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The Relations Between Wind Speed and Discharge on Wind Pump for Irrigation Purpose The case study in Setro's Reservoir

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Abstract- To irrigate thier rice fields, farmers in Gedangan village of Rembang District, North-East of Central Java Province take water from Setro's reservoir. Since the surface level of water in the reservoir lower than the elevation of the fields, the farmers must use water pump to elevate the water into the higher level to the fields. Data from the Institute for Environment and Agricultural Research (2010) show that the annual average wind speed in Gedangan village is minimum 2.3 meter/second and maximum is 9.2 meter/second. Based on those wind speed data, it can be used as a power of water pump by constructing windmill. The research shows that the wider leaf of windmills the more discharge of water can be resulted. However, there is optimum wide of windmill leaf. If the optimum wide of leaf over, the discharge will decrease. increased along with the increase in the diameter of the blade, but the discharge will back down if the blade diameter is enlarged after the maximum discharge.

Keywords**:** reservoir, wind speed, water pumps, windmills

1. Introduction

In the year of 1990 has discovered a new water sources in sub-district of Pamotan and Sale which can be used as the raw material for of drinking water in Gedangan village, replacing the water from Setro's reservoir which the quality of water has not fulfill the specification for drinking water anymore. The function of Setro's reservoir was changed from drinking water sources to use for irrigation purpose. To realize it, the government in the year 2005 has reconstructed this reservoir become the reservoir which have total area of about 10 hectares and about 6 meters in deep or have capacity 60.000 cum, the a capacity which be able to take care of irrigation purpose for farmers surrounding. The volume of water in this reservoir is abundant even in the dry season. The problem of this reservoir is that the elevation of water level far below the elevation of the fields surface. This problem requires that the farmer have to use water pump to be able to elevate water from reservoir to the filed. This will add the farmer's expenceses for rent or buy water pump, fuel expences, and water pump maintenance. To reduce those expenses, windmill become alternative to use as water pump power istead of fuel.

Based on data take from Institute for Environment and Agriculture Resarch (2010) average annual wind speed in the fields area of Gedangan village minimum 2.3 m/s, and maximum 9.2 m/s, and possible to use empowered windmill as energy of water pump. Successful of using windmill can be measured from the amount of water which can be collected, sufficient or not for irrigation demand in that area. Therefore, there is correlation between wind speed and the volume of water which can be collected that must be formulated.

3. Research Methodology

3.1 Place and Time Implementation Research

The research of using windmill as energy of water pump has been performed in Setro's reservoir in Gedangan village. Experiment totally takes 24 hours, conducted every 3 hours.

3.2 Research Variables

Research variables used in this study are:

1. Independent variables

   Independent variables are the variable that have influence to the dependent variable, or can cause the change in dependent variables. There are two independent variables in this research, those are:

   a. Wind speed, determine using Anemometer (tools to measure wind speed)
   b. Windmill revolution for every size of windmill leaf (40 to 130 cm in increment 10 cm)

2. Dependent variables

   Dependent variables are the variable that the value is predicted will change because of the influence of independent variables. In this case the variable of the amount of water resulted from the pump.

4. Results and Discussion

4.1 Relation between revolution of windmill, discharge, wind speed and diameter of windmill leaf.

a. Relation between revolution of windmill and discharge

The relation between revolution of windmill and water discharge can be known from the graph in Figure 1.

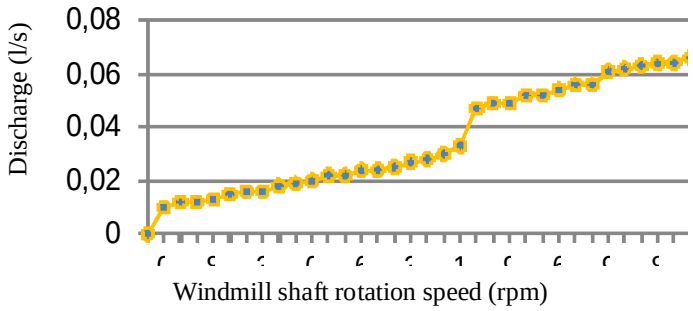

Fig. 1. The relation between revolution of windmill and water discharge

Can be seen from Figur 1 that the relation between windmill revolution and water discharge is directly proportional. The faster the revolution of windmill, the larger the amount of water resulted, and inversely. The water discharge and the revolution of windmill is influenced by wind speed. The faster of wind speed, the faster of windmill revolution and the larger the amount of water discharge, and inversely.

4.2. Relationship Between Wind Speed and Discharge

The relation between wind speed and water discharge is given in Figure 2.

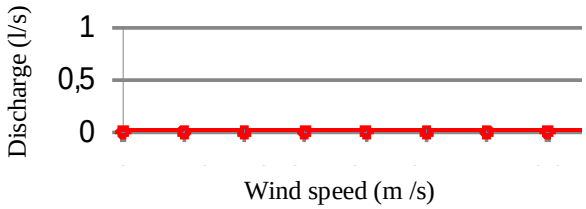

Fig. 2. The relation between wind speed and water discharge for diameter of windmill leaf 40 cm and 50 cm

Figure 2 shows that the water discharge is zero. This shown that 40 and 50 cm diameter of windmill leaf is too small cause the ability to rotate windmill also small.

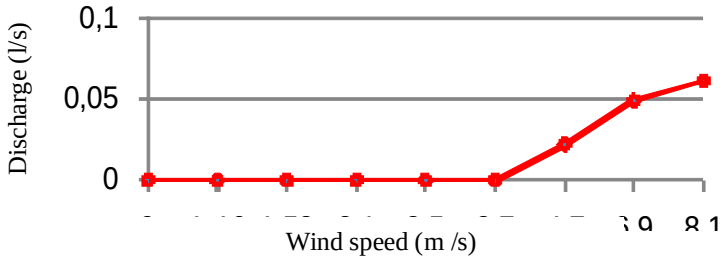

Fig. 3. The relation between wind speed and water discharge for diameter of windmill leaf 60 cm

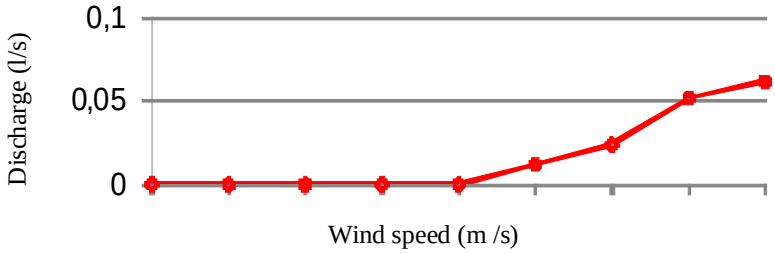

Fig. 4. The relation between wind speed and water discharge for diameter of windmill leaf 70 cm

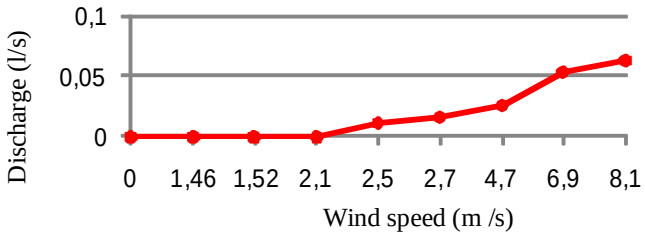

Fig. 5. The relation between wind speed and water discharge for diameter of windmill leaf 80 cm

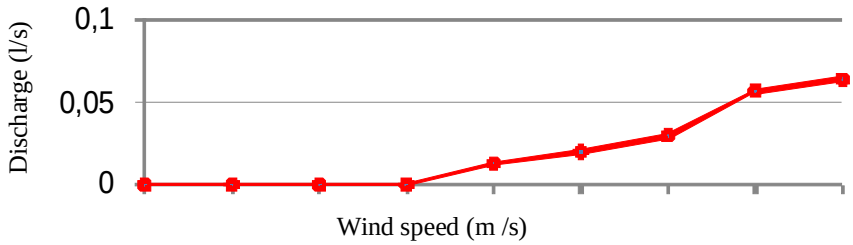

Fig. 6. The relation between wind speed and water discharge for diameter of windmill leaf 90 cm

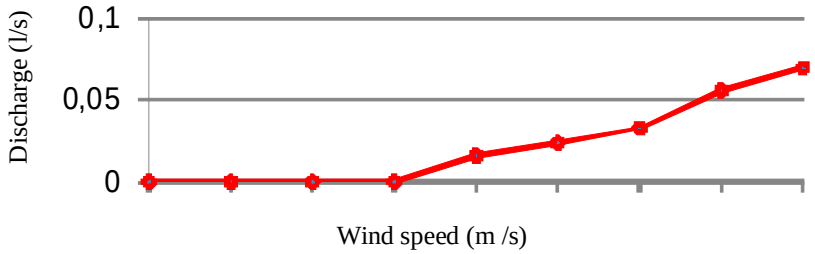

Fig. 7. The relation between wind speed and water discharge for diameter of windmill leaf 100 cm

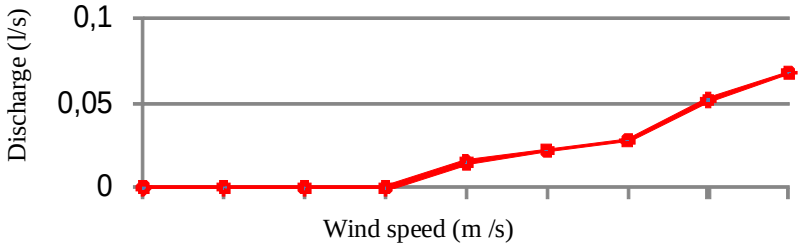

Fig. 8. The relation between wind speed and water discharge for diameter of windmill leaf 110 cm

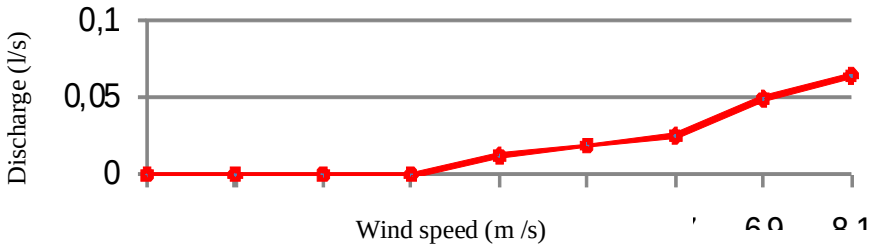

Fig. 9. The relation between wind speed and water discharge for diameter of windmill leaf 120 cm

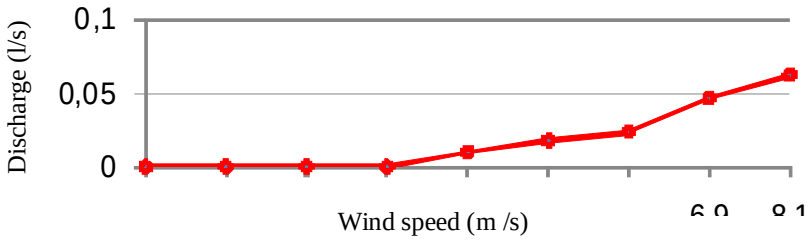

Fig. 10. The relation between wind speed and water discharge for diameter of windmill leaf 130 cm

Figure 2 to Figure 10 show that the water discharge for wind speed below 2.5 m/s is zero. This value is in accordance with the plan where the mill is designed for minimum wind speed 2.5 m/s. Water discharge increase with increasing of wind speed. Therefore can be concluded that the wind speed is directly proportional to water discharge and inversely.

c. The relation between diameter of windmill leaf, wind speed and discharge

The relation between diameter of windmill leaf, wind speed and discharge show in the graph of Figure 11.

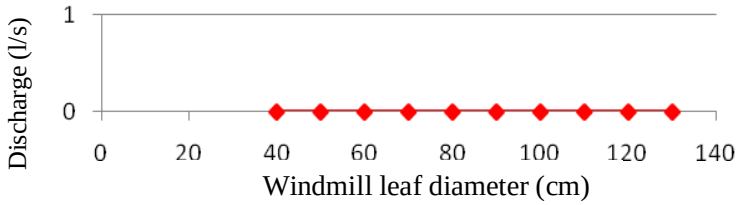

Fig. 11. The relation between diameter of windmill leaf, and water discharge for wind speed of 1.46 m/s, 1.52 m/s and 2.1 m/s

Figure 11 above shows that the value of water discharge is zero for wind speeds below 2.5 m/s. This is cause by the smaller of kinetic energy generated by wind blow, so that cannot able to rotate windmill.

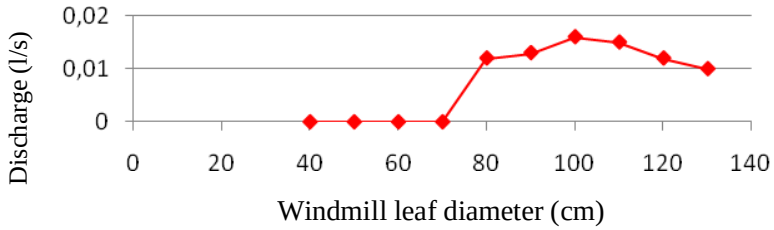

Fig. 12 The relation between the windmill leaf diameter and water discharge for wind speed 2.5 m/s

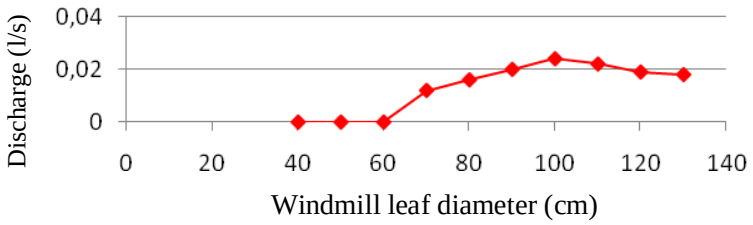

Fig. 13 The relation between the windmill leaf diameter and water discharge for wind speed 2.7 m/s

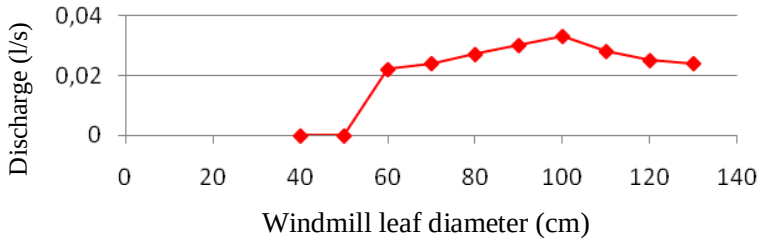

Fig. 14 The relation between the windmill leaf diameter and water discharge for wind speed 4.7 m/s

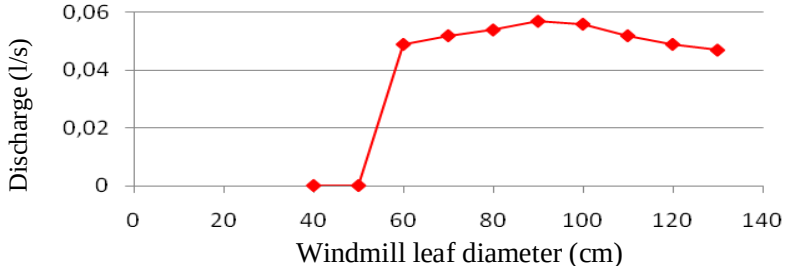

Fig. 15 The relation between the windmill leaf diameter and water discharge

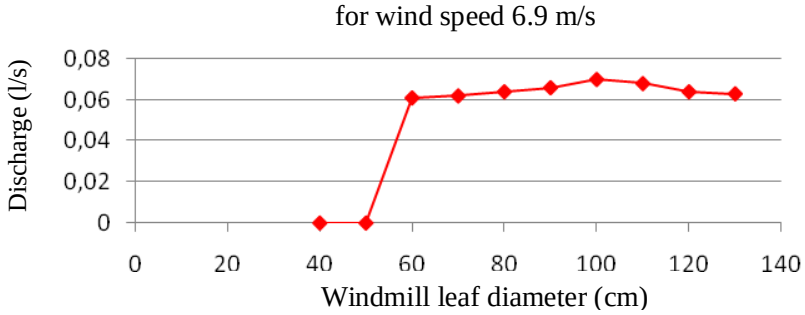

Fig. 16 The relation between the windmill leaf diameter and water discharge for wind speed 8.1 m/s

Figure 12 to Figure 16 show that the relation between windmill leaf diameter and water discharge for each windmill has the same pattern. Firstly, the water discharge increase by increasing the diameter of windmill leaf. Water discharge then will reach optimum value on the certain windmill leaf diameter, and will decrease if the leaf larger. According to Himran (2006) not all of kinetic energy of wind can be converse to the mechanic force or in the other word there is a power loss. The power loss caused by the influence of drag force which can be reduce the lift force when windmill is being rotated. The drag force occur cause by the friction between windmill and wind flow. The ratio between the resulted force to wind force called Force coefficient (Cp) and can be formulated as follows:

$$Cp = \frac{P}{\frac{1}{2}.\rho.A.v^3} \quad \text{..... (1)}$$

where:

Cp : coefficient of power
ρ : density of air (kg/cum)
P : power (Watts)
A : windmill surface area (sqm)
V : velocity of air (m/s)

4.3. Statistical test of between-subjects effects

Table 1. The results of statitically test of between-subjects effects

Dependent Variable : Discharge

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	.034[a]	16	.002	17.706	.000
Intercept	.023	1	.023	193.509	.000
Leaf	.006	9	.001	5.759	.000
Wind	.028	7	.004	33.065	.000
Error	.008	63	.000		
Total	.065	80			
Corrected Total	.042	79			

a. R Squared = .818 (Adjusted R Squared = .772)

This test was conducted to test the influence of each statistic subject, between diameter of windmill leaf and wind speed to the water discharge. The test results using Anova program shows that the average of water discharge which is influenced by windmill leaf diameter is different. It can be known from the value of F = 5.759 and significant at 0.05 (value of p = 0.000 or p<0.05). The value of R adjusted to 0.772, it means that variable of water discharge which can be influenced by variable windmill leaf diameter and wind speed is 77.2%.

5. Conclusion

From the results of the research some conclusion can be drawn as follows:

a. Windmill leaf diameter have significant influence to the amount of water discharge, and have optimum value on the certain diameter.
b. Windmill leaf diameter and wind speed have different water charge.

Acknowledgements

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Note:

Village: in bahasa Indonesia is mean Desa, the lower level of administration system in Indonesia.

Sub-district: in bahasa Indonesia is mean Kecamatan, the level of administration directly under Kabupaten.

District: in bahasa Indonesia is mean Kapubaten the level of adminstration under Province.