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The Experiment of Wind Electric Water Pumping for Salt Farmers in Remote Area of Demak-Indonesia

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Abstract

Local villagers in the remote area of Wedung, Demak, northern of Central Java, Indonesia utilized special equipment called wind-pump for sea water lifting and circulating on salt production processes. The salt farmer has skill to produce, manufacture and maintain his own traditional wind-pump. In the windpump structure unit consisted of four blades horizontal axis windmill and reciprocating pump. This experiment study separated both windmill and pump by 50 meters. The pump was low speed centrifugal type pump. The windmill shaft was connected electrically to the pump shaft. The electric transmission components were an AC generator, diodes circuits and an DC motor. The experiment is carried out in a place that has the same characteristics as the original place at southern region of Bantul, Yogyakarta, Indonesia. The variation of experiment was pump head of 55 cm and 85 cm during 6 hours each variation. The average wind speed at the time of data collection at the head of 55 and 85 cm were 3.9 and 3.8 m/s. The volume flow rate and the volume produced by the pump during 6 hours of operation were 0.134 and 0.215 liter/s and 2901.6 and 4640.6 liters.

Keywords: wind-pump, salt production processes, four blades, electric transmission

1 Introduction

Salt production in Indonesia is still using a traditional technique. This technique applies solar heat and solar radiation to evaporate seawater [1]. The salt production process is usually in a dry season. This process is the easiest and cheapest method. Typically, the salt ponds are spread across the coastline. The salt ponds are plentiful on the north coast of Java-Indonesia.

Wind energy for water pumping is spread worldwide, especially in developing countries [3]. The application of renewable energy for water pumping still exists. The traditional methods use windpump and the modern methods, such as photovoltaic and wind turbine technologies for water pumping [4]. Especially in remote areas, salt farmers do not have electricity or fuel to power the pumps [5]. The salt farmers respond to their issues and built the windmills [2,5]. This windmill is used to assist salt farmers in salt production.

The salt farmers from Demak use the windmill for water pumping [2,5]. Commonly, salt farmers use a reciprocating pump as an instrument for transporting water [2]. This traditional technique is usually called windpump. There are two types of purposes for this windpump. The first type was built to transport water from the sea to salt ponds, and the second type was built to transport water from one pond to another pond [2].

The purpose of this study is to discuss salt farmers' windmills of Demak for water pumping with a slow-speed centrifugal pump. There are two variations on the net head on this research, there are 55.00 cm and 85.00 cm. The dissimilarity on the net head could expand other assistances for salt farmers. The results are windspeed to volume flow rate, efficiency and volume produced in a day.

The study purpose is to investigate the performance of four blades salt farmer's windmill from Demak-Indonesia for water pumping coupled with a centrifugal pump, with two variations of the water level (55.00 cm and 85.00 cm). Velasco et al. [6] explained the theory of wind-electric water pumping. Zevalukito and Lukiyanto [7]

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investigated the salt farmer's windmill from Demak for water pumping with a low-speed centrifugal pump. The transmissions utilize electric transmissions, with electric generators and electric motors. Iswanjono et al. [8] investigated the performance of transmissions with some type of generator, motor, and cable. Lukiyanto and Wahisbullah [9] examined the double U pipe configuration for a centrifugal pump. The double U pipe arrangements aim to escalate efficiency because double U pipe configurations have lower losses than a sliding orifice.

Site and Data Description. The data collection process has completed at Kuwaru Beach (Bantul, Special Region of Yogyakarta, Indonesia). The windpump system was installed about 50 m from the coastline. The windmill was fitted on a beach and the centrifugal pump was arranged 50 m away from the windmill. There was no vast difference in the wind speed range between Kuwaru Beach and Demak's coastline. The place has uncontrollable wind speed by the reason of the natural conditions of the coastline. The data collection was started in the morning until the afternoon on local time (GMT+07.00). The wind speed was ranging between 2.2 up to 3.9 m/s. The information required was wind speed and the windmill's shaft speed on the windmill, and the volume flow rate of the centrifugal pump. The data informations were recorded every 6 minutes.

2 Research Methodology

Fig. 1. illustrates the wind pumping system. The windmill's shaft attached with the AC generator's shaft subsequently produces AC electricity. DC electricity is produced as a result of AC electricity transform into DC electricity by a diodes circuit (Wheatstone bridge). The DC electricity is linked with the DC electric motor. The DC electric motor shaft is coupled with a low-speed centrifugal pump. When the low-speed centrifugal pump rotates, then the water is supplied with centrifugal force. The centrifugal force pushes the water upward.

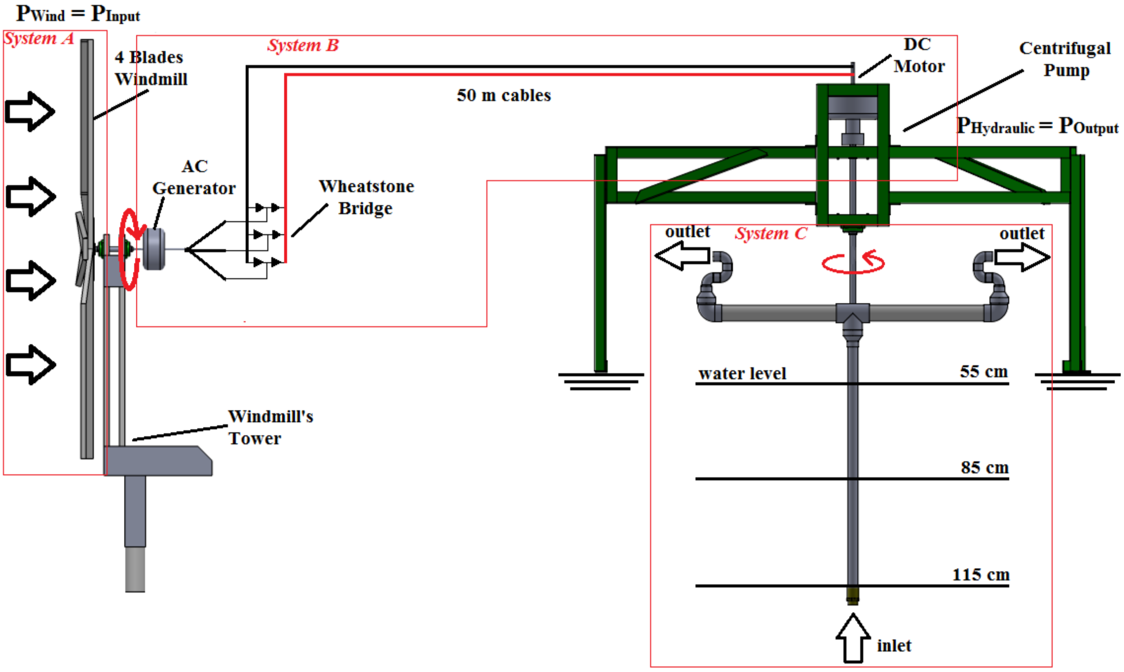

Figure 1. Schematics of Wind Pumping System

This wind pumping system in this study has three principal parts shown in Fig. 1. There are windmills [5], a transmissions system [8], and a centrifugal pump [9]. In this study, the windpump system was used an AC generator and DC electric motor as electric transmissions. Fig. 2. Shows energy losses during energy converting.

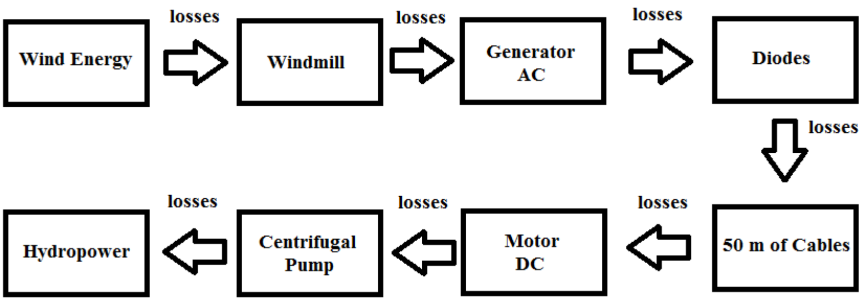

Figure 2. Energy Losses of The System

Windmill (System A). The windmill used in this study purchased directly from one of the salt farmers from Demak-Indonesia. The windmill is arranged with four blades and maybe rearranged with two blades [5]. The windmills have dimensions of 200.00 cm diameter, 22.25 cm wide, and 2.50 cm width. The windmill is attached to a shaft with dimensions of 2.00 cm in diameter and 25.00 cm in length. The shaft is fitted horizontally between the two UCF 204 bearings. The wooden tower was used to install the windmill.

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Usually, the wooden tower is instantly installed above the pond's fence. The wooden tower is attached to the rigid structure due to research purposes.

The performance of windmills was examined by Zevalukito et al. [5]. The windmill has a Coefficient of Performance (Cp) of 10.2% and has maximum torque (T) of 1.90 Nm. The maximum wind energy captured by this windmill is 10.2% could be converted to mechanical shaft power. The mechanical shaft power rotates the generator which is coupled with the AC generator's shaft.

Transmission System (System B). The electric transmissions require some electrical equipment. The transmissions system arrangement in the sequence was an alternating current generator, a diodes circuits, a wire, and a direct current electric motor. The windmill's shaft was coupled to the generator's shaft. The electric generator was 500 Watt alternating current brushless permanent magnet. The electricity production by the generator was alternating current (AC). The AC electric current was transformed to direct current (DC) by diodes circuits [7-8]. The diodes circuit is well-known as the Wheatstone bridge. The DC electricity is transferred by the wire 50 m long. The wire connected to the DC electric motor. The DC electric motor has 450 Watt with a permanent magnet. The DC electric motor's shaft is attached with the low-speed centrifugal pump tube afterwards rotating the pump.

Low-Speed Centrifugal Pump (System C). The centrifugal pump in this study was a low-speed centrifugal pump coupled with DC electric motor's shaft. The centrifugal pump uses a double U configuration as an impeller [6,9]. The centrifugal pump's shaft was connected to DC electric motor's shaft. The suction pipe, two long-arm on two sides, and double U pipes configurations are the three main parts of the centrifugal pump [9]. The centrifugal pump has 110.00 cm in diameter. The height between suction parts and double U pipe are 55.00 cm, 85.00 cm, and 115.00 cm. The suction part could be replaced for each requirement. The centrifugal pump is mounted below the rigid structure. The protective cover is installed around the centrifugal pump to prevent the water splashed everywhere.

The system efficiency in this wind-electric water pumping assessed from wind power (System A) to hydraulic power (System C).

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The energy conversion of the wind electric water pumping begins with wind energy [11]:

$$P_{Wind} = 0.5\rho_{air}Av^3 \quad (1)$$

P_{Wind} as input power; ρ_{air} constant at 1.225 kg/m^3; A as sweep area of the windmill, remain constant at $3.14m^2$; v as wind speed. The windmill system is shown in Fig. 2 of System A.

The energy conversion ends in the low-speed centrifugal pump while the pump starts pumping. The hydraulic power-driven by the wind speed. The wind speed changes into the volume flow rate due to this windpump system. The hydraulic power could be written as [12]:

$$P_{Hydraulic} = \rho_{Water}ghQ \quad (2)$$

$P_{Hydraulic}$ as output power; ρ_{air} persist constant at 1.03 kg/litre; g as acceleration of gravity, steady at 9.81 m/s2; h as the net head pump, there are 55.00 cm, 85.00 cm and 115.00 cm; and Q as volume flow rate.

The system efficiency assess from input power (1) to output power (2). The equation to assess efficiency could be written as:

$$\eta = \frac{P_{Wind}}{P_{Hydraulic}} \times 100\% \quad (3)$$

As a result of this windpump system for developing salt farmers community in Demak-Indonesia, the volume in a day is certainly required, since the salt farmers used to gain advantages from the windmills. The wind speed and volume flow rate recorded every six minutes are assumed to remain constant.

3 Results and Discussions

Fig. 3 shows the relation between windspeed captured and volume flow rate produced by the wind pumping system. The wind speed available during the data collection process ranged between 2.20 m/s up to 3.90 m/s. The highest flow rate produced by the wind pumping system is windpump with 85.00 cm of the net head, followed by the 55.00 cm of windpump's net head. The highest wind energy captured by the wind pumping system could increase the volume produced by the pump. The average wind speed captured for each variation for 55.00 cm and 85.00 cm is 3.10 m/s and 3.30 m/s, respectively. The wind pumping system with 85.00 cm of the net head has the greatest average wind speed and the 55.00 cm has the lowest, affecting the wind pumping system with 85.00 cm of net head producing more energy than 55.00 cm. The wind pumping system could drive the centrifugal pump if the windmill captured 2.5 m/s of a wind speed and up.

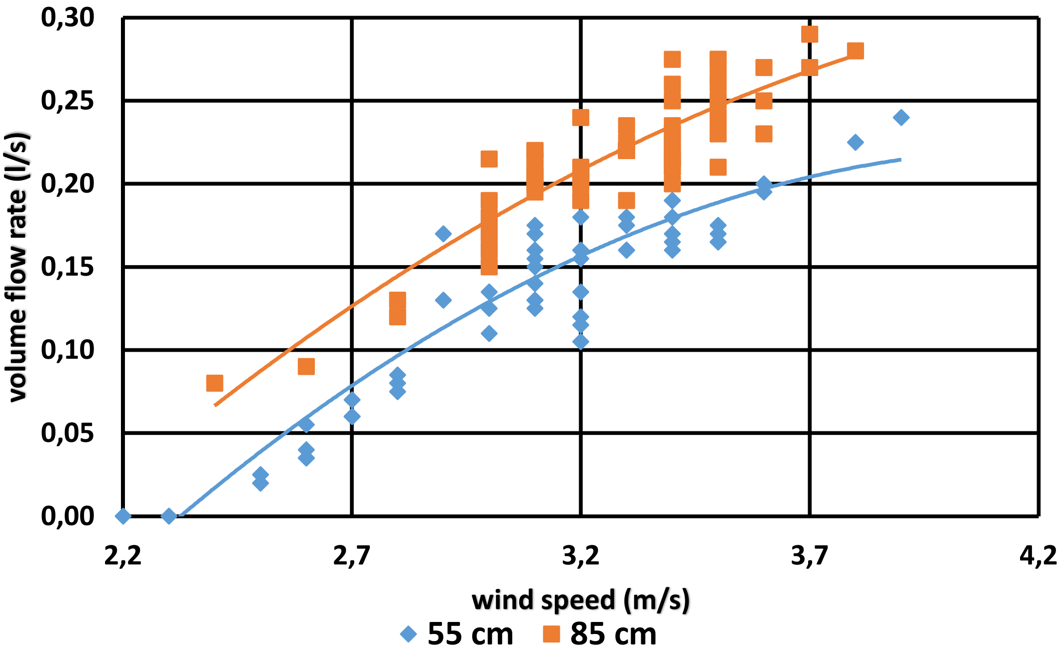

Figure 3. Relation of windspeed and volume flow rate of the wind pumping system

Fig. 4 shows the volume produced in a day as a result of the wind pumping system. The volume produced every 6 minutes is assumed to remain constant. The wind pumping system with 85.00 cm of the net head has the highest volume produced of 4640.58 liters, the net head of 55.00 cm produced volume of 2901.60 liters. The information has been recorded in Fig. 3 shows that the wind pumping system with 85.00 cm of the net head has the greatest average wind speed of 3.30 m/s produced 4640.58 liters of water. Although, the 55.00 cm has the lowest average wind speed of 3.10 m/s produced 2901.60 liters of water. The wind energy captured by the wind pumping system with 85.00 cm of net head is more than 55.00 cm. The consequence are the centrifugal pump with 85.00 cm of net head produce more water than 55.00 cm of net head.

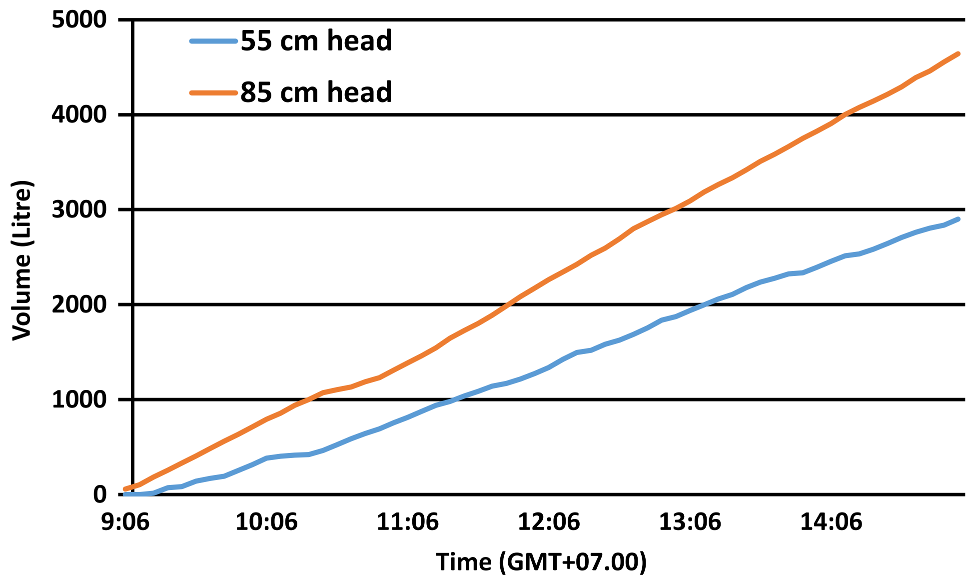

Figure 4. Volume produced in a day

There remains a substantial energy loss in the system which is shown in Fig. 2. The insufficiency of measuring types of equipment became essential during the data collection process. The calculation of system efficiency for each net head merely calculate the average efficiency. The average efficiency of the wind pumping system with 55.00 cm and 85.00 cm are 1.32% and 3.71%, respectively.

4 Conclusions

The experimental study of a wind pumping system with tree variations of the net head was complete. The wind pumping system with 55.00 cm and 85.00 cm of the net head has produced volume flow rate at maximum wind speed are 0.24 liter/s at 3.9 m/s and 0.28 liter/s at 3.8 m/s. The volume produced in a day are 2901.60 liters and 4640.58 liters, respectively. The total average efficiency of the wind pumping system for 85.00 cm and 55.00 cm are 3.71% and 1.32%, respectively.

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