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Analysis af Thermal Overload Relay (TOR) as a Protection Component For 3-Phase Induction Motors in Plastic Seed Chopping Machines

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Article Info	ABSTRACT
Keywords: Thermal Overload Relay (TOR), Protection, 3-Phase Induction Motor.	Three-phase induction motors require a protection system to safeguard them from various electrical threats, such as overvoltage, overload, and short circuits. This study analyzes a protection system used in a plastic seed chopping machine, where a thermal overload relay (TOR) is implemented as an overload protection mechanism. The TOR functions as a load controller to prevent the motor from overheating and burning out during operation. Based on the analysis, the following results were obtained: Premium Efficiency 3-Phase Induction Motor HLS447SR0608 operates with a nominal current of 6.2 A. The appropriate TOR setting is determined by multiplying the nominal current by 120%, resulting in a setting of 7.4 A.Induction Motor Aeef Frame 112m 3 Phase operates at 5.9 A, requiring a TOR setting of 7.08 A. Siemens P21 Plus Efficiency Motor 3 Phase 1LA02864SE41 operates at 4.5 A, with an appropriate TOR setting of 5.4 A. Three Phase Cage Induction Motor ACI-225M-8 operates at 5.5 A, requiring a TOR setting of 6.6 A. These findings demonstrate that using a TOR as a protection component effectively prevents motor damage due to overload, ensuring the safe and efficient operation of three-phase induction motors in plastic seed chopping machines.
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INTRODUCTION

Electric machines play a very important role in driving the production process, especially in the process of shredding plastic seeds. Electric machines are able to provide maximum production results in a very short time. In addition, the use of electric machines can also make workers in carrying out their duties easier. The electric machine used for shredding plastic seeds is a 3-phase induction motor.

This 3 phase induction motor is used in production systems, especially in industry because it can work optimally. 3 phase induction motors require a protection system that can protect them from various threats such as Over Voltage, Overload, Short Circuit. So in this study, the protection system used for plastic seed shredders or called 3 phase induction motors is Thermal Overload Relay (TOR) which functions as an overload controller so that the 3 phase induction motor is not easily burned if damaged when the motor is operating.

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In this case, the use of Thermal Overload Relay (TOR) as a 3 Phase Induction Motor Protection System must be set according to the capacity of the induction motor, so that when an overload occurs, the Thermal Overload Relay (TOR) protection system will work automatically to cut off the current flowing to the motor so that damage can be avoided..

Literature Rview

Induction Motor

Induction motors are basically electromagnetic devices used to convert or change electrical energy into mechanical energy. The results of the changes or mechanical energy obtained can later be used for various purposes such as moving conveyors on machines, pumping fluids from one place to another on pump machines, blowing air on blowers and other purposes. In general, this induction motor is divided into two types, namely 1-phase induction motors and 3-phase induction motors.

The 3-phase induction motor has a construction that is almostsame as other types of electric motors. This motor has two main parts, namely the stator and rotor which are separated by a narrow air gap with a distance ranging from 0.4 mm to 4 mm. Induction motors work based on electromagnetic induction from the stator coil to the rotor coil. Basically, three-phase induction motors have two controls, namely star connection and delta connection.

Figure 1. Three Phase Induction Motor Construction

In running the production process, induction motors will be used continuously so that they are susceptible to interference. To overcome this, a protection system is needed that can protect it from various threats. In general, protection is defined as securing or protecting a particular system to prevent damage or unexpected things that have the potential to harm the system. Disturbances that often occur in 3-phase induction motors include overcurrent and overload. Overcurrent is a current disturbance where the current flowing in the circuit exceeds the normal current when the motor is under full load or Full Load Amps (FLA). Nominal current or FLA is the maximum normal current that the motor can accept without experiencing interference. Meanwhile, according to the National Electrical Manufacturers Association (NEMA), temperature rise is an increase in temperature above ambient temperature or room temperature.

Another purpose of the protection system on an induction motor is to prevent several losses such as internal heat losses of the electric motor, where the heat in the electric motor is caused by power losses generated by the electric motor itself. To overcome several losses and disturbances that often occur in induction motors, the protection system has a very

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important role. There are several components of the most commonly used protection system in induction motors, namely thermal overload relays.

Thermal Overload Relay(TOR) is a protective device that works based on the influence of hot temperature (temperature) where the flowing current will be converted into heat so that it affects the bimetal. This bimetal will then move the lever to stop the current flow if there is an excess current.

Figure 2. Thermal Overload Relay (TOR)

The numbering on the TOR includes numbers 1-3-5 which are the input contacts for the voltage source or input from the contactor on the main circuit (380V) and numbers 2-4-6 which are the output contacts to the electric motor on the main circuit as seen in the image below:

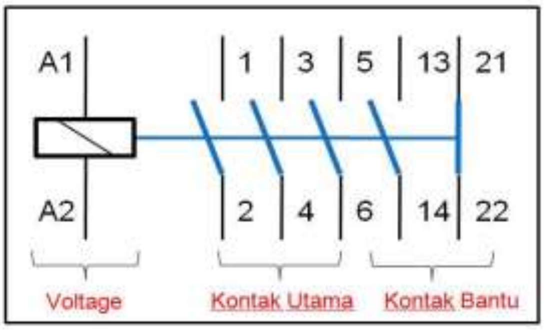

Figure 3. TOR contact diagram

The settings or adjustments on the overload relay on the TOR are the same as the nominal motor current settings, where the calculation equation for the amount of In (nominal current) is as follows:

$$I_n = \frac{P_{in}}{\sqrt{3} x V x Cos\phi} \quad (1)$$

Information:

V= Voltage (V)

P= Input power (W)

In = Nominal current (A)

Meanwhile, to calculate the nominal current setting on TOR for excess current, the following formula can be used:

$$I_{Set} = KxI_n \quad (2)$$

Information:
Iset = Current adjustment
K= Constant on overload relay (110%)
In = Nominal current (A)

Basically, Thermal overload relay has a more effective and economical level of protection, because it can function as overload protection, protection against phase imbalance (Phase failure inequality) and protection against loss or loss of phase voltage (Phase Loss). The way to set the maximum current that can pass through the TOR can be set by turning the current determinant using a screwdriver until the desired value is obtained.

RESEARCH METHODS

The method used in this field research refers to the Research and Development (R&D) method, which is a research method used to produce certain products, and test the effectiveness of these products. This data collection technique is sourced from journals and books. At the stage of theory planting, the input power value is calculated (P_{in}), where the next step is to find the nominal motor current (I_n). The calculation data obtained is used to find the setting current value (I_{Set}) on the TOR calculated using the formula to find out how much current is in accordance with the TOR to be used by referring to the capacity of the three-phase induction motor on the motor nameplate. Furthermore, at the empirical testing stage, data testing and validation are carried out, where this test aims to analyze the TOR through the presence or absence of a trip when the test is carried out.

RESULTS AND ANALYSIS

Thermal Overload Relay (TOR) Calculation

To minimize damage to each induction motor on the biofuel pellet molding machine, a protection system is used that will function as a safety device to prevent damage to the system or equipment on the machine due to overcurrent. The data obtained on each motor can be seen in the table below:

Table 1. Thermal Overload Relay (TOR) Calculation Data on Induction Motors

Induction Motor Name	Voltage (V)	Input power (W)	Nominal Current (A)	TOR Settings (A)
Premium Efficiency 3-Phase Induction Motor HLS447SR0608	380	3,468,5032	6.2	7.44
Induction Motor Aeef Frame 112m 3 Phase	380	3,300,6724	5.9	7.08
Siemens P21 Plus Efficiency Motor	380	2,517,462	4.5	5.4

Induction Motor Name	Voltage (V)	Input power (W)	Nominal Current (A)	TOR Settings (A)
3 Phase 1la02864se41 Motors Three Phase Cage Induction Motor Aci-225m-8	380	3,076,898	5.5	6.6

Based on the data in the table above, it can be seen that the larger the capacity of the induction motor used, the larger the trip setting used on the TOR. If there is a mismatch between the motor capacity and the trip setting value on the TOR, the motor will tend to be damaged when there is an overcurrent. To clarify the data, the following is a graph of the results of the TOR analysis containing the voltage value (V), nominal current (A), input power (W) and trip setting value on the TOR. The trip setting data on the TOR presented is obtained from the calculation results on each induction motor used. To find out the correct trip setting value on the thermal overload relay (TOR), it is necessary to first find the input power value (Pin) and nominal motor current (In).

Premium Efficiency 3-Phase Induction Motor HLS447SR0608

The motor functions to press the raw plastic seed material that enters the biofuel pelletizer molding machine's storage section. It is known that the voltage and current on each of these motors are 380 V and 6.2 A with Cosφ= 0.85

$$P_{In} = \sqrt{3}xVxIxCos\phi$$
$$P_{In} = 1,732x380x6,2x0,85$$
$$P_{In} = 3.468,5032W$$

The next step is to determine the nominal current (I_n) on the motor by referring to the results of the input power calculation (P_{In}) as follows:

$$I_n = \frac{P_{In}}{\sqrt{3}xVxCos\phi}$$
$$I_n = \frac{3.468,5032}{1,732x380x0,85}$$
$$I_n = \frac{3.468,5032}{559,43}$$
$$I_n = 6,2A$$

Based on the calculation, it can be seen that the nominal current on the motor is 6.2 A. Furthermore, to determine the appropriate trip setting value, the nominal current obtained is multiplied by 120%. Thus, the appropriate thermal overload relay (TOR) setting for the Premium Efficiency 3-Phase Induction Motor HLS447SR0608 is 6.2 x 120% = 7.4 A. A TOR is installed on this motor.

Induction Motor Aeef Frame 112m 3 Phase

This motor functions to pump oil to all parts of the engine. The oil is stored in a reservoir equipped with a thermo control that functions to monitor and control the temperature of the oil in the engine. It is known that the voltage and current on this motor are 380 V and 5.9 A with Cosφ= 0.85

$$P_{In} = \sqrt{3}xVxIxCos\phi$$

$$P_{In} = 1{,}732x380x5{,}9x0{,}85$$
$$P_{In} = 3.300{,}6724W$$

To determine the nominal current (I_n) on the motor by referring to the results of the input power calculation (P_{In}) as follows:

$$I_n = \frac{P_{In}}{\sqrt{3}xVxCos\phi}$$
$$I_n = \frac{3.300{,}6724}{1{,}732x380x0{,}85}$$
$$I_n = \frac{3.300{,}6724}{559{,}43}$$
$$I_n = 5{,}9A$$

Based on these calculations, it can be seen that the nominal current on the Aeef Frame 112m 3 Phase Induction Motor is 5.9 A. So, the appropriate thermal overload relay (TOR) setting is 5.9 x 120% = 7.08 A. A thermal overload relay (TOR) is installed on this motor with a current limit on the trip setting of 8 - 10 A.

Siemens P21 Plus Efficiency Motor 3 Phase 1la02864se41

This motor is used for maintenance, namely to clean the inside of the machine from dirt left over from plastic seed powder, you only need to run this motor so that all the dirt will fall into the container. After the dirt falls, this motor part can be opened to remove any dirt. It is known that the voltage and current on this motor are 380 V and 4.5 A

$$P_{In} = \sqrt{3}xVxIxCos\phi$$
$$P_{In} = 1{,}732x380x4{,}5x0{,}85$$
$$P_{In} = 2.517{,}462W$$

To determine the nominal current (I_n) on the motor by referring to the results of the input power calculation (P_{In}) as follows

$$I_n = \frac{P_{In}}{\sqrt{3}xVxCos\phi}$$
$$I_n = \frac{2.517{,}462}{1{,}732x380x0{,}85}$$
$$I_n = \frac{2.517{,}462}{559{,}43}$$
$$I_n = 4{,}5A$$

Based on the calculation, it can be seen that the nominal current on the Siemens P21 Plus Efficiency Motor 3 Phase 1la02864se41 motor is 4.5A. So, the appropriate thermal overload relay (TOR) setting is 4.5 x 120% = 5.4 A. A thermal overload relay (TOR) is installed on this motor with a current limit on the trip setting of 7 - 9 A

Motors Three Phase Cage Induction Motor Aci-225m-8

This motor has a function as a conveyor drive on the machine. The conveyor itself is a mechanical system that can move objects from one place to another. In this case, the conveyor belt will carry the molded plastic seed material and then take it to a temporary storage before entering the packaging section. On this motor, the voltage and current are known to be 380 V and 5.5 A. So to find out the trip setting value on the contactor, first find the input power value and nominal current

$$P_{In} = \sqrt{3}xVxIxCos\phi$$

$$P_{In} = 1{,}732x380x5{,}5x0{,}85$$
$$P_{In} = 3.076{,}898W$$

To determine the nominal current (I_n) on the motor by referring to the results of the input power calculation (P_{In}) as follows

$$I_n = \frac{P_{In}}{\sqrt{3}xVxCos\phi}$$
$$I_n = \frac{3.076{,}898}{1{,}732x380x0{,}85}$$
$$I_n = \frac{3.076{,}898}{559{,}43}$$
$$I_n = 5{,}5A$$

Based on the calculation results, it can be seen that the nominal current on the Three Phase Cage Induction Motor Aci-225m-8 is 5.5 A. So, the appropriate thermal overload relay (TOR) setting is 5.5 x 120% = 6.6 A. A thermal overload relay (TOR) is installed on this motor with a current limit on the trip setting of 7 - 10 A.

CONCLUSION

Based on the discussion that has been presented previously, it can be concluded that Thermal Overload Relay (TOR) is one of the protection devices that works based on the influence of hot temperature (temperature) where the flowing current will be converted into heat so that it affects the bimetal. This bimetal will then move the lever to stop the current flow when there is an overcurrent in the induction motor. As a component that functions to secure the induction motor, TOR must be set according to the capacity of the motor used. Therefore, TOR acts as a safety, the trip current setting value on TOR must be greater than the nominal current value on the motor, this is done to avoid current surges that can occur at any time on the motor

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