Design and Performance Measurement of the Integrated Low Speed Permanent Magnet Generator with the Very Low Head Turbine Prototype

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Abstract

The aim of this work is to investigated the performance of the Axial Flow Turbine prototype integrated with the Permanent Magnet Generator (PMG). The integration of this turbine is to mounted the permanent magnet ring to the propeller tip as a generator rotor, and resulted a simple construction and no need couple between turbine and rotor generator shaft. The stator is located on external of stationary part of the turbine, immediate to the turbine casing. The design of axial flow turbine for this purpose used the non conventional approach, due to the low head (less than 2 meter) and very view information available on the low head axial turbine. Non conventional turbine design, using the principle of radial balance, minimum pressure criteria and inverse design.

The power output is however limited by flow of water which is sufficient to keep generate a suitable number of revolutions per minutes. The designed turbine parameters are based on the available water flow laboratory facility with flow rate of 128 liters/s and available head of 0.3 meters. The Axial Flow Turbine has number of blade for stator and rotor are 24 and 8 blades respectively. The tip and hub diameters of turbine are 600 mm and 360 mm respectively. Turbine will be operated on the rotating speed of 90 rpm. The specification of single phase permanent magnet generator as follow power output of 300 W at 220 V, rotational speed of 90 rpm using the skewing magnet on the rotor. Numerical studies of optimized turbine has successfully demonstrated with a very good performance and the PMG has been tested before put to the system. The result of axial flow turbine with Permanent system test has power of 439 Watt at 219.7 V, 50 Hz and rotational speed of 83 rpm. Efficiency total maximum system achieving of 87% at condition power maximum of 820 Watt, 149.1 V, 50 Hz and rotational speed of 83 rpm. System operate at average effective head 0.3 m and average water flow in canal 0.3 m/s.

Keywords: *Integrated Turbine with permanent magnet generator, Axial Flow Turbine, Low head Turbine, Permanent Magnet Generator, Mounted Tip Magnet, Permanent magnet generator - Turbine for very low head*.

Introduction

This research is to develop hydropower turbine with low cost of construction and manufacture.The concept is to utilize water flow with a low head to generate electricity and may be used as a small, mini, or micro hydro turbine. The turbine does not require the construction of large dams for water reservoir but the water flow is sufficient enough to drive turbine rotors. This research applied the design of Axial Flow turbine integrated with the permanent magnet generator and the aim of this work is to investigate the performance of the turbine system..

Design of Prototype

Numerical analyses are conducted to determine the performance of the designed turbine with the commercial CFD.

The canal space: 0.84 meters width, 1.15 meters of height and 12 meters long. Flow rate of 128 liter/s and head available 0.3 meters are set as the basic design calculation for the developed turbine.

The prototype axial turbine integrated with the permanent magnet generator (PMG) specification :

- The Axial flow turbine will be operated on the rotating speed of 90 rpm.
- Tip and hub turbine diameters are 600 mm and 360 mm respectively.
- The number of blade for stator and rotor are 24 and 8 blades respectively.
- The single phase PMG power output is 300W at 220V, 90 rpm.
- Housing diameters of the PMG is 830 mm.
- Turbine position inside the canal is 45 degree from vertical axis.

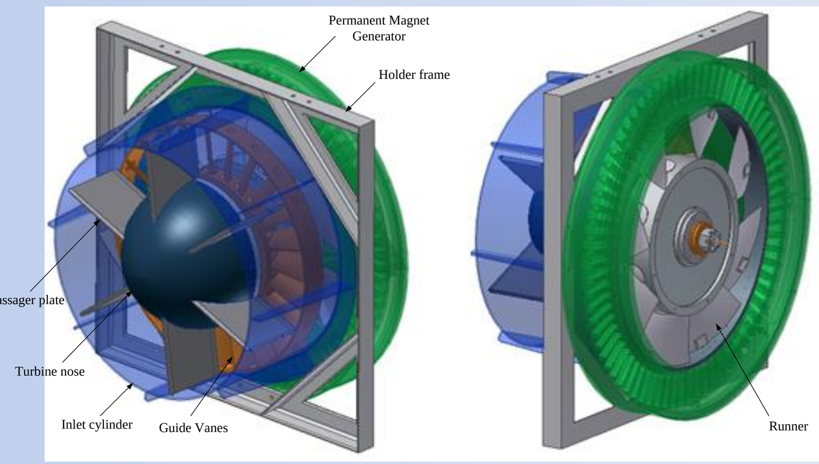

Fig. 1 Axial flow Turbine integrated with PMG design assembly

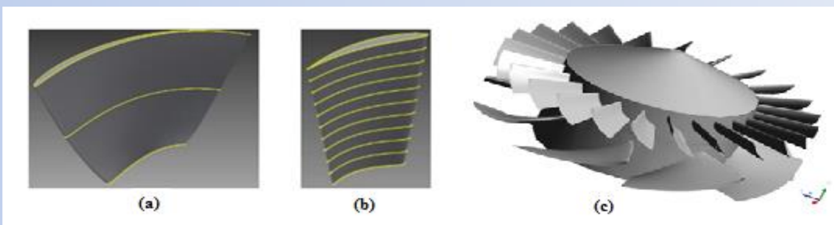

Fig. 2 Sample rotor and stator blade development; (a) rotor, (b) stator, (c) rotor and stator blade arrangement [4]

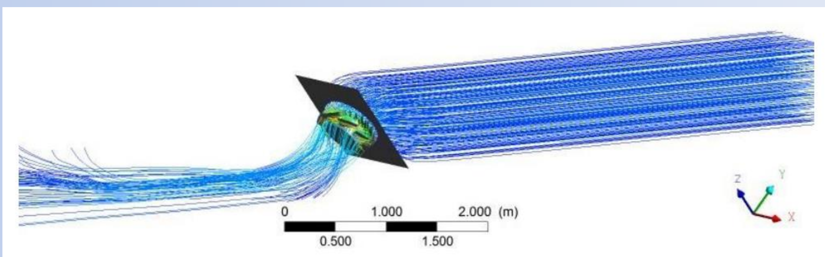

Fig. 3 Turbine installation and fluid flow direction [4]

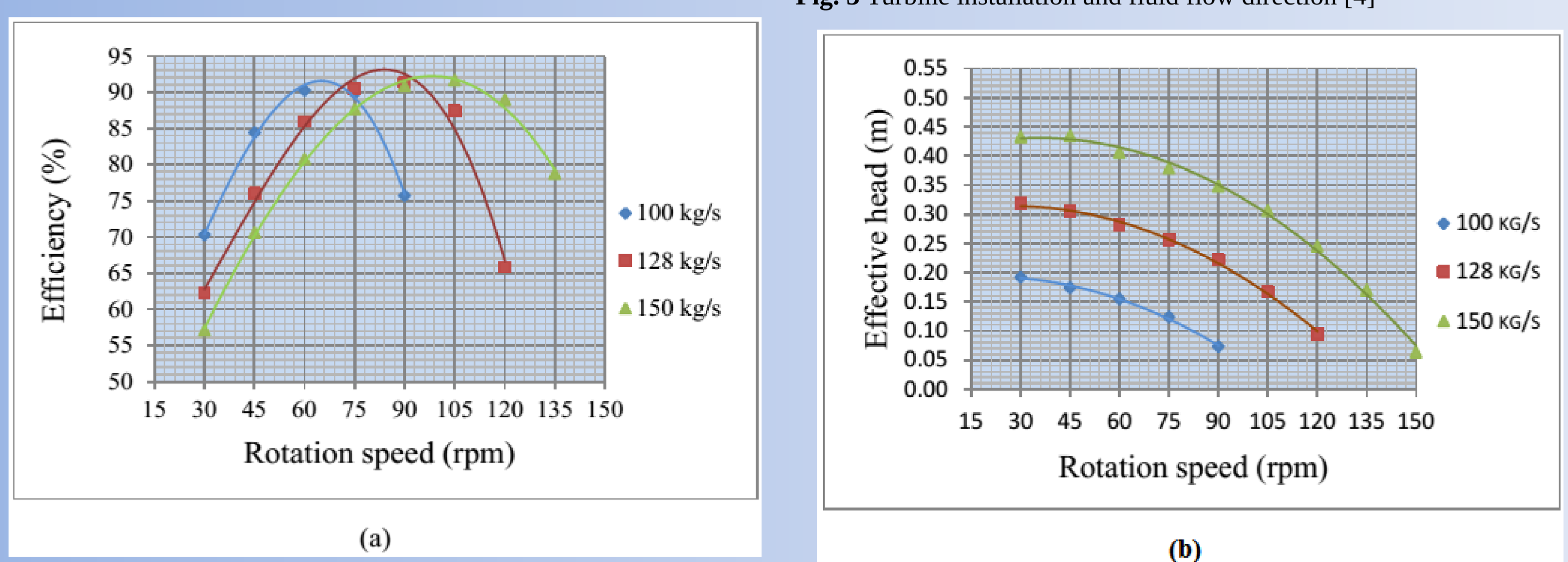

Fig. 4 (a) Turbines efficiencies at various rotation speeds and flow rates, (b) Effective head of turbines at various rotation speeds and flow rates

Numerical studies result of optimized turbine the maximum efficiency of 91% in the operation conditions of mass flow rate of 128 kg/s, head of 0.22 meters and rotational speed of 90 rpm producing power of 254 Watt.

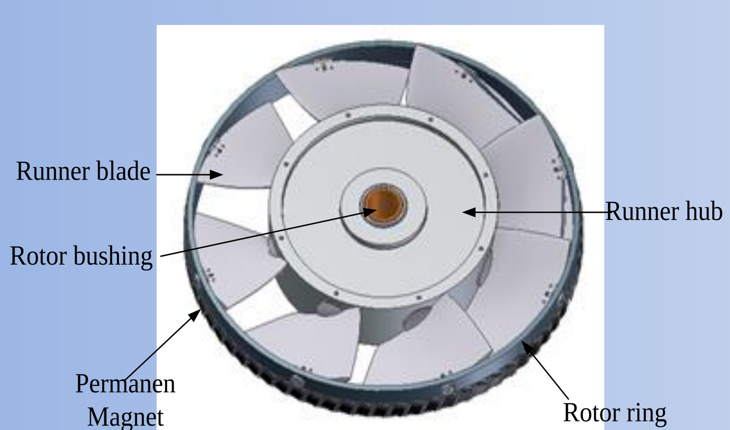

Fig. 5 Design structure of runner blades with PMG runner

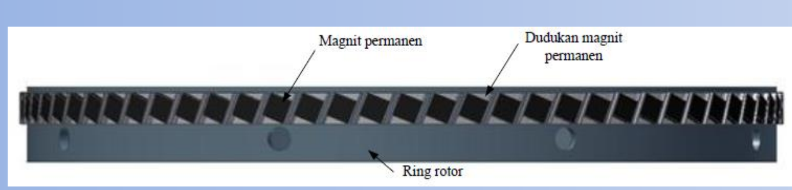

Fig. 6 Structure of the PMG with rotor magnet position are tilted

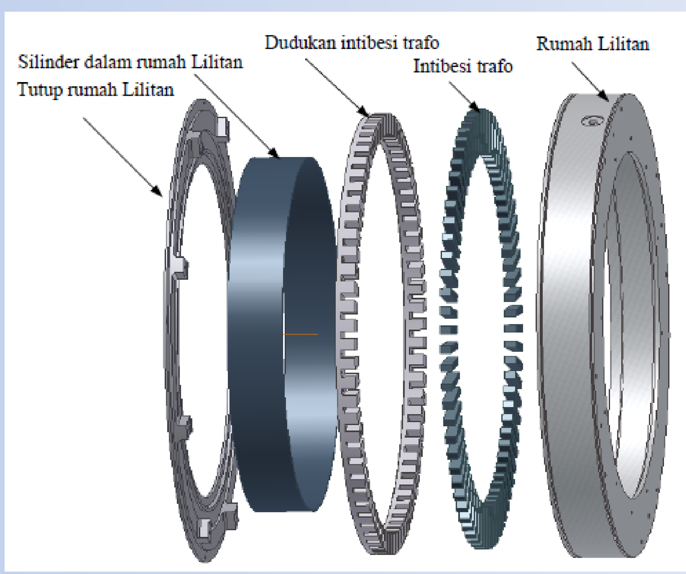

Fig. 7 The Stator PMG constuction

Magnet mounting large angle of inclination (B) is equal to 21.31°

The iron core transformer as stator. Dimension "I" of the iron core transformer is 12.85 mm width, 76.35 mm long and 0.5 mm thick and the number of poles in the design is 72 poles.

The result of generator test has power of 329 Watt at 217.9 V and rotational speed of 83 rpm.

Table 1 Materials of main parts of turbine

No.	Main Parts	Materials	No.	Main Parts	Materials
1	Stator of PMG	Silicon steel sheet	9	Rotor hub	Fiberglass
2	Rotor of PMG	Magnet permanent	10	Stator hub	Fiberglass
3	Stator ring of PMG	Mild steel	11	Spindle shaft	VCN
4	Rotor ring of PMG	Mild steel	12	Bushing	Bronze
5	PMG casing	Mild steel	13	Structure cylinder inlet, passage, and shaft base plate	Mild steel
6	Winding	email copper wire			
7	Rotor blade	Fiberglass	14	Structure of stand frame	Mild steel
8	Stator blade	Fiberglass	15	Turbine Nose	Fiberglass

Testing and Results

Fig. 8 Installation of electrical PMG performance testing

Fig. 9 Installation testing of axial turbine with PMG system

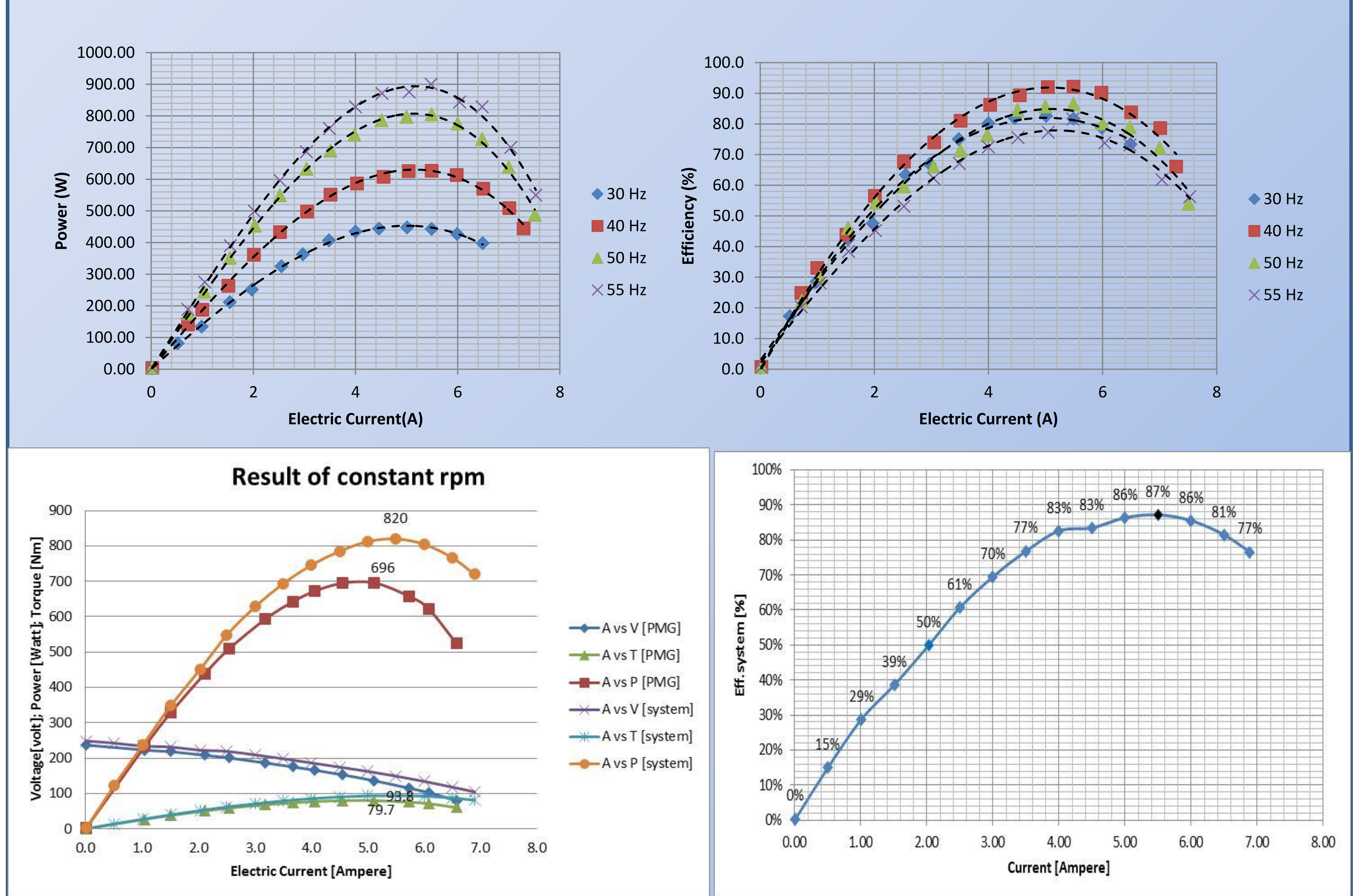

Figure 10 Performance Test Turbine Permanent Magnet Generator

CONCLUSION

- The experimental test of the low head axial hydraulic turbine has succefully demonstrated the good performance of turbine permanent generator system.
- The maximum performance of the turbine with PMG system (VLHHP) is 87 % at 50 Hz or equivalent to rotational rotor speed of 83.3 rpm.
- The maximum power generated is 820 Watt, better than the standalone results of the permanent magnet generator which obtains the maximum power generated 696 Watt at the same frequency.
- Design of turbine integrated with the PMG make a major contribution to improving the performance of generator and the overall performance.

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