Design of motor induction 3-Phase from waste industry to generator for microhydro at isolated village

Rimbawati 1,*, Abdul Azis Hutahsuhut 1, Faisal Irsan Pasaribu 1, Cholish 1, Muharnif 2
1Electrical Engineering Department,  2Mechanical Engineering Department, University of Muhammadiyah Sumatera Utara, Jln.Kapt Mukhtar Basri No. 03 Medan, Indonesia

* rimbawati.umsu@yahoo.co.id

Abstract. There is an electric machine that can operate as a generator either single-phase or three-phase in almost every household and industry today. This electric engine cannot be labeled as a generator but can be functioned as a generator. The machine that is mentioned is "squirrel cage motors" or it is well-known as induction motor that can be found in water pumps, washing machines, fans, blowers and other industrial machines. The induction motor can be functioned as a generator when the rotational speed of the rotor is made larger than the speed of the rotary field. In this regard, this study aims to modify the remains of 3-phase induction motor to be a permanent generator. Data of research based conducted on the river flow of Rumah Sumbul Village, STM Hulu district of Deli Serdang. The method of this research is by changing rotor and stator winding on a 3 phase induction motor, so it can produce a generator with rotation speed of 500 rpm. Based on the research, it can be concluded that the output voltage generator has occurred a voltage drop 10% between before and after loading for Star circuit and 2% for Delta circuit.

1. INTRODUCTION
1.1. Background

Induction motor is one of the driving forces that are most often used in industrial applications. Besides its function is as a driving force, an induction motor can also be used as a generator, either large or small generator power capacity. The construction of an induction motor is generally equal to an induction generator, when the slip is made negative, or in other words the rotational speed of the rotor (nr) is made larger than the synchronous speed (ns) then the machine will function as a generator and the output voltage will be returned to the voltage flowing. Therefore, the induction motor can be operated as an induction generator [1].

An induction motor as a generator is widely used in Micro Hydro Power (MHP). [2] and [3] conducted a study to meet the needs of electrical energy in a rural community near the source of irrigation channels and the flow of rivers in the highlands, to try to make Power Micro Hydro low power < 3 KW by utilizing a single-phase induction motor as an induction generator.

Due to the number of the remains of 3-phase induction motor from water pump, drying machine, blower, and industrial machines, it opens the chance to make modification to utilize the motors to be a hydroelectric generator that can be operated in Micro Hydro Power in all areas that have small water discharge every year.
Rumah Sumbul village, STM Hulu District of Deli Serdang with a population of ± 25 families, has the potential water resources to be utilized as Micro Hydro Power with a capacity of 14,15 kVA.

During this time, the resident’s lighting is only an oil lamp with the expensive cost and it is sometimes not available. Because the geographical location of the village is far from the capital district, it causes that village is more declining than other villages. Based on statistical data on population, the degree of education in that village is very low, so to actualize MISG that has a capacity of 10 kVA is very required.

2. REVIEW OF RELATED LITERATURE

2.1. Induction motor as a generator

Basically, an induction motor can be used as a generator by adding capacitors at the output generator. The capacitor installed in the output of the generator will supply reactive power which will raise the output voltage on the generator. Capacitor value installed in the output generator is various because it is based on increasing voltages in the generator. To get the maximal output, it is needed a control device that can measure the value of capacitors which can be used appropriately. The control device is Induction Generator Control (IGC).

The use of an induction motor as a generator has been applied widely in Micro Hydro Power even though it has shortcoming in terms of efficiency and voltage regulation. Induction generator is widely used because it is easy to be obtained, cheap, has simple construction and easy to be maintained.

[4] states that to operate an induction motor as a generator, it takes mechanical power as prime driving force that will rotate the rotor more than the speed of the synchronization— in other words, slip induction is always negative in the generator. It can be seen in this formula:

\[ S = \frac{n_s - n_r}{n_s} \times 100\% \]  

where S = Slip
N_s = the speed of stator
N_r = the speed of rotor

To generate a voltage at the output terminals of induction generator, reactive power is required in accordance with the need of reactive power of the induction machine. Reactive-power requirement can be met by installing a unit of capacitor at the output terminals of induction generator. There is a residual flux or magnetic field in the stator coil at the induction generator. Voltage generation process will not occur if there is no residual flux.

2.2. Advantages and Disadvantages for Induction Motor as Generator

Induction motor as a generator has advantage and disadvantage. The advantages of induction motor as a generator are:

1. It is cheap prize and easy to find in the market.
2. It is available from low power to high power, single-phase to 3-phase.
3. It does not need the maintenance because it does not have carbon brush and slip ring.

Besides the advantages, the followings are some disadvantages of Induction Motor as Generator:

1. It has low power (< 0.8).
2. It has large voltage drop (>10%).
3. The stability voltage is not maintained at a constant value.
4. It requires a special controller which is quite expensive to increase the power factor.

3. Research Method

The following is the image of test series that will be conducted to determine the parameters of the design generator which will be used as the MHP:

![Figure 1. Testing-Tool Scheme of Generator Design That Will Be Modified](image)

The explanation of the picture:
- **M**: Motor as the first driving force
- **G**: Tested generator
- **T**: Tachometer
- **V**: Voltmeter
- **A**: Ampere meter
- **F**: Frequency Counter

Before the generator is installed in Micro Hydro Power, the generator is tested first. Installation testing tools are as in Figure 1. Since the generator must be rotated at a constant speed of 500 rpm, the induction motor is coupled with a generator by using V-Belt Pulley with a ratio Pulley 3: 2 for the appropriate rotation.

The next step by estimating the water discharge, then first step that needs to be done is to calculate speed of water and calculate the area cross section. The area cross section area is the total number of five squares, with depth as measured at points D1, D2, D3, D4 and D5. The width of each box is one-fifth of the channel / river width. The calculation data is done based on the calculation data conducted on the river flow of Rumah Sumbul Village, STM Hulu district of Deli Serdang with average depth (D) 0.188m width of river (L) = 1.8 m and mean water velocity 1, 9 m / s so obtained the calculation of water debit as follows;

\[ A = D \times L \]
\[ A = 0.188 \times 1.8 \]
\[ A = 0,3384 \text{ m}^2 \]

\[ Q = A \times V \]
\[ Q = 0.3384 \text{ m}^2 \times 1.9\text{m/s} \]
\[ Q = 0.642\text{m}^3/\text{s} \]

From the results of debit and head analysis, an electrical power that can be generated can be calculated as follows;

\[ P = g \times Q \times H \times \eta \]
Before doing a modification, it is required to know the construction and the equivalent circuit of the motor to simplify the design modification. To get more clearly about equivalent circuit of the induction motor and the generator, it can be seen in the following picture.

The above induction motor circuit will be converted into an equivalent circuit generator as in the following picture:

### 4. Analysis and Discussion

#### 4.1. Load Voltage Test

A. The Test of Load 3-Phase Star-Connection Generator.

The test was conducted to the 3-phase star-connection generator. The load that was given was 3 lamps with 60 watt/220 volt. The data with the variation in generator rotation were shown in table 4.1.
Table 4.1 Data of load 3-phase Star connection Generator Test

Based on the table 4.1, it can be seen that output voltage has risen significantly with the changes of the modification generator speed. Despite a high enough voltage drops after the generator weighed is ± 10%, but that rate is still high to calculate working voltage of a generator.

B. The Test of Load 3-Phase Delta-Connection Generator

The test was conducted to the 3-phase delta-connection generator. The load that was given was 3 lamps with 60 watt/220 volt. The data with the variation in generator rotation were shown in table 4.2

Table 4.2 Data of Test of Load 3-Phase Delta-Connection Generator.
Result of testing on the output voltage generator connected by delta indicates that the output voltage produced by the generator is lower than the star circuit. This is suitable to the basic principles of relations with the load generator.

5. Conclusion
After having been analyzed, it can be concluded that:
1. The output voltage generator occurred voltage drop 10% between before and after being loaded for star circuit and by 2% for circuit Delta.
2. The test will still be conducted to the perfection of hydroelectric generators produced.

References
[1] Zuhal, 1988 “Dasar Teknik Tenaga Listrik dan Elektronika Daya”, Gramedia Jakarta
[2] B.S, M. Isnaeni, 2005, “Motor Induksi Sebagai Generator”, Seminar Nasional Ketenagalistrikan, Teknik Elektro Fak Teknik Universitas Diponegoro.
[3] Ion, Catalin Petra. Serban Ioan. 2006: Single-phase Dump Load For Stand Alone Generating Units with Induction Generator, Annals of the University of Craiova.
[4] Effendy M, 2009, “Rancang Bangun Motor Induksi Sebagai Generator (MISG) pada Pembangkit Listrik Tenaga Mikrohidro”, TRANMISI, Jurnal Teknik Elektro, Volume 11, Nomor 2, Juni 72 2009, hlm. 71-76. UMH Malang.
[5] ESDM, 2003, “Kebijakan Pengembangan Energi Terbarukan dan Konservasi Energi (Energi Hijau)”, Departemen ESDM, Jakarta, Indonesia.
[6] Sekeroney F, 2009, “Penggunaan Motor Induksi Sebagai Generator Arus Bolak-balik”, Jurnal Teknologi, Volume 6 Nomor 2, 2009; 697-702, Politeknik Negeri Ambon.
[7] Surya W, (2009), “Analisa Karakteristik Motor Induksi Sebagai Generator (MISG) pada PLTMH”, Teknik Elektro UPI, Bandung.
[8] Yahya S, 2008, “Motor Induksi Split Phase Sebagai Generator Induksi Satu Fasa” Prosiding Seminar Nasional Teknoin 2008 Bidang Teknik Elektro, Politeknik Negeri Bandung.
[9] Yulianus S, 2009, “Perencanaan Motor Induksi Sebagai Generator Induksi”, Jurnal: Adiwidia Edisi Desember 2009, No. 2, Teknik Elektro UKI Paulus Makasar.
[10] Chapallaz, 2002, J.M., J. Dos Ghali, P. Eichenberger, G. Fisher, “Manual on Induction Motors Used as Generators”, GTZ Eschborn.
[11] Ekanayake Dr, 2002, “Small Hydro Schems”, Power Engineering Journal; April 2002