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# Job Scheduling Optimization in Production Machine Using Integer Programming Method

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**Abstract:-According to data released by ministry of trade of Indonesia, since 2014 automobile component industry in Indonesia is one of the fastest growing industries each year., the increase was driven by the growth of the automobile industry so that the needs of motor vehicle components as supporting industries also grew rapidly.However, some suppliers are not prepared with the increasingg job that occured today.Llimited resources such as production machines, causing not all jobs can be completed in one time. The job scheduling method that is currently implemented by processing the job with the shortest processing time, leads to less optimal scheduling which is indicated by the delay in order completion. Scheduling using iinteger llinear programming is proposed as an alternative that is expected to result in a better solution. Job scheduling using integer linear programming was able to generate minimum job placement waiting time and total completion time of all jobs become more optimal than that so far obtained. Scheduling by using integer linear programming method can reduce order completion time up to 60%.**

**Keywords:-** Job Scheduling Optimization, Production Machine, Integer Linear Programming.

## I. INTRODUCTION

According to data released by ministry of trade of Indonesia, since 2014, automobile component industry in Indonesia is one of the fastest growing industries each year,The increase is driven by the growth of the automobile industry so that the needs of motor vehicle components grow rapidly. Until now the production of motor vehicle components in Indonesia not only to meet the needs of the domestic market but also the international market.

In contrast, a local vehicle component supplierin Sidoarjo, East Java, Indonesiaare not well prepared with the increasing demand that occured today.The company is now facing unoptimal production because of itsmachine limitation. Consequently, the job delivery time is often delayed. As a supplier, theysuppose to be able to complete the job as customer expected in accordance with the production capacity owned.

Currently, the jobprocessed is only scheduled based on the estimated processing time. Job with shorter processing time tends to be started first. In contrast, jobs with longer processing time are often delayed. In addition, other difficulties arise when it comes to scheduling multiple jobs with almost equal processing time and limited number of production machines. Job scheduling method that currently implementedis consideredunoptimal.The impact is job completion time and order deliverytime has not fulfilled the expectations of the company's partners.

One productionmachine can only be used on one type of process at one time. This has impacted on job processing. Each job cannot be started at one time. If there are two jobs that require the same production machine then one of the job must wait for another job done first. The job placement waiting time on the production machine includes the processing time and the replacement time of the dies and punch. The more jobs that are scheduled so the waiting time is also longer as well as the completion time of all jobs.At last,it leads to delays in delivery.

Therefore, it needs to optimize the job scheduling that currentlyused. Such optimization is needed to overcome the limited number of production machines owned by the company and determine the order of job placement that minimizes the total completion time.

Through job scheduling optimization is expected to minimize the total time of completion of all jobs thereby reducing the waiting time of job placement on production machines and faster order delivery.

## II. METHOD

In this study,integer linear programming is applied to seek a sequence of job placements that minimize the total completion time of all jobs. The mathematical modelthen formulated to find the optimal solution of the job scheduling problem on the production machine.Detail mathematical model explained in list below:

### A. *Objective Function*

The objective function for this problem is formulated to minimize the completion time of all jobs.

Minimize K

$$K \geq x_{iko} + t_{iko} \quad ........(1)$$

### B. *Constraints*

Constraints in this case study is related to the sequence of job and job conflicts on the same machine. The constraints are formulated as follows:

- *Sequence of Process.*

Job on another machine cannot be started before the job on the previous machine has been completed. the constraint is written as follow:

$$X_{ikn} + t_{ikn} \leq X_{iko} \qquad ........(2)$$

- *Job Conflicts on the Same Machine.*

When a machine is occupied, this machine cannot be used for another job. For that we need to set a constraint that ensures that at one time there is only one job that can be processed. It is currently unknown where the job will be processed first so that a system of constraints is made which will give the choice to which job is processed first and guarantee that at one time there is only one job processed. If conflict in machine n occurs between job i and job j, then the constraint is written as follow:

$$X_{ikn} + t_{ikn} \leq X_{jkn} + M.Y_{ijn} \qquad .......(3)$$

$$X_{jkn} + t_{jkn} \leq X_{ikn} + M.(1 - Y_{ijn}) \qquad ......(4)$$

M is a large positive number and Yijn in this case is a binary number.Its value 1 if job j start earlier than job i on machine n. This constraint is written if there is a conflict between job i and job j on machine n symbolized by binary number Yijn. $Y_{231}$ for example shows a conflict of machine utilization on job 2 and 3 on machine 1.

### C. Decision Variabels

The decision variables used in this formulation are as follows:

$X_{ikn}$ Start Time of Job **i** , Process **k**, on Machine **n**.

The addition of index k is deliberately addedbecause a job can involve in more than 1 process.

$t_{ikn}$ Duration of Job **i** , Process **k**, in Machine **n.**

$X_{iko}$ Start Time Job **i** , Process **k**, in Machine **o**.

Indexes

i An IndexThat States The Job As A Whole.

j J Is Part of i; It Is Necessary to State the sequence and possibility of inter-job conflict on a machine.

k An index that shows the type of process ofr a job on a machine that can be different. between job one with another job. k is part of A which is the whole process variation.

**n ,o : i** indexes for machines; n and o are part of B that is the whole of the machine used. The sequence of job i is from machine n, which can be machine 1, 2, or another machine in accordance with the production process and the order of workmanship, then proceed on machine o, which is another machine required.

### D. Job Scheduling Optimization

Optimization of job scheduling in this case study is achieved by implementing mathematical model into manufactureing of vehicle exhaust component problem. Based on the mathematical model generated it is expected that new job scheduling will be more optimal than currently used by the company.

The optimal job scheduling is obtained byarranging the sequence and the waiting time of job placementin the production machine which minimizeing the completion time of all jobs. The job placement time on the production machine can be minimized by adjusting the frequency of dies and punch replacement. For instance, if 1000 units are created for component 1 and component 2, then if dies and punch is replacedone time, then 1000 component 1 must be completed before 1000 component 2 can be processed. On another hand, when two times replacement of dies and punch is choosen, itonly needed to complyete 500 component 1 first, then component 2 can be processed immediately. Thus, the second job waiting time becomes shorter. However, when dies and punch replacements are too often, the total completion time of all jobs will be greater due to the loss of time in replacement setting-up.

Therefore, we need to find a balance combination between the waiting time of the process using the same machine, and the timee of setting-up due to the replacement of dies and punch.
Scheduling which using more than one dies and punch replacement, formulation below is added to find total completion time for all jobs as follow:

$$\text{Total} = K + (p\text{-}1) \ x \ ((\textstyle\sum_1^l W_{ikn}) + (\sum t_{ikn} \ x \ T)) \qquad .....(5)$$

p is a factor to see how many times the dies and punches are replaced. $W_{ikn}$ is setup time on job i process k in machine n. $T_{ikn}$ is the process time on the job i process k machine n while T is the number of products made in 1 batch.

## III. RESULT AND DISCUSSION

### A. Data Collection

Data were collected based on observations and information from the local supplier. In this case study, 7 jobs and 7 seven machines are available to be scheduled. Each jobs is consist of making of 50.000 pieces vehicle exhaust component.

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- *Production Machine*

Machine used in production process, is press machine which have certain tonnage. Based on the press power, the type of press machine used in the manufacture of vehicle exhaust components is a press machine with tonnage of 150 tons, 100 tons, 80 tons, 63 tons, 40 tons, and 25 tons. In table 1 below can be seen the details of machine used for the manufacturing process.

| Number | Machine Type | Machine Utilization |
|---|---|---|
| 1 | Press machine 150 Ton | Machine for *blanking* |
| 2 | Press machine 100 Ton | Mesin for *embossing* and *extrusion* |
| 3 | Press machine 80 Ton | Machine for *forming* |
| 4 | Press machine 63 Ton | Machine for *punching* |
| 5a | Press machine 40 Ton | Machine for *trimming* |
| 5b | Press machine 40 Ton | |
| 6 | Press machine 25 Ton | Machine for *restrike* and *sloting* |

Table 1. Machine Type and Utilization.

- *Sequence of Job Processing Stage*

Each job consist of different proceedssing stages. The job processed must be corresponding with the order of each processing stage. The first processing stage must be completed first before the next process begin, and so on until the last process. Table 2 showed the sequence of job processing stage.

| number | Job | Process | | | | | |
|---|---|---|---|---|---|---|---|
| | | Process 1 | Process 2 | Process 3 | Process 4 | Process 5 | Process 6 |
| 1 | Front Flange | Blanking | Embossing | Punching I | Trimming | Forming | Punching II |
| | | Machine 1 | Machine 2 | Machine 4 | Machine 5a or 5b | Machine 3 | Machine 4 |
| 2 | Cover | Embossing | Trimming | Restrike | | | |
| | | Machine 2 | Machine 5a or 5b | Machine 6 | | | |
| 3 | Bracket (Support) | Blanking | Forming | Trimming | Punching I | | |
| | | Machine 1 | Machine 3 | Machine 5a or 5b | Machine 4 | | |
| 4 | Middle Flange | Embossing | Punching I | Forming | Punching Ii | | |
| | | Machine 2 | Machine 4 | Machine 3 | Machine 4 | | |
| 5 | End Flange | Blanking | Forming | Extrusion | Punching | | |
| | | Machine 1 | Machine 3 | Machine 2 | Machine 4 | | |
| 6 | Separator | Blanking | Forming | Punching | Extrusion I | | |
| | | Machine 1 | Machine 3 | Machine 4 | Machine 2 | | |
| 7 | Outer Pipe | Blanking | Forming | | | | |
| | | Machine 1 | Machine 3 | | | | |

Table 2. Sequence of Job Processing Stage.

*B. Currently Used Job Scheduling Method*

According to the production unit,the current job scheduling method only estimating the length of process of each job and less attention to job conflict, and sequence of job placement on the production machine.The Jobwhich has short processing time tends to be started first. Consequently, the deliveryeitherexcess the expected time or the quantity supplied does not fit the needs of partner. Table 3 shows the job scheduling which is currently used by the company. Total completion time of all jobs is 78.133 minute.

| Job | Total process time (minute) | Completion time (minute) |
|---|---|---|
| 7 | 6.081 | 6.081 |
| 2 | 9.253 | 15.334 |
| 5 | 10.808 | 26.142 |
| 3 | 11.817 | 37.959 |
| 6 | 12.147 | 50.106 |
| 4 | 12.397 | 62.503 |
| 1 | 15.630 | 78.133 |

Table 3. Job Scheduling Using Existing Method.

*C. Result*

Optimal job scheduling is achieved by implementing mathematical model generated in lingo program. The expected solution of this research produces the optimal objective function. Optimal job scheduling with some dies and punch replacement scenarios can be seen in table 4.

| No | K (minute) | P | Total (minute) |
|---|---|---|---|
| 1 | 24.052 | 1 | 24.052 |
| 2 | 12.177 | 2 | 51.627 |
| 3 | 5.052 | 5 | 70.553 |

Table 4. Job Scheduling Optimization Result.

As mentioned before, the amount of exhaust vehicle component required to be produced in this case study is 50.000 components for each job. Table 4 present the result of job scheduling optimization for 50.000 exhaust vehicle components.K is the completion time of all jobsusing one or more dies and punch replacement.Completion time calculated

In k is the time to complete some of the whole components required.Whereas, Total is completion time of all jobs after all50.000 components are completed.

k number 1, 24,052 minutes is the completion time of job making 50,000 components with one time dies and punch replacement. While k number 2 and 3 respectively is the time of completion of the job of making 50,000 components with 2 times and 5 times dies and punch replacement. In k number 1, the job placement waiting time becomes longer because each job must complete 50,000 components before another job can be started. While at k number 2 and 3 waiting time of job placement becomes shorter because every processing stages only needed to finish 25.000 and 10.000 component only before other job started, yet the whole process must be repeated until 50.000 components are completed.

However, in table 4 can be seen that more dies and punch replacement, total completion timeof all jobs also becomes longer; This corresponds to a relatively long setup time compared to the processing time of each component, thereby job scheduling optimization leads to less frequent dies and punch changes.

Finally, it was determined that the optimal production would be done with a batch of 50,000 units with 1 time replacement of dies and punch.

The optimization result provide more optimaljob scheduling with better completion time of 24.052 minutes from wwhich was previously 78.113 minutes. The result of this optimization visually illustrated asa job sequence in gantt chart. Figure 1 showsgantt chart depicts theresults ofjob schedulingoptimization from mathematical model generated. The colored horizontal block representthe machine used by each joband the grey block represent waiting time of each job to be processed in certain machine.

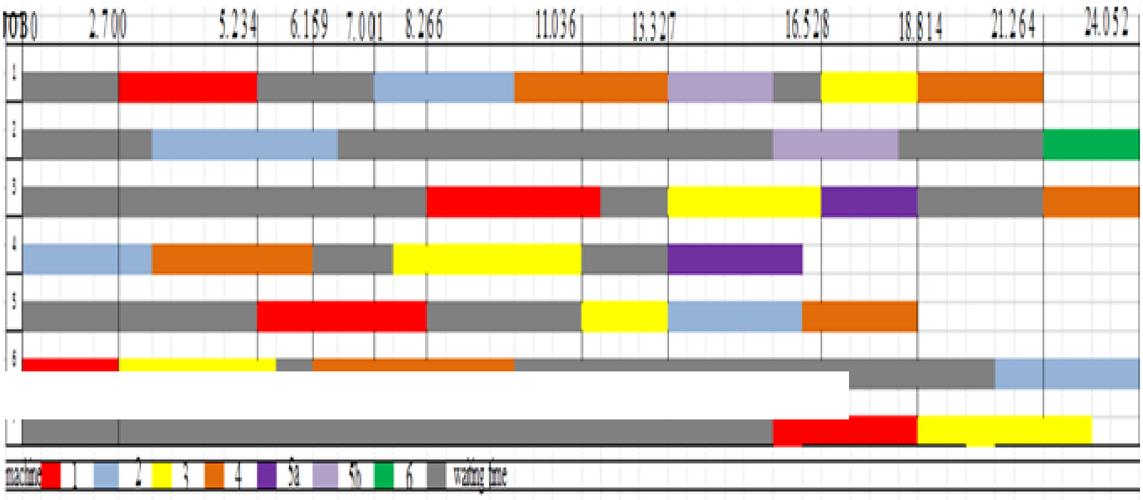


Figure 1.Gantt Chart of Job Scheduling Optimization

## IV. CONCLUSION

- The result of job scheduling optimization at production machine in this research is able to provide the sequence of job placement and waiting time which minimizeing the completion time of all jobs.
- The completion time of all jobs produced is better than the method used by the company from the 78.113 minutes to 24.052 minutes.

## V. SUGGESTION

- To get a more optimal scheduling, the company should pay attention to the order of job placement in each production process so that it gets the waiting time and completion of all the optimal job.
- Further research job scheduling optimization can be directed to the job with certain priority and different arrival time.

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