UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF PROTOTYPE SCHEDULING AND SEQUENCING SOFTWARE FOR JOB SHOP MANUFACTURING IN SHEET METAL FABRICATION

MOHAMAD ZAIHIRAIN MOHAMED RASIN

FK 2002 9

DEVELOPMENT OF PROTOTYPE SCHEDULING AND SEQUENCING SOFTWARE FOR JOB SHOP MANUFACTURING IN SHEET METAL FABRICATION

By

MOHAMAD ZAIHIRAIN MOHAMED RASIN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

December 2001

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

DEVELOPMENT OF PROTOTYPE SCHEDULING AND SEQUENCING SOFTWARE FOR JOB SHOP MANUFACTURING IN SHEET METAL FABRICATION

By

MOHAMAD ZAIHIRAIN MOHAMED RASIN

December 2001

Chairman: Napsiah Ismail, Ph.D.

Faculty : Engineering

A software program has been developed to ease the process of scheduling and sequencing number of jobs to certain number of machines for job shop manufacturing in sheet metal fabrication. The program is designed based on the present operation at Technology Park Malaysia (TPM) - Production Engineering using available priority dispatching rules and multiple performance measures.

For n by m job shop scheduling problems, where n is the number of jobs and m is the number machines, there are $(n!)^m$ possible schedules. In a typical job shop, hundreds of scheduling decisions must be made daily. Scheduling process, which is to organise, maintain, update and reschedule the job, is very tedious work and time consuming. For five jobs passing through one machine, there are 120 time charts just to show all possible sequence patterns. To plot the charts manually is not a practical solution and ridiculous. Identifying the performance measures to be used in selecting

the schedule is important. The schedule should reflect managerially acceptable performance measures. A logical strategy is thus to pursue methods that can consistently generate good schedules with quantifiable quality in a computationally efficient manner.

TPM-Production Engineering involves in sheet metal fabrication activities. On the average, there are 10 to 20 different jobs per month to be produced either as part components or complete assembly products. In general, there are five different processes involved namely shearing, laser cutting, turret punching, bending and welding. Some jobs may require to go through all the processes. At present, machine scheduling and job sequencing is done manually, thus making it difficult to monitor the job progress and the delivery schedule.

A window-based job shop scheduling software (JSS), developed in this study is capable to assist the planner to quickly generate a better schedule. The software proves to be able to generate all the possible schedules with different priority dispatching rules (PDRs), analyse the performance measure of each schedule generated and recommend the best option. JSS is capable to function well and can be used to schedule actual jobs at TPM-Production Engineering.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia bagi memenuhi keperluan untuk ijazah Master Sains

PEMBANGUNAN PROTOTAIP PERISIAN PENJADUALAN DAN TURUTAN BAGI PEMBUATAN JENIS JOBSOP UNTUK FABRIKASI LOGAM KEPINGAN

Oleh

MOHAMAD ZAIHIRAIN MOHAMED RASIN

Disember 2001

Pengerusi: Napsiah Ismail, Ph.D.

Fakulti : Kejuruteraan

Satu aturcara perisian telah dibangunkan untuk membantu memudahkan proses penjadualan dan aturan kerja dan mesin bagi pengilangan jenis jobsop di dalam fabrikasi logam kepingan. Aturcara ini telah dibina berdasarkan kepada operasi semasa di Technology Park Malaysia (TPM)-Production Enginering dengan menggunakan peraturan penghantaran utama yang sedia ada dan petunjuk prestasi berbilang.

Bagi n kali m masalah penjadualan jobsop, di mana n merupakan bilangan kerja dan m pula adalah bilangan mesin, terdapat $(n!)^m$ kemungkinan jenis jadual. Dalam sesuatu jobsop tipikal, beratus jadual perlu diputuskan setiap hari. Proses penjadualan di mana untuk mengurus, menyelenggara, mengemaskini dan menjadual semula kerja adalah satu kerja yang rumit dan mengambil masa. Bagi lima kerja yang melalui satu mesin, terdapat 120 carta masa hanya untuk menunjukkan semua

kemungkinan turutan. Bagi melakar kesemua carta secara manual bukanlah merupakan satu penyelesaian yang praktikal dan tidak munasabah. Mengenal pasti petunjuk prestasi yang akan digunakan bagi memilih jadual adalah penting. Jadual haruslah menggambarkan petunjuk prestasi yang diterima oleh pihak pengurusan. Oleh itu, satu strategi yang logik adalah dengan mengenalpasti dan menggunakan kaedah yang dapat menjana jadual yang berkualiti dalam keadaan pengiraan yang efisyen.

TPM-Production Engineering terlibat dalam aktiviti fabrikasi logam kepingan. Secara purata, terdapat 10 ke 20 kerja yang berlainan yang perlu dikeluarkan sama ada dalam bentuk komponen atau produk terpasang. Secara umumnya, terdapat lima proses berlainan yang terbabit iaitu ricihan, pemotongan secara laser, penebukan, lipatan dan kimpalan logam. Beberapa kerja perlu melalui kesemua proses tersebut. Buat masa ini, penjadualan mesin dan turutan kerja dijalankan secara manual, oleh sebab itu agak sukar untuk mengawasi perkembangan perjalanan kerja dan juga jadual penghantaran. .

Perisian penjadualan (JSS) berdasarkan tertingkap yang dibangunkan mampu bagi membantu pembuat jadual untuk menjana jadual dengan lebih cepat dan lebih baik. Perisian ini terbukti boleh menjana kesemua kemungkinan jadual bagi setiap peraturan penghantaran (PDR) yang berlainan, membuat analisa ke atas petunjuk prestasi bagi setiap jadual yang dihasilkan dan mengesyorkan opsyen yang terbaik. JSS berupaya berfungsi dengan baik dan dapat digunakan bagi membuat jadual kerja di TPM-Production Engineering.

ACKNOWLEDGEMENTS

I would like to express my utmost gratitude and appreciation to the chairman of the supervisory committee, Dr. Napsiah Ismail for all her supervision, guidance, support and help throughout the completion of this study.

I also wish my profound gratitude and appreciation to the members of supervisory committee Dr. Megat Mohamad Hamdan Megat Ahmad and Ir. Dr. Mohd Sapuan Salit for their guidance and constructive suggestions and comments throughout the duration of the study.

Special thanks to Ir. Tuan Haji Mohd Rasid Osman and Puan Rosnah Yusuff for their suggestion and comments and also to TPM-Production Engineering staff for their cooperation and suggestion throughout this study.

Finally, I would like to thank my parents, wife and children for their encouragement, understanding and support given to pursue the interest in the field.

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AD	:	Available date
AI	:	Artificial intelligence
AJFT	:	Average job flow time
CR	:	Critical ratio
DD	:	Due date
EDD	:	Earliest due date
ERP	:	Enterprise resource planning
ESD	:	Early start date
FCFS	:	First Come First Serve
FD	:	Finish date
GAS	:	Generating active schedule
JFT	:	Job flow time
JSP	:	Job shop scheduling problem
JSS	:	Job shop scheduling software
LPT	:	Longest processing time
MAD	:	Machine earliest available date
MRP	:	Material requirement planning
N	:	Number of process
NC	:	Number of process which has been completed
PDR	:	Priority dispatching rule
PM	:	Performance measure
SD	:	Start date
SEC	:	Setting essential conflicts
SPT	:	Shortest processing time

S/RO	:	Slack per remaining operation
SBP	:	Shifting bottleneck procedure
SSD	:	Schedule start date
TC	:	Total process hour which has been completed
T	:	Total process hour
TPM	:	Technology Park Malaysia
WIP	:	Work-in-process

CHAPTER 1

INTRODUCTION

1.1 Importance of the Study

In today's highly competitive markets, companies have come to view customer satisfaction as a key to maintaining and increasing their market share. One of the most important measures of the quality of service a company provides is on-time delivery performance. Orders delivered after a promised due date will result in lost customer good-will and, ultimately, in lost market share. This is particularly true for small make-to-order companies whose business is based on producing a special product to customer specification rather than on producing standardised parts to stock (Ashby and Uzsoy 1995).

Scheduling is a key factor for manufacturing productivity. Effective scheduling will improve on-time delivery, reduce inventory, cut lead times, and improve the utilisation of bottleneck resources. Because of the combinatorial nature of scheduling problems, it is often difficult to obtain optimal schedules, especially within a limited amount of computation time (Zhang 1997). It is very difficult to evaluate the quality of these schedules, and the consistency of performance may also be an issue.

Job shop manufacturing company specializes in low-to-medium-volume production utilizing job or batch processes. Tasks in this type of flexible flow environment are difficult to schedule because of the variability in job routings and the continual introduction of new jobs to be processed. Scheduling mistakes can be costly (Krajewski and Ritzman, 1998).

For n x m job shop scheduling problems, where n is the number of jobs and m is the number of tasks per job, there are $(n!)^m$ possible schedules for n jobs, each requiring m machines. Imagine to schedule only five jobs passing through one machine will already take 120 time charts to show all possible sequence patterns. To plot the charts manually is not a practical solution and ridiculous.

In a typical job shop, hundreds of scheduling decisions must be made daily. Identifying the performance measures to be used in selecting the schedule is important. The schedules should reflect managerially acceptable performance measures. Therefore, a logical strategy is thus to pursue methods that can consistently generate good schedules with quantifiable quality in a computationally efficient manner.

1.2 Problem Identification

Technology Park Malaysia (TPM)-Production Engineering involves in sheet metal fabrication activities. On the average, there are about 10 to 20 different jobs per month to be produced that are either as part components or complete assembly products. There are 5 different processes involve in completing the job. In general, the process starts with shearing, laser cutting, turret punching, bending and ends with welding. Some jobs may require all the processes and some do not.

TPM-Production Engineering sometimes received complaints from customers. Among the complaints are missing deadline and failure to provide feedback on expected job delivery dates. The management views these complaints very seriously as they will create problems to its business activities. The existing customers may not be satisfied with the delivery services and most likely to run away. TPM-Production Engineering then has to always seek for new customer. If TPM-Production Engineering has difficulty in keeping existing customers, continue to loose customers, and always depend on new customers for revenue activities, eventually the centre will have to close shop. The problems therefore have to be solved immediately.

Currently, machine scheduling and job sequencing are done manually. Thus, make it difficult to oversee the whole movement of jobs or machine allocation in order to monitor the job progress and the delivery schedule. Scheduling jobs manually is one of the main reasons that make it difficult to provide feedback to customer on the expected delivery date.

The whole scheduling process is very tedious work and time consuming especially to organise, maintain, update and reschedule the job manually. After having all the required information on process flow and estimated process time, planner has to plan the job so that it meets the customer's requirement or at least to know in advance the expected completion date. Planner has to decide on which job to run first and plot the schedule. The process of deciding the sequence and plotting the operation hours on Gantt chart alone is very time consuming. On the other hand, when few jobs come in at one time, it was difficult to schedule which one to run first as it was difficult to see the actual progress of jobs which is still running. Which priority dispatching rules (PDRs) to use – first come first serve, shortest processing time, earliest due date or critical ratio will provide the best performance measure. To run all the PDRs by manually plotting the Gantt chart is not only expensive but also very time consuming.

Scheduling is a very dynamic process where one has to update the progress and reschedule if necessary. Failing to carry out this process periodically will make it difficult to oversee the whole movement of jobs, machine allocation as well as to monitor the job progress and the delivery schedule. Therefore, an automatic process is very much required to assist the planner to generate a better schedule and thus generate efficient scheduling at TPM-Production Engineering.

Currently, there are varieties of scheduling tools available in the market but most of them are usually designed towards manufacturing database management where it stressed on order entry, estimation, costing, quotation, sale order processing and purchase order. Scheduling usually is just a module in the solution offered. Therefore, most of the available softwares do not stressed on the job scheduling and sequencing. It is more on job tracking, where jobs details are input to the system and users are allowed to play around with the schedule with the help of gantt chart and try to manipulate the chart to do some what-if analysis.

Although there are powerful tools, these technology-driven scheduling software is not widespread due to especially the cost of purchasing the software as well as the cost of implementation which sometimes is even more expensive than the cost of the software itself. The price of the software could range from USD 12,000 to USD 300,000. The cost of purchasing the software usually is expensive because most of the scheduling tools are packaged as one enterprise solutions or as one material requirement planning (MRP) solutions, which is more inclined towards manufacturing database management system.

1.3 Objective of the Study

In a job shop, parts with various due dates and priorities are to be processed on various types of machines. Job shop scheduling is to select the machines and beginning times for individual operations to achieve certain performance measure(s).

The objective of the study is to develop a software program to ease the process of job scheduling and sequencing for job shop manufacturing in sheet metal fabrication. The software program is designed based on the present operation at TPM-Production Engineering using available priority dispatching rules as sequencing rule and multiple performance measures as indicator.

1.4 Scope of the Study

The scope of the study is to schedule n jobs concurrently by developing a schedule for each part travelling among the five machines at TPM-Production Engineering with the objective specified by the performance measures. The five most widely used performance measures namely minimise average job flow time, minimise make span, minimise percentage past due, minimise average days past due and maximise average early delivery are included in the study.

In scheduling multiple workstation, each operation is treated independently. When a workstation becomes idle, priority rule is applied to the job waiting for that operation. The one with the highest priority is selected. When that operation is completed, the job is moved to the next operation. The constraints considered in the study are as follows:

1. Each job consists of operation with a known process sequence and processing time.
2. Each job will be processed at any particular machine only once.
3. One machine can only process one job at one time. No two activities requiring the same machine may execute at the same time.
4. Allocation of job to machine is subject to the earliest machine available time and the availability of the job.
5. Average machine setup time is imposed to a new job at each machine once started. Average setup time at each machine is based on user input.
6. Average setup factor is imposed to each job. This is to make sure that the operation starts immediately after the set up is done. Average setup factor at each machine is based on user input.
7. Handling time is included in the machine process time. Transportation is negligible because distance from machine to machine is very near.
8. For big quantity lot size, batching is applied. User has to split lot into smaller lot quantity.

CHAPTER 2

LITERATURE REVIEW

This literature review chapter includes section on production control, job shop manufacturing, operation scheduling, job sequencing, performance measures, types of scheduling problems and findings and scheduling techniques.

2.1 Production Control

According to Wacker and Hanson (1997), manufacturing planning and control system concerns with the planning and controlling of manufacturing processes including materials, machines and people. Riggs (1981) and Vollman et. al. (1984) describe production control as serving dual purposes of directing the implementation of previously planned activities and monitoring their progress to discover and correct irregularities while quantity control concentrates on delivering the desired output within the expected delivery date.

2.1.1 Types of Production

Groover (2001) describes production as a transformation process in which raw materials are converted into goods that have value in the marketplace while a production system is the design process by which elements are transformed into useful products.

Riggs (1981) points out that there are three types of production namely continuous production, intermittent production and special projects. The characteristic of each production is described in Table 1.

Table 1: Characteristics of three different production designs (Riggs, 1981)

a. Continuous production
Standardised end product and manufacturing routine. High volume of output produced by specialized equipment. Low in-process inventory and long production runs. Low worker skill levels. Limited flexibility of process.

b. Intermittent production
Nonstandard end product requiring extensive production controls. Medium volume of output produced by general-purpose equipment. High in-process inventory and shorter production runs. Medium to high worker skill levels. More flexible process owing to versatile material-handling equipment.

c. Special projects
Unique end product requiring extreme production controls. Low volume of output often requiring the cooperation of several subcontractors. High in-process inventory with a single production run. High worker skill levels. High flexibility of process

2.1.2 Control Designs

There are many production control designs. A control system designed for one plant might not work in another and might not even remain effective for the original plant as production requirement change. Riggs (1981) classified control designs into three types namely special project control, flow control and order control.

The special project category is reserved for distinctive or particularly important undertakings with unusual features. The most common examples are construction projects such as dams, factory modifications, building and bridges. The