Performance Evaluation on Printing Machine Goss Universal Using Reliability Availability Maintainability (RAM) Analysis and Overall Equipment Effectiveness (OEE)

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Abstract—The development of science and technology that has been developed more rapidly at this time, along with the increasing need for information itself. By producing a newspaper every day then the states forced PT Pikiran Rakyat to further improve the smoothness, the effectiveness and efficiency of the printing. One way to measure the performance of machines in general by using OEE and to minimize the possibility of losses to be borne by the company is improving the Reliability, Availability and Maintainability (RAM). By using the data in the form of MTTF (Main Time to Failure) and MTTR (Main Time To Repair) of each subsystem of the printing press. Based on calculations using the method of Overall Equipment Effectiveness, by performing calculations based on three main parameters with a study for eight months or 5760 hours, show that the value of the Availability of 75%, the value of the Performance of 97%, and the value of Quality by 98%, then the system has OEE values of 71.60%. The system has a reliability score of 10.59% at 70 hours based on the analytical approach. Maintainability calculations using modeling reliability block diagram, it is found that the entire unit in the system has a chance to settle down a minimum of 12 hours to be able to function again with a probability of 100% to reach its original state. During the eight-month study, Inherent Availability of the system is 99.52% based on analytical approach and Operational Availability of the system is 73.91%.

Keywords—Reliability, Availability, Maintainability, OEE, MTTF, MTTR

I. INTRODUCTION

The development of science and technology has been developed more rapidly at this time, along with the increasing of need for information itself. Where an agency company in the print media would require printing machine that has a good productivity with the aim to produce a daily newspaper with sufficient quantities in accordance with the needs of society, so that information more quickly and accurately. In order to achieve social services to the public, with the implementation of organizer information in today's information age, the facility will require information that is easy, fast, accurate, and available in many places.

By producing a newspaper every day along with the economy which is not yet stable and the sharpening competition in the industry, then the states are forced PT Pikiran Rakyat to further improve the smoothness, the effectiveness and efficiency of the printing due based on interview general to the head of production, it is emphasized that the common damage to the machine when printing is in progress. One of the things that support the smooth operation of the printing is readiness of production machines in their duties. To maintain the level of preparedness of the engine so that the engine can always be used continuously so that the continuity of production can be kept secure it, print media PT Pikiran Rakyat very need to take care of printing machines that are used in order to maintain the productivity and efficiency of the machine in order to run well and can continue to meet the needs of the information society Bandung. To maintain the level of preparedness of the engine, PT Pikiran Rakyat very needs to take care of printing machines that are used. By taking care of the machines, the continuity of products can be kept secure. Besides that, the productivity and efficiency of the machines, in order to run well, are maintained. As result, it meets the needs of Bandung society for information.

Printing machine in this company is the most important functions tool. With the vital function in the device causes the smooth production process is hampered, in case of system failure or malfunction. The occurrence of engine damage due to damaged components cannot be known with certainty. The condition causes the necessary precaution to perform calculations to determine how well the effectiveness of the print engine and determine the condition of the printing press is located at the level of desirable conditions, it can be measured OEE values by considering three important things, namely availability rate, performance rate and quality rate and perform analyzes of RAM on the printing machine PT Pikiran Rakyat. The condition causes the necessary precaution to perform calculations to determine how well the effectiveness of the print engine. It is also to determine the condition of the printing press located at the level of desirable conditions. Thus, it can be
measured OEE values by considering three important
things, namely availability rate, performance rate and
quality rate and perform analyzes of RAM on the PT
Pikiran Rakyat's printing machine.

II. LITERATURE REVIEW AND RESEARCH
METHODOLOGY
The concept in this research begins with a life of
data analysis using Anderson - Darling Test on
Existing Data Maintenance Time in which there is
time to repair and time to failure [1,4]. Having
obtained the distribution of the most good to represent
failure and repair of any machine, it can be done by
plotting the data to determine the distribution
parameters selected, which is done by using the
software Minitab 17. The results obtained are MTTF
and MTTR value to be used in the calculation of OEE
and RAM Analysis. The calculation of the value of
the OEE can be done by using the calculation results
Quality Rate, Rate Availability, and Performance
Rate.

The calculation of the value of RAM is analytical
Analysis can be done by using the distribution
parameter values of each machine and RBD modeling
to simplify the calculation of the system RAM. The
results of the calculations are analytical RAM RAM?
Analysis, namely Analytical Inherent Availability.
MTTF of machine is used to determine the machine
reliability, and MTTR is used to determine the
maintainability of the engine. MTTF and MTTR
required to perform calculations inherent availability.
RAM Analysis requires modeling of systems to
facilitate an evaluation, so that the model Reliability
Block Diagram (RBD) is used to model the system
from the machine Goss Universal.

The result of the calculation of OEE and RAM
Analysis can be used to determine the maintenance
policy. At the end of the study, each method will
provide answers to any formulation problems. Overall
Equipment Effectiveness OEE will generate value and
RAM Analysis will give the value of Plant
Availability Factor. KPIs can be evaluated by looking
at the results of research based on OEE and RAM
Analysis.

III. DISCUSSION
Time data destruction used for this study is data
destruction in 2015. After the TTF and TTR obtained
then performed plotting distributions to determine the
value of the reliability parameters. In Table 1 shows
the distribution of each TTF and TTR.

| Subsystem         | Distribution TTF | Distribution TTR |
|-------------------|------------------|------------------|
| Ink Fontain Roller| WEI              | WEI              |
| Transfer Roller   | NOR              | WEI              |
| Ink Form Roller   | NOR              | WEI              |
| Washup Device     | WEI              | WEI              |

After getting distribution representative, herein
after in Table 2. and 3. a parameter value
determination based on the reliability of the
distribution that represents.

| Subsystem         | Parameter | MTTF   |
|-------------------|-----------|--------|
| Ink Fontain Roller| $\beta$   | 0.730848 |
|                   | $\eta$    | 50.372 |
| Transfer Roller   | $\eta$    | 192.849 |
|                   |           | 192.849 |
| Ink Form Roller   | $\eta$    | 54.32  |
|                   |           | 54.32  |
| Washup Device     | $\eta$    | 66.0092 |
|                   |           | 76.9430 |

| Subsystem         | Parameter | MTTR   |
|-------------------|-----------|--------|
| Ink Fontain Roller| $\beta$   | 1.80865 |
|                   | $\eta$    | 3.381674 |
| Transfer Roller   | $\beta$   | 1.84562 |
|                   | $\eta$    | 3.80355 |
|                   |           | 2.075907 |
| Ink Form Roller   | $\beta$   | 1.902  |
|                   | $\eta$    | 3.23695 |
|                   |           | 2.147419 |
| Washup Device     | $\eta$    | 4.0616 |
|                   |           | 2.147419 |

Further processing of the data for the calculation of
Overall Equipment Effectiveness rate consist of
availability, performance rate and quality rate.
Furthermore, after his OEE values obtained followed
by RAM Analysis consists of Reliability, Availability,
and Maintainability.

3.1 Availability
Availability Rate calculation is obtained based on
the calculation Loading Time which is the total operating time is 13 hours per day. Furthermore, Total Downtime is obtained from the sum of the Planned Preventive Maintenance Downtime. The Unplanned Downtime which is Corrective Maintenance with units per month. Operating Time for a total production time for one month is obtained from the reduction of the Loading Time minus Total Downtime. As for Production Time, it is obtained from the sum of Unplanned Downtime with Operating Time. Furthermore, to calculate value of the Availability Rate is by dividing the value of the Operating Time Production Time. The following Table 4 represents the value of the Availability Rate already obtained.

### Table 4. Availability Rate

| No | Month   | Shift | Loading Time (Min) | Total Downtime | Planned Downtime | Unplanned Downtime | Operating Time | Production Time | Availability Rate |
|----|---------|-------|-------------------|----------------|------------------|-------------------|----------------|----------------|-------------------|
| 1  | August  | 1     | 390               | 237            | 187              | 50                | 153            | 203            | 75.37%            |
| 2  | September | 1     | 390               | 234            | 184              | 52                | 156            | 206            | 75.73%            |
| 3  | November | 2     | 390               | 233            | 181              | 52                | 157            | 209            | 75.12%            |
| 4  | December | 2     | 390               | 240            | 188              | 52                | 150            | 202            | 74.26%            |
| 5  | January  | 1     | 390               | 231            | 181              | 50                | 159            | 209            | 76.08%            |
| 6  | February | 2     | 390               | 233            | 183              | 50                | 157            | 207            | 75.85%            |
| 7  | March    | 2     | 390               | 239            | 189              | 50                | 151            | 201            | 75.12%            |
| 8  | Month    | 1     | 390               | 234            | 184              | 50                | 156            | 206            | 75.73%            |

### Table 5. Performance Rate

| No | Month | Shift | Operating Time | Net Operating Time | Performance |
|----|-------|-------|----------------|-------------------|-------------|
| 1  | August | 1     | 153            | 150               | 0.980392157 |
| 2  | September | 1     | 156            | 149               | 0.955128205 |
| 3  | October | 2     | 157            | 151               | 0.961783439 |
| 4  | November | 2     | 150            | 149               | 0.993333333 |
| 5  | December | 1     | 159            | 150               | 0.94396226  |
| 6  | January | 2     | 157            | 151               | 0.961783439 |
| 7  | February | 2     | 151            | 150               | 0.993377483 |
| 8  | March  | 1     | 156            | 150               | 0.961538462 |

### 3.2 Performance Rate

Performance Rate calculation is obtained by two parameters, namely the Net Operating Time and Operating Time. The Net Operating Time is obtained from Cycle Time multiplied by the number of production for a month divided by Operating Time. Operating Time is the value obtained from the calculation Availability Rate earlier. Here 5. The value of the Performance Rate is obtained.

### 3.3 Quality Rate

Quality Rate is the probability value of the quality of the machine. The calculations are done based on the division of the two main parameters, namely total Finish Product and Total Production. Total Finish Product obtained from total production minus total product defect. The following Table 6. represents the value of Quality Rate obtained.

### 3.4 Overall Equipment Effectiveness

The value of OEE is obtained by multiplication of the value Availability Rate, Performance Rate and Quality Rate for 8 months. OEE value generated by this research that is equal to 71.60%.

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OEE = \text{Availability Rate} \times \text{Performance Rate} \times \text{Quality Rate}
\]

\[
= 75\% \times 97\% \times 98\% = 71.60\%
\]
Japan Institute of Plant Maintenance (JIPM) establishes benchmark standards that have been practiced widely throughout the world. Due to the value of OEE in the present study obtained below 80% is only equal to 71.60%. It means that the company can know that the value of 71.60% OEE only has a great chance to do improvement to the OEE score reaches 85% or more. The system is not effective because the company is not good at the use of available resources, including equipment, and labor. The company has limited ability to meet customers' needs in terms of delivery. In accordance with the quality specifications and according to the consumer the company decided to obtain the reparation.

3.5 Defining System Inking System

Defining System Inking System is the first step to perform system modeling using Reliability Block Diagram (RBD) [2]. Inking System acts as a system to distribute the ink to provide the color in the printer. Some of the subsystems in the inking system have relevance in the process. This is because one subsystem cannot be moved if there is one subsystem down. To that end, this system hub of each subsystem. This system is called the series and parallel. To subsystems Fontain Ink Roller, Transfer Roller, and Ink Form Roller is a series circuit because if the experience down the other is down. As for the washup device subsystem is a subsystem parallel because its operations are not affected by other subsystems.

3.6 Modeling Reliability Block Diagram

Results from the definition of the system can be poured into the Reliability Block Diagram (RBD) to obtain the modeling of the inking system. In Figure 1. is RBD will show the existing working system of the inking system.

| No | Month   | Finish Product | Production Total | Quality Rate |
|----|---------|----------------|------------------|--------------|
| 1  | August  | 2940000        | 3000000          | 0.98         |
| 2  | September | 2940000      | 3000000          | 0.98         |
| 3  | October | 2940000        | 3000000          | 0.98         |
| 4  | November | 2940000     | 3000000          | 0.98         |
| 5  | December | 2940000    | 3000000          | 0.98         |
| 6  | January | 2940000        | 3000000          | 0.98         |
| 7  | February | 2940000    | 3000000          | 0.98         |
| 8  | March   | 2940000        | 3000000          | 0.98         |

Table 6.
QUALITY RATE

Figure 1. Reliability Block Diagram

3.7 Maintainability

Calculation of maintainability of the subsystem inking System is conducted by using data from Time to Repair. The data can represent clearly how big an opportunity to correct any inking unit subsystem System based on the improvement made by unscheduled maintenance. In this study, a period which will serve as the calculation time is within one hour to 12 hours, using a time interval of one hour. Here is the Table 7 which shows the value of the calculation result Maintainability each subsystem.

3.8 Reliability

Calculation of reliability with the analytical approach is the calculation of reliability that is done by using the RBD on system conditions with frozen state, namely blocks, known only characteristic damage (distribution and selected parameters of the unit) alone, with time given by the time constant. The measures undertaken in this calculation is the formulation of a model system reliability as well as the calculation is based on a formulation that has been done previously [3]. Data used in the calculation is the Time to Failure (TTF) Unscheduled Maintenance Data. In this study, the specified time is between six hours up to 72 hours, with an interval of six hours of the value of the Reliability of each subsystem and system DAPT seen in Table 8.
3.9 Availability Analytical Approach

Calculation of availability with the analytical approach is the calculation of availability which is done by using RBD on system conditions with frozen state, namely blocks, known only characteristic damage (distribution and selected parameters of the engine), with the time given by the researchers based on the time constant. Availability mode used is inherent availability. Calculation analytical approach availability is done by calculating the availability. Based on the key performance indicator of the inherent availability used by PTXYZ IVARA in accordance with the standard of 95%. Fontain that can be found in subsystem Ink Roller has inherent availability is less than 95%. So we can say the performance indicators of availability has not been reached. However, the three other subsystems and the system can be said to have achieved world class KPI that is, in a sense already reached the target performance of the system.

1. Inherent Availability with Analytical Approach

Based on the results of analytical formulation of availability on the RBD that has been done, the inherent availability calculation can be proceeded. Inherent availability only judges about things that are lowered into the system by active repair time (MTTR) and the time between the average machine failure (MTTF). The results of analytical calculations inherent availability of the unit subsystem Fontain Ink Roller, Transfer Roller, Ink Form Roller, and washup device during the observation period August 2015 until March 2016 can be seen in Table 9.

### Table 7. Maintainability Subsystem

| t(hour) | Ink Fontain Roller | Transfer Roller | Ink Form Roller | Washup Device |
|---------|--------------------|-----------------|-----------------|---------------|
| 1       | 26%                | 38%             | 37%             | 24%           |
| 2       | 45%                | 62%             | 61%             | 43%           |
| 3       | 59%                | 76%             | 75%             | 57%           |
| 4       | 69%                | 85%             | 84%             | 67%           |
| 5       | 77%                | 91%             | 90%             | 75%           |
| 6       | 83%                | 94%             | 94%             | 81%           |
| 7       | 87%                | 97%             | 96%             | 86%           |
| 8       | 91%                | 98%             | 98%             | 89%           |

### Table 8. Reliability System

| t(hour) | Ink Fontain Roller | Transfer Roller | Ink Form Roller | Washup Device | Rsystem |
|---------|--------------------|-----------------|-----------------|---------------|---------|
| 5       | 77.81%             | 97.44%          | 91.21%          | 84.88%        | 95.34%  |
| 10      | 60.55%             | 94.95%          | 83.19%          | 72.05%        | 85.41%  |
| 15      | 47.11%             | 92.52%          | 75.87%          | 61.15%        | 74.00%  |
| 20      | 36.66%             | 90.15%          | 69.20%          | 51.91%        | 62.91%  |
| 25      | 28.52%             | 87.84%          | 63.11%          | 44.06%        | 52.91%  |
| 30      | 22.19%             | 85.59%          | 57.56%          | 37.40%        | 44.24%  |
| 35      | 17.27%             | 83.40%          | 52.50%          | 31.74%        | 36.91%  |
| 40      | 13.44%             | 81.27%          | 47.88%          | 26.94%        | 30.76%  |
| 45      | 10.46%             | 79.19%          | 43.67%          | 22.87%        | 25.66%  |
| 50      | 8.14%              | 77.16%          | 39.83%          | 19.41%        | 21.43%  |
| 55      | 6.33%              | 75.19%          | 36.33%          | 16.48%        | 17.92%  |
| 60      | 4.93%              | 73.26%          | 33.14%          | 13.99%        | 15.02%  |
| 65      | 3.83%              | 71.39%          | 30.22%          | 11.87%        | 12.60%  |
| 70      | 2.98%              | 69.56%          | 27.56%          | 10.08%        | 10.59%  |
2. Operational Availability with Analytical Approach

Based on the results of analytical formulation of availability on the RBD that has been done, we do CALC operational availability. The data used is the total of data for operational availability requires real time data that occurs when the operations occur. Time used in operational availability is operational time obtained from the time that the machine performs its functions and the total downtime of each subsystem that occurred during the observation period and its value can be seen in Table 10 below.

| Inherent Availability System | Ink Fontain Roller | Transfer Roller | Ink Form Roller | Washup Device | Asystem |
|------------------------------|--------------------|-----------------|----------------|---------------|---------|
| %                            | 93.71%             | 98.94%          | 96.20%         | 95.53%        | 99.52%  |

| Operational Availability System | Ink Fontain Roller | Transfer Roller | Ink Form Roller | Washup Device | Asystem |
|---------------------------------|--------------------|-----------------|----------------|---------------|---------|
| %                               | 63.12%             | 69.41%          | 66.83%         | 63.12%        | 73.91%  |

3.10 Analysis of Maintenance Key Performance Indicator

Assessment system cannot be separated from the use of key performance indicator, for KPI provides a standard that makes it easy to see a clear limit to determine the good or bad of a system. Bandung to the BTS system, used IVARA World Class Targets for Key Performance Indicator. As well as Plant Availability Factor, KPI is divided into two parts, namely leading indicators and lagging indicators.

1. Leading Indicator Analysis

Calculation of leading indicators used to measure the performance of system availability that can be used as a prediction of a plan to improve performance. At the leading indicator for the availability parameter used is analytical inherent availability of data that can be seen in Table 11 below.

| Inherent Availability Key Performance Indicator | Subsystem            | Inherent Availability | Performance Indicator (95%) |
|------------------------------------------------|-----------------------|------------------------|-----------------------------|
|                                                | Ink Fontain Roller    | 93.71%                 | Not Achieved                |
|                                                | Transfer Roller       | 98.94%                 | Achieved                    |
|                                                | Ink Form Roller       | 96.20%                 | Achieved                    |
|                                                | Washup Device         | 95.53%                 | Achieved                    |
|                                                | Asystem               | 99.52%                 | Achieved                    |

Based on the key performance indicator of the inherent availability used by PTXYZ IVARA in accordance with the standard of 95%. Fontain that can be found in subsystem Ink Roller has inherent availability is less than 95%. So we can say the performance indicators of availability has not been reached. However, the three other subsystems and the system can be said to have achieved world class KPI that is, in a sense already reached the target performance of the system.

2. Lagging Indicator Analysis

Calculation of lagging indicators used to measure the performance of system availability can be used as a prediction of a plan to improve performance. In a lagging indicator for the availability parameter used is the analytical operational availability. Value operational availability can be used as an indicator of the performance of the system inking system. It is because the value of operational availability can demonstrate the ability of the system to do the production. In Table 12 below shows the value of Operational Availability of Key Performance Indicators.

| Operational Availability Key Performance Indicator | Subsystem            | Operational Availability | Performance Indicator (95%) |
|----------------------------------------------------|-----------------------|---------------------------|-----------------------------|
|                                                    | Ink Fontain Roller    | 63.12%                    | Not Achieved                |
|                                                    | Transfer Roller       | 69.41%                    | Not Achieved                |
|                                                    | Ink Form Roller       | 66.83%                    | Not Achieved                |
|                                                    | Washup Device         | 63.12%                    | Not Achieved                |
|                                                    | Asystem               | 73.91%                    | Not Achieved                |

Based on the above comparison, it can be found that all subsystems and systems on the operational availability inking system has less than 95%, so we can say the performance indicators of availability has not been reached.
IV. CONCLUSION

Based on calculations using the method of Overall Equipment Effectiveness, the system is not effective. It needs to be improvement further as OEE values is still below 85%. The calculations were performed based on three main parameters, namely the value of the Availability of 75%, the value of the Performance of 97%, and the value of Quality by 98%. Based on calculations using the RAM Analysis that uses reliability modeling block diagram, the system has a reliability score of 10:59% at 70 hours based on analytical approach. Maintainability calculations using RAM Analysis that uses reliability block diagram modeling, it is found that the entire unit in the system has a chance to settle down a minimum of 12 hours to be able to function again with a probability of 100% to reach its original state. During 2011, Inherent Availability of the system is 99.52% based on analytical approach and Operational Availability of the system is 73.91% standard IVARA not reached the target of 95% in terms of availability of the system needs to be improved.

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