ENERGY EXTRACTION EFFICIENCY OF IN-STREAM MULTISTAGE MICRO-HYDRO TURBINE

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ABSTRACT: *This paper describes the techniques for estimating the kinetic energy extraction efficiency of a multistage micro-hydro turbine with five blades. The broad objective of this study was to measure the overall energy extraction efficiency of the said turbine system. This experiment was conducted in a closed-loop water channel, and the velocity range was from 0.5 m/s to 1.1 m/s. The estimated overall energy efficiency of this turbine ranged from 12.8 percent to 25 percent. However, the most energy-inefficient component here appeared to be the turbine's blades, whose value was 84 percent. Indeed, energy inefficiency of the blades contributed to a reduction in the overall energy efficiency. This study concludes that in-stream multistage micro-hydro turbines are a useful mechanical device for generating low-cost green energy from water. However, the energy extraction efficiency of micro-hydro turbines depend on the interaction between the turbine blades and water flux; these two variables can be manipulated to increase the energy extraction efficiency. The goals for future studies are to find out the causes of energy extraction inefficiency and to increase the efficiency so that such turbines can become economically sustainable.*

Keywords: Multi Stage; Energy Efficiency; Hydro Turbine; Energy Transfer

1.0 INTRODUCTION AND BACKGROUND

This paper discusses the techniques of efficient energy extraction by a multistage micro-hydro turbine (MMHT). This is an extension of the research that has been published earlier by Shahidul *et al*. [1]. The aforementioned research was on a laboratory-scale MMHT. Energy security and environmental sustainability have always been highlighted in all countries for their smooth economic growth. Both developing and developed economies are struggling to increase the energy utilisation efficiency and productivity in the harnessing of renewable energy. For example, between 2000 and 2012, the renewable energy production capacity in the USA has increased by about 100 percent. The USA alone produced more than 163 gigawatts per year, which was about 12% of total electricity usage of that country [2]. Likewise, in Malaysia, various projects concerning energy extraction from in-stream water have been undertaken.

JARIMAS, which was conducted from 2010-2012 in collaboration with JKR Malaysia and Universiti Malaysia Sarawak (UNIMAS), was one such project. This research was conducted on a single-stage blade micro-hydro turbine (SMHT). Similar researches have been conducted at the operations research laboratory of UNIMAS using MHT and MMHT[3]. Hydrovolt Inc [4] and Verdant Power [5] have conducted similar nature of researches on MHT. All these projects have been conducted to characterise the energy extraction behaviour and model the blades of MHT. There are not many reports on the energy extraction efficiency of MHT or MMHT in the published journals. This scenario demanded a research to model the energy extraction efficiency of MHT and MMHT. In order to address this issue and fill the research gap, we have conducted a research on energy extraction from in-stream water via MMHT.

2.0 LITERATURE REVIEW

The literature review in this paper was aimed to study the latest researches on MHT and MMHT in order to gather information and knowledge on energy extraction efficiency. The published scientific journals have also been studied in order to obtain relevant theories and equations for estimating the energy parameters.

2.1 Multistage Blade Micro-Hydro Turbine

Traditionally, MHT has been designed with one set of blades, and it has been reported that when water flux left the turbine system, the water velocity remained significantly high. A five-stage MMHT designed by Shahidul *et al*. in order to utilize unused Kinetic energy[1]. The fundamentals of multi stage Turbine is in Figure 1.

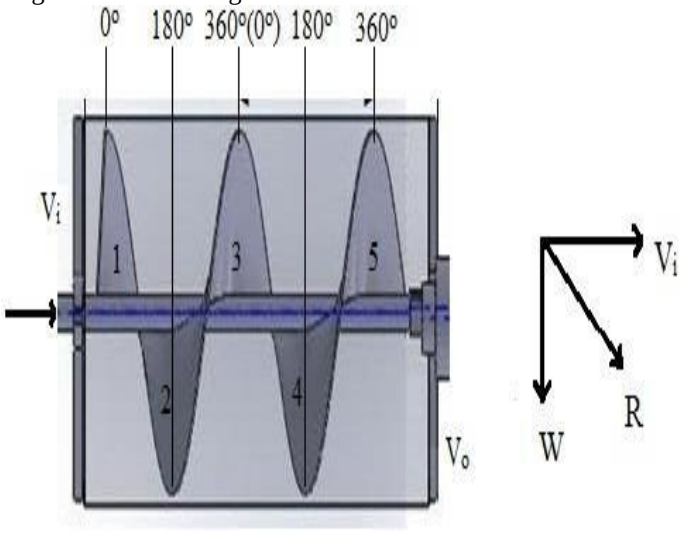

Fig. 1: Multistage blade micro-hydro turbine [1]

During the operation of MHT at in-stream water bodies, the water flux interacts with the blades, and a part of the kinetic energy transfer to the turbine shaft occurs through the blades. Traditionally, MHT has been designed with one set of blades, and it has been reported that when water flux left the turbine system, the water velocity remained significantly high. It meant that the velocity drop across the blades was not much. This operating behaviour was responsible for the low energy efficiency of MHT [1,6]. It was then suggested that additional blades in the turbine shaft could increase the interaction between water flux and blade, which would facilitate higher energy extraction levels by the turbine. The MMHT designed by Shahidul et al.[1] is shown in Figure 1, while the area of the turbine blades is presented in Eq 1.