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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

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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.

Table 1.
Distribution of 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.

Table 2.
Parameter of TTF

Subsystem	Parameter		MTTF
Ink Fontain Roller	β	0.730848	50.372
	η	41.3896	
Transfer Roller	η	192.849	192.849
Ink Form Roller	η	54.32	54.32
Subsystem	Parameter		MTTF
Washup Device	β	0.772	76.9430
	η	66.0092	4

Table 3.
Parameter of TTR

Subsystem	Parameter		MTTR
Ink Fontain Roller	β	1.80865	3.381674
	η	3.80355	
Transfer Roller	β	1.84562	2.075907
	η	2.33695	
Ink Form Roller	β	1.902	2.147419
	η	2.426	
Washup Device	β	1.9463	2.147419
	η	4.0616	

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	Avaibilty Rate
1	August	1	390	237	187	50	153	203	75.37%
2	September	1	390	234	184	50	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%
								Availabilty	75%

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.

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	0.943396226
6	January	2	157	151	0.961783439
7	February	2	151	150	0.993377483
8	March	1	156	150	0.961538462
				Performance	97%

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%.

OEE = Availability Rate x Performance Rate x Quality Rote

= 75% x *97%* x *98%*

= 71.60%

TABLE 6.
QUALITY RATE

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
			Quality Rate	98%

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.

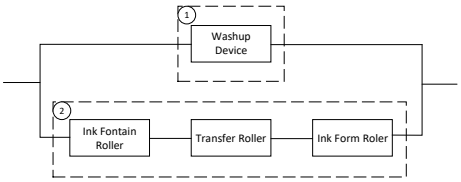

Figure 1. Reliability Block Diagram

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.

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%
9	93%	99%	98%	92%
10	95%	99%	99%	94%
11	96%	100%	99%	95%
12	97%	100%	100%	96%

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%

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 9.
INHERENT AVAILABILITY SYSTEM

Ink Fontain Roller	Transfer Roller	Ink Form Roller	Washup Device	Asystem
93.71%	98.94%	96.20%	95.53%	99.52%

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.

TABLE 10.
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.

TABLE 11.
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.

TABLE 12.
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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