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SCHEDULING ANALYSIS AND METALLURGY TESTING RESOURCE ALLOCATION AT METALLURGY LABORATORY B4T BANDUNG

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ABSTRACT

Balai Besar Bahan dan Barang Teknik (B4T) is an institution to have an engineering service on metallurgy testing. Metallurgy Laboratories as the organizer of metallurgy testing in B4T has a high demand to complete the 14 days testing program based on minimum standard services. From the public satisfactory index and services performance rank on 2012, the speed of services was on the lowest rank. Based on that result and B4T has competitors, so it needs to conduct a research to determine the factors that effecting the low speed of testing completion, which one of them is scheduling

The scheduling to demand was conducted by the rules of dispatching method of First Come First Served (FCFS), using WinQSB 2.0. It means that the sequence is based on each job incoming time. Then it was written in Precedence Diagram Method (PDM) notation to have a clear description of inter operation relationship using Microsoft Office Project 2007. Resource allocation was done by considering the FCFS scheduling that was been adjusted with machine and operator availability.

The research's result for 106 jobs, the average completion time was 3744 minutes or 62.4 hours or 8 days. If it was compared to testing completion due date, all tests can be done on time and the allocated machines and operators have managed all demands are done.

Keywords*: Resource allocation, First Come First Served, PDM, Scheduling*

1. INTRODUCTION

1.1 Background

Balai Besar Bahan dan Barang Teknik (B4T) is one of institution of Litbang (R&D) under the Indonesian Industry Ministry, has role to give services to the industries society on research and development, testing, calibration, engineering inspection, engineering training certification, failure analysis, and consultation. But B4T is not the only institution which organized those services, there are more institutions such as LIPI, Sucofindo, etc.

B4T has managed to make service time standard for metallurgical testing service, 14 days, for metallurgy laboratory. By this standard B4T has a high demand to complete the tests within 14 days including administration services.

Based on public satisfactory index on 2012, the service speed was put on the lowest rank then the other services. The service speed is intended to fail to fulfill the standard time. From the pre research which was conducted earlier, it was known that the technicians cannot handle the demand due to the many jobs arrived. This because of the lack of number of technician availability. Human resource was not the only problem, also the machines scheduling.

1.2 Objectives

1. Determining the test completion schedule to meet 14 days due date
2. Determining the human resource and machines allocation to meet the target

1.3 Scope

1. Research is conducted in Metallurgy Laboratory B4T.
2. Research was conducted to most frequent testing based on 2012 data.
3. Allocation of resources was limited to human and machine
4. Priority rule was First Come First Served (FCFS)

2. THEORITICAL BACKGROUND

Manufacturing industries are the backbone in the economic structure of a nation, as they contribute to both increasing GDP/GNP and providing employment. Productivity, which directly affects the growth of GDP, and benefits from a manufacturing system, can be maximized if the available resources are utilized in an optimized manner. Optimized utilization of resources can only be possible if there is proper scheduling system in place. This makes scheduling a highly important aspect of a manufacturing system. This chapter presents a review of scheduling in general and Job-Shop Scheduling in particular. Finally, a brief review of the scheduling procedures applied to CMS is also given at the end.

2.1 Scheduling:

Scheduling can be defined as, *"the allocation of resources over a period of time to perform a collection of tasks"* (Noor [2007]). Also, another definition of scheduling is that, "*it is a function to determine an actual (optimal or feasible) implementation plan as to the time schedule for all jobs to be executed; that is, when, with what machine, and who does what operation*" (Hitomi [1996]). Scheduling has its applications everywhere, for example; flights scheduling, train scheduling and production scheduling. According to Wiers [1997] manufacturing scheduling is the performance of operations on a set of jobs, with the help of already allocated set of machines, within a specified time.

According to the nature of activities, scheduling can be broadly divided into project scheduling and operations scheduling

2.1.1 Project Scheduling:

It is actually the scheduling of activities involved in carrying out a project. A project can be construction of a factory, a bridge, a high way or maintenance and repair of a factory or a plant etc. A number of software based approaches are availableto handle such type of scheduling. Some well known techniques involve; Graphical Evaluation and Review Technique (GERT), Critical Path Method (CPM), Project Evaluation and Review Technique (PERT).

2.1.2 Operations Scheduling:

Operation scheduling can be defined as, "the processing of a set of jobs, in a given amount of time, on the already allocated corresponding set of machines, in a workshop consisting of several machines or production facilities including operative workers" (Hitomi [1996]). Jain [1998] classified the available operations scheduling models as job sequencing, flow-shop scheduling, mixed-shop scheduling, Job-Shop scheduling and open-shop scheduling.

The job sequencing model determines the sequence or order in which a set of jobs would be processed on one machine. For *N* jobs there are a set of *N*! number of possible schedules (sequences). From these *N*! number of sequences, one sequence is selected based on the maximization or minimization of certain objective functions.

"A flow-shop has a typical flow pattern for mass production" (Hitomi [1996]). Here the processing sequence is the same for all jobs. The flow-shop scheduling is carried out by finding out the sequence of machines according to the multiple-stage manufacturing.

In a Job-Shop every job may have a separate processing sequence. "Job-Shop has a typical arrangement for the case of varied production of most jobbing types and batch types" (Hitomi [1996]). The scheduling of Job-Shop is bit more complicated as compared to the flow-shop. Since every job has a separate processing sequence, therefore for each machine a separate job sequence has to be determined and these job sequences should be inter-related with each other in such a way that all the jobs can be processed within the minimum possible time (Makespan minimization).

A mixed-shop is basically the combination of flow-shop and Job-Shop. In this case some jobs have fixed machine sequence like a flow-shop, and some are processed in an arbitrary sequence like a Job-Shop. In other words, "jobs must be processed in a sequence consistent with a given partial order of machines in mixed shop" (Jain [1998]).

The proper sequence of machines is not followed in an open-shop and therefore the processing of jobs can be carried out in any sequence or order. All the models discussed above are actually the derivatives of open-shop model.

In a manufacturing cell, ideally, all the jobs should have similar processing requirements (no intercellular moves), but still the processing sequence may not be the same each jobs. Therefore, a manufacturing cell can be termed as a Job-Shop. Since this research is mainly concerned with the scheduling of manufacturing cells, therefore the main focus will be on Job-Shop scheduling and the rest of the discussion would be only related to this class of scheduling only.

2.3 Job-Shop Scheduling:

"*Job-Shop Scheduling Problem (JSSP) is one of the well-known hardest combinatorial optimization problems. JSSP being amongst the worst* members *of the class of NP-hard problems*" (Gary and Johnson, [1979]), there is still a lot of room for improvement in the existing techniques. Because of its large solution space JSSP is considered to be comparatively one of the hardest problems to solve. "If there are *n* jobs and *m* machines the number of theoretically possible solutions is equal to $(n!)^m$" (Noor [2007]). Among these solutions an optimal solution, for a certain measure of performance, can be found after checking all the possible alternatives. But the checking of all the possible alternatives can only be possible in small size problems. For example, a very simple problem of 5 jobs and 8 machines will give $4.3x10^{16}$ numbers of alternatives. Even with a high performance computer, that can evaluate one alternative per micro second, complete enumeration of this problem to find out the optimal solution would take more than 1000 years of continuous processing (Hitomi [1996], Morshed [2006]).

2.4 Priority Dispatching Technique

Dispatching is a method that the start time for every machine is ascending determined. The decision for processing products choosing can be done when the machine is empty and ready for processing.

In this technique, priority rules is applied to choose one operation among all operations that has conflict at m machine for every stage. The rule is used to choose which machine will be the first. The solution of scheduling conflict needs a specific heuristic algorithm. Some priority dispatching techniques are,

a. R (Random)
   Choose jobs in the line with the same probability for every jobs.
b. FCFS (First Come First Served)
c. SPT (Shortest Processing Time) MOPR
   This rule is tend to reduce work-in-process, mean flow, and mean lateness.
d. LPT (Longest Processing Time)
e. EDD (Earliest Due Date)
f. CR (Critical Ratio)
   Priority index calculated by present due date/the remain lead time).
g. LWR (Least Work Remaining)
   Considering the remaining process time to job completion.
h. S/ROP (Slack/Remaining Operations)
   Variation from slack time that divides slack time by number of scheduled operations.
i. ST (Slack Time)
   Variation from EDD rule by reducing process time from due date, priority for job with smallest ST will be scheduled first.
j. TWK (Total Work)
   Choosing operation with the largest number of jobs.
k. LWK (Least Total Work)
   Choosing operation with the smallest number of jobs.
l. LSU (Least Set Up)
   Choosing job with the smallest setup time to minimized change over time.
m. LCFS (Last Come, First Served)
n. MWKR (Most Work Remaining)

Choosing operation with the largest remaining time.

3. METHODS

3.1 Dispatching Rule Method

Dispatching Rule is a method used in job allocation by sequencing jobs to job center. There are many rules in this method, the most popular are FCFS (First Come, First Served), SPT (Shortest processing time), EDD (Earliest Due Date) dan LPT (Longest Processing Time). Priority rule is chosen depend on objective criteria by sequencing the jobs, there are minimum makespan, minimum weighted mean completion, minimum waiting time, minimum weighted mean waiting, and so on. This research was using priority rule FCFS in Dispatching Rule Method.

3.2 Precedence Diagram Method (PDM)

This method is networking of Activity on Node (AON) in square form, while arrows are indicator of relationship. On PERT and CPM, an activity may be started when a predecessor job has been done. On PDM an activity may be started without waiting for the predecessor was 100% done, this will be done by overlapping.
This research was using PDM to show a logic complex relationship among the activities.

4. RESULT AND DISCUSSION

4.1 FCFS Scheduling

Using WinQSB, the result as shown in figure 4.1.
The result of FCFS scheduling makespan is 11599 minutes or 193 hours or 28 days.

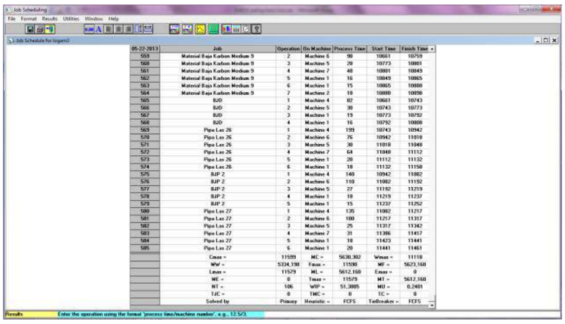


Fig. 4.1 Result from WinQSB

4.2 Precedence Diagram Method

PDM is a method to planning or scheduling in network diagram. Precedence diagram shows a relationship of inter-item job, as follows,

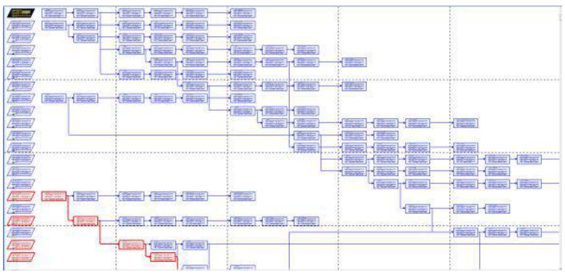


Fig 4.2 Testing Scheduling PDM

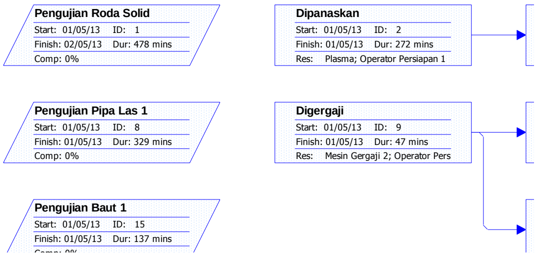
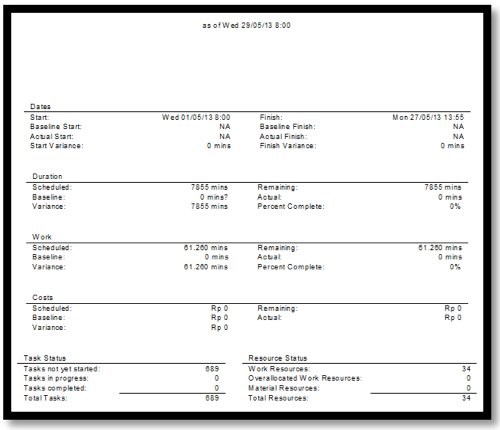


Fig 4.3 PDM Format

4.3 Data Spread in MsOffice Project 2007

After having scheduling by actual machine, the next step was determining machine allocation, which it was done by WinQSB 2.0, and operator will be allocated.
Operators allocation were not been scheduled. As an initiate step, number of operators are 6, number of testing operators are 5, are defined to be setup operator 1 up to setup operator 6 and do the same for testing operators.
Initiate allocation was done by put operators in sequence to each job, and it assumed that every machine need only one operator.
Result from MsOffice Project 2007, is follows



as of Wed 29/05/13 8:00

Dates			
Start:	Wed 01/05/13 8:00	Finish:	Mon 27/05/13 13:55
Baseline Start:	NA	Baseline Finish:	NA
Actual Start:	NA	Actual Finish:	NA
Start Variance:	0 mins	Finish Variance:	0 mins
Duration			
Scheduled:	7855 mins	Remaining:	7855 mins
Baseline:	0 mins?	Actual:	0 mins
Variance:	7855 mins	Percent Complete:	0%
Work			
Scheduled:	61.260 mins	Remaining:	61.260 mins
Baseline:	0 mins	Actual:	0 mins
Variance:	61.260 mins	Percent Complete:	0%
Costs			
Scheduled:	Rp 0	Remaining:	Rp 0
Baseline:	Rp 0	Actual:	Rp 0
Variance:	Rp 0		
Task Status		**Resource Status**	
Tasks not yet started:	689	Work Resources:	34
Tasks in progress:	0	Overallocated Work Resources:	0
Tasks completed:	0	Material Resources:	0
Total Tasks:	689	Total Resources:	34

Fig 4.4 Summary Report

The result shows, makespan for 106 jobs, on average, was 3744 minutes or 62.4 hours or 8 days.
Job Scheduling result was done on time for every job, means that it was meet the standard time with no lack of machine source and operator source.
Comparing to the WinQSB 2.0 result, there was a big differences.
In WinQSB 2.0 result, makespan is 7855 minutes or 131 hours or 19 days,
WinQSB2.0 assumed that only one unit machine while MsOffice Project 2007 was considering actual machine availability. So

makespan from MsOffice Project 2007 is the smallest.

5. CONCLUSION

1. As a initiate step using WinQSB 2.0, based on FCFS priority rule on dispatching method rule, the completion time for 106 jobs is 7855 minutes or 131 hours or 19 days.
2. Recalculate using PDM on MsOffice Project 2010, the average makespan was was 3744 minutes or 62.4 hours or 8 days. This result will meet the due date.
3. The average utility for operator source was 50% for 106 jobs.

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