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MODIFICATION OF TWO POLES SINGLE PHASE INDUCTION MOTOR AS WIND PICO GENERATOR

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Abstrak

Sebagai salah satu sumber energi alternatif untuk menghasilkan tenaga listrik, potensi tenaga angin di Indonesia cukup tinggi. Beberapa kendala yang ada dalam pembangkit listrik tenaga angin diantaranya adalah keberadaan angin yang hilang timbul dan kecepatan rata-rata angin di wilayah Indonesia tergolong rendah, atau hanya daerah-daerah tertentu saja yang memiliki kecepatan angin yang sedang sampai tinggi, sehingga angin yang tidak terlalu kencang dapat menyebabkan turbin tidak berputar. Penelitian ini adalah tentang modifikasi motor induksi dua kutub satu fase sebagai pico generator tenaga angin. Modifikasi dilakukan pada bagian squirel cage rotor motor induksi menjadi axial flux permanent magnet rotor dan membentuk dua grup kutub magnet utara-selatan (N-S). Hasil pengujian menunjukkan, pico generator dua kutub tidak cocok untuk diterapkan pada unit pembangkit listrik tenaga angin. Daya listrik yang dihasilkan dengan penggerak mula berkecepatan tinggi, diatas 1000 Rpm yaitu mencapai 2.53 Watt. Sedangkan pada saat dioperasikan pada kecepatan rendah, kurang dari 200 rpm, daya listrik luaran generator tidak maksimal yaitu maksimum 44 mW.

Kata kunci: *Modifikasi, Motor Induksi Satu Fasa, Pico Generator*

Abstract

As an alternative energy, the potential of wind power in Indonesia is quite high. Some of the constraints of wind power include the presence of intermittent winds, the average wind speed in the Indonesian is relatively low, or only certain areas that have moderate to high wind speeds, so that winds that are not too tight can cause the turbines not spinning. This study is about modifying a two pole single phase induction motor as a wind pico generator. Modifications is made to the squirrel cage rotor induction motor become two poles axial flux permanent magnet rotors and make two magnetic pole groups N-S. The test results show that a two pole pico generator is not suitable to be applied to wind power units. Electric power produced by high-speed prime mover, above 1000 rpm only 2.53 Watts. Whereas when it is operated at low speed, less than 200 rpm, the maximum output power only 44 mW.

Keywords: *Modification, Single phase induction motor, Pico Generator*

1 INTRODUCTION

Based on the government data in www.esdm go.id, the value of Indonesia's electrification ratio as of June 2017 is 92.8%. From these data, although the tendency of electrification ratio increases every year, the distribution of values per region still has a high gap. Indeed, it cannot be denied that in the big cities or Java islands the electrification ratio has a high value, above 90%. Unlike the case with other regions such as the Riau Islands, Central Kalimantan, NTB (Nusa Tenggara Barat) is below 80%, even NTT (Nusa Tneggara Timur) is below 60% and Papua is below 50%. This uneven electrification ratio can be caused by several factors. One of these factors is Indonesia's electricity capacity which is still minimal [1].

The government and the private sector have made several efforts to increase the national electrification ratio. One example of the efforts made by the government is the use of clean energy [2]. As one of the alternative energy sources producing electricity, wind power is a fairly high energy source in Indonesia. Based on RUPTL (*Rencana Usaha Penyediaan Tenaga Listrik*) in 2016 until 2025 the potential for wind power (PLTB) development reaches 2500 MW [3]. Constraints that exist in PLTB (*Pembangkit Listrik Tenaga Bayu*) include the presence of a constant wind which causes the electricity produced to be fluctuating or intermittent. Apart from that, the average wind speed in the Indonesian region is classified as low speed, only certain regions have moderate to high wind speeds, such as in coastal areas or on hills [4]. Weak winds can cause the designed turbine to not rotate [5].

Therefore, in order to support the increase in the distribution of the electrification ratio through the provision of clean energy, this study carried out an attempt to install PLTB at the Batam State Polytechnic Campus using a modified pico generator from single phase induction motors. By using Pico generator, it is expected that the provision of alternative electricity can be done by utilizing the potentials of wind power even though on a small scale.

2 METHODE

The method used in this study to produce the desired electrical energy was to modify the squirrel cage rotor induction motor to become an axial flux permanent magnet generator. As a field excitation in the induction generator pico generator, the rotor was installed with a certain amount of Neodymium-Iron-Boron permanent magnet (NdFeB) so that it can be used to capture the potential of wind power even though on a small scale. Figure 1 is a flow diagram ofthe modification process carried out.

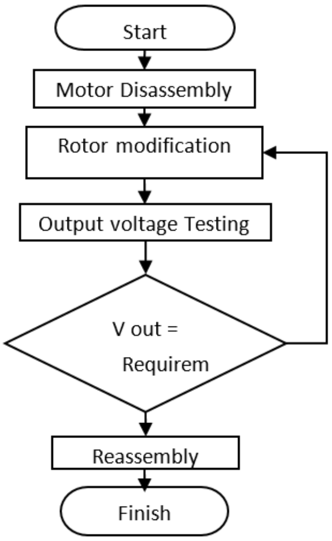


Figure 1. Modification of Diagram

2.1. Rotor and Stator Modification

The design of modified in the induction motor rotor section will produce the desired output voltage. In this study, the rotor with the shape of a squirrel cage of a single phase induction motor was modified by attaching several NdFeB permanent magnets to form two pole groups north pole group (N) and south pole group (S).

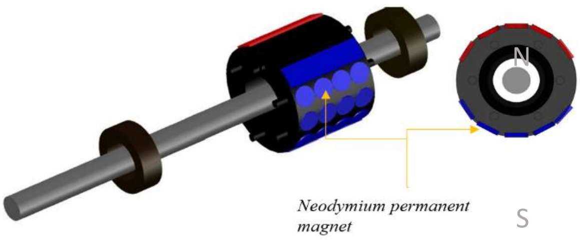


Figure 2. Rotor and stator Modification

The stator winding section used as the original coil of the default motor was shown in Figure 3. The stator part using a 24 slot core with winding configuration is a full two-pole concentric pitch.

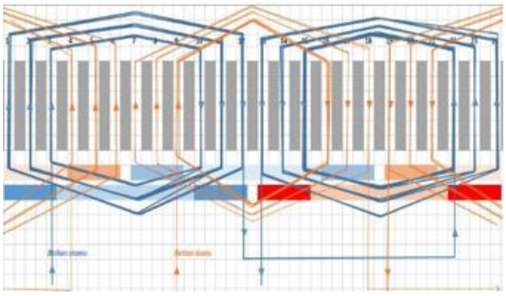


Figure 3. Stator konfiguration without modification

2.2. Experiment Test

Several tests were carried out to obtain a modified pico generator output from a one-phase induction motor. These tests are observations of output voltage waveforms, observation of no-load output voltage, and observation of load-bearing external stresses. The scheme for testing a loaded pico generator can be shown in Figure 4.

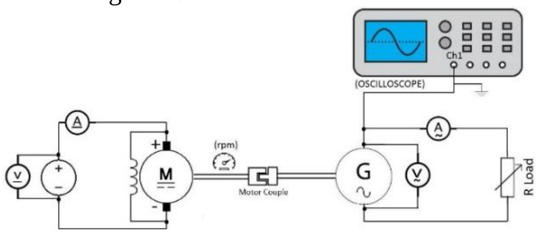


Figure 4 . Testing a loaded pico generator scheme

3 RESULT AND DISCUSSION

Pico generator modified by one two-pole induction motor in this study is shown in Figure 5

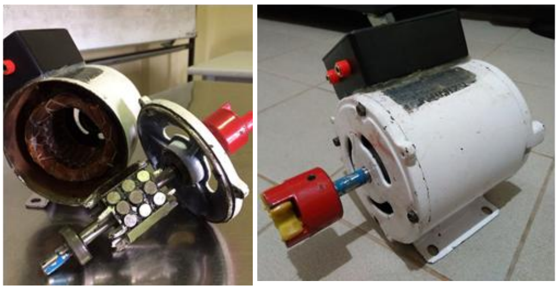
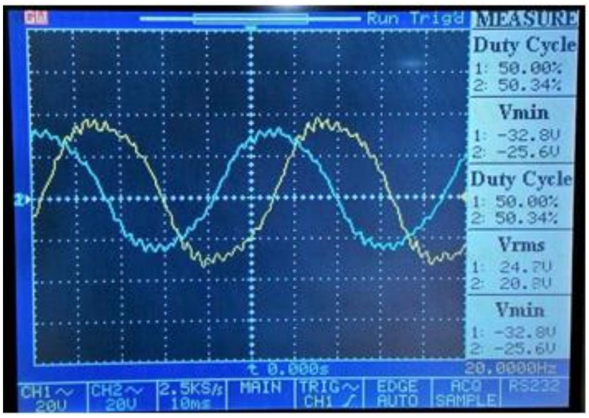


Figure 5. The result of modified two pole pico generator

3.1 Output Voltage Experimental

The shape of two pole pico generator output as shown in Figure 6 was not pure sinusoidal. There are several ripple components in the output wave peaks of the main winding terminal and auxiliary winding, and the output voltage Vo1 and Vo2 have a phase shift of around 90°. The ripple voltage seen in Figure 6 may be caused by the installation of a permanent magnet that is not uniform Figure 5. Whereas the phase shift between Vo1 and Vo2, this is due to the shape of the stator winding induction motor Figure 3, which uses full pitch i.e. 2 poles with 24 slots. Each main winding pole and auxiliary winding each have a span of 12 slots and have a distance of around 90°.



Picture 6. Pico external voltage waveform generator two poles

The results of the observation of the two-pole pico generator output in this study was shown in Table 1 and the relationship between the speed of the prime mover and the output voltage generated is shown in the curve of Figure 7.

Table 1. Experimental no load output voltage characteristic of modified pico generator

No.	n1 (rpm)	Vo1 (Volt)	n2 (rpm)	Vo2 (Volt)
1	136.8	2.6	105.4	2.9
2	236.7	4.3	218.5	4.7
3	328.5	5.6	352.3	7.6
4	407.5	7.9	462.7	10.4
5	547.9	10.5	575.5	13.1
6	681	12.8	628	15.1
7	847.3	15.9	807.2	18.9
8	958.6	18.0	856.9	20.5
9	1042	19.6	1047	24.3
10	1138	21.9	1140	26.1

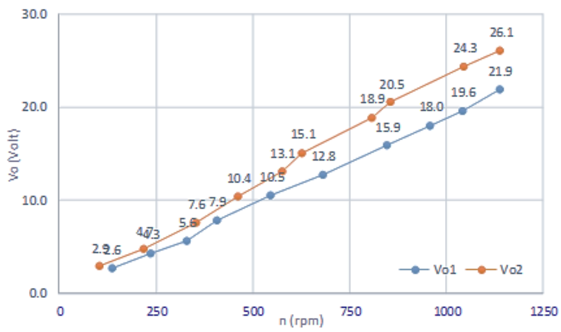


Figure 7. The Characteristic of Output voltage pico generator two pole without load

Based on Figure 7 the output voltage of a two-pole pico generator has a characteristic that is nearly linear with respect to the speed of rotation of the initial drive.

Mathematic Formulas for the output voltage in generator as follow:

E= KΦN

With E is Electromotive force (e.m.f) in volts, K is machine constant (type and machine construction), Φ is flux in webers and n is the speed of rotation (rev/s).

Based on Figure 7 can be seen that with the change in the initial drive speed from 105 rpm to 1140 rpm, the output voltage of the pico generator changes in the range of 2.6 volts to 26.1 volts.

However, when compared between the main winding with auxiliary winding, the auxiliary winding has a higher output voltage of around 120% compared to the main winding. In this test, the minimum output voltage of the main winding is 2.6 Volts while the auxiliary winding is 2.9 Volts, and the maximum output voltage of the main winding is 21.9 Volts and the auxiliary winding is 26.1 Volts. This result is in accordance with formula 1 that the construction of auxiliary winding in a one-phase induction motor was always made with a greater number of turns than its main winding.

3.2 *The Output Power Experimental*

The output power characteristics of two poles modified pico generator have identical characteristics in their stator winding. These results can be seen in Figures 8 and 9

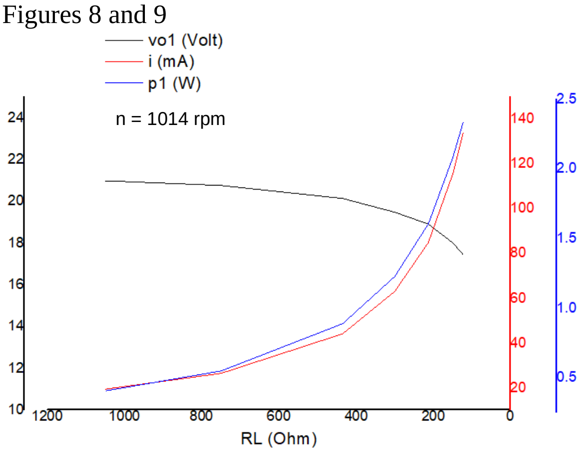


Figure 8. Experimental load characteristic of main winding modified two poles pico generator

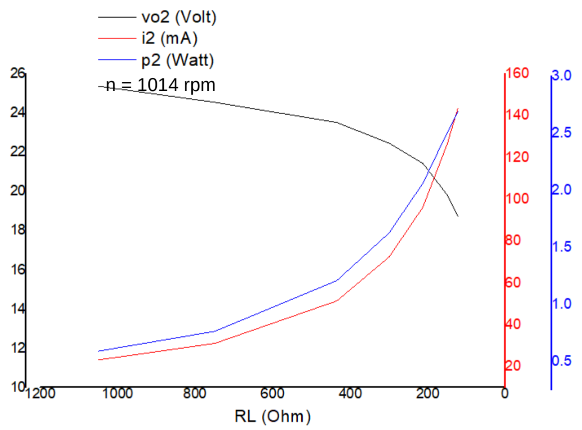


Figure 9. Experimental load characteristic of auxiliray winding modified pico generator two poles

Based on Figures 8 and 9, it can be seen that through pure R load testing, both significant differences are in the drop voltage that occurs in each winding. The voltage drop due to loading a pure R load for the main winding is 4.11 Volt or about 19.1% from 21.55 volts while for auxiliary windings is 7.45 volts or about 28.5% of 26.19 volts. So that the maximum power that can be produced by a two-pole pico generator is 2.33 Watt and 2.68 Watt for each main winding and auxiliary winding. The maximum total power produced in this condition is 5.01 Watts.

The Output Power in Series

The result of observing the output power modified two poles pico generator when the main winding and winding connected in series was shown in Table 2.

Table 2. Experimental characteristic of low speed two pole pico generator in series winding

NO.	n (RPM)	RL (OHM)	Vo (V)	Io (mA)	Vd (%)	Po (mW)	f (Hz)
1	153	NO LOAD	3.08	0.0	0.00%	0.0	2.71
2	160	1078	2.65	3.0	13.96%	8.0	2.64
3	161	778	2.70	4.0	12.34%	10.8	2.69
4	166	452	2.55	8.0	17.21%	20.4	2.70
5	159	308	2.24	13.0	27.27%	29.1	2.61
6	152	221	1.98	18.0	35.71%	35.6	2.55
7	162	155	1.99	21.0	35.39%	41.8	2.69
8	157	129	1.77	25.0	42.53%	44.3	2.63
avg	158.75						2.65

Table 3. Experimental characteristic of medium speed two pole pico generator in series winding

NO.	n (RPM)	RL (OHM)	Vo (V)	Io (mA)	Vd (%)	Po (mW)	f (Hz)
1	518	NO LOAD	13.50	0.0	0.00%	0.0	8.51
2	514	1078	12.60	11.0	6.67%	138.6	8.46
3	516	778	12.60	16.0	6.67%	201.6	8.63
4	513	452	11.60	26.0	14.07%	301.6	8.40
5	516	308	11.70	36.0	13.33%	421.2	8.80
6	511	221	11.70	48.0	13.33%	561.6	8.80
7	515	155	9.80	65.0	27.41%	637.0	8.68
8	518	129	9.26	74.0	31.41%	685.2	8.62
	515.1						8.61

The electrical power characteristic curve output when the main windings and auxiliary winding was connected in series are shown in Figure 10.

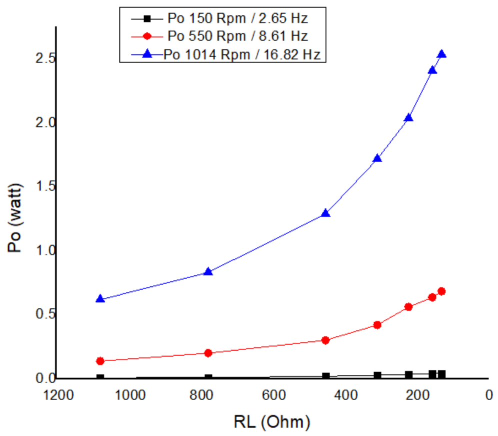


Figure 10. Electrical power characteristic in two pole pico generator with series circuit

Based on Figure 10, the experiment consist of three categories. They are low speed, medium speed, and high speed testing. All test do not produce significant electrical output. When the modified of wind pico generator operate in low speed (150 Rpm) the output power produced is only around 0.044 watts or 44 mW and the drop voltage at the output terminal more than 10% and reaching 42.5% at maximum load. While operate at medium speed, the maximum power produced is slightly increased, which is 0.69 Watts or 690 mW with the value of the drop voltage on the output terminal reaching 31%. In this test the drop voltage still below 10% when the output power is not more than 300 mW. Then for operate at high speed the output power of pico generators can reach 2.53 Watts with the voltage drop at the terminal still high, reaching 36%. In this condition, the drop voltages are less than 10% of its output power or pico generator load is less than 300 mW.

4. CONCLUSION

Based on the results of this research can be concluded that pico generators can be produced from the modification of a single phase induction motor. Apart from that, the results of the research show that by simply modifying the rotor parts the electrical power produced by the pico generator will be optimal if the pico generator is operated with a high-speed prime mover that is 2.53 Watts. Whereas when it is operated at low speeds, the output power of the generator is not maximum, which is a maximum of 44 mW.

Besides, the modification of a one-phase induction motor as a two-pole pico generator has a low output frequency. The resulting output of frequency is around 2.65 Hz or not reaching 5 Hz for the results of the low speed test and the resulting output of frequency is 16.82 Hz during high speed testing. Therefore this two-pole pico generator is not suitable to be applied to units of low-speed renewable energy power plants such as PLTB or micro-Hydro.

For this reason, other techniques need to be modified, not only on the rotor but also on the stator, such as multi-polished pico generators so that pico generators can be obtained with low speed high power characteristics and are suitable for renewable energy units with low rotational speed characteristics.

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