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Analysis of Preventive Maintenance on Forklifts and Reach Trucks by Calculating Mean Time Between Failure and Mean Time to Repair at PT. DSV Solutions Indonesia

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Abstract - The aim of this research is to analyze preventive maintenance for material handling equipment, specifically Forklifts and reach trucks, at PT. DSV Solutions Indonesia over a one-year period (January-December 2023). The analysis employs the Mean Time Between Failure (MTBF), Mean Time To Repair (MTTR), and Availability methods. The findings reveal that the Forklift has an MTBF of 35,926 minutes, MTTR of 85 minutes/breakdown, and an availability of 77.83%, while the reach truck has an MTBF of 26,865 minutes, MTTR of 95 minutes/breakdown, and an availability of 90.14%. Based on this analysis, a recommended preventive maintenance schedule is devised, suggesting maintenance every 25 working days for Forklifts and 19 working days for reach trucks. The evaluation of the improvement in preventive maintenance indicates that Forklifts require maintenance 12 times and reach trucks 16 times in a year, resulting in a significant reduction in downtime and repair costs, ultimately enhancing overall operational efficiency. In conclusion, the enhancement of preventive maintenance schedules proves beneficial in increasing the operational uptime of Forklifts and reach trucks within the operational environment over the course of one year.

1. INTRODUCTION

PT. DSV Solutions Indonesia is a logistics industry company offering warehousing services to customers. This multinational company originated in Denmark in 1990 and currently operates in Indonesia. The company focuses on logistics and transportation, with its main activities being the provision of supply chain solutions for customers on a daily basis.

In the warehouse of PT. DSV Solutions Indonesia, material handling is used for the processes of incoming and outgoing goods, as well as the relocation of goods within the warehouse. The material handling equipment used includes forklifts and reach trucks. From January to December 2023, the maintenance of forklifts and reach trucks has been using the breakdown maintenance method. Breakdown maintenance is performed when the material handling equipment experiences a failure. The forklifts have experienced 12 failures, and the reach trucks have experienced 18 failures, leading to interruptions in the warehouse's material handling processes (downtime). Therefore, to avoid unexpected failures or damages that could be detrimental to the company, it is necessary to schedule preventive maintenance for the forklifts and reach trucks using the mean time between failure (MTBF) and mean time to repair (MTTR) methods.

Mean time between failure (MTBF) is a method for calculating the average operational time of forklifts and reach trucks from after repairs until they experience failure again. Meanwhile, mean time to repair (MTTR) is a method for calculating the average time taken from the start to the completion of repairs for the forklifts and reach trucks.

2. RESEARCH METHODOLOGY

The encountered problem was initially addressed through observation and examination of the damages and repairs to the material handling equipment, specifically forklifts and reach trucks. The first step taken was to collect maintenance data for the forklifts and reach trucks from January to December 2023. After acquiring all the necessary data, it was processed using the predetermined methods to address the identified issues, specifically by calculating the mean time between failure (MTBF) and mean time to repair (MTTR). Once the data processing was completed, the results were analyzed and evaluated to determine the necessary actions. Finally, conclusions and recommendations were made, as illustrated in the flowchart below:

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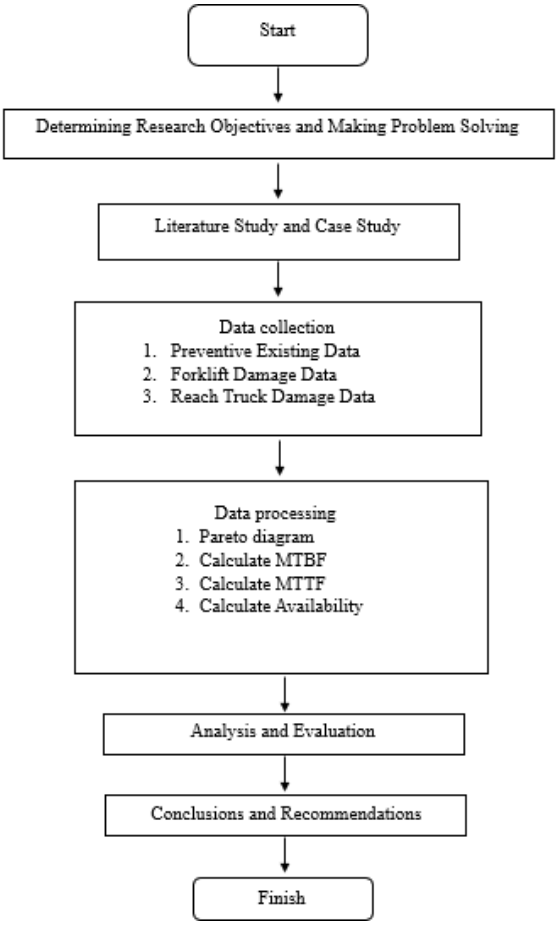

Figure 1. Research Flowchart

3. RESULTS AND DISCUSSION

Preventive maintenance at PT. DSV Solutions Indonesia is not scheduled. The company only made repairs to the damaged components of the forklift and reach truck. Because it is very important in repair, lubrication and electrical components. The following is data on damage to forklifts and reach trucks from January to December 2023:

Table 1.Components of Forklift damage from January to December 2023

Components	Problem	Repair Date	Repair Time
Engine	Change oil, dirty diesel filter, dirty air filter	26/01/2023	09.30-11.00
Engine Mast	Change oil, dirty diesel filter, dirty air filter Mast chain, lever handle, dirty handbrake, and thinning lubricant on Mast chain	24/02/2023	10.00-11.30
Battery	Battery drain	08/03/2023	09.30-10.30
Engine Mast	Change the oil, the diesel filter and the oil filter are worn out Mast, chain, rail lubricant is thinning	27/03/2023	10.30-12.00
Engine Mast	Change oil, replace oil hose Mast, chain, rail lubricant thinning	28/04/2023	10.00-11.30
Unit Engine Mast	Dusty, check unit Change the oil, replace the oil filter, diesel filter, air filter Lubricant on Mast, chain, rail is thinning	29/05/2023	10.30-12.00
Engine Hidrolik Mast	Change the oil, replace the oil filter, diesel filter, air filter The hydraulic oil is about to run out lubricant on Mast, chain, rail is thinning	26/06/2023	10.30-11.30
Engine Wheel Mast	Change oil, dirty air filter The lubricant is thin on the bearing, and replace the solid wheel Lubricant on Mast, chain, rail is thinning	15/07/2023	09.30-12.00
Hidrolik Engine	The hydraulic oil is about to run out Change oil, change oil filter, diesel filter, air filter	18/08/2023	11.30-13.10

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Mast	Lubricant on Mast, chain, rail is thinning		
Unit	Dusty, check unit		
Unit	Dusty, check unit		
Engine	Change oil, change oil filter, diesel filter, air filter	19/09/2023	10.00-11.15
Mast	Lubricant on Mast, chain, rail is thinning		
Indicator Alarm	No sound		
Engine	Change oil	21/10/2023	10.00-11.00
Mast	Lubricant on Mast, chain, rail is thinning		
Engine	Change oil, change oil filter, diesel filter, air filter	22/11/2023	11.00-12.15
Mast	The lubricant on the mast, chain and rails is running low		

Table 2.Components of Reach Truck damage from January to December 2023

Components	Problem	Repair Date	Repair Time
Battery	Air Battery is about to run out		
Mast	Lubricant thins on Mast chain, Mast post	26/01/2023	11.00-12.00
Unit	Dusty		
Battery	Air Battery is about to run out		
Mast	Lubricant thins on Mast chain, Mast post	24/02/2023	11.30-12.30
Unit	Dusty		
Battery	Air Battery is about to run out		
Mast	Lubricant thins on Mast chain, Mast post	21/03/2023	10.30-12.00
Unit	Dusty		
Battery	Air Battery is about to run out		
Mast	Lubricant thins on Mast chain, Mast post	13/04/2023	11.00-12.15
Unit	Dusty		
Battery	Air Battery is about to run out		
Mast	Lubricant thins on Mast chain, Mast post	28/04/2023	11.30-13.15
Unit	Dusty		
Wheel	Bearing Broken		
Wheel	Thin load wheel	29/05/2023	12.00-13.30
Mast	Mask post bearing damaged		
Battery	Air Battery is about to run out		
Mast	Lubricant thins on Mast chain, Mast post	12/06/2023	10.00-11.00
Unit	Dusty		
Hidrolik	Hydraulic oil is about to run out		
Battery	Air Battery is about to run out		
Unit	Dusty	20/07/2023	10.00-11.00
Mast	Lubricant thins on Mast chain, Mast post		
Battery	Air Battery is about to run out		
Unit	Dusty	11/08/2023	11.00-12.00
Mast	Lubricant thins on Mast chain, Mast post		
Wheel	The drive wheel broke	21/08/2023	10.00-13.00
Gear Box	Leak		
Gear Box	The seal is leaking, change the gear box oil	26/08/2023	10.30-12.00
Wheel	drive wheel not installed		
Wheel	drive wheel does not fit	02/09/2023	11.00-12.15
Unit	Dusty	08/09/2023	10.00-11.00

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Battery	Air Battery is about to run out		
Mast	Lubricant thins on Mast chain, Mast post		
Wheel	Drive wheel broke and had to order it	06/10/2023	10.00-16.00
Battery	Air Battery is about to run out		
Unit	Dusty	20/10/2023	12.30-13.30
Mast	Lubricant thins on Mast chain, Mast post		
Battery	Air Battery is about to run out		
Unit	Dusty	11/11/2023	10.15-11.15
Mast	Lubricant thins on Mast chain, Mast post		
Hidrolik	Loose hydraulic hose	22/11/2023	12.15-13.45
Kabel	Socket cable broken		
Wheel	Bearing broken	29/12/2023	10.00-11.30

In tables 1 and 2 above, there is data on component failures for forklifts and reach trucks over one period, from January to December 2023. After collecting this data, calculations were performed to determine the Mean Time Between Failure (MTBF) and Mean Time To Repair (MTTR).

Table 3.Calculating the Mean Time Between Failure and Mean Time ToRepair on Forklifts

Components	Problem	Repair Date	Repair Time	MTBF	MTTR
Engine	Change oil, dirty diesel filter, dirty air filter	26/01/2023	09.30-11.00	41.700	90
Engine	Change oil, dirty diesel filter, dirty air filter				
Mast	Mast chain, lever handle, dirty handbrake, and thinning lubricant on Mast chain	24/02/2023	10.00-11.30	17.600	90
Battery	Battery drain	08/03/2023	09.30-10.30	27.360	60
Engine	Change the oil, the diesel filter and the oil filter are worn out	27/03/2023	10.30-12.00	45.960	90
Mast	Mast, chain, rail lubricant is thinning				
Engine	Change oil, replace oil hose				
Mast	Mast, chain, rail lubricant thinning	28/04/2023	10.00-11.30	44.580	90
Unit	Dusty, check unit				
Engine	Change the oil, replace the oil filter, diesel filter, air filter	29/05/2023	10.30-12.00	40.230	90
Mast	Lubricant on Mast, chain, rail is thinning				
Engine	Change the oil, replace the oil filter, diesel filter, air filter	26/06/2023	10.30-11.30	27.420	60
Hidrolik	The hydraulic oil is about to run out				
Mast	lubricant on Mast, chain, rail is thinning				
Engine	Change oil, dirty air filter				
Wheel	The lubricant is thin on the bearing, and replace the solid wheel	15/07/2023	09.30-12.00	48.930	150
Mast	Lubricant on Mast, chain, rail is thinning				
Hidrolik	The hydraulic oil is about to run out				
Engine	Change oil, change oil filter, diesel filter, air filter				
Mast	Lubricant on Mast, chain, rail is thinning	18/08/2023	11.30-13.10	45.980	100
Unit	Dusty, check unit				
Unit	Dusty, check unit				
Engine	Change oil, change oil filter, diesel filter, air filter	19/09/2023	10.00-11.15	46.005	75
Mast	Lubricant on Mast, chain, rail is thinning				
Indicator Alarm	No sound				
Engine	Change oil	21/10/2023	10.00-11.00	46.080	60
Mast	Lubricant on Mast, chain, rail is thinning				
Engine	Change oil, change oil filter, diesel filter, air filter				
Mast	The lubricant on the mast, chain and rails is running low	22/11/2023	11.00-12.15	0	75
	Total (Minute)			**431.114**	**1.030**

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Table 4. Calculating the Mean Time Between Failure and Mean Time ToRepair on Reach Truck

Components	Problem	Repair Date	Repair Time	MTBF	MTTR
Battery	Air Battery is about to run out				
Mast	Lubricant thins on Mast chain, Mast post	26/01/2023	11.00-12.00	41.730	60
Unit	Dusty				
Battery	Air Battery is about to run out				
Mast	Lubricant thins on Mast chain, Mast post	24/02/2023	11.30-12.30	35.880	60
Unit	Dusty				
Battery	Air Battery is about to run out				
Mast	Lubricant thins on Mast chain, Mast post	21/03/2023	10.30-12.00	33.060	90
Unit	Dusty				
Battery	Air Battery is about to run out				
Mast	Lubricant thins on Mast chain, Mast post	13/04/2023	11.00-12.15	21.555	75
Unit	Dusty				
Battery	Air Battery is about to run out				
Mast	Lubricant thins on Mast chain, Mast post	28/04/2023	11.30-13.15	44.565	105
Unit	Dusty				
Wheel	Bearing Broken				
Wheel	Thin load wheel	29/05/2023	12.00-13.30	19.950	90
Mast	Mask post bearing damaged				
Battery	Air Battery is about to run out				
Mast	Lubricant thins on Mast chain, Mast post	12/06/2023	10.00-11.00	54.660	60
Unit	Dusty				
Hidrolik	Hydraulic oil is about to run out				
Battery	Air Battery is about to run out				
Unit	Dusty	20/07/2023	10.00-11.00	31.680	60
Mast	Lubricant thins on Mast chain, Mast post				
Battery	Air Battery is about to run out				
Unit	Dusty	11/08/2023	11.00-12.00	14.280	60
Mast	Lubricant thins on Mast chain, Mast post				
Wheel	The drive wheel broke	21/08/2023	10.00-13.00	7.050	180
Gear Box	Leak				
Gear Box	The seal is leaking, change the gear box oil	26/08/2023	10.30-12.00	10.020	90
Wheel	drive wheel not installed				
Wheel	drive wheel does not fit	02/09/2023	11.00-12.15	8.505	75
Unit	Dusty				
Battery	Air Battery is about to run out	08/09/2023	10.00-11.00	40.260	60
Mast	Lubricant thins on Mast chain, Mast post				
Wheel	Drive wheel broke and had to order it	06/10/2023	10.00-16.00	19.950	360
Battery	Air Battery is about to run out				
Unit	Dusty	20/10/2023	12.30-13.30	31.485	60
Mast	Lubricant thins on Mast chain, Mast post				
Battery	Air Battery is about to run out				
Unit	Dusty	11/11/2023	10.15-11.15	15.900	60
Mast	Lubricant thins on Mast chain, Mast post				
Hidrolik	Loose hydraulic hose	22/11/2023	12.15-13.45	53.055	90
Kabel	Socket cable broken				

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Wheel	Bearing broken	29/12/2023	10.00-11.30	0	90
Total (Minute)				**483.585**	**1.725**

The operating time for forklifts and reach trucks over one year is assumed to be non-operational for 69 days in a year, which includes: 1 day for Isra' Mi'raj of Prophet Muhammad SAW, 1 day for Nyepi Day, 1 day for Good Friday, 7 days for Eid al-Fitr, 1 day for Ascension Day of Jesus Christ, 1 day for Eid al-Adha, 1 day for Islamic New Year, 1 day for Indonesian Independence Day on August 17, 1 day for the Birth of Prophet Muhammad SAW, 1 day for Christmas, and 52 Sundays in a year. In total, the forklifts and reach trucks are non-operational for 99,360 minutes. The operating time for the forklifts and reach trucks over one year is 296 days, equivalent to 426,240 minutes. Based on the component failure data of forklifts and reach trucks over one year, from January to December 2023, the calculation for Availability is as follows:

1. Availability Forklift =(431.115 – 99.360) / 426.240 X 100 % = 77,83 %
2. Availability Reach Truck = (483.585 – 99.360) / 426.240 X 100 % = 90,14 %

The standard availability for machinery/material handling is 90%. Therefore, it can be said that the forklift machinery/material handling is operating suboptimally and inefficiently. In contrast, the reach truck machinery/material handling is operating efficiently and effectively.

Based on the failure data from January to December 2023, the calculations for Mean Time Between Failure (MTBF) and Mean Time To Repair (MTTR) for forklifts and reach trucks are as follows:

1. Forklift

Mean Time Between Failure (MTBF) $= \frac{431.115}{12}$ = 35.926 Menit

Mean Time To Repair (MTTR) $= \frac{1030}{12}$ = 85 Menit

2. Reach Truck

Mean Time Between Failure (MTBF) $= \frac{483.585}{18}$ = 26.865 Menit

Mean Time To Repair (MTTR) $= \frac{1.725}{18}$ = 95 Menit

Table 5. Calculations of Mean Time Between Failure (MTBF) and Mean Time to Repair (MTTR)

Material Handling	Period	MTBF (Minute)	MTTR (Minute)	Availability
Forklift	January – December 2023	35.926	85	77.83 %
Reach Truck	January – December 2023	26.865	95	90.14%

Based on the results of the Mean Time Between Failure (MTBF), the calculated results for forklifts and reach trucks are 35,926 minutes and 26,865 minutes, respectively. If one day equals 1,440 minutes, then the preventive maintenance schedule for forklifts is every 24.95 days or 25 working days, which is equivalent to 4 weeks. The preventive maintenance schedule for reach trucks is every 18.65 days or 19 working days, which is equivalent to every 3 weeks. Below is the preventive maintenance schedule planning table for forklifts and reach trucks:

Table 6. Preventive maintenance schedule planning for Forklifts and Reach Trucks

Job Activity	Jan				Feb				Mar				Apr				Mei				Jun				Jul				Ags				Sep				Okt				Nov				Des			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Forklift																																															
Reach Truck																																															

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4. CONCLUSION

In an effort to maintain the quality of material handling operations and ensure stability, it is essential to implement preventive maintenance. Although the performance of the equipment is already effective and optimal, unexpected failures can occur due to irregular preventive maintenance schedules for the components of forklifts and reach trucks. Therefore, preventive maintenance is an effective step to reduce such failures.the creation of a preventive maintenance schedule uses the formulas for mtbf, mttr, and availability. Based on the analysis and evaluation results of the forklifts and reach trucks from january to december 2023, it was determined that preventive maintenance for forklifts should be performed every 25 working days, equivalent to 4 weeks, and for reach trucks, every 19 working days, equivalent to 3 weeks.this scheduling aims to reduce failures, breakdowns, and downtimes, which can be costly for the company in terms of repair costs, operational downtimes, and the lifespan of the forklifts and reach trucks.

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