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The Effects of Turbine Baffle Plates on the Efficiency of Water Free Vortex Turbines

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Abstract

This article is based on a study that focuses on increasing the efficiency of the water free vortex turbine by installing baffle plates on the propellers. In order to find the most suitable size and proportion for the baffle plates, the study used the CFD program to design baffle plates which have a diameter of 45 cm. and a height of 32 cm. The results showed that 5 baffle plates, with a propeller baffle area of 50%, gave the highest degree of torque. Propellers, with no baffle plates, were also created and were tested along with a turbine with 50% baffle plates at the flow rate of 0.04 – 0.06 m^3/s. The results showed that the propellers with a 50% baffle plate proportion helped to increase the torque at an average of 10.25% and with an average of overall efficiency of 4.12%.

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Keywords: Baffle Plates, Free Vortex Turbine, Turbine Efficiency

1. Introduction

Hydro energy is a natural resource with high potential for producing electricity. Hydro energy is a clean source of energy that does not create pollution to the environment. However, in order to produce electricity from water, it is necessary to build large dams which have an effect on the natural environment and are often opposed by the people in the area. Therefore, producing electricity from small water sources, such as rivers or streams, that have water flowing in them throughout the year, is an option that has currently piqued the interests of researchers.

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There are two methods to generate electricity from small water resources as follows: 1. The Bypass Method: bypassing water from the main canal to a separate electricity generating system, and 2. The Open Canal Method: installing an electricity generator directly across the canal with no need for any additional structure.

Many researchers have studied generating electricity from small water resources, such as Wanchat and Suntivarakorn [1] who undertook to design the Free Vortex Electricity Generating System. From the study, a cylindrical whirlpool was designed with a hole at the bottom and water inflow was restricted to a tangential course so that the flow would imitate a tornado. In addition, a suitable water turbine was designed to be placed into the cylinder to generate electricity. Shabara, et al. [2] studied the important factors that affect the generation of electricity from the power generated from the water free vortex by using the CFD program. The results showed that at the highest water flow rate, the efficiency was at 40% at 28 rpm and 38 rpm.The result was in accordance to the study of Wanchat, et al. [3] in which the highest electricity generating efficiency was 35% at 40 rpm. Apart from research studies on the factors that affect the electricity generating efficiency from the power generated from the water free vortex, other researchers have also studied different methods to increase the electricity generating efficiency from power generated from the water free vortex. Dhakal, et al. [4] analyzed different basin structures and how they can create a water free vortex and the best water flow position in the basin that can increase the power of the turbine. The test results determined that a funnel basin was more efficient in generating electricity than the cylindrical type and that changing the materials used to make the turbine can also increase its electricity generating efficiency via the power generated from the water free vortex. Sritram, et al. [5] conducted a laboratory study on steel and aluminum, as the materials to be used to construct turbines in order to see how they affect the electricity generating efficiency from power generated by the water free vortex. The result was that the electric torque and the efficiency of the turbine made from aluminum was higher (8.4%) than the one made from steel (8.14%). In addition, modifying or installing accessories to the turbine can also increase its efficiency. Jeon, et al. [6] studied the effects of baffle plates on the efficiency of Savonius wind turbines by installing baffle plates at the highest and the lowest points of the turbine. This increased the efficiency by 36% when compared to the turbines without baffle plates. However, installing steel plates to increase the efficiency has only been studied on wind turbines.

From the information above, the researcher became interested in increasing the electricity generating efficiency from the power generated from the water free vortex by installing baffle plates to the turbine in a similar manner to the work of Jeon, et al. This was undertaken because it can be easily adapted, is not wasteful of the budget, and can increase the efficiency more than other methods. This article shows the details of the study and the tests on the turbines in order to find out how the installation of baffle plates on the turbine can affect the electricity generating efficiency of the water free vortex turbine.

2. Design and Efficiency of Turbine

2.1 Design of the Baffle Plate

This research used the CFD program to design the baffle plates. The program assisted the researchers in finding the appropriate design shape of the baffle plate to do the actual testing. The fluid used in this research was viscous with an incompressible flow. The equations used were the mass conservation equation and the momentum conservation equation with a k-ε standard Turbulent model. The details of the equation, that was used, were in accordance with the results of the study by Triputtarat [7]. The Bouyancy force equation was also used in the study.

The study simulated water flow at the mass flow rate of 60 kg per second, and the water head level was at 0.3 m. The water flowed through the propeller while the researcher conducted the study on which of the baffle plate shapes created the highest torque. From the study, a turbine was created using the CFD program for the actual testing.

2.2 The Torque and Efficiency of the Turbine

Finding the turbine torque was done by using the Prony Brake Absorption Dynamometer by installing it directly on the turbine's axle. The Prony Brake had an attached arm (L) that was 40 cm long. When the turbine