Optimize Performance of Cross Flow Turbine with Multi Nozzle

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Abstract. This research is conducted to optimize cross flow turbine performance with multi nozzle and compare with cross flow turbine performance using only single nozzle. The results showed that turbine cross flow with multi nozzle has more optimal performance because the water jet energy from the nozzle is more effective to move the turbine blade runner with a more stable rotation so that the output power and turbine efficiency is more optimal.

1. Introduction
The potential energy of water in nature is very large in its availability as a base energy to be converted into mechanical energy and electrical energy or thermal energy [1]. The basic energy resources that are already available in nature are appropriate to be managed well for the community's welfare [2]. Water is a natural resource having an energy potential as a driver of a water turbine to produce mechanical energy as a prime mover of electrical generator equipment and other equipment [3].

The utilization of water energy is excellent because the water energy is widely available naturally and environmentally friendly because the water energy is only generated from the movement of water flow naturally as a driver of water turbines, pumps and other [4]. The development of technology greatly influences the increase of high energy consumption due to large part of industrial activity is driven by electric power. Indonesia as a developing country utilization of water energy is currently still low because most use of industry use fossil energy [5]. Utilization of water energy can be done everywhere, either in flat areas, ramps, hilly and highlands or mountains. Energy utilization in Indonesia is still a step, in terms of its utilization is possible to development of science and technology poteny in Indonesia Water turbine is needed to improve the utilization of water energy and water energy converter into mechanical energy to generate electricity, because the utilization of natural resources is not exhausted [6]. Along with the rapid development of water energy technology, it is very appropriately applied to help rural communities reside in rich water energy [7].

Hydro energy sources can be utilized maximally, because it is very economically attractive and the technology has been available. Water turbines are the heart of any hydro energy generation system. In general, the cross flow turbine as impulse turbines is widely used in micro hydro power systems [8]. Cross-flow turbines or Banki Turbines, well-known for their performance characteristics are directly...
proportional to head and water discharge changes [9], and operating with low efficiency [10]. Increasing the need for electricity use over time, certainly a new problem in Indonesia especially in industrial sector actors is the high cost of operating expenses of companies that use a lot of electrical energy [11]. Cross flow turbine performance testing can be defined and calculated [12], with the following equation

$$\eta_t = \frac{P_t}{9.81 \rho Q h}$$

Eksplanation:
- $P_t$ = turbine power (Watt)
- $\rho$ = density of water (kg/m$^3$)
- $9.81$ = constante of gravitity (m/s$^2$)
- $Q$ = water flow rate (m$^3$/s)
- $h$ = head net (m)

2. Methods
In the research activity is using turbine cross flow multi nozzle, test turbine performance through measurement of flow rate, load, spin and head. Further testing is also done by varying the flow of water, where the head, the number of blades and nozzle angle constant and mass load remains. The main parts of the test installation system are cross flow turbines, multi-nozzle, dial gauge, pulleys, valves, water pumps, reservoirs, pipes, electrical regulators, as shown below:

![Figure 1. Installation of Multi Nozzle Turbine Testing](image)

3. Results And Discussion
Based on the observation and analysis of data that the greater the discharge of water into the turbine through the nozzle will increase the water power to drive the turbine

![Fig 2. Graphics Power Turbine Vs Water Flow Rate](image)
Based on the experimental results through multi-nozzle cross flow turbine performance testing at the maximum debit of $2.0 \times 10^{-4}$ m$^3$/s with constant load of 2 Newton obtained optimal turbine performance of 3.26 Watt power. While cross flow turbine performance with single nozzle is minimal ie at the maximum water discharge of $2.0 \times 10^{-4}$ m$^3$/s only obtained performance with 3.17 Watt power. For more details can be seen in Figure 2 of the graph of turbine efficiency relationship to the presentation of valve opening changes as follows:

![Efficiency Turbine Vs Water Flow Rate](image)

**Fig 3. Graphic Efficiency Turbine Vs Water Flow Rate**

Figure 3 shows the effect of changes in the increase of water discharge which gives a clear picture that if the flow of water discharge gets bigger into multi-nozzle cross flow turbine, it is obtained by increasing the optimization of turbine efficiency by 83.60%. While cross flow turbine with single nozzle only obtained efficiency of 81.37%. The water power received by the turbine has increased so that the impact on the increase of multi nozzle cross turbine power. The power changes and the efficiency of the turbine produced are very proportional to the magnitude of the turbine inlet discharge. It is clearly shown in figure 3 above that the greater the change in water discharge, given to the turbine, the greater the resulting performance [10]. Improved turbine performance with the use of multi nozzle turbine, flow more directed, effectively driving the turbine so that the efficiency of the turbine generated increased [11].

Multi-nozzle cross flow turbine is the most optimum turbine power and efficiency, because the greater the water energy absorbed by the turbine blades increases, causing the turbine to spin to increase and the greater the power output. In this case the water power is directly proportional to the turbine output power [12]. The water energy rotates the cross flow turbine through the exposure of the water jets from the nozzle, so it is causing to produce rotary motion on the turbine shaft [13]. The blades absorb the water energy and converts it into mechanical energy on the turbine shaft to drive the generator or other equipment. Turbine power and efficiency are also increased with the use of multi-nozzle because the water jets to the turbine blades are distributed well and effectively to drive the turbine blades. It is also found in cross flow impulse turbines that power and efficiency are produced more optimally using multi-nozzle than a single nozzle [14]. The advantages of cross flow turbine are capable of operating at head and low water discharge needlessly wide area, easy maintenance and practical, directional, driven by blowing water from various directions [15].

4. Conclusions
Optimizing the performance of the multi flow nozzle cross flow turbine is better because the efficiency is more optimal than the cross flow turbine with a single nozzle

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