurs
WIP	-	Work in progress
$\bar{X}$	-	Mean
σ	-	Standard deviation

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This study focuses on applying various sequencing rules in a company with a high mix/low volume manufacturing environment and simulates all the sequencing rules in order to suggest the best rules approach for manufacturing multiple high mix / low volume products. Proper scheduling leads to increased efficiency and capacity utilization, reduced time required to complete tasks and consequently increased profitability of an organization (Vinod and Sridharan, 2008). The most common high mix/low volume environment is in a job shop.

This project is a simulation-based experimental study of sequencing rules for scheduling a dynamic job shop with five similar CNC milling machines. The job-shop scheduling problem (JSSP) is one of the most critical problems in scheduling. It aims to allocate a number of machines over time to perform a set of jobs with certain constraint conditions in order to optimize a certain criterion for example, minimizing the makespan (Yang, 2007). In classical job shop scheduling problem, n jobs are processed to completion on m machines. Each job has distinct routes according to the technology constraints which are fixed and known. Every machine requires a setting up period before any operation. Setup time is defined as the time interval between the end of processing of the current job and the beginning of processing of the next job (Vinod and Sridharan, 2008). Setup is the activities to prepare a machine or work station to perform the next machining operation. For example, in a CNC milling machine, the setup including key in all the commands, clean up the cooling used for

the pervious operation, insert the cutting tool or jig, and get the zero point. Over the years, many sequencing rules have been proposed by many researchers that no single rule has been found to perform well for all important criteria such as mean flow time, mean tardiness and utilization. The choice of a sequencing rule depends on which criterion is intended to be improved upon (Holthaus and Rajendranb, 1996).

Traditionally, when dealing with scheduling problem, researchers tend to neglect setup time. By doing this, the complexity of the scheduling problem is reduced but the result may be unrealistic. In this study, setup time is taken into account when applying all the sequencing rules. There are six setup oriented sequencing rules selected in this study, including: shortest setup time (SST) , shortest processing time (SPT), shortest processing + setup time (SPST) , Least process (LP) with SPST, Earliest due date (EDD) with SPST, and Lowest volume (LV) with SPST. The performances of each sequencing rules can be measured by determining the average work in progress (WIP), average time a part spent in the system, percentage of idle or busy of a machine and total completion time. WITNESS is used to simulate all the six basic sequencing rules proposed in this study. By comparing the results of each rule, the best sequencing rules can be determined.

1.2 Background of The Study

Due to market trends, product orders of low volume and high variety types have been increasing in demand. The job-shop scheduling problem is one of the most popular manufacturing optimization models used in practice (Tay and Ho, 2008).This project is a real case study which involved a job shop with five similar CNC milling machines. The products of this job shop are printers and photocopy machine metal parts. The machines in the job shop can perform all jobs in the job shop by changing the setup. Each job has its own specific routing which cannot be altered. The five similar CNC milling machines have a multiple flow path. The jobs will just enter any of the machines which are vacant at that particular time. This multiple flow path of the five machines make the situation complicated and the difficult to measure the performance of each rule. The performances that are focused

are maximum average time a part spent in the system, percentage of busy of the workstations, average work in progress (WIP) and total completion time. Due to the complexity of multiple flow among the five CNC milling machines, manual calculation to measure the performance is impossible. Thus, WITNESS is used to simulate all the six sequencing rules and the performance report is generated. This project aims to suggest the best sequencing rules for the job shop by comparing the performance of the six rules.

1.3 Problem Statement

Priority selecting of each job is vital for every manufacturing company and it becomes very complicated especially in a high mix and low volume manufacturing environment. Without a proper sequencing of jobs, often lead to longer completion time, delay in schedule and force the company to do overtime.

1.4 Scope of study

This project focuses on

- All the 5 similar CNC milling machines in the factory
- 6 types of parts which constantly receive orders in every month.
- Use of sequencing rules
- WITNESS simulation

1.5 Objective

The objective of this project is to simulate various sequencing rules and to suggest the best rule for a job shop with five similar machines to perform a set of jobs.

1.6 Contribution of This Study

This study proposes new sequencing rules by combining the basic rules with the setup time. The five similar machines with multiple flows increase the complexity of the system. Traditional rules or mathematical model cannot be applied because the performance is difficult to be calculated manually. Simulation is done to measure the performance of each sequencing rules and suggest the best rule for the company. This allows the company to make better and faster decisions when selecting the job to run production.

1.7 Arrangement of Report

This report consists of six chapters, and is summarized as below:

Chapter 1 Introduction

Chapter 1 gives the overview of the project.

Chapter 2 Literature Review

Chapter 2 discusses on several topics related to this study. Topics reviewed in this chapter including: sequencing rules, job shop description and WITNESS simulation. Some previous studies which related to this study are also being discussed in this chapter.

Chapter 3 Methodology

Chapter 3 discusses the method used to conduct this research**.** The flow of the entire project is shown and the company problem is identified. This chapter also discusses the six sequencing rules used in this project.

Chapter 4 Data Collection and Simulation Modelling

Chapter 4 discusses about the data collection process and sample size calculation. All the data collected in the company is shown in this chapter. This chapter also explains how the simulation is modeled.

Chapter 5 results and discussions

Chapter 5 shows all the results obtained from WITNESS and provides explanation for each of them. A summary of the result is discussed at the end of the chapter.

Chapter 6 Conclusion

Chapter 6 gives a summary of the entire project, provides recommendations for future research and concludes the study.

1.8 Conclusion

This chapter provides an overview of the entire study**.** The introduction is supported by the background of the project to provide a clear view of this research. The objective and scopes of the project were stated to address the goals and boundaries of the study. The problem statement and the contribution of this study are also explained in this chapter. Finally, the arrangement of the report with brief summary of all the chapters is listed down.