KAJIAN ANALITIK TERHADAP HUBUNGKAIT ANTARA PERATURAN PENGHANTARAN DAN PRESTASI UNTUK PERSEKITARAN PENJADUALAN DINAMIK BAGI SUSUNAN MESIN SELARI YANG SERUPA

(AN ANALYTICAL REVIEW OF THE RELATIONSHIP BETWEEN DISPATCHING RULES AND PERFORMANCE FOR DYNAMIC SCHEDULING IN AN IDENTICAL PARALLEL MACHINE ENVIRONMENT)

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NOMENCLATURE

i	job
j	machine
n	number of jobs to be scheduled
m	number of machine
P_1	processing time for job i
F_i	Flow time (the length of time job i is in the shop)
D_i	Due date (final time to complete job i)
L_i	Lateness (total time when job i completion time exceed due date)
T_i	Tardiness for job i
E_i	Earliness for job i
$\overline{F_i}$	Mean flow time for job i
Z_i	Priority index assigned for job i
W_i	Weighting or customer priority of job i
t_i	Total processing time for job i
w_i	Total waiting time for job i

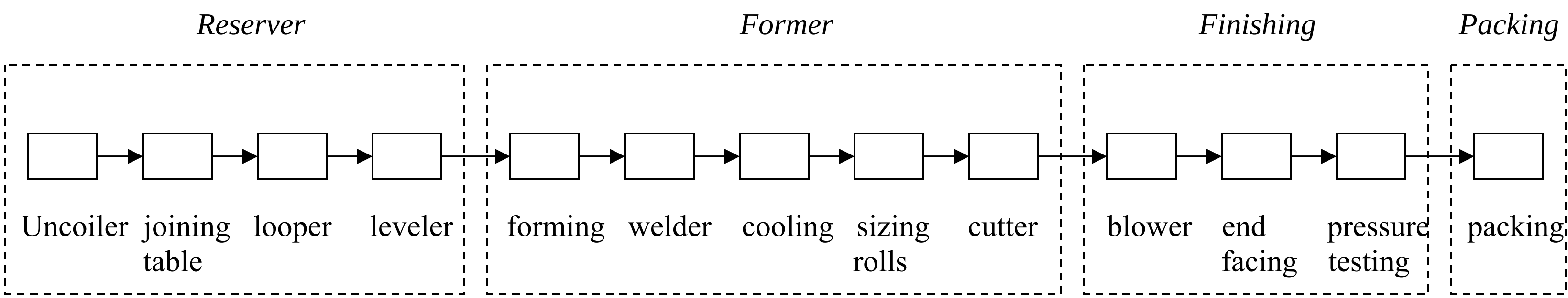

Figure 3.2 Machine grouping for simulation model building

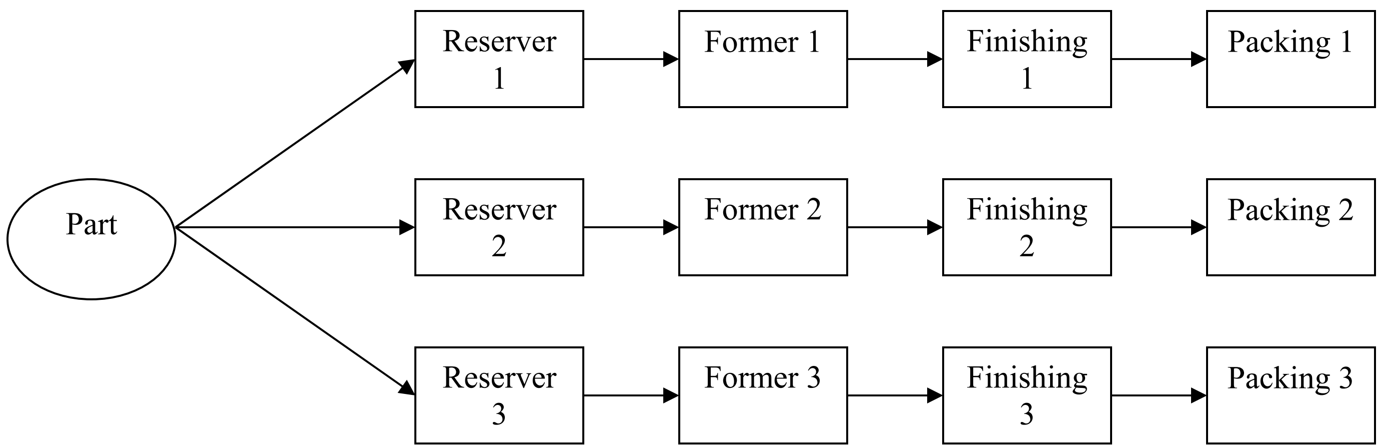

Figure 3.3 Illustration of simulation model

ABSTRACT

This report consist an analytical review of the relationship between dispatching rules and performance measure for dynamic scheduling problem. The review is focused on an identical parallel machine environment. The dynamic issues that considered are machine breakdown and operator absent. The main objective of the research work is to analyze the performance of dispatching rules against different performance measures. Five suitable dispatching rules that considering the priority of weighs which called weighted dispatching rules is used. Dispatching rule is used to specify which job should be selected for work next from among a queue of jobs. Simulation model is developed based on real world case study using WITNESS software. Than the experiment model is developed by adding disturbance parameter likes machine breakdown and operator absent. The experiment is done to determine the effects of the disturbance parameter to the performance of dispatching rules used. The experiment result is proved by analysis of variance (ANOVA). From the experiment analysis, the different dispatching rules provide the different result of performance measures. Dispatching rules can be used to determine the minimum throughput time, minimum lateness and earliness of the jobs. The performance of dispatching rules also depends on disturbance parameter that used in the experiment model and the quantity of jobs required.

ABSTRAK

Laporan ini membincangkan kajian analitik terhadap hubungkait di antara peraturan penghantaran dan ukuran prestasi untuk masalah penjadualan dinamik. Kajian ini memfokuskan kepada susunan mesin selari yang serupa. Isu-isu dinamik yang dibincangkan ialah kerosakan mesin dan ketidakhadiran pekerja. Objektif utama kajian ini ialah untuk menganalisa prestasi untuk peraturan penghantaran yang digunakan terhadap ukuran prestasi yang berbeza. Lima peraturan penghantaran yang mengambil kira pemberat keutamaan telah digunakan dan peraturan penghantaran ini dinamakan peraturan penghantaran berpemberat. Peraturan penghantaran digunakan untuk menyusun dan menentukan tugasan yang dipilih daripada jujukan kerja yang ada. Model simulasi dibangunkan menggunakan sofwer WITNESS berdasarkan maklumat daripada kajian kes dari industri sebenar. Model ujikaji di bangunkan dengan menambah parameter gangguan seperti kerosakan mesin dan ketidakhadiran pekerja. Ujikaji dijalankan untuk menentukan kesan parameter gangguan yang digunakan terhadap prestasi peraturan-peraturan penghantaran yang dipilih. Keputusan ujikaji dibuktikan dengan menggunakan kaedah menganalisa pembolehubah (ANOVA). Daripada keputusan ujikaji, didapati bahawa penggunaan peraturan penghantaran memberi kesan kepada ukuran prestasi yang digunakan. Peraturan penghantaran boleh digunakan untuk menentukan masa celusan yang paling minima, masa lewat yang minima dan masa awal. Prestasi peraturan penghantaran juga bergantung kepada parameter gangguan yang digunakan dan jumlah tugasan yang perlu disiapkan.

Chapter 1

INTRODUCTION

1.1 Background

Production scheduling is a function to determine an actual implementation plant as to the time schedule for all jobs to be executed (Hitomi, 1996). Normally, production scheduling is done after many other managerial decisions have been made. Three basic types of production scheduling are *demand scheduling*, which assigns customer to a definite time for order fulfillment, *workforce scheduling* that determines when employees work and *operation scheduling* that assigns jobs to workstations or employees to jobs for specified time periods. (Krajeweski and Ritzman, 2005)

Operation scheduling is used to allocate the jobs to be processed on the corresponding machine in a given time span for a shop floor that consisting several machines or production facilities including operative worker. Operation scheduling is divided into two conditions, static and dynamic. For static condition, a set of independent jobs is available for processing at time zero. If those jobs is randomly enter the shop floor, this situation is called dynamic. In real system, operation scheduling is dynamic in nature. Many uncertainties encountered in real manufacturing system such as machine breakdowns, increase priorities of jobs, changes in due date, order cancellation and operators absent. These uncertainties have to consider before a set of permutation schedule is done.

Besides uncertainties event that mention above, operation scheduling also depend on allocation of machine on the shop floor. For multiple machine models, parallel machine is frequently encountered in practice. Parallel machine is used when additional processing capacity is needed. Basically, parallel machine can be identical or non identical. Identical parallel machine means each line in manufacturing cell consists same machine with same the configuration. Figure 1.1 shows the schematic diagram for parallel machine. (Hitomi, 1996)

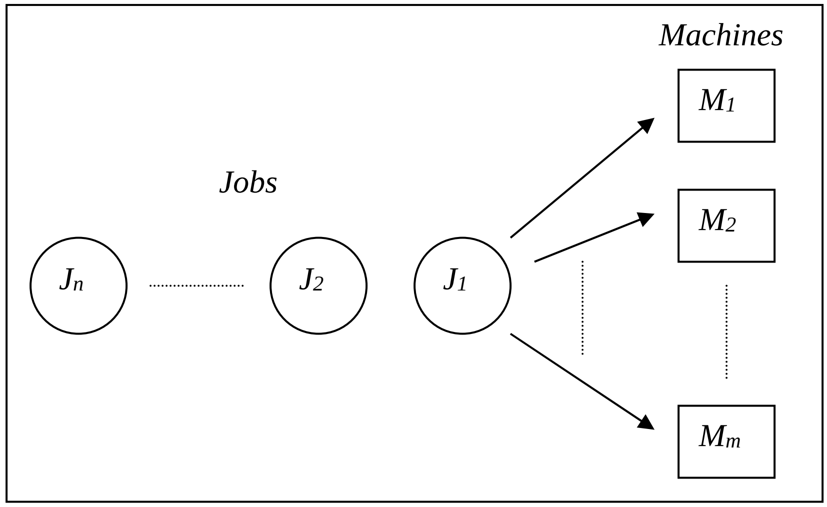

Figure 1.1: Parallel machine

1.2 Problem Statement

A basic problem in operation scheduling is to determine the order of processing of jobs waiting to be processed on a machine. In other hand this is known as job sequencing. The reasonable sequence of jobs should be used to reduce the processing time. An optimal job sequence can be selected from among a set of permutation schedules or by using dispatching rules. When more than one job is in a queue in front of machine, the order of processing such jobs must be determined to specify what the machine should do next. Dispatching rules can be applied to obtain reasonable schedules for these jobs. Dispatching rules specifies which job should be selected for work from among a queue of jobs. The application of dispatching rules should be measure using suitable performance measures.

1.3 Objective

The objectives of this project are:

i. To develop the simulation model based on real world case study
ii. To determine the suitable dispatching rules in dynamic scheduling for identical parallel machine environment perform by simulation model
iii. To analyze the performance of dispatching rules used
iv. To chose the best dispatching rules from the performance analysis

Chapter 2

LITERATURE REVIEW

This chapter consists the review of some research that related to dynamic scheduling, parallel machine, dispatching rules, performance measures and simulation.

2.1 Dynamic Scheduling

For the operation scheduling problems, most research focused on optimizing the makespan under static conditions. A scheduling problem is called static if all information required to develop a feasible (optimal or non-optimal) schedule is available before the first task is actually processed. This means that the number of tasks, their processing times, and precedence constraints are known in advance (Antonio et. al., 2003).

Rajendran and Ziegler (2000) investigate the performance of dispatching rules and undertaken a heuristic for scheduling in static flowshops with missing operations. The measure of performance is the minimization of total flow time of jobs. Four dispatching rules, including a new dispatching rule are considered. Two types of flow shop are studied: one with no missing operation of jobs and another with missing operation of jobs.

In practical, a scheduler often has to react to unexpected events. The main uncertainties encountered in real manufacturing system are the following (Dimopoulos and Ali, 2000):

i. Machine breakdown including uncertain repair time;
ii. Increased priority of jobs;
iii. Change in due dates;
iv. Order cancellation.

Whenever an unexpected event happens in manufacturing plant, a scheduling decision must be made in real time about the possible reordering of jobs. This process is known as 'rescheduling'.

Following is the review of some research that related to dynamic scheduling. The first study in this area was initialized in 1974 by Holloway and Nelson who implemented a multi-pass procedure in a job-shop by generating schedules periodically. They conclude that a periodic policy (scheduling/rescheduling periodically) is effective in dynamic job shop environments. Muhleman et al. (1982) analyzed the periodic scheduling policy in a dynamic and stochastic job shop system. Their experiments indicate that more frequent revision is needed to obtain better scheduling performance. Church and Uzsoy (1992) considered periodic and event-driven rescheduling deteriorates as the length of rescheduling period increases and event-driven methods achieve a reasonably good performance.

Then, Ovacik and Uzsoy (1994) studied a dynamic single machine problem with sequence-dependent set-ups by comparing heuristic rules that use global information in making local scheduling decisions at the machine level to several myopic dispatching rules, which use only local information.

Sabuncuonglu and Karabuk (1997) proposed several reactive scheduling policies to cope with machine breakdowns and processing time variations. Their result indicates that it is not always beneficial to reschedule the operation in response to every unexpected event and the periodic response with an appropriate length can be quite effective in dealing with the interruptions. In 2000, Subramaniam et al. demonstrated the significant improvements to the performance of dispatching in dynamic job shop could be achieved easily through the used of simple machine selection rules.

Carloss (2003) developed a dynamic scheduling in multiproduct batch plants. He considered the insertion of new order arrivals, the reassignment of existing batches to alternative units due to equipment failures and the reordering and time-shifting of old batches at the current processing sequences.

Kogan (2004) studied about operation scheduling for parallel machines, which produce one product-type with controllable production rates subject to continuously divisible, time-dependent resources. The objective is to produce the required amount of product-type units by a due date while minimizing inventory, backlog and production related costs over a production horizon. With the aid of the maximum principle, a number of analytical rules of the optimal Scheduling is derived whereby the continuous-time scheduling is reduced to discrete sequencing and timing. As a result, a polynomial-time algorithm is developed for solving the problem.

Jayamohan and Rajendran (2004) develop and analyze cost-based dispatching rules for job shop scheduling. They propose dispatching rules by explicitly considering different weights or penalties for flow time and tardiness of a job. Many measures of performance related to weighted flow time and weighted tardiness of jobs are considered, and the results of simulation are presented.

S.Q. Liu et al. (2005) analyzed the characteristics of the dynamic shop scheduling problem when machine breakdown and new job arrivals occur, and present a framework to model the dynamic shop scheduling problem as a static group-shop-type scheduling problem. They are using makespan as the performance measures. As the result, the dynamic shop-scheduling problem can be solved by metaheuristics purposed which have been successful applied to the several types of static shop scheduling problems.

2.2 Parallel Machine

Parallel machine used to produce one product-type with controllable production rates subject to continuously divisible, time-dependent resources. (Askin and Goldberg, 2002)

Lin and Jeng (2004) considered a parallel machine batch scheduling problem to minimize the maximum lateness and the number of tardy jobs. Two dynamic programming algorithms were proposed for finding optimal solutions to the two objectives, respectively. The proposed algorithms take exponential times in delivering optimal schedules.

Lin and Liao (2004) consider the identical parallel machine problem with makespan minimization subject to minimum total flow time. First, they develop an optimal algorithm to the identical parallel machine problem with the objective of minimizing makespan. To improve the computational efficiency, two implementation techniques, the lower bound calculation and the job replacement rule, are applied. Based on the algorithm, an optimal algorithm, using new lower bounds, to the considered problem is developed. Computational experiments are conducted up to six machines and 1000 jobs. Although the proposed algorithm has an exponential time complexity, the computational results showed that it is efficient to find the optimal solution.

2.3 Dispatching Rules

A dispatching rule specifies which job should be selected for work next from among a queue of jobs. When a machine or worker becomes available, the dispatch rule is applied and the next job selected (Schroeder, 1993).

Dispatching rules can be classified in a number of ways (Haupt, R., 1989). One such classification is as follows:

i. Process-time based rules,
ii. Due-date based rules,
iii. Combination rules, and
iv. Rules that are neither process-time based nor due-date based.

The shortest process-time (SPT) rule is an example of a process-time based rule. The process-time based rules ignore the due-date information of mean flowtime and a good performance with respect to the mean tardiness objective has also been observed under highly loaded conditions in the shop. (Blackstone et.al, 1982). Due date based rules schedule the jobs based on their due date information. An example of a due-date based rule is the earliest due-date (EDD) rule. In general, the due date based rules give good example result under light load condition, but the performance of these rules deteriorates under high load levels (Ramasesh, 1990). Combination rules make use of both process-time and due-date information. The example of combination rules is least slack rule and critical ratio rule (CR) (Blackstone et.al, 1982). The rules that do not fall into any of these categories load the job depending on shop floor conditions rather than on the characteristics of jobs. An example of this type of rule is the WINQ rule (total work content of jobs in the queue of next operation of a job) (Haupt, R., 1989).

Montazeri and Van Wassenhove (1990) reviewed the performance of a number of dispatching rules for an FMS simulation model. They concluded that dispatching rules have a great impact on various system performance criteria, such as average machine utilization, average buffer utilization, and makespan.

Bellow is the others popular rules that often used in operation scheduling: (Askin and Standridge)

- FISFS (First in system, First serve). Select a job that has been on the shop floor the longest.
- FCFS (First Come, First Served). Selec a job that has been in the workstation's queue the longest.
- S/RO (Slack per Remaining Operation). Select a job with the smallest ratio of slack to operation remaining to be performed.
- Covert. Order jobs based on ratio of slack-based priority to processing time.
- LTWK (Least Total Work) Select a job with smallest total processing time
- LWKR (Least work remaining). Select a job with smallest total processing time for unfinished operation.
- MOPNR (Most operation remaining). Select a job with the most operation remaining in its processing sequence.
- MWKR (Most work remaining). Select a job with the most total processing time remaining.
- RANDOM (Random). Select a job at random.

Holthaus and Rajendranb (1999) study on the performance of dispatching rules in flow shops and job shops dynamic manufacturing systems. They consider 13 dispatching rules for the analysis and purposed three new dispatching rules.

2.4 Performance Measures

Identifying the performance measures to be used in selecting a schedule is important. Selecting a suitable performance measures can represent the reasonable result for performing of dispatching rules. The following list describes the most common performance measures used in operations scheduling. Each of these measures can be expressed as a statistical distribution having a mean and variance (Krajewsky and Ritzman, 2005)

i. Job Flow Time

The amount of shop time of the job. It is the sum of the moving time between operation, waiting time for machines or work orders, process time (including setups), and delay resulting from machine breakdowns, component unavailability, and the like.

Job flow time = Time of completion – Time job was available for first processing operation

Note that the starting time is the time the job was available for its first processing operation, not necessarily when the job began its first operation. Job flow time is sometimes referred to as *throughput time*.

ii. Makespan

The total amount of time required to complete a group of jobs.

Makespan = Time of completion of last job – Starting time of first job

iii. Past due

The amount of time by which a job missed its due date or the percentage of total jobs processed over some period of time that missed their due dates (also refer to as tardiness).

iv. Work-in-Process (WIP) Inventory

Any job in a waiting line, moving from one operation to the next, being delayed for some reason, being processed, or residing in component or subassembly inventories.

v. Total inventory

The sum of scheduled receipts and on-hand inventories.

Total inventory = Scheduled receipts for all items + On hand inventories of all items

This measure could be expressed in weeks of supply, dollar or unit (individual item only)

vi. Utilization

The percent of work time productivity spent by a machine or worker.

$$\text{Utilizaton} = \frac{\text{Productive work time}}{\text{Total work time available}}$$

Utilization for more that one machine or worker can be calculated by adding the productive work times of all machines and dividing by the total work time they are available

2.5 Simulation

A simulation is a model that mimics reality. There are two types of simulation; Continuous simulation and discrete event simulation. Discrete event simulation involves the modeling of a system as it progresses through time and is particularly useful for modeling queuing system (Robinson, 1993).

Simulation is one of the most powerful tools available to decision-makers responsible for the design an operation of complex process and system. Simulation model development is divided into four major phase called project definition, model building and testing, experimentation and project completion. Simulation model can be developed using simulation software. Below are three main types of simulation software: (R. and Robinson, 2001)

i. Programming languages
ii. Simulation languages
iii. Visual interactive modeling systems (VIMS)

VIMS is generally easier and quicker to develop but more expensive that other types of simulation software. Witness software is the example of VIMS.

Kamrani et al. (1998) presents a simulation-based methodology, which uses both design and manufacturing attributes to form manufacturing cells. The methodology is implemented in three phases, part grouping, machine grouping and simulation model building and verification. The mathematical and simulation models are used to solve a sample production problem. They conclude that the mathematical model is more optimistic in its predictions of the performance of he cell. Simulation model is more pessimistic in its projections. The simulation model can easily be modified to reflect changes in the machine cell such as changes in the processing rate of machine tools, increases or decreases in machine reliability and changes in part type mix.

Mehta (2002) explains about the methodology that should be followed for successful outcome of simulation project. He also discusses and illustrates some of advanced modeling capabilities provided by a simulation tools call Witness. Witness enables the user to build complex models very quicly and at the same time, incorporate desirable characteristic like high flexibility, sharability and re-usablity. He concludes that the modeler should build an accurate simulation model in minimum possible project time.

Chapter 3
METHODOLOGY

3.1 Case Study

The case study has been done about MIG-MARUICHI Melewar Industries Group Berhad. The company produce steel pipe from 10mm to 355mm and these product are widely used in the construction, furniture, automotive, bicycle and engineering industries. As a manufacturing industry, this company have to face with customer demand and unexpected event such as machine breakdown, operators absents, change of order and change in due dates. To overcome the problem, this company should have good management and select good schedules for their jobs.

Based on problem occurs from MIG-MARUICHI Melewar Industries Group Berhad, a discrete even simulation of a manufacturing cell was developed using WITNESS software. Two disturbance parameter was considered to create a dynamic environment on the simulation model. Then, the dispatching rules were applied to sequence the part order before it was processed by simulation model. The result obtained by dispatching rules is analyzed against different performance measures. Conclusion was drawn from the impact of the disturbance parameters and dispatching rules in the simulation model. Finally, the best dispatching rules is chosen.

A detail about dispatching rules and performance measures that used in this project will explain in section 3.2 and 3.3. Later in this chapter, the detail about development of simulation model is described sequentially.

3.2 Dispatching Rules

A dispatching rules specifies which job should be selected for work from among a queue of jobs. In this project, dispatching rule is use to arrange the part order before its feeds into simulation model. There are many rules are often used in shop floor scheduling. The existing rules is modified by apply the weight of job. This weight is based on customer priorities of the part order.

The priority of customer is divided into three categories; new customer, intermediate customer and regular customer. New customer is the customer that first time provides the orders. Intermediate customer is rarely obtained the order and regular customer is the most frequent customer that obtains the order. From Table 3.1, the highest weigh is put on the regular customer and it means the regular customer should be on the first consideration to process the order. Regular customer is the most important compared to intermediate and new customer. The weight for new customer is lower than intermediate customer.

Table 3.1: Ranking of the customer priorities

Customer Priority	Weighting
New customer	1
Intermediate customer	2
Regular customer	3

There are five dispatching rules is using to sequence the part order. The explanation and basic formulation for each rule is given as follows:

i. WFCFS (weighted first come, first served)
   FCFS rule means the job is selected in order of arrival at the machine. However, the important weight is also considered for sequencing the order. The order with the most weight is processed first.

ii. WSPT (weighted shortest processing time)

SPT rule means a job with minimum processing time is selected first. WSPT rule used the priority index to sequence the order. The priority index, *Zi* is calculated as follows:

$$Z_i = \frac{P_i}{W} \tag{1}$$

Where,

$$P_i = \textit{Cycle Time x Quantity Required}$$

The order with the minimum value of Z_i is chosen first.

iii. LSPT (weighted longest processing time)

SPT rule means a job with maximum processing time is selected first. WLPT rule also used the priority index to sequence the order but the order with the maximum value of Z_i is chosen first.

iv. WEDD (weight earliest due date)

EDD rule means Jobs are processed in increasing order of due date. WEDD rule used the priority index to sequence the order. The priority index, *Zi* is calculated as follows:

$$Z_i = \frac{D_i}{W_i} \tag{2}$$

The order with the minimum value of Z_i is chosen first.

v. WSLACK (weight minimum slack time)

SLACK rule means select a job with the smallest ratio of slack to operation remaining to be performed.

$$S_i = D_i - P_i \tag{3}$$

$$Z_i = \frac{S_i}{W_i} \tag{4}$$

For WSLACK rule, the order with the minimum value of Z_i is chosen first.

3.3 Performance measure

In this project, performance measures are added into simulation model to obtain the result. The result from five dispatching rules under study are evaluated with three performance measures; throughput time, earliness and lateness. Throughput time is the most applicable to compare the performance of dispatching rules. The minimum throughput time shows the optimum utilization of machine. Earliness and lateness also can be used to evaluate the performance of dispatching rule. Earliness and lateness specify the jobs which complete before or after due date. The basic formula (Hitomi, 1996) and detail about those performance measure is discuss below:

i. Throughput time (Flow time)

   Throughput time is the amount of shop time of the job. It is the sum of the moving operation, waiting time for machine or work order, process time (including setup time) and delay resulting from machine breakdowns, component unavailability, and the like.

$$F_i = w_{i1} + t_{i1} + w_{i2} + t_{i2} + \dots\dots\dots + w_{ij_i} + t_{ij_i} = t_i + w_i$$

   Where,

$$t_i = \sum_{j-1}^{ji} t_{ij} \tag{5}$$

$$w_i = \sum_{j-1}^{ji} w_{ij} \tag{6}$$

ii. Lateness, Tardiness and Earliness

   Lateness is define as the difference between the completion time and due date. It can be expressed as:

$$L_i = F_i - D_i \tag{7}$$

   If $F_i > D_i$, a positive amount of lateness, namely tardiness occurs an its express as:

$$D_i = \max\{0, L_i\} \tag{8}$$

   If $D_i > F_i$, a negative amount of lateness, namely Earliness occurs.

3.4 Development Simulation Model

Simulation is a widely used approach for assisting design and improvement of manufacturing systems. Simulation is defined as an experimental technique, usually performed on a computer, to analyze the behavior of any real-world operation system (Meyers and Stephens, 2000). To improve design and performance of manufacturing cells, simulation has become an effective method for its versatility in modeling complex and dynamic operations. Simulation is used to estimate performance measures based on input parameters and given cell configurations (Shi-Jie et. al., 2001).

In this project, the simulation model is developed based on real world case study. The process in developing a discreet event simulation model includes project definition, model building and testing, experimentation and project completion. Figure 3.2 show the process flow chart for developing the simulation model (R. and Robinson, 2001).

3.4.1 Problem formulation

The simulation modelling for this project is begins with identifying the problem. From the research about MIG-MARUICHI Melewar Industries Group Berhad., this company have a problem to schedule the jobs in their production line. The problem causes the company cannot complete the order from customer on time. The company has to find the minimum production time in order to improve the quality and productivity of products.

3.4.2 Objectives

Based on problem formulation mention above, the objective of the project is set. The objective of the model is:

i. To evaluate the performance of dispatching rules against different performance measures
ii. To identify the suitable dispatching rules that produce the optimum production time

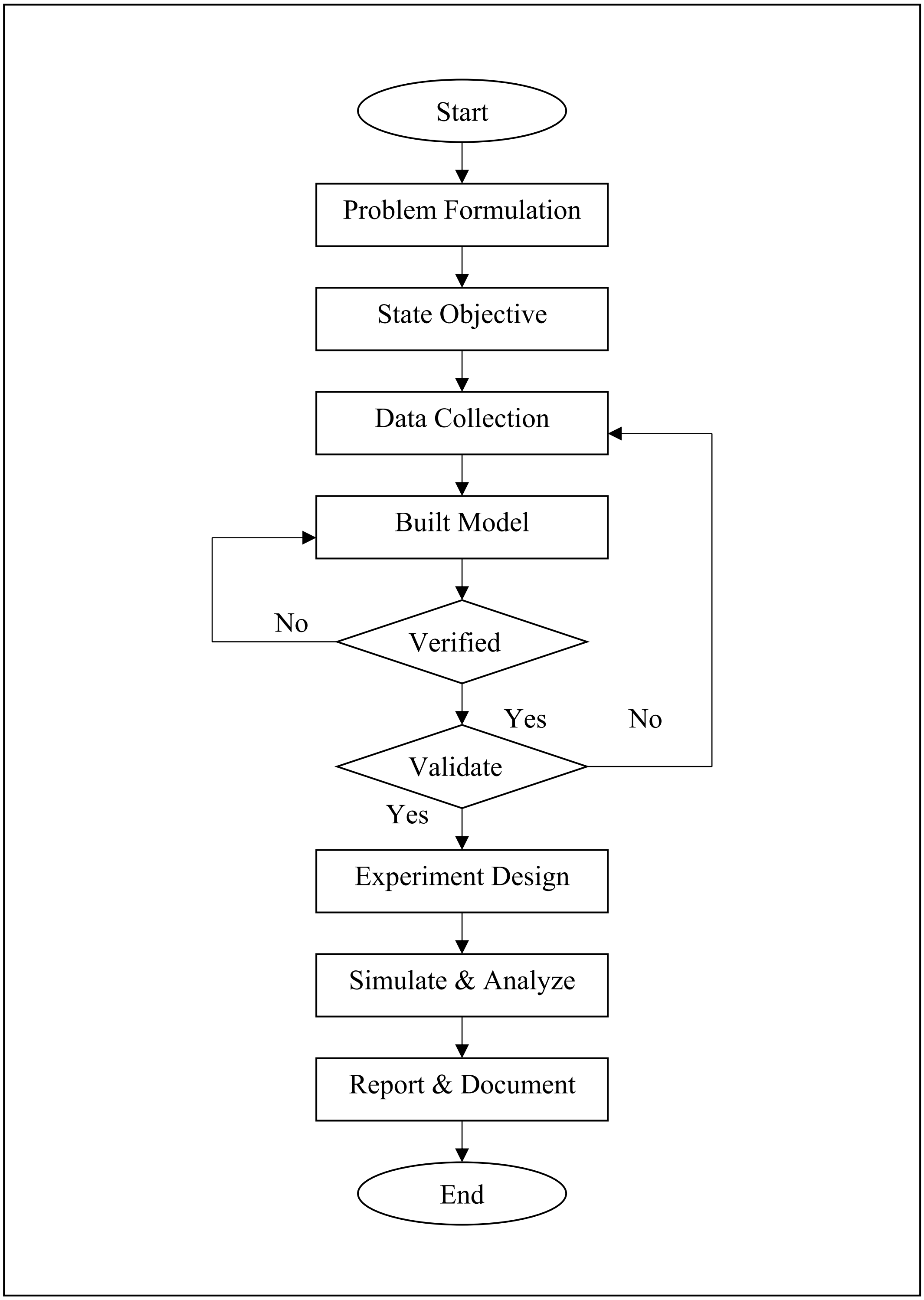

Figure 3.1: Simulation development flow chart

3.4.3 Data collection

After determining the objectives, a second stage is collecting data from existing physical system. The data for modeling the simulation model was obtained from MIG-MARUICHI Melewar Industries Group Berhad. The company is produce steel pipe from 10mm to 355mm and this product is widely used in the construction, furniture, automotive, bicycle and engineering industries. The data used to build a simulation model is a real manufacturing layout for tube mill, includes machine type, number of machines and machine arrangement. Refers Appendix A for more detail about the layout. Cycle time for each line is based on pipe size that will be produced.

The machine specification for each pipe size is shown on Table 3.2.

Table 3.2: Machine specification

Pipe size	Cycle time (min)	Quantity per day
2 ½" AA	0.171	2800
2 ½" A	0.200	2400
2 ½" B	0.200	2400
2 ½" C	0.240	2000
3" AA	0.171	2800
3" A	0.240	2000
3" B	0273	1760
3" C	0.429	1120
3 ½" AA	0.200	2400
3 ½" A	0.273	1760
3 ½" B	0.300	1600
3 ½" C	0.429	1120
4" AA	0.300	1600
4" A	0.333	1440
4" B	0.400	1200
4" C	0.400	1200

5" A	0.400	1200
5" B	0.400	1200
5" C	0.429	1120
6" A	0.353	1360
6" B	0.400	1200
6" C	0.500	960
Maico R 108.8	0.273	1760
Maico P 116.2	0.300	1600
Maico K 121.9	0.429	1120
Maico JΦ 156.3	0.429	1120

The number of operator for each line is nine operators include one machine setter. The working time is seven days per week and three shifts are justified per day. However, the tube mill productions just run on one shift per day.

3.4.4 Model development

From data collection, a simulation model is build using WITNESS software. WITNESS is one the common software used to build a simulation based model and this software was categorized under Visual Interactive Modeling Systems (VIMS) type. This type of software is generally easier and quicker to models compared to other type but quite expensive.

Based on MIG-MARUICHI production, there are three stages to produce steel pipe as follows:

i. Slitting line
ii. Tube mill
iii. Galvanizing plant

This project only focused on manufacturing cell for tube mill processing. Tube mill is process using 13 series of machines. To increase the production of tube mill, this company using three production line of an identical parallel machine, which run on one shift per day.

Based on tube mill production line, a simulation model is developed using WITNESS software. The original manufacturing cell to produce tube mill contains 13 series of machine. Before apply this production line into simulation model, the machine is grouped into four groups as shown in Figure 3.2. The groups of machine are called reserver, forming, finishing and packing is developed. Tube mill was produced using three production line of an identical parallel machine. Therefore, a completed model that contains three lines and four group of machine as shown in Figure 3.3 is developed. This model also consists 24 operators and three machine setter which working during machine operation.

After the simulation model is completed, the verification and validation process is applied to the model. Verification is the process by which the results generated by the simulation model are checked against data from actual physical system. Verification is also made to ensure each job or part order is elapse the sequences of machine needed. After verification, the experiment design is made based on disturbance parameter and experimentation is done to collecting a result. The experiment procedure is mentioned in detail in Chapter 4. Finally the result from experimentation stage is analyzed and conclusion is made based on final result.

3.5 Analysis Data of Variance

In general, the purpose of analysis of variance is to test for significant differences between means. For this project, one-way analysis of variance called ANOVA is used. However, the analysis of variance only applied on the result for machine breakdown condition.

3.5.1 Null Hypothesis (H_0)

Null hypothesis is a hypothesis of no differences. It is a statistical hypothesis usually formulated for the express purpose of being rejected. If H_0 is rejected, alternate hypothesis (H_1) can be accepted. H_1 is research hypothesis and confirmation H_1 of will lend support to the theory from which it was derived. H_0 for this project is different dispatching rules provide no significant effect on performance measures. The alternate hypothesis is different dispatching provide significant effect on performance measures.

3.5.2 Level of Significance (α)

There are two level of significance is considered, α=0.5 and 0.1. Level of significance is used to compare the single factor element (F) theory and calculation. If F-ratio from calculation is greater than F-ratio for theory, the performance of dispatching rules is significance and the null hypothesis is rejected. If F for calculation is equal less than F for theory, the performance of dispatching rules is insignificance and the null hypothesis can be accepted.

3.5.3 One-way Analysis of Variance (ANOVA)

For this project, one-way ANOVA is used and it’s also called one-factor ANOVA. On-way ANOVA tests the differences in a single interval dependent variable among two, three, or more groups formed by the categories of a single categorical independent variable. The design of on-way ANOVA deals with one independent variable and one dependent variable. On-way ANOVA is used to determine whether the groups formed by the categories of the independent variable seem similar. If the groups seem different, then it is concluded that the independent variable has an effect on the dependent. The calculation for ANOVA is shown on Appendix D.

Chapter 4

EXPERIMENT

4.1 Simulation Model

Based on tube mill for MIG-MARUCHI production line, a simulation model is developed using WITNESS software. Figure 4.1 shows the simulation model from WITNESS software. This simulation model consist three production lines and four group of machine for each line. This simulation model also consists 24 operators and three machine setter which working during machine operation. However, a detail of simulation model is different based on experimental design. The simulation model also consists three performance measures called throughput time, earliness and lateness. Performance measure is used to compared the results and evaluate performance of dispatching rules.

Figure 4.1: Simulation model

Before starting simulation, two categories of part order called A and B are created. The different between order A and B is the quantity required for each order. Quantity required for order B is higher than order A. Each category of part order consist three types of orders. The type of order is low, medium and high. Low order contains 10 numbers of orders, medium