Turnitin A Study on Electric Cycle Motor as an Alternator

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A STUDY ON ELECTRIC CYCLE MOTOR AS AN ALTERNATOR

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ABSTRACT

An alternator is an important part of alternative energy issue, especially in small capacity. A good alternator should have high efficiency, reliability and low speed one. A motor for electric cycle is an alternative for such machine which has proven for some cases.

A test, especially for its magnetic characteristic was done to get parameters of the motor as an alternator as well as a dc motor. The test was done on similar motor which were coupled. The first motor was connected to adaptor and assumed to be the mover. The other one was connected to some 24V bulbs as the load. Mechanical parameters, that are speed, torque as well as the electrics which are voltage and intensity were measured in variation of the load.

The result of the test shows that the output voltage of the device was linear on low speed. It has measured internal resistance of 2.130 ohm and internal inductance of -0.0382 H. This condition makes the motor has good performance as alternator in low speed. Therefore, the motor is good alternator for small capacity hybrid system.

Kata kunci : alternator, alternative energy

I. Introduction

An alternator is an important part of alternative energy issue especially in generating small capacity electricity. A mirco-capacity usually is applied as off-grid hybrid system in remote area. Such system needs a reliable alternator which is mechanically simple and operates in low speed. A permanent magnet synchronous motor is an alternative due to its simple operation [1- 10].

A small motor for driving an electric cub is a permanent magnet motor which is easily got. The motor is designed for 100 kg load with 40 km/h speed which is operated by three 12Ah 12 V batteries. It is only 6 kg in weight and totally protected. Therefore the motor is applicable to some characteristics of alternator for small capacity hybrid system.

The PM motor for an electric cub has to produce high torque for starting. While the people may drive in varying constant speed, the motor has to operate in very wide speed range. It should accommodate the low speed until maximum speed in relatively adequate efficiency.

The motor operation range characteristics share common needs of small alternative energy alternator. It is light enough, operating in wide range speed and protected. But the magnetic problem of the alternator and motor is bit different. The motor never get magnetically overload if it can work, while the alternator may get magnetically overload that may reduce it capacity. Therefore understanding the magnetic related characteristic is important.

The paper will describe the research of measuring magnetic related parameters of a permanent magnet motor which is functioned as the synchronous generator. The motor is designed for a cub. A simple of magnetic circuit model and electric circuit model will be used to the magnetic related parameters.

II. Theoritical Review

II.1. Magnetic Model

A synchronous generator with permanent magnet poles can be seen as a machine which induct magnetic fluxes into armature winding. The circuit of the magnetic model can be shown on Figure 1. The source of the magnetic fluxes is the permanent magnet pole. The other elements are reluctance of the core (Rc), reluctance of the air gap (Rg) and reluctance of the inductance. The magneto motive force of the winding has different direction to the source. In static condition, the winding is assumed as the reluctance. In dynamic condition, it could be seen as the opposite mmf.

In a simplified model, without any fluxes dispersion and losses, the model of the **Figure 1** can be put into equation 1.

$$\frac{B_{eff}}{\mu} l = NI_o \qquad (1)$$

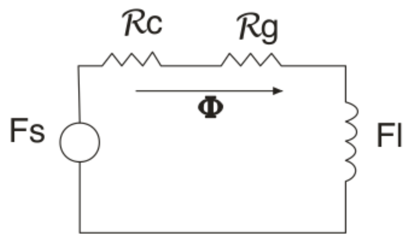

Figure 1. A model of magnetic circuit, with source as Fs and the winding magnetic load as Fl.

II.2. Electric Model

A synchronous generator can be modeled as shown in **Figure 2**. The figure shows that a generator can be assumed as a voltage source (Eg) in serial circuit with internal impedance (Zg) and load (Zl). Therefore it will follow equation (2).

$$E_g = E_x + I_o Z_l \quad (2)$$

While the circuit is serial, the equation could be put as

$$E_g = I_o(Z_g + Z_l) \quad (3)$$

Measured voltage is defined as

$$V_o = I_o Z_l \quad (4)$$

In open circuit, equation (2) can be

$$E_g = E_o \quad (5)$$

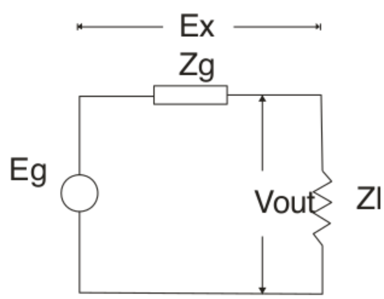

Figure 2. Model of generator circuit

The winding of the generator is an inductive element. It also has resistant characteristic. Therefore the impedance of the generator could be seen as serial elements of resistor and inductor. The equation of the model can be put as

$$E_g = I_o(j\omega L_g + r_g + Z_l) \quad (6)$$

with ω, L_g and r_g are angular speed, winding inductance and resistance of the generator copper respectively. When the Back-EMF is constant, the equation (6) produce the Single-Phase Fixed Load and Variable Speed model.

III. Research Method

The research was done to explore magnetic related parameters of the permanent magnet motor which was functioned as synchronous generator. The parameters are impedance and inductance generator. The measured parameters were electric parameters and mechanic parameter. They are voltage, current, speed and torsion. The experiment was done with speed variation as well as the load. The variation of the speed were 122 rpm, 148 rpm, 172 rpm, 198 rpm, and 222 rpm. The number of the bulbs was used as variation of the load. They were 0,1,2,3,4,5,6 and 7 bulbs of 24 V, 10 W.

From the voltage and current graph we can derive the resistance of the load. The resistance is the gradient of such graph. The crossing point of the vertical axis will be the voltage different between terminal voltage and armature voltage. The impedance of the generator can be derived from the plot of loaded terminal voltages to unloaded terminal voltages. Then, this impedance will plot into a graph of speed to get inductance and resistance. From the model of magnetic, it will be derived the function of fluxes that produce the voltage.

IV. Discussion

The generator had terminal voltage which is linear function of the speed. It is shown on Figure 3. It is interesting that the gradient of the open circuit is smaller than gradient of loaded circuit. The open circuit graph also shows that the generator produced very high terminal voltage in very low speed. Theoretically it can produce 25 V on zero speed. On the other hand, the zero speed on loaded generator will give negative voltage that mean the generator needs 18 rpm speed to produce zero voltage on output terminals as it is shown on the crossing point of the graph.

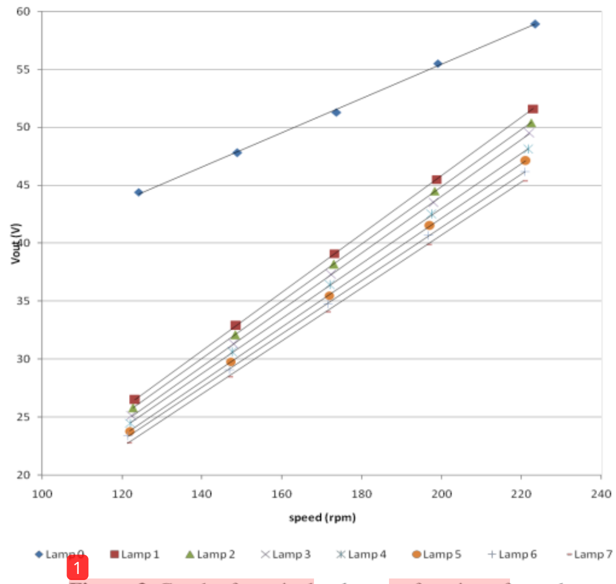

Figure 3. Graph of terminal voltage as function of speed.

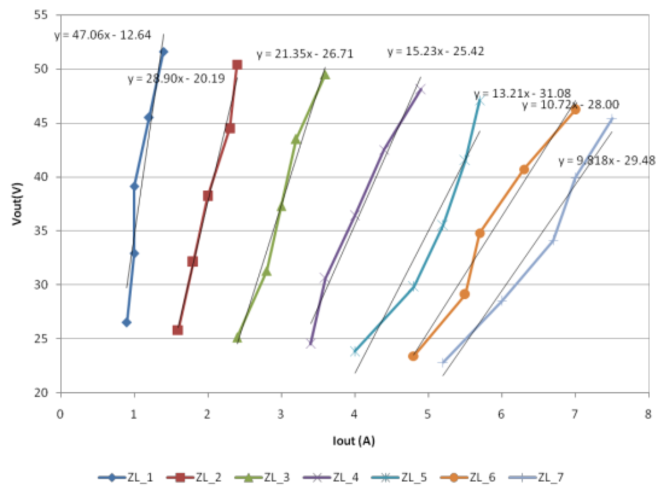

Figure 4. Graph of terminal voltage as the function of its current. Their gradients show the impedance of the load.

The **Figure 4** shows that addition of the bulbs reduce the resistance of the load. The bulbs were added parallel. Theoretically a bulb contributes R resistance. Two bulbs brings half R resistance. Three bulbs makes one-third R resistance and so on. From the gradients, resistance of a bulb is 61 ohm in average. This result confirms that each bulbs is around 24 V, 10 W.

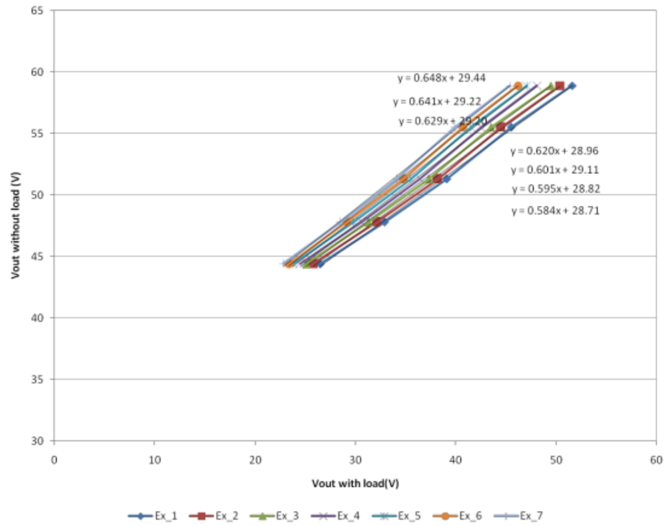

Figure 5. Relation of open circuit output voltage and loaded circuit output voltage can be used to define the different voltages that also can be used to define the impedance.

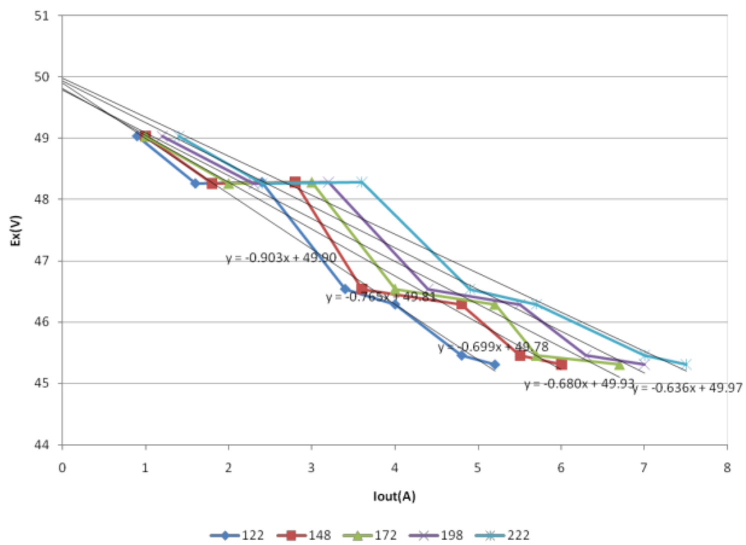

Figure 6. The internal impedance voltage as function of current.

Figure 5 tells us again that terminal voltages are linear each other. More bulbs mean smaller resistance. The crossing point of vertical axis also tells us voltages of internal impedances. One bulb load had internal impedance voltage of 49 V. Two bulbs load had internal impedance voltage of 48 V. Three bulbs load had 48 V voltage of internal impedance and so on. These internal impedance voltages can be plotted into the terminal current. They give us the impedances of the speed as the inverse of the gradients. Internal impedance of each speed are put on **Table 1**. They also has the same crossing point of vertical axis on 50 V. These are shown on **Figure 6**.

The internal impedance from the **Table 1** can derive the internal inductance and internal resistance using the equation (6) model. The value of the terminal resistance is 2.13 ohm and its inductance is -0.0382 H. These values are important to the generator electrically and they are related to magnetic properties of the alternator. The small internal impedance confirms good performance of the device as the low speed generator. It performed linear and very stable output until 7 bulbs load because it had smaller impedance than the load.

Table 1. Internal impedance of the generator as function of speed

rpm	Zg (Ω)
122	1.572327
148	1.470588
172	1.430615
198	1.30719
222	1.10742

V. Conclusion

The generator has good performance of the low speed. The output voltage is linear to its speed and it also has low internal resistance. The small internal resistance give the generator ability to operate in low speed. The internal resistance of the generator is 2.13 ohm. Its inductance is 0.0382 H. Because of this performance, the motor is suitable for alternator in small alternative energy use [1,5,6,7,8].

Acknowledgment

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References

1. Diding, S.,2010, " Generator Listrik 100 watt Putaran Rendah untuk Pembangkit Listrik dan Angin Mikro : Disain, Perencanaan, dan Pembuatan", Jurnal Gamma,5,2
2. Irasari, P., Hidayati, N.D., 2006," Analisis Prototipe Generator Kecepatan Rendah untuk Pembangkit Listrik Skala Kecil", Teknologi Indonesia, 29, 1, 47-57
3. Prasetyadi, A., 2012, "Generator Axial Magnet Permanen ND-35", Prosiding Seminar Nasional Sains dan Teknologi 2012, Kupang, T23-T26
4. Prasetyadi, A.,2013, "Generator Radial Magnet Permanen ND-35 Phasa Tunggal dengan Rangka Akrilik Knock Down", Prosiding Ritektra 2013, Jakarta,113-115
5. Dorrel, D.G.,2007,"Design Requirements for Brushless Permanent Magnet Generators for Use in Small Renewable Energy Systems",IECON 2007, 216-221
6. Madani, N,2011,"Design of a Permanent Magnet Synchronous Generator for Vertical Axis Wind Turbine", Master of Science Thesis in Electrical Machines and Power Electronics at The School of Electrical Engineering of Royal Institute of Technology of Stockholm
7. Muljadi, E., Butterfield, C.P., Wan, Y.H.,1998, "Axial Flux, Modular, Permanent Magnet Generator with Toroidal Winding for Wind Turbine Applications", Report of NREL/CP-500-24996,
8. Chen,J.Y., Nayar,C.V., 1997,"A Low Speed, High Torque,Direct Coupled Permanent Magnet Generator for Wind Turbine Application", Proceedings of Solar '97, Paper 146
9. Wai, J., Jahn, T.M., 2001,"A New Control Technicque for achieveing Wide Constant Power Speed Operation with interior PM Alternator Machine", 0-7803-7116-X,807-814
10. Budiman, A., Asy'ari, H.,Hakim, A.R.,"Desain Generator Magnet Permanen Untuk Sepeda Listrik",Jurnal Editor, 12, 1,59-66

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