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An Analysis Of Electrical Energy Usage In Alternating Current (AC) Motors 1 Phase Using Inverter

Sigit Pratama[1], **Solly Aryza**[2], **Haris Gunawan**[3]
Universitas Pembangunan Pancabudi, Medan, North Sumatera, Indonesia

Article Info	ABSTRACT
Keywords: Use of Electrical Energy, Alternating Current (AC) Motor 1 Phase, and Inverter	1 Phase AC motors are often used as drivers on equipment with full speed or relatively constant speed, especially in industry or households. Power consumption on 1 Phase AC motors with constant speed is greater, therefore it can cause waste in the use of electrical energy. To overcome this problem, a way is needed to save electrical energy, especially in the operation of 1 Phase AC motors. One effort to save on electrical energy consumption, especially in the use or operation of 1 Phase AC motors is by using a power converter in the form of an inverter. From the results of the study that has been obtained, the use of 1 Phase AC Motors when operated using two motors without being connected to an inverter, the power measured on the measuring instrument reaches 0.796 kW with electrical energy of 1.194 kWh. If the 1 Phase AC Motor is operated using an Inverter, the power measured on the measuring instrument reaches 0.408 kW with electrical energy of 0.612 kWh. The comparison of the use of electrical energy of 1 Phase AC motors using an inverter is lower than the use of electrical energy of 1 Phase AC motors without using an inverter, which can be used as savings in electrical energy in monthly usage.
	Corresponding Author: Sigit Pratama Universitas Pembangunan Pancabudi, Medan, North Sumatera, Indonesia sigit7pratama19@gmail.com

INTRODUCTION

Motor Alternating Current(AC) is widely used in industry and households because this induction motor has a simple construction, is easy to operate, and is relatively cheaper to maintain. Use of induction motors Alternating Current(AC) when viewed from the voltage supply is one type of motor Alternating Current(AC) 1 phase that operates using an alternating current source. Motor Alternating Current(AC) 1 phase is often used as a driver in equipment with full speed or relatively constant speed. Motor power consumption Alternating Current(AC) with a greater constant speed and this can cause waste in the use of electrical energy. To overcome this problem, a way is needed to save the use of electrical energy in the motor. Alternating Current(AC). One of the efforts to save on electrical energy usage in motor operation Alternating Current(AC) is by using a power converter system in the form of an inverter. In addition, the use of motors Alternating Current (AC) currently still uses many conventional methods, namely using a direct-on-line starting system or directly connected to a power source. Using this method can cause high starting currents in the motor Alternating Current(AC), which can result in wasteful use of electrical energy. This can also be overcome by using an inverter module, which regulates the voltage and frequency on the motor. Alternating Current (AC), to reduce the starting current on the motor alternating Current(AC) in an effort to save on electrical energy usage.

The use of electric motors, especially 1-phase Alternating Current (AC) motors, has a significant role in various household and light industrial applications. These motors are used in equipment such as water pumps, fans, compressors, and washing machines. However, high electrical energy consumption is often a challenge, especially in systems that operate continuously. This encourages the need for innovation to improve the efficiency of electrical energy use in 1-phase AC motors. One solution that can be applied to optimize energy consumption is the use of an inverter. The inverter functions to regulate the frequency and voltage supplied to the AC motor, so that the speed and torque of the motor can be adjusted as needed. With this arrangement, energy consumption can be minimized without reducing motor performance. In addition, the inverter also provides advantages in terms of more flexible speed control and increased motor life.

This study aims to analyze the efficiency of electrical energy use in 1-phase AC motors with the application of an inverter. The analysis was carried out by comparing the energy consumption of motors without an inverter and motors operated using an inverter. This study also includes an evaluation of the technical and economic aspects of the application of inverters, such as their effect on motor performance, energy savings, and implementation costs.

With the results of this study, it is hoped that it can provide recommendations that support the use of inverters as a solution to increase electrical energy efficiency, reduce operational costs, and support energy sustainability in the household and industrial sectors. From the explanation above, we can see the use of electrical energy consumption on the motor.*Alternating Current*(AC) 1 Phase using an inverter, this research is needed to analyze the use of electrical energy in motors.*Alternating Current*(AC) 1 Phase, namely in conditions without using an inverter and using an inverter and in conditions without being connected to a load and using an electrical load.

Theoretical Basis

Motor Alternating Current (AIR CONDITIONING)

In general, motors Alternating Current (AIR CONDITIONING) or commonly called induction motors are known to be of two types based on the number of phases used, namely: 1 (One) Phase induction motors and 3 (three) Phase induction motors. As the name implies, 1 (One) Phase induction motors are designed to operate using a single-phase voltage supply and three-phase induction motors with a 3 (three) Phase voltage supply. Induction motors are often used as drivers on equipment with relatively constant speeds. This is because 1 (One) Phase induction motors have several advantages, namely a fairly simple construction, almost constant rotational speed against changes in load, and low electrical conductivity.

The main problem associated with the design of a 1 (Single) Phase induction motor is the absence of a rotating magnetic field as in a 3 (three) Phase induction motor. Since there is only 1 (one) Phase in the stator winding, the magnetic field in a 1 (one) Phase induction motor does not rotate, but only produces a pulsating field that is in a fixed position, not a field that rotates in space. Since there is no rotating magnetic field in the stator, a 1 (one) Phase induction motor has no starting torque.

Electrical energy is an effort to optimize the work of equipment under full load conditions so that the use of electrical energy becomes more effective, efficient and rational without having to reduce production performance by using Variable Speed Drive which is useful as a regulator of the speed of an induction motor. There are several ways to control the rotational speed of an induction motor, including by controlling the voltage and frequency known as constant V/f control. Constant V/f control is one way to control the rotational speed of an induction motor by changing the voltage and frequency, but still keeping the ratio of the two constant. So with this control method, the torque produced can be kept constant throughout the speed control area. The most common thing in applying this method is to use a tool known as an inverter.

Inverter

An electric inverter is a device that converts direct current (DC) to alternating current (AC). The input voltage, output voltage, and frequency depend on its design. In the world of electricity, inverters are very popular for various purposes. An inverter is a device that can convert direct voltage to alternating voltage with adjustable frequency and voltage levels. Inverters can be broadly classified into two types, namely single-phase inverters and three-phase inverters. Each type of inverter can use controlled turn-on and turn-off devices (such as BJTT, MOSFET, IGBT, MCT, SIT, GTO) or forced commutated thyristors depending on the application.

An inverter is a converter circuit that changes DC voltage to AC voltage by switching. The power semiconductor components used can be SCR, transistors, and MOSFETs that operate as switches and converters. Inverter applications can be found in power supplies, uninterruptible power supplies (UPS), industrial (induction motor) drives, active filters, HVDC and others. The block diagram of the inverter can be seen below

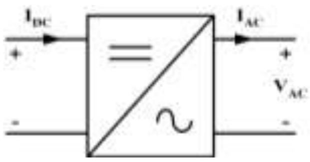

Figure 1. Inverter Block Diagram

The input voltage from the inverter is pure DC voltage (without ripple). *Output*from the inverter in the form of AC voltage and can be grouped into three waveforms, namely square wave, pulse width modulation (PWM) and sinusoidal.

Induction Motor Construction

The construction of a single-phase induction motor is almost the same as the construction of a three-phase induction motor, namely consisting of two main parts, namely the stator and the rotor. Both are cylindrical and symmetrical magnetic circuits. Between the

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rotor and stator there is a narrow air gap. The construction of a single-phase induction motor is as shown in the image below

Figure 2. General construction of a single phase induction motor

The working principle of a single-phase induction motor can be explained by the double rotating field theory. The double rotating field theory is another method to analyze the rotation principle of a single-phase induction motor besides the crossed rotating field theory. According to this theory, a magnetic field that pulsates in time but is stationary in space can be divided into two magnetic fields, which are equal in magnitude and rotate in opposite directions. In other words, the alternating sine flux can be represented by two rotating fluxes, each of which has a value equal to half of the alternating flux value and each rotates synchronously in opposite directions.

Energy and Electrical Power

Electrical energy is the amount of electrical power used or absorbed during a certain time, electrical energy is measured using an electrical measuring instrument commonly called a watt hour meter or kWh meter or MWh meter. Units of electrical energy include: watt second, Watt hour, kilo Watt hour (kWh), Mega Watt hour (MWh). Electrical energy can be written with the following formula:

$$W = P \times t \qquad (1)$$

Where:
W=Electrical Energy (Wh)
P=Power (Watts)
t=Time

Power is a force that causes an object to move (move) or the amount of work that can be done in a unit of time and is given the symbol P with units of watts or Joules/second and can be written using the formula below:

$$P = V \times I \qquad (2)$$

Where:
P=Power (Watts)
V=Voltage (Volt)
I=Current (Ampere)

The power calculation for a 1 (one) phase induction motor can be calculated using the following formula:

$$P = V \times I \times Cos\varphi \qquad (3)$$

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METHODS

The 1 (one) phase induction motor data from the name plate data on the motor is:

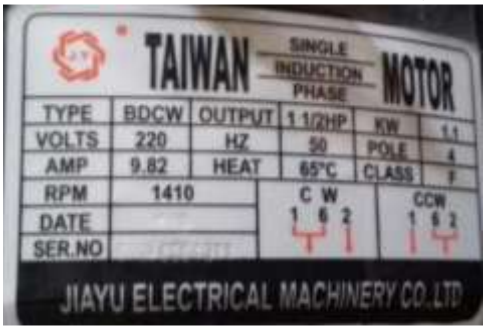

Figure 3. Name plate Motor AC 1 Phase

The 1 (one) phase induction motor data from the name plate data on the motor is:
Motor Power: 1/2 HP = 372.85 Watt
Number of Poles: 4 (Four)
Frequency : 50 Hz
Voltage: 220 Volts
Rotation: 1410 rpm
While the inverter data is in the form of *Variable Speed Drive*(VSD) as follows:
Brand : ATO Single Phase VFD
Power (kW) : 0.4 kW 1/5 HP
Frequency : 47~63Hz
Output voltage: 1 phase AC 220V,
Output *frequency*: 0~500Hz
The research methods used in this study are:

a. Data collection
The method used in the data collection process in this study is from the object being studied, namely a 1 (one) Phase induction motor with a large power capacity of 0.5 HP or 372.85 Watts, 220 Volts, 50 Hz, 1410 rpm, by conducting experiments and measurements to obtain measurement data for current, power and power factor of a single-phase induction motor without an inverter, as well as measurements of current, power and power factor of a single-phase induction motor with an inverter.

b. Data processing
From the data obtained from the experiment and measurement of a 1 (one) phase induction motor without using an inverter and using an inverter, the current value is obtained, the power and power factor of the 1 (one) phase induction motor and the data is used to calculate the use of electrical energy.

c. Data analysis
From the data obtained, the next step is to analyze the data to obtain the power and electrical energy values on a 1 (one) Phase AC motor without using an inverter with load conditions for a certain period of time, analyze a 1 (one) Phase induction AC motor using an inverter to determine the power and electrical energy values with load conditions for a certain period of time using an inverter. After that, it is done by

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comparing the use of electrical energy when the 1 (one) phase induction AC motor is in electrical energy without using an inverter compared to electrical energy using an inverter.

RESULTS AND DATA ANALYSIS

Testing Induction Motor.

In this study, testing of a single-phase induction motor using an inverter, using two (2) 1 (one) Phase induction motors. The image below is a model of a 1 (one) Phase induction motor power supply without using an inverter and using an inverter.

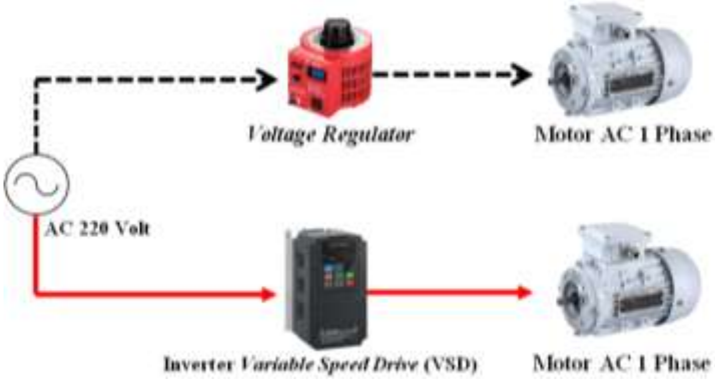

Figure 4. Single phase AC motor models without inverter and using inverter

Data collection through measurement of 1 (One) Phase AC motor without using an inverter and then for measurement data using 1 (One) Phase AC motor. The following are the measurement results of 1 (One) AC motor.

Table 1. Results of measuring voltage, current, power and electrical energy on 2 1 (One) Phase AC motors without using inverter

Time (hour)	Rated Voltage On Motor (V)		Rated Current On Motor (Ampere)		Total Power (kW)	Energy (kWh)
	1	2	1	2		
10.00. to 11.30	220	220	1.80	1.82	0.796	1,194

Table 2. Results of measuring voltage, current, power and electrical energy on a 1 (single) phase AC motor Using an inverter

Time (hour)	Rated Voltage On Motor (V)		Rated Current On Motor (Ampere)		Total Power (kW)	Energy (kWh)
	1	2	1	2		
12.00. to 14.30	217	218	0.93	0.95	0.408	0.612

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Calculation of power and electrical energy of a 1 phase AC motor without an inverter

Power consumption and electrical energy on 2 1 Phase AC motor units can be calculated using the following equation:

AC Motor Power To I

$$P_{m1} = V\,x\,I\,x\,\phi$$
$$= 220\,x\,1{,}80\,x\,0{,}85$$
$$= 336{,}6 \text{ Watt}$$
$$= 0{,}336 \text{ kW}$$

Electricity consumption of AC motor I:

$$W_{m1} = 0{,}336 \text{ kW } x\ 1{,}5 \text{ Jam}$$
$$= 0{,}549 \text{ kWh}$$

AC Motor Power II

$$P_{m2} = V\,x\,I\,x\,\phi$$
$$= 220\,x\,1{,}82\,x\,0{,}85$$
$$= 340{,}34 \text{ Watt}$$
$$= 0{,}340 \text{ kW}$$

Electricity consumption of AC motor II:

$$W_2 = 0{,}340 \text{ kW } x\ 1{,}5 \text{ Jam}$$
$$= 0{,}51 \text{ kWh}$$

The total electrical energy consumption of AC motors 1 and 2 can be calculated:

$$W_{\text{Total}} = W_{m1} + W_{m2}$$
$$= 0{,}549 + 0{,}51$$
$$= 1{,}051 \text{ kWh}$$

Calculation of power and electrical energy of 1 Phase AC motor using inverter

AC Motor Power Using Inverter To I

$$P_{m1} = V\,x\,I\,x\,\phi$$
$$= 217\,x\,0{,}93\,x\,0{,}85$$
$$= 171{,}538 \text{ Watt}$$
$$= 0{,}171 \text{ kW}$$

Electricity consumption of AC motors using inverter I:

$$W_{m1} = 0{,}171 \text{ kW } x\ 1{,}5 \text{ Jam}$$
$$= 0{,}256 \text{ kWh}$$

AC Motor Power Using Inverter II

$$P_{m2} = V\,x\,I\,x\,\phi$$
$$= 218\,x\,0{,}95\,x\,0{,}85$$
$$= 176{,}035 \text{ Watt}$$
$$= 0{,}176 \text{ kW}$$

AC motor electrical energy usage using Inverter II:

$$W_{m1} = 0{,}176 \text{ kW } x\ 1{,}5 \text{ Jam}$$
$$= 0{,}264 \text{ kWh}$$

Total electrical energy consumption of AC motors using inverters for 1 and 2 can be calculated:

$$W_{\text{Total}} = W_{m1} + W_{m2}$$
$$= 0{,}256 + 0{,}264$$
$$= 0{,}52 \text{ kWh}$$

The calculation result for the use of electrical energy from a 1 Phase AC motor is that if a 1 phase AC motor is supplied with electricity without an inverter as many as two AC motors, the electrical energy consumption reaches 1.051 kWh and if the 1 Phase AC motor is supplied with electricity using an inverter as many as two AC motors, the electrical energy consumption reaches 0.52 kWh. From these results, there are much lower electrical energy savings if using an inverter.

Calculation of the cost of electricity usage per kWh of electricity is Rp. 1,444, so it can be assumed that the usage is for 1.5 hours a day.

Without Using Inverter
Electricity Cost = 0.796 x 1.5 Hours x Rp 1,444 = Rp. 2,276
Using Inverter
Electricity Cost = 0.612 x 1.5 Hours x Rp 1,444 = Rp. 1,126

CONCLUSION

A 1 Phase AC motor when operated using two motors without being connected to an inverter, the power measured on the measuring instrument reaches 0.796 kW with electrical energy of 1.194 kWh. If a 1 Phase AC Motor is operated using an Inverter, the power measured on the measuring instrument will reach 0.408 kW with electrical energy of 0.612 kWh. The comparison of the use of electrical energy for a 1-phase AC motor using an inverter is lower than the use of electrical energy for a 1-phase AC motor without using an inverter, which can be used as a saving of electrical energy in monthly usage.

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