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Review Article

End Suction Centrifugal Pump Operating in Turbine Mode for Microhydro Applications

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This paper reviews the current research works on the end suction centrifugal pump coupled with induction generator running in turbine mode for microhydro application. The information can be used by practicing engineers, researchers, and plant managers to understand the potential of pump running as turbine. Review on experimental and simulation works was carried out encompassing end suction single stage low specific speed which is less than 10 kW. This is followed by review of their efficiency improvement through modifications. The results show that centrifugal pump can operate in turbine modes without any modification on mechanical components. However, to achieve the best efficiency point (BEP), it requires higher flow rate and head than pumping rating. Efficiency improvement is viable through geometric modification to improve hydraulic characteristic. The studies also show that pump as turbine (PAT) can be directly coupled with modified induction motor as generator by adding capacitor and electric control system, regulating voltage and frequency at the output terminal. It was found that PAT offers the best low cost solution for microhydro application especially for third world countries that do not have local microhydro manufacturer.

1. Introduction

Hydropower is a well-known renewable energy source generating clean, secure, and predictable electric power. It has zero carbon emission, low operational cost, and virtually zero greenhouse gas emission. With the technology of over one hundred years, hydropower is considered as the most established technology to provide energy in a small or large scale. By far, hydropower is the largest renewable energy produced accounting for 90% of the total renewable energy worldwide [1]. In 2010, hydropower has been utilized in 150 countries with installed capacity of 860 GW and Europe having the highest installed capacity followed by East Asia and Oceania [2].

While large hydropower plants feed the national grid, typical off-grid microhydro is the most popular solution for electrification among rural communities which supplies power in the range of 5–100 kW which usually use a run-of-the-river to divert some of the water from the river before dropping into a pressurized penstock. The water potential energy from the gravitational force over height difference is converted to rotational mechanical energy. A hydro turbine is used to transform energy from the flowing water to mechanical rotational energy and then a generator transforms the rotational mechanical energy to electrical energy regulated by electric control system. Microhydro configurations vary depending on the topography and hydrological site conditions [3].

The main components that comprise typical microhydro schemes are electromechanical equipments, civil structures, and energy distribution systems [4]. An optimum operational design, smart selection of equipment, and reduced professional consultation input can lower the overall cost [5–7]. It is important to pay attention to actions to reduce the whole microhydro cost because it is always the main concern for small communities especially in rural areas. In order to minimize the overall cost, microhydro system must be in the optimal operation and component selection. Furthermore, the microhydro must be reliable, robust, and manageable with minimum technical knowledge by local communities.