DEVELOPMENT OF MODEL OF PROPELLER-CROSS FLOW WATER TURBINE FOR PICO HYDRO POWER GENERATORTITLE

Purwantono[1], Refdinal[2], Hendri[3], and Syahrul[4]
Fakultas Teknik, Universitas Negeri Padang, Padang,Indonesia
*Corresponding author:purwantonomsn@gmail.com

ABSTRACT: According to literature survey, the most suitable water turbines for power generator at low debit and water head is a cross-flow turbine. The objective of this research is to develop a cross-flow turbine combined to a propeller as a Pico hydro power generator. The water in cross-flow turbine exhausts system still keeps kinetic energy that can be reused as propeller propulsion. Caplan-type propellers mounted on the bottom of the turbine. The intermediate medium connecting the two turbine models is the conductive blades, which are installer between cross flow and Kaplan turbines. These blades serve to guide the water out of the cross-flow turbine to the Kaplan turbine. The parameters to be analyzed in the study are the water head, flow rate, and water velocity. The results showed that the energy absorption level of cross-flow exhaust water depending on debit water velocity.

Keywords: *Pico hydro, cross flow, propeller.*

1. INTRODUCTION

Electricity needs for remote villages with low electricity consumption levels require relatively small generating capacity. This can be fulfilled by exploiting the potential of hydro power available and located around them [1].The micro hydro power plant is a small-scale power plant that uses hydropower as its driving force such as irrigation channels, rivers or natural waterfalls by utilizing head and the amount of water discharge [2].Recently, micro hydro become attractive because of its clean energy sources, renewable and has a good future development [3]. Recently, small hydropower attracts attention because of its clean, renewable and abundant energy resources to develop [4].Nowadays in the 21st century most popular is small-scale hydropower i.e. micro hydro power [5].

The potential of hydro power in Indonesia reaches 75,620 MW, while the newly built 3,530 MW in 2006 or only 4.7% of available energy, it is still not included on small energy scale such as pico-hydro or micro hydro [6].Micro hydro energy scale is very much scattered in the hills or mountains in the countryside, especially the area of West Sumatra which is geographically located in the Bukit Barisan.The potential of micro hydro power plant that can be utilized to become electrical energy for West Sumatera Province consists of:(1) Liki Solok 60 kilowatt, (3) Lubuk Gadang Solok 103 Kilowatt, (4) Agam 238 kilowatts, (5) Sigiran Malalak Agam 99 kilowatt, (6) Pariaman Pariaman 185 kilowatts, and many other areas that have potential sources of water that can be utilized by using a micro hydro power plant [7]. Small hydro offers today one of the most promising energy resources for long-term sustainable development in rural areas of many of the world's poorer countries [8].

The principal working principle of the micro hydro power plant is to make the most of water energy that can be captured by its main equipment called turbine or waterwheel [9].

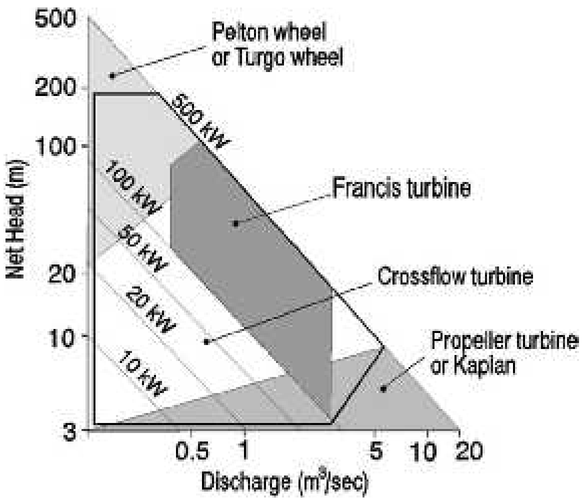

Fig. 1: Head-flow ranges of hydro turbine [10]

Tabel 1. Impulse and reaction turbines [8]

Turbine type	Head classification		
	High (> 50 m)	Medium (10-50 m)	Low (L<10 m)
Impulse	Pelton Turgo Multi-jet pelton	Crossflow Turgo Multi-jet pelton	crossflow
Reaction		Francis (spiral case)	Francis (open-flume) Propeller Kaplan

From fig 1. and table 1, type of turbine category of the micro hydro power plant is turbine crossflow and propeller turbine.This study aims to develop microhydro power plants by combining two types of turbines into a multilevel (crossflow with propeller).The basic concept used in a multilevel system is to utilize the remaining energy from water coming out of the cross flow turbine to drive the propeller turbine.

2. METHOD

The micro hydro power plant model developed in this research is by building test apparatus. This test apparatus consists of a water pump, reservoir, measuring tools such as rotation, torque, head and flow meter and so on.The type of turbine used is a cross flow turbine and propeller, with the specification adjusted to theoretical planning.

The test method is done by controlling some test parameters, where as turbine power input is a head parameter with flow discharge.The turbine output after the water passes through the turbine is rotation, torque, effective power, and flow velocity. Once the water crossed the crossflow turbine then the water will continue to flow downwards.The flow of water that has crossed this turbine is used to turn turbines on the second level of propeller turbines. So the flow at this second level can be utilized to rotate the turbine propeller runner.This residual energy flow becomes the combination of cross flow turbine and propeller.

The model of multi-story turbines (crossflow and propeller) developed can be seen in figure 2.

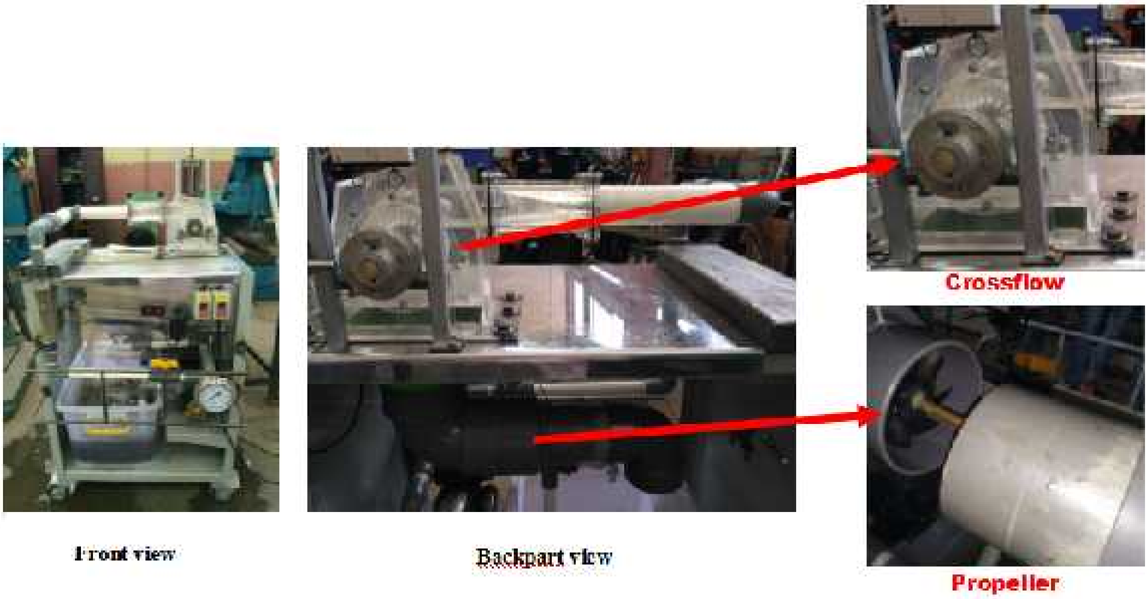

Fig. 2: Model turbin bertingkat yang dikembangkan

This turbine performance test uses the hydraulic bench as the main component of testing. The hydraulic bench is equipped with a water reservoir and centrifugal pump.This hydraulic bench uses a piping system that connects the turbine to a valve and measuring tools.Measuring tools used such as digital tacho meter in units of rpm (rotation per minute).Measurement of flow rate of water flow using flow meter in units of LPM (liter per minute).Measurement of flow height or Head using a pressure gauge that can be converted into the head. Torque measurement using the braking system. Braking system uses a brake belt that is directly related to the main cross flow turbine shaft.

On this turbine shaft is equipped with a brake belt tromol that is connected directly to the spring balance.In the event of braking on the axle shaft then the spring balance will be attracted and depressed.Spring balance installed two pieces with the same capacity.When braking spring balance will experience drag and press.The difference between the two tensile readings and press is the direct readable braking force. Braking force multiplied by the radius of the brake drum is the size of the torque. By converting torque with other parameters is obtained the amount of effective power turbine generated.

3. RESULT

The result of turbine model performance test developed is presented in table 2.

Table 2. Turbine Testing Results

Crossflow turbine							Propeller turbine	
Head (m)	Rated speed of turbine (r.p.m)	Brake force (N)	Discharge (m^3)	Turbine Output in Theory (w)	Affective of turbine output (w)	Efficiency	Rated speed of turbine (r.p.m)	Affective of turbine output (w)
7	700	40	0.00167	114.68	91	0.8	250	20
6	700	35	0.00167	98.3	73	0.74	250	15
5	700	32	0.00167	82	62	0.76	250	15

4. DISCUSSION

The data of this crossflow turbine model test shows that the average torque test shown as effective power and theoretical power produces this turbine efficiency in the range of 65% to 80%. The flow of water after crossing the turbine flow turbine at the first level is fed to the propeller turbine.The test results show that the power generated from this propeller turbine ranges from 10% - 15% of the remaining hydro power. The total of theoretical water power is about 114 watts. The effective power produced on the first cross flow turbine is 91 watts and the power generated from the level of two 20 watt propeller turbines.This condition at head 7 m and water debit 0.00167 m³ / s. The total power generated from both turbines becomes (91 + 20 = 111 watts).If the total power produced is theoretically 114 watts. At the first level, crossflow di turbin means there is additional power in the turbine propeller. In the head of 6 meters to produce power ranges 74 watts and the head 5 meters to produce power ranges 68 watts.

Head or height of the water is a parameter that affects the power generated by the turbine.The distance between the cross flow turbine and propeller shafts is also a decisive parameter against the power generated from the propeller turbine. Theoretically, the greater the distance is proportional to the effective power generated. The flow discharge and dimensions of the propeller turbine must also be carefully calculated.This condition causes the amount of water out of cross flow turbine is not accommodated by turbine propeller then water will overflow.

5. CONCLUSION

The result of the model of turbine development model that has been done can be concluded that the remaining flow of water released by crossflow turbine can be utilized again to make turbine propeller.Combination of two types of the turbine can optimize the potential of existing water to be utilized in generating electrical energy.From the results of empirical testing using a multilevel turbine model (crossflow and propeller) that has been done can be concluded the distance between crossflow turbine axis with propeller turbine axis influences the discharge and water pressure in moving the turbine propeller.

6. REFERENCES

[1] H. D. Ibrahim (2013), *Konsensus Nasional untuk Ketahanan Energi*, Rubrik Opini Padang Ekspres Selasa, 2 April 2013. s

[2] D. Rafli and M Hazwi. (2014). Simulasi Numerik Penggunaan Pompa Sebagai Turbin Pada Pembangkit Listrik Tenaga Mikro Hidro (PLTMH) denga Head 9,29 m dan 5,18 m menggunakan perangkat lunak CFD pada pipa berdiameter 10,16 cm. *e-dimanis*. Vol. 8. 4 (214-223).

[3] J. Haurissa et al. (2012). The cross flow turbine behavior towards the turbine rotation quality, efficiency, and generated power.

[4] Y H lee et al. (2007). Current Status and Prospect of Micro & Small Hydropower in Korea. *International conference on small Hydropower- hydro Sri Langka, 22-24 Oktober 2007.*

[5] S. U. Patel and P. N. Pakale. (2015). Study on power generation by using cross flow water turbine in micro hydro power plant. *International journal of research in engineering and technology*. Vol. 04 Issue:05 (1-4).

[6] U. M. Dewanto (2013), *Pembangkit Listrik Tenaga Mikro Hydro* . online: =http: //bumn.go.id/jasatirta1/berita/732/PLTM.serba.serbi Diakses tanggal 3 Pebruari 2016.

[7] Yanziwar. (2007). Perencanaan Turbin Cross Flow. *Jurnal Teknik Mesin*. Vol. 4. No. 1 (51-61).

[8] O. Paish. (2002). Small hydro power: technology and current status. *Renewable and sustainable energy reviews*. Published by Elsevier Science Ltd. 537-556.

[9] Yusri et al. (2011). Rekayasa Turbin Air Jenis Cross Flow Sebagai Pembangkit Listrik Tenaga Mikro Hidro Jorong Labuah Selasih, Kecematan Gunung Talang, Kabupaten Solok. *Jurnal Teknik Mesin*. Vol. 8, No. 2 (72-77).

[10] O.Paish (2002). Micro-Hydro Power: Status and Prospects. *Journal of power and energy, professional engineering publishing*.