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Design of hollow rotor PMG for pico-hydroelectric application

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ABSTRACT – This paper discusses about design of hollow rotor Permanent Magnet Generator (PMG) for Pico-Hydroelectric Application. Hollow rotor has higher performance compared to other PMG type because it minimizes the unused flux below permanent magnet and maximizes PMG performance. Thus, the limitation of this research is to design hollow rotor PMG that is used for Pico-Hydroelectric application where the maximum output power is below 5 kw. Finite Element Method (FEM) had been used to simulate the parameters such as backemf and fluxlinkage. The usage of hollow rotor for PMG will benefit the mankind in the field of renewable energy.

1. INTRODUCTION

Nowadays, energy resources play an important role in economics, politics, social life, and science. There are many renewable energy resources, such as rivers, the flow of seawater, wind, geothermal, and the sun; however, hydropower plants are mostly used as a renewable energy supply compared to the others[1]. Pico hydro is one of the renewable resources that is widely being used. Pico-Hydro is a term used for hydroelectric power generation of under 5 kW. Water turbine is known as one of Pico-Hydroelectric application. A water turbine is a simple machine usually made of wood or steel with a fixed blade attached to the surrounding circles [1]. The blade is driven by a stream of water flowing around the wheel. Water flowing over the blade produces a torque on the shaft and makes the wheel spin [1].

Figure 1 shows Permanent Magnet Generator (PMG) that is connected to a pico-hydroelectric water wheel. A PMG consists of stator, rotor and coil. Shaft from PMG is connected to water wheel gear. As PMG rotate, blades which is mounted towards shaft will rotatates too. Energy accumulated in the water, which moves on the blade attached to the turbine wheel, generates kinetic energy to the turbine shaft [1].

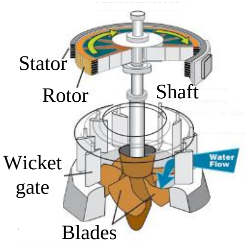
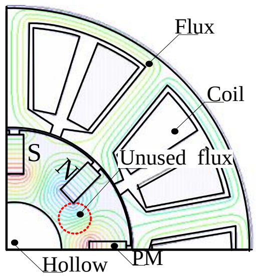


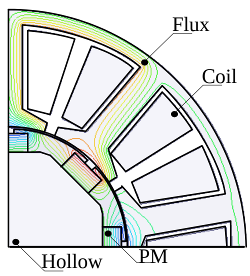
Figure 1 Pico-Hydroelectric Water wheel

2. BASIC STRUCTURE

The concept of hollow rotor is to minimize unused flux below permanent magnet so that motor performance improved [2]-[3]. Figure 2 (a) shows conventional BLDC model which is commonly used in industry. As there is space below permanent magnet, flux will be circulate at that area and not been used [3]. So, in order to maximize usage of flux, hollow rotor PMG is proposed. Figure 2 (b) shows distribution flux in a hollow rotor model. It can be seen that, all flux below permanent magnet move towards stator. There are none unused flux below permanent magnet. This concept of hollow rotor could improve PMG performance.



(a) Conventional BLDC



(b) Hollow rotor
Figure 2 Flux distribution.

3. DESIGN OF HOLLOW ROTOR PMG

Figure 3 shows overall methodology for design of hollow rotor PMG. The first part is designing the hollow rotor PMG. The process starts by determining magnetic equivalent circuit for hollow rotor. Next is the process for stator sizing, coil sizing, permanent magnet and rotor sizing. The second part of methodology is analysis of hollow rotor PMG. If selected result for FEM is satisfied, further process will be carried out for PMG analysis. If the result is not convinced, process for rotor and permanent magnet sizing will be repeated. The expected output power for hollow rotor PMG is 2 kw.

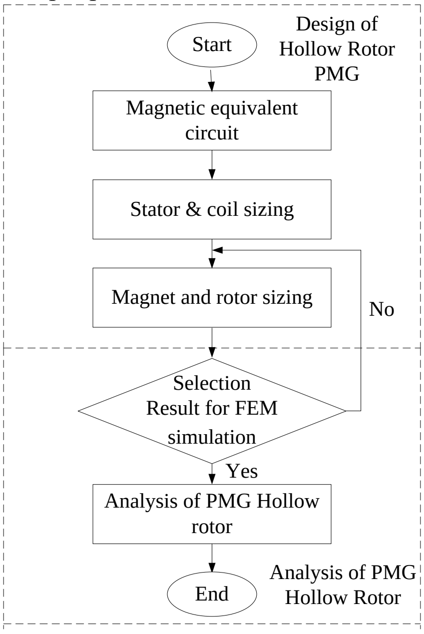


Figure 3 Overall methodology.

4. PERFORMANCE ANALYSIS OF PMG

As all sizing value of hollow rotor PMG had been determine, full diagram of hollow rotor is extruded by using CAD software and export to FEM. Figure 4 shows hollow rotor basic structure that consume of stator, rotor, coil and permanent magnet.

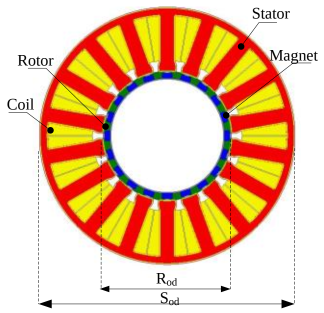


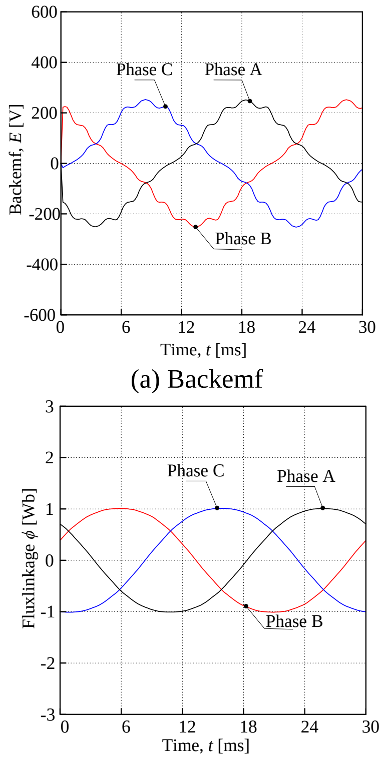
Figure 4 Hollow rotor basic structure.

Table 1 shows hollow rotor PMG basic parameter where stator outer diameter, S_{od} is 300 mm, rotor outer diameter, R_{od} is 49 mm, airgap, Ag is 1.0 mm, stack length of motor, S_l is 105 mm and permanent magnet size, P_m is 12 X 6 mm.

Table 1 Hollow rotor basic parameter.

Symbol	Parameter		Size
S_{od}	Stator outer diameter	[mm]	300
R_{od}	Rotor outer diameter	[mm]	149
A_g	Air gap	[mm]	1.0
S_l	Stack length	[mm]	105
P_m	Permanent magnet size	[mm]	12X6

Figure 5 shows result for FEM analysis at speed 200 rpm. Figure 6 (a) shows backemf for all phase. Maximum backemf is 600 V. The shape of backemf is sinusoidal. Figure 6 (b) shows fluxlinkage result It can be seen that the maximum value of fluxlinkage is around 1 Wb.



(a) Backemf

(b) Fluxlinkage

Figure 5 FEM analysis.

5. CONCLUSIONS

As a conclusion, the model of hollow rotor PMG for pico-hydroelectric application has been designed and analyzed by using FEM analysis. Result for backemf and fluxlinkage had been presented.

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