Parallel Machine Scheduling using Simulation Software

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Abstract— This article aims to bring the program Flexsim simulation applied to production scheduling and to search makespan optimization of parallel machine production scheduling, the production process of this plant is parallel machine. For the problem of parallel machine scheduling is complicated. Due to limitations in the production scheduling, such as setup time, production time and machine eligibility at some jobs cannot produce some machines and also the problems NP-Hard (Non Polynomial Hard) which takes in searching solutions for a long time. When the size of the problem increases, it will take time to search solution increases in exponential. Flexsim simulation program can specify the number of solution and the time to search solution. The result indicated that the Flexsim simulation program performing well, in solving parallel machine production scheduling.

Keywords— Simulation, production scheduling, parallel machine.

I. INTRODUCTION

The production scheduling is a process that is important in the production, because the job scheduling optimization by considering the resources and time with the machine is suitable for the job, will result in more efficient production. In addition, efficient production scheduling also results in lower overhead costs, reduce time lost during the process. It also increases the competitiveness with other productions. The problems mentioned above can be seen that the production scheduling plays a huge role in the competitiveness of the industry. The case study plant produce net - trawl, using the weaving machine automatic production. That the production process of this plant is the production of parallel machines, each product takes a long production time. For a parallel machine scheduling problem is one which is complicated because there are limitations in scheduling, such as setup time, production time and Machine Eligibility at some jobs cannot produce some machines and also the problems NP-Hard which takes in searching solutions for a long time. When the size of the problem increases, it will take time to search solution increases in exponential. According to this problem, this article has a concept the simulation, to simulate the production process in virtual with the actual production. The simulation program is Flexsim, which has the function Experimenter in design of experiments and optimizer to search the optimal solution. In addition, the Flexsim can also set the number of solution to and time in searching the solutions. This will result in the effective production scheduling is increasing.

II. LITERATURE REVIEWS

At present, the problem of parallel machine scheduling is one of the problems that have been interesting as well, Vahid Kayvanfar, Amin Aalaei,
Mahtab Hosseininia and Mahdi Rajabi study how to search the makespan of production under the condition of setup machine affect the production scheduling. The way this article is presented is Initial Sequence based on Earliness Tardiness Criterion on Parallel Machines (ISETP) used a computer calculation and compare how Mathematical Model using Lingo in calculation, it is found that the method ISETP calculate faster than Mathematical Model averaged 20.46% in [1]. After that Simon Thevenin, Nicolas Zufferey and Jean Yves Potvin proposed the Adaptive Memory Algorithm (AMA) used in solving production scheduling parallel machine by the AMA method to compare with the Two Tabu Search Methods with examples of 200 problems. The results showed that the AMA calculates faster than Two Tabu Search Methods average 35.69% in [2]. Recently, Eduardo Lalla-Ruiz, Stefan Voß proposes a mathematical model developed from the Set Partitioning Problem (SPP), which can resolve small problems within 2 seconds in [3]. Simultaneously, Luis Fanjul-Peyro, Federico Perea, Rubén Ruiz test cases are large problems (50 jobs and 15 machines) the results show us that the mathematical model is not suitable for large-scale solutions. Therefore, proposes a method matheuristic that solve the large problem better in [4]. In the simulation model used in production scheduling. G. Caputo, M. Gallo and G. Guizzi the simulation model to help arrange the production scheduling. This model will reduce the cost of stock and determining the cost of production is more constant. Simulation is a technique that allows to determine with precision in the use of resources has changed. This method is highly efficient in terms of production scheduling, which allows analyzing various feasible sequences. The use of the tools available in the software ARENA is Opt Quest for Arena to search the optimal solution and confirm the accuracy of the study to use simulation model to verify production capabilities in [5]. After that, Robert Schoch, Ruth Fleisch, Thorsten Prante and Alexander Walch Get tools to Flexsim to identify the best performance of the production plants. By working with software control of the plants. Simulation results are analyzed for modifying the parameters of the decision rule used in the plants control software. By doing this repeated until you get the optimal solution in [6]. This article is a concept that brings Flexsim used to makespan optimization of parallel machine production scheduling.

**III. Problem description**

Parallel machine scheduling means to define the relationship of the task sequence to produce under the limiting resources such as machine, man, material handling equipment, etc, to provide finished products within the time limit. For the problem of production scheduling for jobs N work and machine M machine in the form of group of machinery. Each machine is placed parallel to each other, setup time with

Fig. 2 The operation process of a weaving.
production time each product is different and machine eligibility at some jobs cannot produce some machines.

IV. THE PROPOSED METHODOLOGY

FlexSim is 3D simulation software that models, simulates, predicts, and visualizes systems in manufacturing, material handling, healthcare, warehousing, mining, logistics, etc. FlexSim helps to optimize current and planned processes, identify and decrease waste, reduce cost, and increase revenue. Modeling simulation follow the step below in Fig. 1.

A. Study and Analyze the Production Process

The plant in the case study of production and distribution of nets, fishing accessories, agricultural as well as other industry related. Starting from plastic injection, spin a web, Hit thread, weaving, weigh, bundle, pack. And this factory works 7 days, is produced 24 hours, divided into 3 shifts. The weaving process is a process that is the problem in scheduling the most. Due to the pattern of a parallel machine scheduling problem and the weaving process show in Fig. 2.

B. Data Collection and Analysis

Data collection weaving process started from a meeting with the plant. Then the weaving process layout, the measured area and drawing in AutoCAD, for the 3D shapes of weaving machines have been drawn in Sketch Up, then ask for setup time the machine, production time, Sample products production for customers and machine eligibility at some jobs cannot produce some machines. The data shown in Table 1, where number 1 represent the jobs can produce that machines, number 0 represent the jobs cannot produce that machines.

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Setup Time (s)</th>
<th>Process Time (s)</th>
<th>C1</th>
<th>C7</th>
<th>C11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product1</td>
<td>699</td>
<td>117504</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Product2</td>
<td>845</td>
<td>47520</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Product3</td>
<td>730</td>
<td>180576</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Product4</td>
<td>1130</td>
<td>438912</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Product5</td>
<td>715</td>
<td>175392</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Product6</td>
<td>740</td>
<td>167616</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Product7</td>
<td>725</td>
<td>121824</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

C. Build System Model

The simulation model established based on Flexsim software, and set each module properties according to the actual production conditions. When the product arrives in the system are selected to production the
machine number according to the information provided in table 1. The actual model which has been connected is shown on Fig. 3.

D. Model Optimization

According to the weaving process model, use the experiment function to determine the decision variables (sequence of product) and optimizer functions to permutation the sequence of product is show below in Fig. 4. When the optimizer is running, it is searching for better and better configurations for the model. Using the basic search algorithm follow steps below:

1. Generate a model configuration (a solution).
2. Set the current model to match that configuration.
3. Run the simulation. This is also called evaluating the solution.
4. Get the outputs from that run.
5. Rank the solution.
6. Generate a new solution based on the results from all evaluated solutions.
7. Repeat from step 2.

The above algorithm repeats until the optimizer runs out of time, evaluates a maximum number of solutions, press stop during the run, or until it evaluates all feasible solutions of the model in [7].

V. ANALYZE THE RESULTS

In this section, we have experimented to search the makespan optimization of parallel machine production scheduling, the number of problems is 7 jobs, 3 machines. The computer of our experiments is CPU: Intel Core i7-7700HQ (2.80 – 3.80 GHz) memory: 8 GB and operating system: Microsoft windows 10 Pro X64. A number of problems 7 jobs, the sequence of the products will be alternately have all 7! , or solution all possible with 5040. The results from Table 2 show that searching a total of 5040 solutions takes a total of 2834 seconds, which is a very long time to search the solution and the optimal solution is 66 solutions. The experiments were reduced to 4000, 3000, 2000, 1000, 750, 500, 250, 100 and 50 respectively, will that time in searching the solutions reduce likely is an Exponential. Sometimes it may not be the optimal solution, if determine the number of solutions is too small. Which to find the answer of Optimizer, the random sequence of the products until the conditions of the number of determine solutions. Although in this case, the solution to 50 is not the optimal solution, but it also has optimal solutions to the nearby 99.83%.

<table>
<thead>
<tr>
<th>Determine how many solutions</th>
<th>Time to search a solution (s)</th>
<th>Number of optimal solutions that are search</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE II

Experiment results from the optimizer function
From the Fig. 5, example results in searching the solution of Optimizer number solutions is 5040. By the X axis is the solution ID and Y axis is the solution. Which the answer can all Export to file excel, in the format CSV.

Finally, when the sequence of product are used in sequence to put in model. To see which product produced at any number of machines, see in Fig. 6 and follow in Fig. 7 can see when the production time is finished.

<table>
<thead>
<tr>
<th>50</th>
<th>6</th>
<th>0</th>
</tr>
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<tbody>
<tr>
<td>100</td>
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<td>1</td>
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<td>250</td>
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<td>500</td>
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<td>94</td>
<td>40</td>
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<tr>
<td>1000</td>
<td>147</td>
<td>40</td>
</tr>
<tr>
<td>2000</td>
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<td>49</td>
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<tr>
<td>3000</td>
<td>858</td>
<td>54</td>
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<tr>
<td>4000</td>
<td>1486</td>
<td>66</td>
</tr>
<tr>
<td>5040</td>
<td>2834</td>
<td>66</td>
</tr>
</tbody>
</table>

CONCLUSION

In this paper we present the makespan optimization of parallel machine production scheduling through simulation technique base on Flexsim. The results showed that the use of simulation techniques, if we can model simple, can reduce the search space, decreasing the time the optimizer will spend evaluating infeasible solutions. However, simulation techniques can also determine the number of feasible solutions. Although sometimes it may not be the optimal solution, but it has a near optimal solution in determining the number of the desired solution. It can be seen that the simulation technique suitable to complex problems and time in searching the solution.

REFERENCES


and matheuristics for the unrelated parallel machine scheduling problem with additional resources.

