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The Comparison Of Starting Current In Three-Phase Induction Using Direct And Autotransformer Using Matlab Simulation

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ABSTRACT

Starting an induction motor can lead to a substantial initial current surge, causing a voltage drop that may surpass permissible limits. This surge, known as starting current, is characterized by a sudden and high-value current that occurs during the operation of a transformer or motor. Therefore, it is imperative to implement a proper starting method for a 3-phase induction motor. This study focuses on a 10 hp or 7.5 kW induction motor and employs Matlab simulation to analyze the starting characteristics. The simulation results reveal that an increase in the source voltage correlates with a proportional rise in the starting current. Adjusting the source voltage entering the Autotrafo provides a means to regulate and reduce the magnitude of the starting current. In the case of direct starting, the simulation indicates a starting current of 108.5 A at a speed of 1476 rpm, contrasting with a normal current of 9.218 A at a speed of 1464 rpm. On the other hand, starting with the autotransformer method yields a starting current of 76.14 A at a speed of 1467 rpm, with a normal current of 9.078 A at a speed of 1424 rpm. This results in a notable difference in starting current of 32.36 A. Comparatively, direct starting generates the highest starting current, emphasizing the necessity to avoid this method to prevent rapid motor breakdown. The autotransformer method proves to be a more efficient alternative, showcasing a reduced starting current and providing a more reliable and sustainable approach to initiate the induction motor.

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INTRODUCTION

The background of this research is based on the need to understand the differences in starting current in three-phase induction motors when using direct connection (DOL) and autotransformer methods. Three-phase induction motors are one of the most common types of motors used in various industrial applications. Starting current, also known as starting current, is the current that flows through a motor when it is first started.

The direct connection (DOL) method is the simplest and most commonly used method for starting a three-phase induction motor. In this method, the motor is directly connected to an electrical power source without any additional control devices. However, use of the DOL method can result in high starting currents, which can affect the power supply system and impact the life of the motor.

As an alternative, the use of an autotransformer to start a three-phase induction motor can reduce high starting currents. An autotransformer is a transformer that is connected to the power system and reduces the voltage applied to the motor at start-up. By reducing the voltage, the starting current can be reduced, thereby reducing stress on the motor and power supply system.

In this research, a comparative analysis of the starting current in a three-phase induction motor using the DOL and autotransformer methods was carried out using simulation using MATLAB software. This simulation allows researchers to model and analyze the starting current characteristics of three-phase induction motors under various operating conditions.

With a better understanding of the differences in starting current between the DOL and autotransformer methods, it is hoped that this research can contribute to selecting the appropriate connecting method for three-phase induction motors. Apart from that, this research can also provide useful information for designers and users of three-phase induction motors in designing systems that are efficient, safe, and can reduce the risk of failure due to high starting currents.

The emergence of an inrush current when the motor is started is one of the phenomena that occurs in electric power systems. Starting current is a current that has a fairly high value and is sudden in nature which arises when the motor starts to be operated. This current has a value several times the normal full load current. This current can occur in electrical equipment, including incandescent light bulbs, AC electric motors, power converters and transformers. This current can cause various disturbances in the electric power system. If there is no effort to reduce this current, both in the short and long term it will have a negative impact on the motor and the electric power system.

Literature Review

Induction Motor

An alternating current motor (induction motor) is a a machine whose function is to convert electrical energy into mechanical power or mechanical power, where this mechanical energy is in the form of rotation of the motor shaft. One type of AC motor is an induction motor or asynchronous motor. It is called an asynchronous motor because the rotation of the motor shaft is not the same as the rotation of the stator magnetic flux field. In other words, between the rotation of the rotor and the rotation of the magnetic flux there is a difference in rotation which is called slip. Polyphase induction motors are widely used in industry. This is related to several advantages, including:

1. Very simple and strong durability (construction almost never experiences damage, especially the type squirrel cage rotor).
2. Relatively cheap price and easy maintenance.
3. High efficiency. Under normal rotating conditions, no brushes are needed and therefore the resulting power losses can be reduced (especially winding rotor induction motors).

Working Principle of Induction Motor

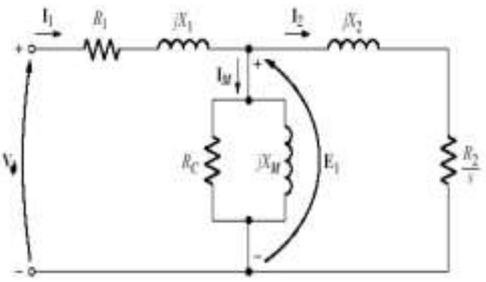
The rotation of the rotor in an induction motor is caused by there is a rotating field generated in the stator coil. This rotating field will occur if the stator coil is connected to a three-phase voltage source. The working principle is described as follows.

1. If a 3 phase voltage source is installed on the stator coil, a rotating field will appear with speed
2. The rotating field of the stator will cut the conductor rod on the rotor so that an induced voltage (Induced EMF) arises in the rotor coil.
3. Because the rotor coil is a closed circuit, current (I) will flow. A conducting wire (rotor coil) carrying current in a magnetic field will cause a force (F) on the rotor.
4. If the initial couple produced by the force (F) on the rotor is large enough to support the load, then the rotor will rotate in the same direction as the stator rotating field.
5. As has been explained, the induced voltage will arise due to the cutting of the conductor rod (rotor) by the rotating field of the stator. This means that in order for the voltage to be induced there needs to be a relative difference between the stator rotating field speed (ns) and the rotor rotating field speed (nr).

Induction Motor Equivalent Circuit.

The work of an induction motor is similar to that of a motor transformer is based on the principle of electromagnetic induction. Therefore, induction motors are seen as transformers that have special characteristics, namely:

1. Stator as primary side.
2. Rotor as the secondary side that conducts the conductor is short-circuited and rotates.
3. Clutch between primary side and secondary side separated by an air gap.



Figures 1. Wiring Circuit Equivalen.

The equivalent circuit of Figure 1 shows that the total power transferred across the air gap from the stator (power input to the rotor) is

$$P_r = 3I_r^2 \frac{R_r}{s}$$

From the equation above, the mechanical power generated by the induction motor,

$$P_m = P_r - P_{cu} = 3I_r^2 \frac{R_r}{s} - 3I_r^2 R_r = 3I_r^2 R_r \frac{(1-s)}{s}$$

$$P_m = T\omega_r = T\omega_s(1-s)$$

Wheres:

ωr = Rotor Speed in Rad/sec.

ω = Stator Speed in Rad/sec

Steady State Performance.

The condition of the motorbike in Steady State is a condition where the motorbike is in a steady state. Where there is almost no change in current, voltage, torque and speed. This Steady State is an overall picture of the motorbike which can be used as a reference for its use. Transient Performance. The transient or changing state is a momentary condition of the motorbike where the situation changes and can determine several important factors in motor control, while the Steady State state is a condition where the motorbike is in a steady state.

METHOD

Three-phase induction motors do not experience starting problems like synchronous motors. An induction motor can be started directly by simply connecting it to a voltage source. However, sometimes for better considerations this is not done. For example, the resulting starting current can cause a 'dip' voltage in the power system. For a three-phase wound rotor induction motor, starting can be done by adding resistance to the rotor winding through a slip ring. The addition of this resistance not only causes the starting torque to increase but also reduces the starting current. For induction motors with cage rotors, starting the induction motor can be done in many ways depending on the nominal power of the motor and the effective resistance of the rotor when the motor is started.

To determine the rotor current at starting, all current cage rotors have a letter code (so as not to be confused with the motor class design) on their nameplate. Code letter determines the amount of current at start. This limit is expressed as a function of horse power (hp). Table 1 is a table containing the risk VA/hp for each code letter. To determine the starting current of an induction motor, read the nominal motor power voltage (hp) and the code letter from the nameplate. Then the apparent power of the motor when starting is expressed as Sstart = (nominal horsepower)(codeletter factor)

RESULT

The test carried out aims to observe the starting current value in a three-phase induction motor. The three-phase induction motor name plates obtained are represented in Table 1.

Table 1. Induction Motor Name Plate

Parameter	Value
Maximum Power	Maximum Power kW
Voltage	400V
Frequency	50 Hz
Stator Resistance	0,73
(Rs)	8 Ω
Stator Inductance(Lis)	0,003 H
Rotor Resistance (Rr)	Rotor Resistance (Rr) Ω
Rotor Inductance (L Ir)	0,003 H
Mutual inductance (LM)	0,12 H
Speed Motor	1440 rpm

Each component is filled with parameters that are available on the name plate. After the simulation is run, the simulation results will be obtained in the form of a graph of current versus time as shown in Figure 2.

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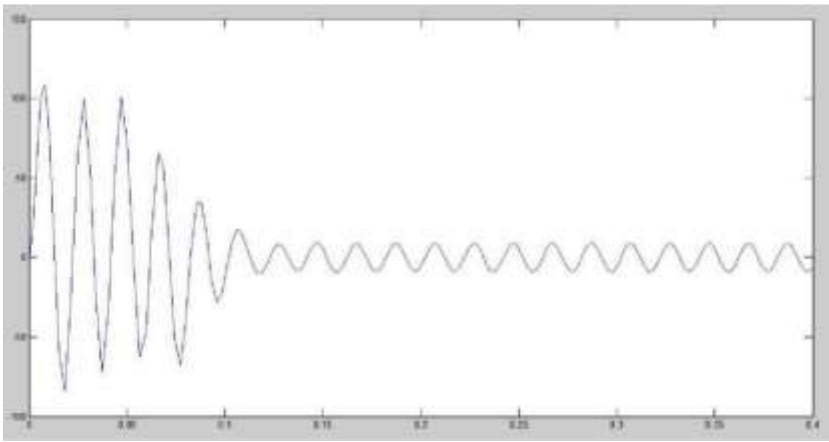

Figures 2. Direct starting current graph

From Figure 2 above, it can be seen that the motor's starting current is very large, reaching 108.5 A and then dropping to its normal value of 9.218 A. This very large current can cause damage to the motor. Apart from the motor current, the simulation results also show the motor speed. Figure 3 below represents motor speed (rpm) versus time.

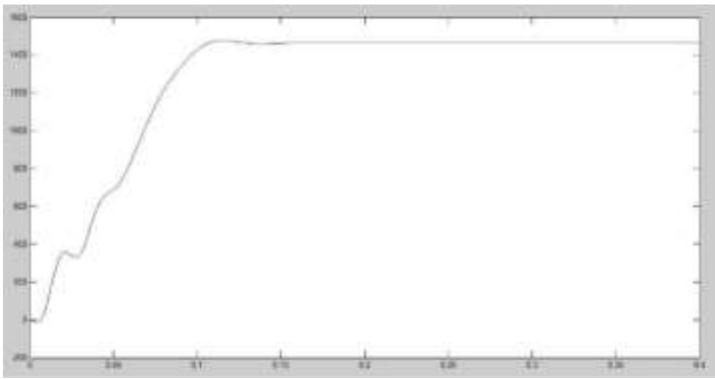

Figure 3. Direct starting speed graph

From Figure 3, it can be seen that the motor speed increases from t = 0 s to t = 0.2 s. During transients the motor speed rises to 1476 rpm and then drops to its normal speed of 1464 rpm. The next experiment is to run a simulation with the starting autotransformer, then the simulation results will be obtained in the form of a graph of the current versus time as shown in Figure 4, which shows the starting current of the autotransformer.

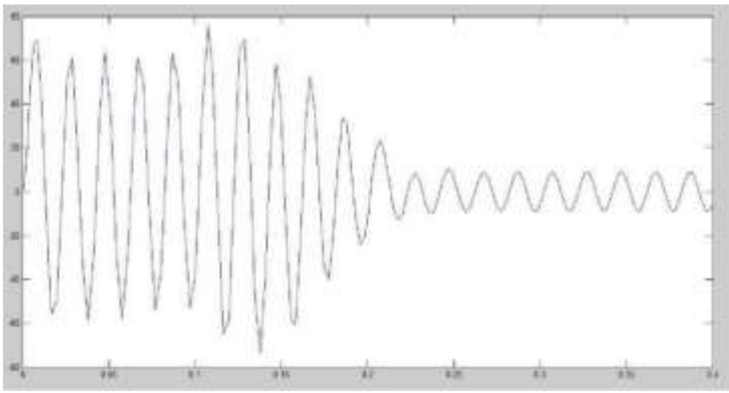

Figure 4. Current graph resulting from starting the autotransformer

From Figure 4 above, it can be seen that the motor starting current is very large, reaching 76.14 A and then decreases to its normal value of 9.078 A. It can be seen that there is a reduction in the motor starting current during direct starting, namely 108.5 A to 76.14 A by using autotransformer, or there is a reduction of 32.36 A. Apart from the motor current, the simulation results also show the motor speed. Figure 5. below represents motor speed (rpm) versus time.

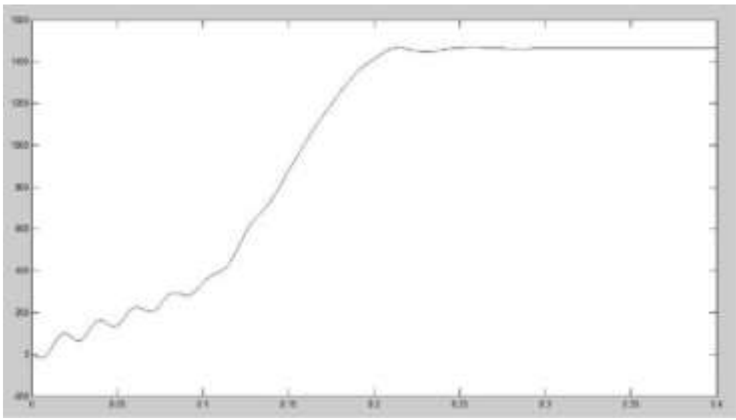

Figure 5. Graph of autotransformer starting speed

From Figure 5, it can be seen that the motor speed increases from t = 0 s to t = 0.2 s. During transients the motor speed rises to 1467 rpm and then drops to its normal speed of 1463 rpm. A comparison of the two methods above can be seen in Table 2.

Table 2. Comparison of Direct Starting and Autotransformer Results

Parameter	Transient		Normal	
pengasutan	Kecepatan	arus	Kecepatan	arus
Langsung	1476	08,5	1464	9.2
Autotrafo	1467	6,14	1424	9

CONCLUSION

From the simulation results of measuring starting current when starting an induction motor, the following conclusions can be drawn: The greater the source voltage provided, the greater the starting current. The source voltage entering the Autotrafo can be adjusted, so that the starting current that will be generated can be reduced in size. Starting using the Direct method produces a starting current of 108.5 A at a speed of 1476 rpm, while the normal current is 9.218 A at a speed of 1464 rpm. Meanwhile, starting using the autotransformer method produces a starting current of 76.14 A at a speed of 1467 rpm, while the normal current is 9.078 A at a speed of 1424 rpm. From these results, the starting current difference is 32.36 A. From the above starting, direct starting produces the largest starting current and this starting method must be avoided, because if you continue to use this starting the motor will quickly be damaged.

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