Discrete-event simulation of a production process for increasing the efficiency of a newspaper production

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Abstract. One of the characteristics of the newspaper industry is the cycle time of production is limited. The production time cycle is depending on several aspects, namely the quantity of paper produced, as well as the utility of each machine and operator. Because of the cycle time of production is limited, the production process of a newspaper industry is required to have a high level of efficiency so that the level of productivity can be increased. A high level of efficiency can be achieved by optimizing aspects of raw materials, machines, and operators. In this article, the method used for modelling real-time production floor systems is Discrete Event Simulation (DES). DES is done by representing the interaction between all components in the system as an event. Flexsim software used to model the actual production system. Analysis of the results of the simulation conducted to determine the utility level of each machine. In this article, there are three scenarios simulated. Each scenario is replicated ten times. Scenario 1 is the scenario of the current system, then the scenario 2 and 3 are proposed as improvements of composition newspaper production systems. From 2 improvements scenarios, the scenario 3 was chosen to be the best scenario that could improve the efficiency of newspaper production systems.

1. Introduction

Some of the characteristics of a newspaper industry that makes it different from other industries are the cycle time of the production are very limited, strict delivery deadlines, and doesn’t have inventory system [1]. The reason why newspaper industry doesn’t apply inventory system is because the newspaper industry needs to maintain the accuracy of the news that will be presented [2]. Some of the above characteristics affect the newspaper production process, whether the production process is good or must be improved.

Newspaper production process consist of pre-printing process and printing process [3]. In the pre-printing process, the newspaper in digital form is printed on a plate. The printing process through the
Computer To Plate (CTP) machine by the radiation process. Then, printing process requires some raw materials, such as paper, ink, and plate [4].

The production process of a newspaper industry is required to have a high level of efficiency so that the level of productivity can be increased. One of the efforts to improve the efficiency is to push the production process to be on time. This will affects the scheduling strategy of production and delivery of newspaper to the destination [5]. Beside of that, delivery of newspaper to the destination constrained by deadlines [2]. In particular, it will be impact the feasibility of synchronization both production schedules and delivery schedules so the newspaper can be shipped as soon as the production process is complete. Newspaper production process depends on several aspects, such as raw materials, machines, and operators. Therefore, a high level of efficiency in aspects of raw materials, machines, and operators are needed to optimizing the newspaper production process.

There are several previous studies that aim to increase the efficiency and productivity of the newspaper industry. Among them are predict printed newspaper demand to minimize the number of returns and to keep off the missed sales and to restrain the oversupply [6]. Optimization of distribution channel vehicle routing problem with time windows [7]. The use of house of risk approach to map the risks in the printing company and formulate risk mitigation alternatives [8]. The use of quantity approach to map the risks in the printing company and formulate risk mitigation alternatives to determining the best strategy for dealing with possible risks in the newspaper industry [9]. Application of analytical model to minimize the total cost between the integration of production planning and distribution on newspaper supply chain [10].

Other than the method used in the previous research, there is one other method that can be used in improving the efficiency of a newspaper production process is Discrete Event Simulation (DES) [11]. DES is able to provide solutions in modeling an actual system by representing the interaction between all components in the system as an event [12]. DES is known to be widely used for several manufacturing system problems, such as: improve the efficiency, stability analysis, the design of manufacturing system, production system, and even the design of transportation systems [13]. In addition, DES also an effective tool in analyzing and evaluating the impact of an alternative or improvement scenarios for the actual production system [14]. In this research, improvement scenarios consist of composition newspaper production systems such as raw materials, machines, and operators.

There are several previous studies that apply the DES method as a problem-solving method. One of them is DES used as a method for increasing the productivity of small and medium enterprises [11]. The evaluation of small and medium enterprises based on the simulation summary report. Simulation show high value idle on some machines. And, two alternatives was arranged to solve the problem. Other that that, DES used to optimizing the performance of load balancing [15]. Evaluation of production planning and management strategies in the sawmill industry [16]. The combination of DES and optimization for short-term forest planning [17]. DES of the process of information-based allocation of raw materials to improve the efficiency of the wood supply chain [18]. Synchronization methods in parallel and distributed discrete-event simulation [19]. Performance analysis of dependencies between variables in the supply chain by using design techniques and DES scenario along with statistical analysis [20]. Simulation model as a tool for strategic capacity planning for an outpatient physical therapy clinic in Taipei [21].

Based on the explanation above, this research aims to determine the most efficiently composition of the newspaper production system to improve manufacturing productivity newspapers. In this article, the research was conducted in PT. Solo Grafika Utama and the composition seen from the utility of each machine.

2. Method of Research
One of the methods to determine the composition of the newspaper production system is Discrete Event Simulation (DES). This method is applied to the queuing system process flow of raw materials during the process of newspaper production in PT. Solo Grafika Utama. DES method is used to
determine the process flow of raw materials, determine the level of utility machine, and identify potential bottlenecks that can occur. In this study, the software used is Flexsim. Flexsim simulation software used for modelling an actual newspaper production system and the improvement scenarios. Once the simulation was successful, then the best improvement scenarios that can solve the problems during the processing of raw materials to become a newspaper and ready to be sent to the agency can be chosen. There are several steps in applying the method of DES in the newspaper production process in PT. Solo Grafika Utama, namely:

2.1. Identifying problems through observation.
Observations is required to know the problems that occur on the actual system. Some problems that can occur are high idle value and bottleneck.

2.2. Set goals.
After identifying the problem, then set goals as a primary key for seeking alternative best improvement during the production process in PT. Solo Grafika Utama.

2.3. Collecting conceptual data.
Conceptual data were collected are entities, resources, and events that happen in newspaper printing process. Entities is object that moving through the system, in this article the entity is a raw material. Raw materials that used in newspaper printing process are paper, ink, and plate. Event is the process which entity through of, in this article the event are the pre-printing and printing process. Resources are object that trigger event, in this article the resources are machines, tools, and operators.

2.4. Formulate models.
To run DES, beside requiring data on entities, resources, and events, data on working hours, the standard time of each process, the waiting time, the quantity of raw materials used, the engine capacity, and the number of operators are also required. This datas are necessary in order that the simulation results can presenting the actual system.

2.5. Creating a model using the software.
In this article, the software used is FlexSim. Flexsim simulation software used for process modeling and optimization. And then, flexsim use 3D objects that represent process activities and queuing.

2.6. Verify and validate the model.
Verification is used to ensure that the model will be implemented as they should be. Validation of the model is a process to check whether the model is suitable with the actual system. Validation of the model is done by replicating each model as much as 10 times. This is because if the replication is only done once, then the simulation results doesn’t enough to represent the actual system.

2.7. Doing experiments by changing the parameters.
Experiments by changing the parameters used to find some alternative improvements composition that can be applied to the actual production system which make the production process more efficient. In this article, there are two scenarios in determining the best options for improvement based on the parameters of utility machines.

2.8. Analyze and summarize the results output.
Three scenarios were analyzed, and then select the best scenarios that can be applied to the actual production system in PT. Solo Grafika Utama. Flowchart of analysis research as shown in Figure 1.
3. Result and Discussion

Newspaper production system consists of two processes. At the stage of pre-printing, the operator print digital file papers at the plate by using Counter to Plate (CTP) machine for 3 minutes. Then plate inserted into processor plate machine for 1 minute to provide color. Next is the printing process by using the raw material. After the printing process, the quantity of paper is calculated using the counter machine and packaged before being sent to the agency car expedition.

When simulating an actual newspaper production process using flexsim software, source objects is used as a resource that will produce raw materials. Then, there are several inputs based on the actual system which are the parameters in determining the configuration of each source object, so that the time and results of this simulation can approach the actual conditions in the newspaper production process. Some of the inputs, namely: The amount of raw material quantity is the total overall of raw material for 3 machines, the arrival time of raw materials are adjusted to the completion time of the pre-printing stage and the material movement time to each machine in the actual newspaper production process, and processing time for resources are adjusted to the time of printing process in actual newspaper production process.

The configuration of paper for each of scenario listed in Table 1.

| Arrival Time | Quantity |
|--------------|----------|
| Paper        | 78 minute| 9 roll   |

The configuration of ink for each of scenario listed in Table 2.

| Arrival Time | Quantity |
|--------------|----------|
| Ink          | 79 minute| 6 pail   |

The configuration of plate for each of scenario listed in Table 3.
Table 3. Arrival Time and Quantity of Plate

| Plate | Arrival Time | Quantity |
|-------|--------------|----------|
|       | 0 minute     | 6 plate  |
|       | 3 minute     | 10 plate |
|       | 6 minute     | 10 plate |
|       | 9 minute     | 10 plate |

In this simulation of the newspaper production process, the time used is the arrival time of raw materials. This is due to the newspaper printing process, all raw materials must be prepared on the machine. And then, processor object, combiner object, and separator object used as a resource that will combine all of the raw materials and produce copies of newspaper. Afterwards, quantity of newspaper calculated by processor objects. The configuration of resource for each of scenario listed in Table 4.

Table 4. Processing Time of Combiner, Separator, and Processor

| Processing Time |
|-----------------|
| Combiner        | 0.01 minute   |
| Separator       | 0.01 minute   |
| Processor       | 0.01 minute   |

Processing time shows the length of time needed to print and calculate the quantity of newspaper. There are three scenarios in implementing DES using software Flexsim. Scenario 1 is the actual model of newspaper production process. While scenario 2 and 3 are the alternative improvement of the actual model. Improvement of each scenarios are done by adding 1 type of machine. The addition of 1 type of machine is based on high idle value. Thus, a high idle value can be reduced by the addition of 1 type of this machine. Here, three scenarios in implementing DES using software Flexsim:

3.1. Scenario 1 or the Actual Model

In the actual model there are 3 printing machines and 2 counter machines as shown in Figure 2.

Figure 2. Model of Actual Production System in Scenario 1 using Flexsim Software.

Each printing machines produce 9,000 copies of the newspaper and the total newspaper are 27,000 copies. For printing machines 1 and 2, the calculation of the quantity of newspaper using a counter machine 1. Then, for the printing machine 3, the calculation of the quantity of newspaper using the counter machine 2. Then, the raw materials that required for the printing process for each machine listed in Table 5.
Table 5. Raw Material for each Machine in Scenario 1

|        | M1   | M2   | M3   |
|--------|------|------|------|
| Paper  | 3 roll | 3 roll | 3 roll |
| Ink    | 2 pail | 2 pail | 2 pail |
| Plate  | 12    | 12    | 12    |

The simulation results with replication as many as 10 times show a same value. Among three machines, printing machine 3 have a high idle value, which amounted to 80% as shown in Table 6. The replication is done by using the same scenario parameter and random stream in the flexsim software.

Table 6. Simulation Results of Each Printing Machine with 10 Replications

| Replication | PM 1 (Idle) | PM 2 (Idle) | PM 3 (Idle) |
|-------------|-------------|-------------|-------------|
| 1-10        | 5%          | 52%         | 80%         |

High idle value on the printing machine 3 due to the process of calculating the newspaper on the machine 1 and machine 2 only use one counter machine, while the printing machine 3 using one counter machine. One machine counter for 2 printing machine makes the time needed is longer than one machine counter for one printing machine and cause a bottleneck on the machine 1 (95%) due to printing machine 1 waiting for the process of calculating the newspaper of the machine printing 2. The unequal quantity have an impact on printing machine 3, so printing machine 3 has a high idle value. Here, the recapitulation data of each printing machine in scenario 1, as shown in Figure 3.

Figure 3. Recapitulation Data of each Printing Machine in Scenario 1

Similar to the printing machine, the simulation results show a high idle value on the counter machine 2 as shown in Table 7.

Table 7. Simulation Results of Each Counter Machine with 10 Replications

| Replication | CM 1 (Idle) | CM 2 (Idle) |
|-------------|-------------|-------------|
| 1 - 10      | 5%          | 80%         |

The simulation results with replication as many as 10 times show a same value. Among two machines, counter machine 2 have a high idle value due to counter machine 2 counting copies of newspaper that produced from printing machine 1 and printing machine 2, which amounted 9,000 copies of newspapers. While counter machine 1 only counting copies of newspaper that produced from printing machine 1, which amounted 18,000 copies of the newspaper. The unequal quantity have an impact on counter machine 2, so counter machine 2 has a high idle value. Here, the recapitulation data of each counter machine in scenario 1, as shown in Figure 4.
3.2. Scenario 2 or Alternative Improvement 1.

In the second scenario, the parameters that are changed in this model are the number of printing machines. There is additional to the printing machine, so there are 4 printing machines and 2 counter machines, as shown in Figure 5.

![Figure 5. Model of Actual Production System in Scenario 2 using Flexsim Software.](image)

The addition of the printing machine is intended to reduce the quantity of newspaper production on each machine before. Thus, each printing machines produce 6,750 copies of the newspaper and the total newspaper are 27,000 copies. For printing machines 1 and 2, the calculation of the quantity of newspaper using counter machine 1. Then, for printing machines 3 and 4, the calculation of the quantity of newspaper using the counter machine 2. The raw materials required for the printing process for each machine listed in Table 8.

|                     | M1  | M2  | M3  | M4  |
|---------------------|-----|-----|-----|-----|
| Paper               | 3   | 2   | 2   | 2   |
| Ink                 | 2 pail | 2 pail | 2 pail | 2 pail |
| Plate               | 12  | 12  | 12  | 12  |

The simulation results with replication as many as 10 times show a same value. Based on the simulation results with 10 times replication indicates that the addition of one printing machine doesn’t reduce the waiting time at each machine. Idle value in machine 3 increase until 90% as shown in Table 9. The replication is done by using the same scenario parameter and random stream in the flexsim software.

| Replication | PM 1 | PM 2 | PM 3 | PM 4 |
|-------------|------|------|------|------|
| 1 – 10      | 5%   | 52%  | 90%  | 80%  |

Idle value of machine 3 has increased due to the process of calculating the newspaper on the machine 3 and the machine 4 are faster than the calculation of the newspaper on the machine 1 and machine 2. Then bottleneck’s percentage value on machine 1 as yet as in scenario 1 or 95%. Here, the recapitulation data of each printing machine in scenario 2, as shown in Figure 6.
Similarly, with printing machine, the result of counter machine simulation as yet as in scenario 1, as shown in Table 10.

Table 10. Simulation Results of Each Counter Machine with 10 Replications

| Replication | CM 1     | CM 2     |
|-------------|----------|----------|
| 1 – 10      | 5% (Idle)| 80% (Idle)|

Here, the recapitulation data of each counter machine in scenario 2, as shown in Figure 7.

Figure 7. Recapitulation Data of each Counter Machine in Scenario 2

3.3. Scenario 3 or Alternative Improvement 2.

In the third scenario, the parameters that are changed in this model are the number of counter machine. There is additional to the counter machine, so there are 3 printing machines and 3 counter machines, as shown in Figure 8.

Figure 8. Model of Actual Production System in Scenario 3 using Flexsim Software.

The addition of the counter machine is intended to accelerate the process of calculating the quantity of raw materials. However, for each printing machine still produce 9,000 copies of the newspaper and the total newspaper are 27,000 copies. The raw materials required for the printing process for each machine listed in Table 11.

Table 11. Raw Material for each Machine in Scenario 2

|       | M1     | M2     | M3     |
|-------|--------|--------|--------|
| Paper | 3 roll | 3 roll | 3 roll |
| Ink   | 2 pail | 2 pail | 2 pail |
| Plate | 12     | 12     | 12     |
The simulation results with replication as many as 10 times show a same value. Result of simulation with 10 times replication show a high idle value on printing machine 1 and printing machine 3 as shown in Table 12. Notwithstanding printing machine 1 and printing machine 3 show 40% idle value, this percentage value decreases from scenario 1 and 2. This is because, the copies of newspaper from each printing machine is calculated on each counter machine. The replication is done by using the same scenario parameter and random stream in the flexsim software.

Table 12. Simulation Results of Each Printing Machine with 10 Replications

| Replication | PM 1   | PM 2   | PM 3   |
|-------------|--------|--------|--------|
| 1 - 10      | 40% (Idle) | 13% (Idle) | 40% (Idle) |

The simulation results also show that 87% blocked occurred on the machine 2. This means that the machine 2 is inhibited to the counter machine 3. Inhibition of the machine 2 due to a maximum quantity calculation on one process are 20 copies of the newspaper. Here, the recapitulation data of each printing machine in scenario 3, as shown in Figure 9.

![Figure 9. Recapitulation Data of each Printing Machine in Scenario 3](image)

Here, the recapitulation data of each counter machine in scenario 3, as shown in Figure 10.

![Figure 10. Recapitulation Data of each Counter Machine in Scenario 3](image)
3.4. Analysis of three scenarios.

Based on the 3 scenarios above and with 10 times replication, it can be concluded that the value of the idle printing machine in scenario 1 is 80%, scenario 2 is 90%, and the scenario 3 is 40%. Then the blocked on the printing machine in scenario 1 and 2 are 95%, and the scenario 3 is 87%. Then, the value of the idle counter machine in scenario 1 and 2 are 80%, and the machine 3 is 42%.

By adding 1 counter machine, it can reduce idle value on printing machines 3 from 80% to 40%. This is because, copies of newspaper from printing machine 1 and 2 can be directly counted on counter machines 1 and 3. So, the machine counter can count the number of newspapers with the same quantity. The blocked percentage on the printing machine in scenario 1 and 2 to scenario 3 also reduce from 95% to 87%. This is due to the calculation of the copies of newspaper from printing machine 1 and 2 are not hampered because it only uses one counter machine. The idle value on the counter machine in scenario 1 and 2 to scenario 3 also decrease from 80% to 42%. This is due to three of the counter machines counting the equal quantity of newspaper.

Based on these values, scenario 3 have the most efficiently composition of the newspaper production system to improve manufacturing productivity newspapers that can be applied in an actual system. This is because, by adding 1 counter machine, the idle value on the printing machine and counter machine can decrease. The blocked percentage value which shows the amount of bottleneck also decrease. So, with the addition of 1 counter machine, it can be seen that each machine used in the production process of this newspaper has the same load which will result in increasing efficiency in the newspaper production process.

4. Conclusion

Discrete Event Simulation (DES) method is a solution in modeling an actual system by representing the interaction between all components in the system as an event. In this study, DES used to improve efficiency in newspaper production systems. Production of the newspaper prosecuted to have a high level of efficiency due to the cycle time of the production is very limited. To find an alternative improvements to the actual system production of the newspaper, then three scenarios with various composition used in this research. In scenario 1, the composition of the production system consists of 3 printing machines and 2 counter machines. Scenario 2 consists of 4 printing machines and 2 counter machines. Then, scenario 3 is composed of 3 printing machines and 3 counter machines. Between the three scenarios, scenario 3 have the most efficiently composition of the newspaper production system to improve manufacturing productivity because has the smallest idle and blocked value.

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References

[1] Kaia K F and Espen H R 2014 Supply chain optimization in the newspaper industry Norwegian University of Science and Technology Management

[2] Geir H 2012 Routing applications in newspaper delivery Sintef 1-28

[3] G V R K Acharyulu 2014 Supply chain management practices in printing industry Operation and Supply Chain Management 7 39-45

[4] Shafagh J, Qi L and Gabriel W 2013 Synchronization methods in parallel and distributed discrete-event simulation Simulation Modeling Practice and Theory 30 54-73

[5] Shubham S 2014 Supply chain management in the newspaper industry: A case of responsiveness Annual Conference of the Production and Operations Management Society 1-9
[6] Carina I P, Wahyudi S and Muhammad H 2018 Sales forecasting newspaper with ARIMA: A case study AIP Conference Proceedings 1931 030018-1-030018-11
[7] Iqbal W S, Wahyudi S and Muhammad H 2018 Optimization of distribution channel vehicle routing problem with time windows using differential evolution algorithm a case study in newspaper industry Asia-Pacific Management and Business Application 10 1-10
[8] Sintya R, Muhammad H and Wahyudi S 2018 Supply chain risk management of newspaper company: House of risk approach AIP Conference Proceedings 1931 030016-1-030017-9
[9] Viny S, Muhammad H and Wahyudi S 2017 Supply chain risk management of newspaper industry: A quantitative study AIP Conference Proceedings 1931 030017-1-030017-10
[10] Era F A, Wahyudi S and Muhammad H 2018 The Integration of production-distribution on newspapers supply chain for cost minimization using analytic models: Case study IOP Conference Series: Materials Science and Engineering 319 1-6
[11] Joko S and N A Hidayah 2017 Discrete-event simulation system on small and medium enterprises productivity improvement IOP Conference Series: Materials Science and Engineering 277 1-6
[12] Zhiqian S, Matthew M, Neil H and Shrideep P 2015 Autonomouse orchestration of distributed discrete event simulation resource in the presence of uncertainty ACM Transactions on Autonomous and Adaptive Systems 10 1-20
[13] Andrian K, Grzegorz G and Iwona P 2017 Discrete event simulation method as a tool for improvement of manufacturing systems Computers 6 1-12
[14] Carsten E and Jürgen Z 2012 Simulation-based optimization in make-to-order production: scheduling for a special-purpose glass manufacturer Proceedings of the 2012 Winter Simulation Conference
[15] Zhiqian S, Matthew M, Neil H and Shrideep P 2013 Autonomous, failure-resilient orchestration of distributed discrete event simulation Proceedings of the ACM Cloud and Autonomic Computing and Workshops 1-10
[16] Ludwig D, Jonathan G, André Thomas, Philippe M, Nadia L and Hind E A 2015 simulation framework for the evaluation of production planning and order management strategies in the sawmilling industry IFAC-PapersOnLine 48 622-627
[17] Alexandra F M, Jorge S, Mikael R and Ricardo J 2014 Combining optimization and simulation tools for short-term planning of forest operations Taylor & Francis 29 166-177
[18] Shafagh J, Qi L and Gabriel W 2013 Synchronization methods in parallel and distributed discrete-event simulation Simulation Modeling Practice and Theory 30 54-73
[19] Johannes W, Kari V, Perttu A, Mikko N, Juha L, Antti A and Lauri S 2015 Discrete-event simulation of an information-based raw material allocation process for increasing the efficiency of an energy wood supply chain Applied Energy 149 315-325
[20] Roberto C, Margherita P, Tommaso R and Andrea S 2013 Linking supply chain configuration to supply chain performance: A discrete event simulation models Simulation Modelling Practice and Theory 40 1-11
[21] Chi-Lun R, Pei-Fang J T, Sheau-Farn M L, Jhiih-Cian T, Hong-Cheng S, Yue-Ling J, Ting-Syuan C and Fu-Shan Jaw 2013 Using discrete-event simulation in strategic capacity planning for an outpatient physical therapy service Health Care Management Science 16 352-365