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Utilization of Solar Power Plants to Drive Organic Waste Shredding and Grinding Machines

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ABSTRACT

Solar power plants continues to experience good development and even PLTS can be used to overcome environmental problems, so this research aims to utilize renewable energy as a driving force for waste processing machines by designing organic waste chopping and grinding equipment. The specified motor power is 2 HP or 1.5 kW with 275 rpm, so the number of panels required is 12 pieces which are converted into AC from DC by the inverter. Based on power and rotation, the torque calculation results obtained are 2760 kg cm, the shaft diameter is 18.86 mm, the belt type is type A with a top belt width of 12.5 mm and a thickness of 8 mm, and transverse pegs with a width of 8 mm, a thickness of 7 mm. and 40 mm long based on ISO 2292 (according to pulley hub thickness). Based on the calculations and transmission design, a waste processing tool was built and then tested. From the tests, it was found that the power produced by PLTS was 1.5583 kW at 2239 Lux light to chop up 2 kg of organic waste.

Keywords: Solar Power, Waste Shredding and Grinding Machine, Transmission

INTRODUCTION

The use of PLTS in the environment continues to experience changes in terms of quantity and quality to overcome the problems faced by society, especially environmental problems. One form of environmental problem that often occurs in society is the problem of waste and its management. In general, waste production is divided into two categories: organic waste and inorganic waste [1][2].

Organic waste is waste that comes from the remains of living organisms which can be easily broken down by natural decomposing bacteria without human intervention. If organic waste is not managed properly, the natural decay process causes disease and unhealthy odors, but this waste can be useful and have economic value over time [3]. Organic waste has the potential to be processed into useful products such as compost or organic fertilizer. Fertilizer is an important part of crop production. In this era, the use of fertilizers to increase crop production continues to increase, but farmers, especially communities using organic fertilizers, are starting to shift from chemical fertilizers to organic materials and also compost processed from the organic waste composting process[4][5]. Composting is a process in which organic materials are decomposed, specifically by microbes that use organic materials as an energy source. Composting is an activity that regulates and controls natural decomposition to produce compost more quickly. This process involves a balanced mixture of organic waste, soil, water, husk charcoal, lime, and additional liquid fertilizer or activator solution. Generally, the activator used is effective microorganisms 4 (EM4). Em4 is a liquid fertilizer, which consists of a mixed culture of various beneficial microorganisms and fertilizes the soil [6][7].

Compost raw materials that come from organic waste or other organic materials must be chopped first. Shredding rubbish or organic materials such as leaves, small branches, household waste, and so on can be done manually, but to speed up and simplify the process, use a shredding machine [8][9]. The components of the organic waste chopping machine consist of a hooper or funnel which functions as a container for adding organic waste, chopper knife cover, machine frame, transmission system (belt, pulleys, shaft, pegs, and bearings), chopper knife, wheels, handle for thrusters, chopped output, and DC motors. The trash or organic material that has been chopped is then ground using a grinding machine [10][11].

The components used in grinding machines are almost the same as the components in chopping machines, namely consisting of hoopers or funnels, grinding knife covers, machine frames, transmission systems (belts, pulleys, shafts, pegs, and bearings), and wheels. The only difference is the blade, whereas on the grinding machine, the knife used is the grinding wheel [12][13]

[14]. These two machines generally use fossil fuel motors which do not support the direction and goals of developing environmentally friendly and sustainable technology as stated by the Indonesian government at the world forum at the G20. At the G20 meeting held in December 2022 in Bali, Indonesian President Joko Widodo argued for developing environmentally friendly green technology, not just technology. President Joko Widodo also called on entrepreneurs to start changing the direction of the economy towards a green economy [15][16].

One of the actions that support the recommendations from the G20 regarding green energy is the process of converting solar energy into electrical energy. The energy conversion process is carried out using a device that can convert sunlight into electrical energy, namely solar panels. A solar panel is a collection of solar cells arranged or arranged in such a way on a frame and connected using cables so that they are effective in absorbing sunlight. The task of absorbing sunlight is the solar cells. In the 1970s, solar panels had an efficiency of 15%, and this has increased consistently around 0.5% per year since 2010 [17][18]. Many factors play a role in increasing the efficiency of solar panels, including three main components, namely material components, reflectance efficiency, and efficiency thermodynamics. After carrying out various technological developments on these three components, currently solar panels have an efficiency of 20% - 30% [19][20].

So this research aims to design the use of solar power plants to drive organic waste chopping and grinding machines.

RESEARCH METHOD

This research was carried out using the design and construction method of testing equipment for organic waste processing machines using renewable solar energy as the engine drive. Before designing the transmission and making testing equipment for organic waste processing, the motor power used is first determined to be 2 HP or 1.5 kW with 275 rpm, so the number of panels needed is 12 pieces which are converted into AC from DC by an inverter.

In this research, the components needed for the testing equipment are shown in Table 1.

Table 1. Material used

Material	Number
Solar panels	12 pcs
Motor power	2 HP
Factor design	1.4
Shaft	1 pcs
Belt	1 pcs
Key	1 pcs

RESULT AND DISCUSSION

The motor power required to drive the chopping machine is 2 PK or 1.5 kW, so 12 solar panels of 300 Wp each with a voltage of 36 volts are used. The DC obtained is converted into AC using a 14 kW inverter with an output of 220 Volts, where the minimum input voltage to the inverter is 90 V and the

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maximum is 580 Volts. Thus, 12 solar panels are installed in series until a maximum voltage of 432 Volts is obtained. In this research, there were 2 types of solar panels used, namely: 6 pieces of Jeni Mono Crystalline Solar Panels and 6 pieces of Poly Crystalline solar panels.

The driving motor power (P) is 2 PK or 1.5 kW at a rotation (N) of 725 rpm, then the torque generated (T) $= \frac{P \times 4500}{2 \times \pi \times N} = \frac{2\,HP \times 4500}{2 \times \pi \times 725} =$ 1.9 $kg\ m$. By taking a design factor of 1.4 then Pd = 1.4 x 1.5 kW = 2.1 kW or 2.8 HP, so that the resulting torque (T) is $T = \frac{P \times 4500}{2 \times \pi \times N} = \frac{2.8\,HP \times 4500}{2 \times \pi \times 725} =$ 2.76 kg m or 2760 kg cm.

Several cutting knives are installed on the shaft so that the shaft is also subjected to bending loads and from the calculation results it is obtained that the bending moment is 1.7 kg m = 1700 kg mm. The equation for shaft size is $d_s = [\left(\frac{5.1}{\sigma_s}\right)\sqrt{(Km.M) + (Kt.T)}]^{\frac{1}{3}}$, where K_m and K_t are each taken as 1.5. The shaft material used is S30C-D with a permissible shear stress of 4.58 kg/mm^2. Then the shaft diameter obtained is: $d_s = [\left(\frac{5.1}{4.58}\right)\sqrt{((1{,}5\ \times\ 1700)^2 + (1{,}5 \times 2760)^2}]^{\frac{1}{3}} =$ 18.86 mm. From the calculation of the strength of the shaft, it is found that the shaft size is small, but because a peg is installed on the shaft, the shaft diameter is taken to be 25 mm and on the part where the cutting knife is installed, the shaft diameter is made large, D = 70 mm.

By taking the pulley diameter 1 (d_1) = 150 mm; pulley diameter 2 (d_2) = 75 mm; rotation on pulley 1 (n_1) = 725 rpm; rotation on pulley 2 (n_2) = 1450 rpm. By the drive motor power of 2 HP or 1.5 kW with a drive rotation of 1450 rpm, based on the table below for determining the belt, type A belts are used with a top belt width of 0.50" (12.5 mm) and a thickness of 0.31" (8 mm).

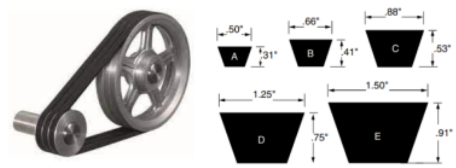

Figure 1. Belts and belt type selection

Based on the ISO 2292 transverse post standard, with a shaft diameter of 25 mm, the size of the post required in width and thickness is 8 mm and 7 mm with a length of 40 mm (according to the thickness of the pulley hub)

After calculating and designing, the next step is making the tool which is then tested. Test results data on the design of using solar power plants to drive organic waste chopping and grinding machines are shown in the following table 2.

Table 2. Test result

No	1	2	3	4	5	6
Data recording time (Second)	0.35	0.35	2.52	2.52	4.02	8.04
Garbage weight (Kg)	0	0.2	0.4	0.6	1	2
Machine rotation (RPM)	1411	1468	1468	1484	1484	1484

PV 1	Currents (A)	3.4	3.5	3.6	3.65	3.6	3.65
	Voltage (V)	215	216	220	222	222	222
	Power (W)	731	756	792	810.3	799.2	810.3
PV 2	Currents (A)	2.9	3.2	3.3	3.3	3.2	3.4
	Voltage (V)	214	216	218	220	220	220
	Power (W)	620.6	691.2	719.4	726	704	748
Solar power generation power (KW)		13.516	14.472	15.114	15.363	15.032	15.583
Light intensity (Watt/m2)		125.3	130.6	133.7	133.2	133.2	133.2
Lux		2137	2158	2211	2230	2235	2239
Temperature (0C)		32.9	34.7	35.4	35.6	35.6	35.6
Humidity (%)		43	43	43	43	43	43

Based on the test results in Table 2, as the amount of waste shredded by the machine increases, the power required increases. From the observations, there is some test data that is not synchronous. First, if the power produced by the solar panels exceeds the power requirements of the machine, it cannot be monitored on the inverter.

CONCLUSION

Based on the design and testing on the use of solar power plants to drive organic waste chopping and grinding machines that have been carried out, it can be concluded that the weakness of solar panels is that, in theory, 12 panels with a capacity of 300 Wp each should be able to produce 3600 Watts of electrical power. However, in the tests carried out the power produced was 1.5583 kW.

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