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Preventive Maintenances of Waste Crushing Equipment at Subang State Polytechnic

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ABSTRACT

The research in this final project aims to determine the preventive maintenance schedule for the plastic waste smelter and to determine the application of preventive maintenance to the plastic waste smelter. The maintenance process for this tool uses preventive maintenance with inspection, small repair, medium repair and overhaul (ISMO) methods. The implementation method of waste smelter into plastic involves data collection through direct observations of the smelter area, component identification, maintenance schedule planning, expert validation, and routine preventive maintenance execution. The research findings indicate that the systematic and scheduled application of maintenance effectively preserves the optimal performance of the smelter machine. These measures not only enhance operational efficiency but also reduce the risk of damages and potential downtime that could disrupt the production process, contributing to the sustainability and quality of plastic waste processing.

Keywords: Preventive Maintenance, Plastic Waste, Smelter Machine

INTRODUCTION

Plastic is a very practical object for any purpose and is used in everyday life, without having to spend a lot of money we can also use it. However, its practicality makes people use it less. People only use it once and throw it away carelessly. In general, plastic waste is very difficult to decompose because waste disposal is not managed properly and is not reprocessed [1][2].

Furthermore [3][4] plastic waste management can be addressed by converting waste into other forms that can be utilized. [5][6]. Added that the best solution for managing plastic waste is to use a waste shredding machine. The design of the waste shredder needs to be done to get optimal results. A plastic waste shredder can be a very effective solution in reducing the volume of plastic waste that is thrown away. By using a shredder, plastic waste can be converted into a form that is easier to manage, such as small flakes or raw materials that can be reused. This crushing process not only makes it easier to transport and store waste, but also opens up opportunities to recycle plastic into new products. With this technology, society can be more actively involved in managing plastic waste efficiently and contribute to environmental protection eforus.

The importance of designing efficient and environmentally friendly plastic waste shredder is also a crucial aspect in the successful use of this technology. Well-designed tools can ensure that the crushing process takes place optimally without producing additional negative impacts on the environment. Apart from that, careful design can also consider safety aspects so that the operator can use this machine safely [7][8]. With an effective plastic waste shredder, it is hoped that it can encourage wider recycling practices and reduce the burden of plastic waste on the ecosystem.

Waste chopping equipment that is used routinely must receive regular maintenance to prevent damage to the tool [9][10]. added by [11] maintaining the machine makes the machine more optimal. One of the machine maintenance is preventive maintenance [12].

This method includes planned maintenance which is a form of scheduled maintenance implementation [13],[14]. Therefore the improvement cycle becomes important. The classification of maintenance activities in planned maintenance can be divided into 4 categories, namely, Inspection, Minor Repairs (S), Medium Repairs (M), and Overhaul (O).

In general, the inspection has the following work limitations, (a) check the function of the rotating speed and cutting speed mechanisms; (b) check and adjust friction clutch, gear clutch, main shaft, bearing, slide, brake, nut retainer, etc.; (c) clean the lubricating oil and cooling oil filters, the oil and oil delivery systems, and the powdered dirt and dust from the guides; (d)

tighten the fastening nuts and bolts, replace if necessary.

Minor repairs have general work limits, as follows: (a) carry out all activities carried out in the inspection; (b) disassemble 2-3 pieces of equipment that may be worn or dirty then clean them, if necessary, add another oil bag, replace the damaged parts then assemble and adjust; (c) carry out repairs if necessary or noted during the inspection.

Medium repairs must meet general work limits, as follows: (a) carrying out all maintenance activities in the form of minor repairs, plus dismantling all parts that may be worn out and must be replaced or repaired; (b) paint the surface of the damaged machine; (c) calibrate by leveling the machine.

Overhaul has general work limitations, as follows: (a) repeat all maintenance actions carried out on medium repairs, but with disassembly involving each unit, all damaged and worn components are replaced with new components.; (b) machine foundation inspection (foundation depth installation) and repairs if necessary; (c) grind/grease all guide surfaces; (d) painting all surfaces that must be painted with new paint [15].

The results of observations in the field at the Department of the Environment (DLH) show that previously there was a plastic waste recycling tool called a "plastic waste smelter", there are still several things that need to be done, namely making a maintenance schedule and carrying out work steps using preventative maintenance. by using inspection, minor repair, medium repair and overhaul methods at plastic waste smelters with the aim of extending service life, streamlining the production process and minimizing major damage and minimizing maintenance costs [16][17] also added that regular machine maintenance needs to be carried out every week, month and year. The ISMO method is the most suitable method to be applied in this case.

RESEARCH METHOD

In carrying out the maintenance of the plastic waste smelter with this drive system, various steps of the activity process are required, some of which can be seen in the following steps.

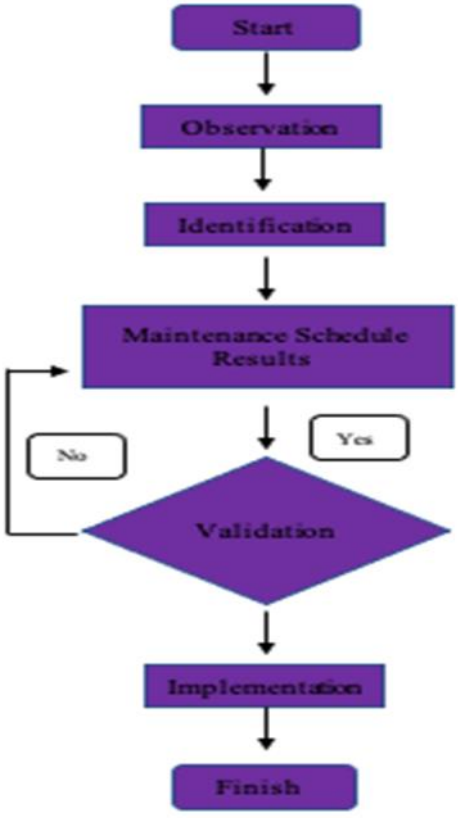

Figure 1. Research flowchart

Research designs for the effectiveness of plastic waste processing equipment need to pay attention to approaches that are appropriate to the research objectives. For example, an experimental approach can be used by comparing a group that uses processing tools with a control group that does not use those tools. Another alternative is a problem study approach that focuses on implementing the tool in a real environment. In this research design, variables such as waste processing efficiency, environmental impact, and desirability need to be taken into account to ensure a thorough understanding of the tool's performance

Research sampling must pay attention to representative coverage of the relevant population. For example, if plastic waste processing equipment is used in a city or region, sample selection can include various community groups that reflect the diversity of behavioral patterns and habits in managing plastic waste. In addition, instruments such as interviews, observations and surveys must be carefully designed to gather relevant information regarding the effectiveness of plastic waste processing equipment from the user's perspective and its impact on the environment. Accurate and relevant data analysis is the key to gaining a deep understanding of the performance of plastic waste processing equipment.

RESULT AND DISCUSSION

1. Observation

Direct observation of the field at the environmental service in Subang Regency and conducting interviews about plastic waste and waste processing machines. From the results of these observations and interviews there is a problem with plastic waste of the Aluminum Foil type which is very difficult to decipher and there was once a plastic smelting machine in the Subang Regency area but for now the machine can no longer be operated due to lack of maintenance on the machine and lack of knowledge about maintenance on the machine. So it needs periodic maintenance on the waste smelting machine so that the machine can work optimally when it is in operation [18][19].

Figure 2. Research observations

2. Component Identification

Component identification is carried out to group or determine which component parts will be treated in a plastic waste smelter. Treatment is carried out with preventive maintenance with the ISMO method [20][21].

Table 1. Component classification

No.	Part	Component	Picture
1.	Main Frame	Frame	
		Melting tube	
		Electric Motor	
2.	drive system	*Reduser*	
		Pillow block	
		Screw	
3.	Electricity system	*Band heater*	
		Thermo control	
		Thermo couple	
		Contactor	

3. Maintenance Results

The result of making this maintenance schedule plan is the total time in 1 year needed in the maintenance process for Tofu Presses and Cutters with a Pneumatic System, namely inspection (1008 minutes), and small repairs (150 minutes). With the time needed for each main component, namely, the frame system (312 minutes inspection, 30 minutes small repair), propulsion system (428 minutes inspection, 0 minutes small repair). Compressor (24 minutes inspection, 120 minutes small repair), knife (144 minutes inspection, 0 minutes small repair).

4. Discussion

The importance of preventive maintenance for plastic waste shredding equipment is crucial in ensuring optimal

performance and a longer lifespan. Firstly, preventive maintenance helps prevent damage and functional failures of the equipment. By conducting routine inspections and scheduled maintenance [22], potential issues with critical components can be detected early, allowing for timely intervention before they escalate into more serious problems. This not only reduces the cost of major repairs but also avoids downtime that could disrupt the smooth operation of the equipment [23][24].

Moreover, preventive maintenance supports operational efficiency. Well-maintained plastic waste shredding equipment tends to exhibit better performance, producing consistent plastic shreds and optimizing energy consumption. Thus, preventive maintenance can help reduce the risk of producing substandard waste and enhance the efficiency of the recycling process, ultimately contributing to environmental sustainability. Overall, investing in preventive maintenance for plastic waste shredding equipment is not only a preventive measure but also a long-term strategy to improve productivity and have a positive impact on the environment.

a. Main Frame

The main frame of the tofu press and cutter with a pneumatic system is the main frame that will support the load from the pneumatic system and the components in the electric car, including: installation mounting plate, tofu mold, tofu drawer, tofu press plate, press plate, pneumatic tube, drain, tofu cutting knife and other supporting components.

b. Drive System

The drive system is the most important component in the plastic waste smelter because the drive system is the main component to run and drive this tool. In the drive system here to move the screw to push the plastic melt when melting the plastic towards printing. Inspect once a month in the 3rd week for 2 minutes to check the condition of the electric motor and do a small repair every 3 months in the 2nd week for 10 minutes to check the condition of the electric motor if you experience noise problems. Inspect once a month in the 3rd week for 2 minutes to check the condition of the oil in the reducer and do a small repair once a month in the 3rd week for 5 minutes to change the oil in the reducer. Do an inspection once a month in the 3rd week for 2 minutes to check the condition of the pillow block and do a small repair once a month in the 3rd week for 5 minutes to lubricate the pillow block. Inspection every time it is used for 5 minutes to check the condition of the screw.

c. Electricity

The electrical system is the most important part of this plastic waste smelter which is to move and provide electric current to all electrical components. Maintenance of the band heater, do an inspection every time it is used, for 5 minutes to check the

temperature of the band heater and check the amperage of the band heater. Maintenance on the thermo couple. Inspect every time you use it for 5 minutes to check the connection cable on the thermo control. maintenance on thermo control. Do an inspection every time you use it for 5 minutes to check the connection cable on the thermo control. Contactor maintenance. every time it is used for 5 minutes to check the cable connection to the contactor.

d. Evaluation

The formulation of the proposed maintenance schedule plan, the author has undergone several revisions through validation by experts, specifically concerning the rationality of maintenance timing and ensuring alignment with the equipment usage. The schedule must be in accordance with the operational demands of the tools. Upon validation, if the proposed maintenance schedule is deemed suitable and aligns with the practical utilization of the equipment, it is declared valid. This validation process ensures that the schedule is not only theoretically sound but also practically applicable. The iterative nature of the revisions reflects a commitment to refining and optimizing the schedule based on expert input[25][26].

CONCLUSION

In the process of working on this final project several conclusions can be drawn

1. The preventive maintenance schedule for the plastic waste smelter includes monthly and annual maintenance using inspection and small repair methods. For monthly maintenance it is carried out every month while for annual maintenance it is the calculation result of monthly maintenance. The results of the total time on the maintenance schedule are 1,692 minutes of inspection and 210 minutes of small repairs. There are 3 main parts to the plastic waste smelter, namely the frame manufacturing system, the drive system and the electrical system.

2. Implementation of the maintenance schedule for the plastic waste smelter includes 3 main parts, namely the frame manufacturing system, drive system and electrical system. The frame manufacturing system includes checking welding joints, frame surfaces, outside of the fusing tube, inside of the fusing tube using a wire brush, sandpaper, rags to ensure that the plastic waste smelter remains in good condition. The drive system includes checking the electric motor, checking the condition of the reducer, pillow block, screw, the tool needed is a tachometer. Forward, 12,14 spanners. Then the electricity will include checking the temperature of the band heater, this process is carried out to determine the temperature conditions that work on these components. The temperature detected on the servocontrol is 150° Celsius, which is the normal working temperature. Then check the

current using a clamp meter to get around 2 A, servocontrols, thermocouple, contactor.

REFERENCES

[1] and N. J. S. J. H. Wong, M. J. H. Gan, B. L. Chua, M. Gakim, "Shredder machine for plastic recycling: A review paper," 2022.

[2] R. Castro-Amoedo, J. Granacher, I. Kantor, A. Dahmen, A. Barbosa-Povoa, and F. Maréchal, "On the role of system integration in plastic waste management," *Resour. Conserv. Recycl.*, vol. 201, no. June 2023, p. 107295, 2024, doi: 10.1016/j.resconrec.2023.107295.

[3] Y. Cheng, E. Ekici, G. Yildiz, Y. Yang, B. Coward, and J. Wang, "Applied machine learning for prediction of waste plastic pyrolysis towards valuable fuel and chemicals production," *J. Anal. Appl. Pyrolysis*, vol. 169, no. December 2022, p. 105857, 2023, doi: 10.1016/j.jaap.2023.105857.

[4] E. Setyaningsih, S. D. Hariyanto, D. Wahyuningtyas, and S. Kristiana, "Performance improvement of the shredder machines using IoT-based overheating controller feature," *J. Infotel*, vol. 14, no. 4, 2022, doi: 10.20895/infotel.v14i4.812.

[5] P. Adjie Suwignyo, R. Kusumastuti, Amir, D. Mulyadi, and Khoirudin, "The Design of a Plastic Shredder Machine with The Crusher Cutting Knife Model for Environmentally Sustainable," *J. Tek. Mesin Mech. Xplore*, vol. 3, no. 2, pp. 58–66, 2022, doi: 10.36805/jtmmx.v3i2.2821.

[6] and L. N.-T. W. Alvarado-Diaz, J. Chicoma-Moreno, B. Meneses-Claudio, "Design of a Plastic Shredding Machine to Obtain Small Plastic Waste," 2021.

[7] D. Song *et al.*, "Highly energy-efficient and safe-environment-friendly ultra short electrical arc machining for titanium alloy: Mechanism, characteristics, and parameter estimation," *J. Clean. Prod.*, vol. 417, no. March, p. 137842, 2023, doi: 10.1016/j.jclepro.2023.137842.

[8] O. B. van Leeuwen *et al.*, "Sequential hypothermic and normothermic machine perfusion enables safe transplantation of high-risk donor livers," *Am. J. Transplant.*, vol. 22, no. 6, pp. 1658–1670, 2022, doi: 10.1111/ajt.17022.

[9] N. T. Putri, Taufik, and F. S. Buana, "Preventive Maintenance Scheduling by Modularity Design Applied to Limestone Crusher Machine," *Procedia Manuf.*, vol. 43, no. 2019, pp. 682–687, 2020, doi: 10.1016/j.promfg.2020.02.123.

[10] I. Tseremoglou, P. J. van Kessel, and B. F. Santos, "A Comparative Study of Optimization Models for Condition-Based Maintenance Scheduling of an

Aircraft Fleet," *Aerospace*, vol. 10, no. 2, 2023, doi: 10.3390/aerospace10020120.

[11] R. Thakur, "Design & Fabrication of Portable Waste Shredder Machine for Domestic Compost," 2019.

[12] H. Peng, Y. Wang, X. Zhang, Q. Hu, and B. Xu, "Optimization of preventive maintenance of nuclear safety-class DCS based on reliability modeling," *Nucl. Eng. Technol.*, vol. 54, no. 10, pp. 3595–3603, 2022, doi: 10.1016/j.net.2022.05.011.

[13] Z. A. Yamayee, "Maintenance Scheduling: Description, Literature Survey, and Interface with Overall Operations Scheduling," *IEEE Power Eng. Rev.*, vol. PER-2, no. 8, pp. 50–51, 1982, doi: 10.1109/MPER.1982.5519768.

[14] E. F. xiaodid yao, "Optimal preventive maintenance scheduling in semiconductor manufacturing," 2014.

[15] X. Zhou, L. Xi, and J. Lee, "Opportunistic preventive maintenance scheduling for a multi-unit series system based on dynamic programming," *Int. J. Prod. Econ.*, vol. 118, no. 2, pp. 361–366, 2009, doi: 10.1016/j.ijpe.2008.09.012.

[16] N. H. A. R. and A. N. H. M. Khatib, "Development of PET bottle shredder reverse vending machine."

[17] K. Alhamad, Y. Alkhezi, and M. F. Alhajri, "Nonlinear Integer Programming for Solving Preventive Maintenance Scheduling Problem for Cogeneration Plants with Production," *Sustain.*, vol. 15, no. 1, 2023, doi: 10.3390/su15010239.

[18] A. Tyagi, R. Tripathi, and S. Bouarfa, "Learning from past in the aircraft maintenance industry: An empirical evaluation in the safety management framework," *Heliyon*, vol. 9, no. 11, p. e21620, 2023, doi: 10.1016/j.heliyon.2023.e21620.

[19] M. H. Hagström, K. Gandhi, D. Bergsjö, and A. Skoogh, "Evaluating the effectiveness of machine acquisitions and design by the impact on maintenance cost – A case study," *IFAC-PapersOnLine*, vol. 53, no. 3, pp. 25–30, 2020, doi: 10.1016/j.ifacol.2020.11.005.

[20] A. Kurnia and H. Istiqlaliyah, "Analysis Maintenance Of The 2 Kg Capacity Meatball Printing Machine Using The Ismo Method," *Semin. Nas. Inov. Teknol.*, vol. 6, no. 2, pp. 350–357, 2022.

[21] A. R. Fachrudin, "Penerapan Sistem Perawatan Metode Ismo Pada Turbin Tipe Vertical Francis Kapasitas 35 Mw," *Mach. J. Tek. Mesin*, vol. 7, no. 2, pp. 22–29, 2022, doi: 10.33019/jm.v7i2.1916.

[22] W. Kosasih, I. K. Sriwana, and W. J. Purnama, "Perancangan Sistem Informasi Perawatan Mesin Menggunakan Pendekatan Analisis

Berorientasi Objek," *J. Ilm. Tek. Ind.*, vol. 6, no. 3, pp. 201–208, 2019, doi: 10.24912/jitiuntar.v6i3.4246.

[23] A. Akhtar Khan *et al.*, "Structural analysis of cotton stalk Puller and Shredder Machine," *Alexandria Eng. J.*, vol. 64, pp. 335–347, 2023, doi: 10.1016/j.aej.2022.09.002.

[24] S. Reddy and T. Raju, "Design and Development of mini plastic shredder machine," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 455, no. 1, 2018, doi: 10.1088/1757-899X/455/1/012119.

[25] P. J. S. et Al, "Optimizing Maintenance Scheduling for Industrial Equipment," Journal of Maintenance Engineering,."

[26] A. R. Johnson et al., "Effective Maintenance Planning: A Comprehensive Review," 2020.