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Experimental Study Of The Performance Of The Thermal Energy Water Pump Using Tilled Evaporator

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ABSTRACT

Water is one of the important or basic needs for human life. The availability of water in Indonesia is an advantage that our nation has that has not been optimized. Generally, water pumps are driven by electrical energy, but it is possible to be driven by other energy, namely petroleum energy (with a combustion motor). Alternative energy that can be used is thermal energy. Thermal energy can come from coal, solar energy, geothermal or waste heat from industries that are no longer used. The purpose of this study was to determine the discharge, pump power and maximum efficiency. The working fluid used is diethyl ether. The heat comes from an electric stove which will heat the working fluid, namely diethyl ether. The variables measured were temperature, volume and pumping time. Variables that are varied are variations in the height of the pumping head, (1) 170cm, (2) 244cm and (3) 325cm. Variations in the volume of diethyl ether in the reservoir tube, (1) 653ml, (2) 717ml and (3) 844ml. Variations in the volume of compressed air in the compressed tube, (1) 5.49 liters, (2) 4.71 liters, and (3) 3.14 liters. Variations in the use of compressed air tubes, (1) one compressed air tube and (2) two compressed air tubes. The results showed that the maximum discharge of 0.63 liters/minute was obtained at variations in the height of the pumping head 1.7m, ether volume 653ml, compressed air volume 3.14 liters, and using one compressed air tube. The maximum pump power of 0.185 watt and the maximum pump efficiency of 0.047% were obtained at variations in pumping head height of 3.25m, volume of ether 653ml, compressed air volume of 3.14 liters, and using one compressed air tube.

Keywords:
water pump, thermal energy, diethyl ether, power, efficiency

INTRODUCTION

Water is one of the important or basic needs for human life. Water has been used for bathing, cooking, washing, and other necessities[1]. The availability of water in Indonesia is an advantage that our nation has that has not been optimized. But all of that will become less useful if what is owned is not processed as well as possible. Water sources are generally located lower than where the water is needed, so a water pump is needed to drain water from the water source to where it is needed[2].

In general, water pumps are driven by electrical energy, but it is possible to be driven by other energy, namely by petroleum energy (with a combustion motor).[3]. Not all regions in Indonesia have good electricity networks and transportation facilities, so it is difficult to obtain fuel. In addition, the use of electrical energy causes the cost of water supply to be expensive, so that it can reduce the community's ability to meet the needs of life. In addition to water supply being expensive, water supply using human labor such as drawing, carrying with a bucket, or using a hand pump will reduce time and energy to be able to carry out other more productive activities.[4]. Alternative energy that can be used is thermal energy. Thermal energy can come from coal, solar energy, geothermal or waste heat from industries that are no longer used. In Indonesia, the performance of thermal energy water pumps has not been widely studied, especially with diethyl ether working fluid.

In this study, a thermal energy water pump model was made using a diethyl ether working fluid with a single heater with a slope of 300. The heater is positioned with a slope of 300 in order to adjust the conditions for the use of solar collectors. In addition, to determine the discharge, pump power and maximum pump efficiency produced[5].

Research on solar energy water pumps shows that the condensation time of the steam is affected by the temperature and the cooling water discharge entering the condenser[6]. Theoretically research on solar energy water pumps with two kinds of working fluids, namely n-pentane and ethyl ether, showed that the efficiency of pumps with ethyl ether was 17% higher than n-pentane for a head height of 6 m.[7]. Research on heat energy pumps based on Stirling motors can effectively pump water with a variaso head between 2-5 m[8]. Smith's research on thermal water pumps shows that the right size condenser can increase the power output by up to 56%.[9]. Research on solar energy water pumps using a mathematical model shows that the pump performance is determined by the steam fraction of the cycle[10].

Thermal energy water pumps generally consist of three types, namely pulse jet (water pulse jet), fluidyn pump, and nifte pump type. Thermal energy water pumps generally consist of several components, namely the water pump actuator, evaporator, suction line, and pressure line[11]. Utilization of solar energy to produce mechanical energy driving a water pump can be grouped into two, namely the thermodynamic method and the direct conversion method. In the thermodynamic method, solar thermal energy is collected using thermal collectors, both flat and focused plate types. Thermal energy is used to increase the temperature and pressure of the working fluid. The working fluid with high temperature and pressure is used directly or indirectly to produce mechanical energy. The mechanical energy produced is used to drive the water pump. Water pumps with special designs can be grouped based on the working fluid vapor cooling medium, namely air or water cooled. In the direct conversion method, solar energy is converted into electrical energy (by photovoltaic, thermoelectric or thermionic), The electrical energy produced is used by an electric motor to drive a water pump. In this study, diethyl ether (diethyl ether) was used.[12]. In the evaporator section there is a pipe sheath that is useful as a place to receive heat in the form of water vapor that comes from heating water. In the evaporator there is a working fluid in the form of ether, because it receives heat from water vapor, the diethyl ether will evaporate, the boiling point of diethyl ether is around 360C[13]. Because the ether in the evaporator evaporates, the pressure in the pump will rise and will push the water in the submersible pump up to the holding tank. The diethyl ether vapor will enter the condenser and experience cooling, so that the diethyl ether vapor will condense[14]. Due to condensation, the pressure in the pump will drop to the pressure condition before the evaporation of the diethyl ether begins, causing water from the water source to be sucked into the submersible pump, along with this, the diethyl ether will return to the evaporator to be heated. return. This cycle is repeated as long as there is a heat source from the water vapor. Each pump pressure step (in the diethyl ether evaporation process) and one suction step (in the diethyl ether vapor condensation process) can be called one pumping cycle.[15]. The submersible pump is equipped with two unidirectional valves, one on the suction side and one on the pressure side. The valve functions so that the pressure stroke only flows into the holding tank and the valve on the suction side serves to suck water from the water source tank.

METHOD

The method used is an experimental method, namely making a model of a thermal energy water pump with diethyl ether working fluid.

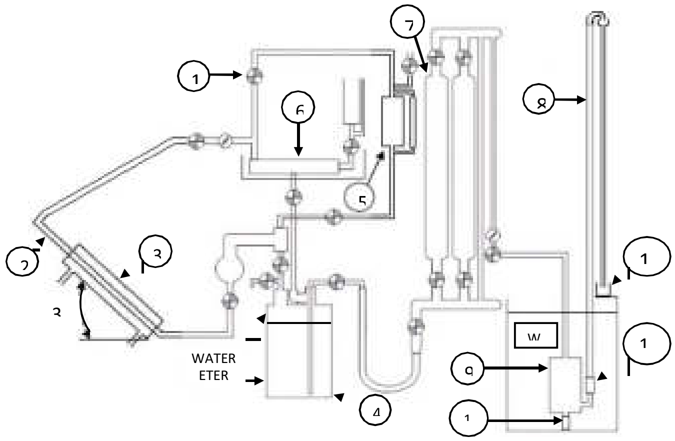

Figure 1. Tool Schematic

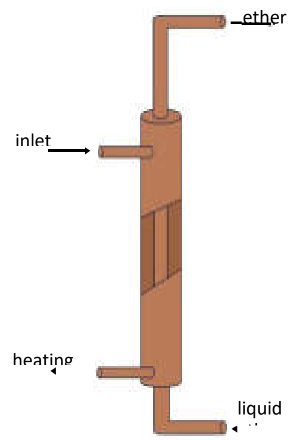

Figure 2 Evaporator

The water pump used is a thermal energy water pump using a diethyl ether working fluid. Evaporator containing diethyl ether and pump system filled with water. At first the evaporator is heated using water vapor produced from heating water using a stove. The resulting water vapor will flow by itself into the casing on the evaporator through a hose. The heat from the water vapor will cause an increase in the temperature of the evaporator. Diethyl ether will evaporate because of its low boiling point, which is 360C. Evaporation will provide sufficient pressure so that the water in the water pressure tube can be pushed into the air pressure tube. The water contained in the compressed air tube will rise and push the air connected through the hose, into the submersible pump filled with water. Through the one-way valve to the exhaust pipe above, water will be pushed out during the evaporation of the diethyl ether, after which condensation occurs. Condensation causes the pressure in the system to drop so that the suction valve will open and the water in the submersible pump will increase. The water in the compressed air tube will return to its initial state. The condensed ether will return to the evaporator to be reheated. Each one compression stroke and one suction stroke is called one pumping cycle. Submersible pumps are equipped with one-way valves on the suction and pressure sides, respectively. The function of the valve is that on the pressure stroke the water does not return to the source but flows to the destination. The condensed ether will return to the evaporator to be reheated. Each one compression stroke and one suction stroke is called one pumping cycle. Submersible pumps are equipped with one-way valves on the suction and pressure sides, respectively. The function of the valve is that on the pressure stroke the water does not return to the source but flows to the destination. The condensed ether will return to the evaporator to be reheated. Each one compression stroke and one suction stroke is called one pumping cycle. Submersible pumps are equipped with one-way valves on the suction and pressure sides, respectively. The function of the valve is that on the pressure stroke the water does not return to the source but flows to the destination.

Variables that are varied are:

1. Variation in pumping head height, (1) 170cm, (2) 244cm and (3) 325cm.
2. Variations in the volume of diethyl ether in the reservoir tube, (1) 653ml, (2) 717ml and (3) 844ml.
3. Variations in the volume of compressed air in compressed air cylinders, (1) 5.49 liters, (2) 4.71 liters, and (3) 3.14 liters.
4. Variations in the number of pressure tubes, (1) one pressure tube and (2) two pressure tubes

The variables measured include

1. The temperature at the top of the evaporator (T1),
2. The temperature at the bottom side of the casing where the water in and out (T2),
3. The temperature at the inlet of the evaporator (T3),
4. The temperature in the copper cooler box (T4).
5. Volume
6. Pumping time

For Furthermore, from these variables calculations are carried out to get the discharge, pump power, heating power and pump efficiency.

Pump data collection steps:

a. Head height adjustable
b. The volume of diethyl ether is adjusted and filled in the ether container
c. Thermocouples and measuring instruments used are installed
d. The volume of compressed air in the compressed air tube is regulated
e. Evaporator heating starts
f. The temperature T1, T2, T3, T4, time and the volume of water produced by the pump are recorded.
g. Cooling is done by flushing the copper cooler box with water.
h. Repeat 1-7 on the test with heads of 1.7m, 2.44m, and 3.25m using one compressed air tube, 653ml ether volume and 5.49 liter compressed air volume.
i. Repeat 1-7 on the test with a head of 3.25m, volume of compressed air 5.49liters and volume of ether 653ml, 717ml, and 844ml using a single compressed air tube.
j. Repeat 1-7 on the test with a head of 3.25 m, ether volume of 717 ml, using one compressed air tube, with compressed air volumes of 5.49 liters, 4.71 liters, and 3.14 liters.
k. Repeat 1-7 in the test with a head of 3.25, the volume of ether 717ml, using two compressed air tubes, with a compressed air volume of 3.14 liters.

RESULTS AND DISCUSSION

Calculation of heating power using the mass of diethyl ether, the mass is obtained from measurements in the field. For the volume of ether 653ml has a mass of 465.8 grams, 717ml has a mass of 511.5 grams, and 844ml has a mass of 602.1 grams. With Hfg diethyl ether of 360.2 KJ/Kg.

The final compressed air volume is the volume of compressed air that cannot be compressed again or the volume of compressed air remaining in the compressed air tube during the compression stroke process. The press stroke time is the time it takes from the beginning of the pressing stroke to the end of the pressing stroke. Pumping time is the time recorded when the water pumped from the water source starts to come out until it stops, when the pressure stroke occurs. The intake stroke time is the time obtained during cooling, that is, when the volume of compressed air will return to its initial volume until it reaches the initial volume of compressed air. Volume is the amount of pumped water measured during the pumping process. Discharge is the ratio between volume and pumping time. The heating power is the product of the mass of the ether and the hfg of the ether at the time of heating. Pump power is the product of the density of water, acceleration due to gravity, discharge, and pumping head. Efficiency is the ratio of pump power to heating power.

Table 1. Calculation data obtained on variations in head height of 325cm, volume of ether 171ml, volume of compressed air in a compressed air tube of 3.14 liters, and using two compressed air tubes

Air volume (liters)		P2 (bars)
start (V1)	3.14	1.38
end (V2)	2.27	

Table 2. The calculation data obtained on variations in head height is 325cm, ether volume is 717ml, compressed air volume is 3.14 liters of compressed air, and uses one compressed air tube.

Air volume (liters)		P2 (bars)
start (V1)	3.14	2.10
end (V2)	1.49	

Discussion

The results of the study in Figure 3 show that the maximum water discharge is 0.63 liters/minute by using a pumping head variation of 1.7 meters.

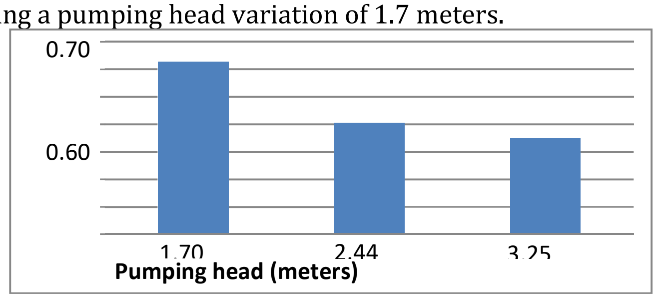

Figure 3 that the maximum water discharge

The resulting pump discharge has a large enough difference. This is due to the difference in head height so that the energy required to drain water to a high head will be greater than to drain water to a lower head. The energy generated by heating diethyl ether is small because losses occur in the heating line that do not completely evaporate the diethyl ether, so that some of the energy obtained must be wasted because it pushes the remaining diethyl ether that has not evaporated. The energy that can be used to raise the water is small.

Maximum pump power is obtained 0.185watt by using a pump head variation of 3.25 meters. The resulting pump power has a large enough difference. This is due to losses in the pumping process. The energy required to pump the water is used to drain the diethyl ether that has not evaporated. The evaporated diethyl ether is only in contact with the walls of the evaporator pipe so that when the diethyl ether evaporates, the ether vapor will push the ether liquid that has not evaporated, so that the ether that should have been heated is carried up and then falls back into the evaporator. The power generated becomes unstable and affects the pumping process.

It can be seen that the resulting efficiency between pumping heads has a large enough difference. The 1.7m head variation has an efficiency of 0.027%, the 2.44m head variation has an efficiency of 0.028%, the 3.25m head variation has an efficiency of 0.047%. This shows that the higher the head, the better the efficiency because the heating power used on the 3.25m head is smaller than the heating power on the 1.7m and 2.44m heads, so the efficiency will increase.

The resulting pump discharge has a large enough difference. At 653ml ether volume no pumping occurs. This is due to losses in the pumping process. The diethyl ether that evaporates is only in contact with the walls of the evaporator pipe, so that when the diethyl ether evaporates, the ether vapor will push the ether liquid that has not evaporated, so that the ether that should have been heated is carried up and then falls back into the evaporator. The water column also has a big influence. The height of the water column will affect the volume of compressed air that must be compressed. The lower the water column, the greater the volume of compressed air that must be compressed. Air has compressible properties, so the amount of increase in the water column is not the same as the rise of water into the exhaust pipe.

The results showed that the maximum pump power was 0.164watt using a 5cm height variation of diethyl ether. The resulting pump power has a large enough difference as shown in the graph above. At 653ml ether volume there is no pump power because there is no pumping. This is due to losses in the pumping process. The amount of diethyl ether used can affect pumpability. From Figure 4.5 it can be seen that the higher, or the more diethyl ether used, the greater the pump power produced. The 653ml ether volume variation has no efficiency, because there is no pumping process, the 717ml ether volume variation has an efficiency of 0.014%, the 844ml ether volume variation has an efficiency of 0. 021 This shows that the higher or more diethyl ether is used, the better the efficiency will be. The less amount of ether used, the lower the resulting efficiency.

Variation of compressed air volume of 5.49 liters has an efficiency of 0.014. The low efficiency in the compressed air volume of 5.49 liters is due to losses in the pumping process. The amount of air in the compressed air volume of 5.49 liters causes considerable power loss, because air has compressible properties. So that the water that rises in the compressed air volume of 5.49 liters is not the same as the water that rises in the exhaust pipe. Maximum pump power is obtained 0.185watt by using a variation of one compressed air tube. There is no pumping of the two compressed air tubes. This is due to the low height of the water column. The lower the water column will increase the volume of compressed air in the pressure tube, so it requires more power if the water column is lower. By using two compressed air tubes, the air contained in the pressure tube will be doubled, so that the power produced will be divided in half to press each press tube. So that energy will be wasted in the pressure tube to push compressible air. The efficiency produced in one compressed air tube is 0.028%. There is no pumping of the two compressed air tubes. This is because using a pressure tube, the air contained in the pressure tube will be doubled, so the power produced will be divided in half to press each pressure tube. So that energy will be wasted in the pressure tube to push the air. Not optimal heating can also cause the pumping process not to occur. Insufficient pressure in the pumping process is also a factor that affects the pumping cycle. The pressure generated by the variation of two compressed air tubes has a smaller pressure than the pressure in one compressed air tube. This causes the water in the submersible pump to not rise at a head of 3.25m. So that the volume does not come out and does not produce a discharge.

CONCLUSION

Based on the results of the analysis obtained the following conclusions: Has successfully made a model of thermal energy water pump. The maximum discharge of 0.63 liters/minute was obtained at variations in the height of the pumping head 1.7m, ether volume 653ml, compressed air volume 3.14 liters, and using one compressed air tube. The maximum pump power of 0.185watt is obtained at variations in pumping head height of 3.25m, ether volume of 653ml, compressed air volume of 3.14 liters, and using one compressed air tube. The maximum pump efficiency of 0.047% was obtained at the variation of the pumping head height of 3.25m, the volume of ether 653ml, the volume of compressed air 3.14 liters, and using one compressed air tube.

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