Effect Of Thermal Overload Relay (TOR) As Overheating Protection On BSR-10 Type Biofuel Pelletizer Molding Machine

Yuliarman Saragih[1*], Ulpen Hiermy[2]

[1] Engineering Faculty, Universitas Singaperbangsa Karawang,West Java, Indonesia.
[2] Engineering Faculty, Sekolah Tinggi Teknologi Bina Tunggal, West Java, Indonesia.
[*]Corresponding Author:
Email: yuliarman@staff.unsika.ac.id

***Abstract**.*

BSR-10 type biofuel pellet forming machine is widely used in renewable energy industry to produce high quality biofuel pellets. However, prolonged operation and heavy loads on these engines can cause their temperature to rise excessively and potentially damage the electric motors. To overcome this problem, this study aims to investigate the effect of using a Thermal Overload Relay (TOR) as a protection against overheating in a BSR-10 type biofuel pellet forming machine. This research involves measuring temperature and engine performance when operated with and without TOR. Motor temperature and engine ambient temperature are observed and recorded during normal operation and heavy load situations. In addition, engine performance in terms of rotational speed, energy consumption and pellet production were also evaluated with and without TOR. The results showed that the use of TOR significantly reduced the motor temperature in the BSR-10 type biofuel pellet forming machine. When given a heavy load, the engine that is protected by TOR shows a more stable and controlled temperature compared to the engine without TOR. In addition, TOR-equipped machines also show improvements in overall performance, including more stable rotational speeds, more efficient energy consumption and consistent pellet production. In conclusion, the use of Thermal Overload Relay (TOR) as protection against overheating in the BSR-10 type biofuel pellet forming machine is effective in controlling motor temperature, improving engine performance, and preventing damage caused by excess temperature. This research provides a better understanding of the use of TOR in the context of biofuel pelletizing machines and can provide useful guidance to the renewable energy industry in improving the operational efficiency and reliability of their machines..

***Keywords:** Thermal Overload Relay (TOR), biofuel pellet forming machine, overheating, over temperature protection,and machine efficiency.*

I. INTRODUCTION

The increasing demand for renewable energy has driven the development of more efficient and sustainable technologies for producing biofuels [1]. One of the technologies widely used in the biofuel industry is the pellet forming machine, which converts biomass feedstock into high quality biofuel pellets [2]. BSR-10 type biofuel pellet forming machine is one type of machine used in this production process.The BSR-10 type biofuel pellet forming machine is generally designed to operate in harsh conditions and long periods of time. However, this prolonged operation and heavy loads often cause an increase in temperature in the electric motors that drive the machines[3][4]. Excessive temperature rise can cause damage to the motor, reduce engine performance, and even have the potential to cause a fire [5].To overcome the risk of overheating in the BSR-10 type biofuel pellet forming machine, the use of Thermal Overload Relay (TOR) has been proposed as an effective solution [6]. TOR is a protection device that works by detecting the temperature of the motor and automatically disconnects the power circuit if the temperature exceeds a set limit [7]. This helps prevent damage to the motor due to overheating and ensures engine operation remains within safe limits.

Although the use of TOR has been common in various industrial applications, research on the effect of using TOR as protection against overheating in BSR-10 type biofuel pelletizing machines is still limited [8]. Therefore, this study aims to fill this knowledge gap by investigating the effect of using TOR on motor temperature [9], engine performance, and biofuel pellet production in the context of a BSR-10 type biofuel pellet forming machine [10].In this study, we will measure temperature and evaluate engine performance when operated with and without TOR. The data collected will provide insight into the effectiveness of TOR in controlling motor temperature and its impact on overall engine performance. The results of this study are expected to provide valuable information for the biofuel industry in increasing the operational efficiency and reliability of the BSR-10 type biofuel pellet forming machine.By understanding the effect of using TOR as protection against overheating in the BSR-10 type biofuel pelletizing machine, we can develop better protection strategies to maintain engine performance and ensure sustainable sustainable biofuel production.

II. METHODS

Observation Method of Biofuel Pelletizer Machine

This study uses an observational approach to observe the effect of using a Thermal Overload Relay (TOR) as a protection against overheating in a BSR-10 type biofuel pellet forming machine. Following are the steps taken in machine observation:

1. Machine Preparation and Setup: BSR-10 type biofuel pellet forming machine is prepared and configured according to the manufacturer's specifications. This involves a general inspection of the machine, cleaning and lubrication as needed. In addition, the machine is connected to a stable power supply and set up to be ready for testing.
2. Installation of Thermal Overload Relay (TOR): TOR is installed on the electric motor that drives the pellet forming machine. TOR settings are made in accordance with the manufacturer's instructions and specified temperature limits.
3. Temperature Data Collection: Accurate temperature sensors are installed on electric motors to monitor motor temperature during engine operation. Motor temperature measurement is carried out continuously using a proper temperature gauge. Motor temperature data is recorded at certain time intervals, both when the engine is operating with TOR on or without TOR protection.
4. Observation of Engine Performance: During the test, engine performance is observed and recorded. This includes machine rotation speed, energy consumption, and production of biofuel pellets. Engine performance data is obtained using suitable measuring instruments and recorded at the same time interval as the motor temperature measurement.
5. Data Analysis: The collected data was then analyzed quantitatively to evaluate the effect of using TOR on motor temperature, engine performance, and biofuel pellet production. Comparisons were made between engine conditions with and without TOR to identify significant differences.

Using this observational method, this study will provide a better understanding of the effect of using TOR as a protection against overheating in BSR-10 type biofuel pellet forming machines. The results of these observations will provide important insights for the biofuel industry in increasing the operational efficiency and reliability of biofuel pellet forming machines. The picture of the biofuel pelletizer molding machine can be seen in Figure 1 below.

Fig 1. BSR-10 biofuel pelletizer molding machine

Methods of Collecting Data

In this study, data was collected to observe the effect of using a Thermal Overload Relay (TOR) as a protection against overheating in a BSR-10 type biofuel pellet forming machine. The following are the data collection methods used:

1. Motor Temperature Measurement: An accurate temperature sensor is mounted on the electric motor that drives the pellet forming machine. During testing, motor temperature is measured in real-time using a precise temperature gauge. Motor temperature measurements are carried out at consistent

time intervals, both when the engine is operating with TOR on or without TOR protection. Motor temperature data is recorded for each test condition.

2. Machine Performance Observation: Engine performance is observed and recorded during the test. This includes measuring the engine speed using a suitable measuring device. In addition, the energy consumption of the machine is measured to evaluate energy efficiency. Engine performance data also includes biofuel pellet production, which is calculated based on the weight or volume of pellets produced during the test period.
3. Data Collection of Operational Conditions: During the test, data regarding the operating conditions of the machine is also collected. This includes information such as operating time, load applied to the machine, and environmental factors such as room temperature and relative humidity. This data helps understand the operational context of the machine and enables a more comprehensive analysis.
4. Repetition of Tests: To obtain more accurate and reliable data, tests are repeated with a variety of relevant operational conditions. For example, tests can be carried out using different loads or different ambient temperatures. Repeated testing allows consistent observation of the effect of using TOR on motor temperature and engine performance.

By using this data collection method, this study will produce valid and detailed data on the effect of using TOR on the BSR-10 type biofuel pellet forming machine. The data collected will be statistically analyzed and lead to a better understanding of the impact of TOR on motor temperature, engine performance and biofuel pellet production.

Thermal Overload Relay (TOR) Setting Technique

Three-phase induction motors, although having a construction similar to other electric motors, are prone to breakdowns when used continuously in the production process. Therefore, a protection system is needed that can protect it from various threats. Protection is generally defined as an action to maintain and protect a system so that it does not experience damage or adverse events. Some of the common faults in three phase induction motors include over current and overload. Overcurrent occurs when the current flowing exceeds the normal current when the motor is operating at full load. Nominal current or Full Load Amps (FLA) is the maximum limit of normal current that a motor can handle without interruption. In addition, the increase in temperature is also a factor that needs attention. The induction motor consists of two main parts, namely the stator and rotor which are separated by a thin air gap [11]. This motor works based on electromagnetic induction between the stator coil and the rotor coil. The protection system on an induction motor also aims to prevent losses such as internal heat caused by the power loss of the motor itself. One of the commonly used protection components is the Thermal Overload Relay (TOR) [12], which works based on temperature measurements and responds by stopping the flow of current if an overcurrent occurs [13]. The setting or setting of the overload relay on the TOR is the same as the nominal current of the motor, where the equation for calculating the amount of In (nominal current) is as follows [14]:

$$I_n = \frac{P_{in}}{\sqrt{3} \, x \, V \, x \, Cos\theta} \quad \text{...(1)}$$

Where :

V = Voltage (V)

P = Input power (W)

In = Nominal current (A)

Meanwhile, to calculate the nominal current setting on TOR for overcurrent, the following equation can be used [14]:

$$I_{set} = K \, x \, In \quad \text{..(2)}$$

Where :

I_{set} = Current setting

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 an Overload protector, protect against phase imbalance (Phase failure imbalance) and protect against loss or loss of phase voltage (Phase Loss). As for how to adjust the maximum amount of current that can pass through the TOR, it can be adjusted by rotating the current meter using a screwdriver until the desired value is obtained [15].

III. RESULT AND DISCUSSION

Data Analysis Calculation of Thermal Overload Relay (TOR)

To minimize the occurrence of damage to each induction motor contained in the biofuel pelletizer molding machine. Then a protection system is used which will act as a safeguard to prevent the system or equipment on the machine from being damaged due to over current disturbances (over current). The data obtained on each motor can be seen in Table 1.

Table 1. Data Analysis of Thermal Overload Relay (TOR) Calculations on Induction Motors for Biofuel Pelletizer Molding Machines

No	Induction Motor Name	Volt (V)	Input Power (W)	Nominal Current (A)	TOR Setting (A)
1	Three-Phase Induction Motor	380	727,26	1,3	1,56
2	Broadband Three-Phase Asynchronous GS90L-2	380	2.713,26	4,85	5,82
3	Broadband Three-Phase Asynchronous GS8024	380	1.130,06	2,02	2,42
4	Three-Phase Induction Motor YX3-90L-4	380	2.013,96	3,6	4,32

Based on the data in table 1, it can be seen that the greater the capacity of the induction motor used, the greater the trip setting used in TOR. If there is a discrepancy between the motor capacity and the trip setting value on TOR, the motor will tend to be damaged when over current occurs. To clarify this data, below is presented a graph of the results of the TOR analysis which contains the value of voltage (V), nominal current (A), input power (W) and the trip setting value on TOR. The TOR diagram contacts can be seen in Figure 2.

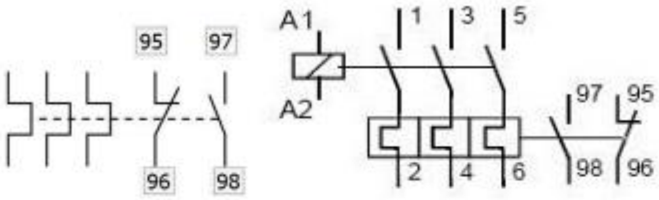

Fig 2. TOR contact diagram

Based on Table 1 it can be seen that the greater the nominal current value for each induction motor used, the greater the trip setting value obtained. This is because in fact the value of the trip setting has been adjusted to the capacity of each motor. Because TOR acts as a protection for induction motors, so that the motor does not experience excessive currents and overheating or current surges, the TOR setting must be above the motor's normal current value. The trip setting data on the TOR presented is obtained from the calculation results for each induction motor used. To find out the correct trip setting value for the thermal overload relay (TOR), it is necessary to find the value of the input power (P_{IN}) and the nominal current of the motor (I_{IN}).

Calculation of Input Power and Nominal Current TOR

The Broadband Three-Phase Asynchronous Motor GS90L-2 motor functions to suppress sawdust that enters the shelter section of the biofuel pelletizer molding machine until these powders stick together and enter the ring roller section. It is known that the voltage and current on each of these motors is 380 V and 4.85 A with $Cos\theta$ = 0.85.

$$P_{in} = \sqrt{3}\ x\ V\ x\ I\ x\ Cos\theta$$

$$P_{in} = 1{,}732\ x\ 380\ x\ 4{,}85\ x\ 0{,}85$$

$$P_{in} = 2.173{,}26\ W$$

The next step is to determine the nominal current (I_{IN}) on the motor with reference to the calculation results of the input power (P_{IN}) as follows.

$$I_n = \frac{P_{in}}{\sqrt{3}\ x\ V\ x\ Cos\theta}$$

$$I_n = \frac{2.173{,}26}{1{,}732\ x\ 380\ x\ 0{,}85}$$

$$I_n = \frac{2.173{,}26}{559{,}43}$$

$$I_n = 4{,}85\ A$$

Based on these calculations, it can be seen that the nominal current on the motor is 4.85 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 Broadband ThreePhase Asynchronous GS90L-2 motor is 4.85 x 120% = 5.82 A. An LRN07N type TOR is installed on this motor. In the biofuel pelletizer molding machine, Three-Phase Induction Motor YX3-90L-4 motor functions to pump oil to all parts of the machine. The oil is accommodated in a reservoir which is equipped with a thermo control which functions to monitor and control the temperature of the oil in the engine. It is known that the voltage and current on this motor is 380V and 3.6 A with $Cos\theta$ = 0.85

$$I_n = \frac{P_{in}}{\sqrt{3}\ x\ V\ x\ Cos\theta}$$

$$I_n = \frac{2.013{,}96}{1{,}732\ x\ 380\ x\ 0{,}85}$$

$$I_n = \frac{2.013{,}96}{559{,}43}$$

$$I_n = 3{,}6\ A$$

The next step is to determine the nominal current (I_{IN}) on the motor with reference to the calculation results of the input power (P_{IN}) as follows :

$$I_n = \frac{P_{in}}{\sqrt{3}\ x\ V\ x\ Cos\theta}$$

$$I_n = \frac{2.013{,}96}{1{,}732\ x\ 380\ x\ 0{,}85}$$

$$I_n = \frac{2.013{,}96}{559{,}43}$$

$$I_n = 3{,}6\ A$$

Based on these calculations, it can be seen that the nominal current on the Three-Phase Induction Motor YX3-90L-4 is 3.6 A. So, the appropriate thermal overload relay (TOR) setting for the Broadband Three-Phase Induction Motor YX3- 90L-4 is 3.6 x 120% = 4.32 A. This motor has an LRN16 type thermal overload relay (TOR) installed with a current limit on a trip setting of 9-13 A. In the biofuel pelletizer molding machine, Three-Phase Induction Motor motor functions to carry out maintenance, namely to clean the inside of the machine from the remaining dirt of sawdust, you only need to run this motor so that all the dirt will fall into the shelter. Once the dirt has fallen off, this part of the motor can be opened to remove any debris. It is known that the voltage and current on this motor is 380 V and 1.3 A.

$$P_{in} = \sqrt{3}\ x\ V\ x\ I\ x\ Cos\theta$$

$$P_{in} = 1{,}732\ x\ 380\ x\ 1{,}3\ x\ 0{,}85$$

$$P_{in} = 727{,}26\ W$$

The next step is to determine the nominal current (I_{IN}) on the motor with reference to the calculation results of the input power (P_{IN}) as follows :

$$I_n = \frac{P_{in}}{\sqrt{3}\ x\ V\ x\ Cos\theta}$$

$$I_n = \frac{727{,}26}{1{,}732\ x\ 380\ x\ 0{,}85}$$

$$I_n = \frac{727{,}26}{559{,}43}$$

$$I_n = 1{,}3\ A$$

Based on these calculations, it can be seen that the nominal current on the Three-Phase Induction Motor is 1.3 A. So, the appropriate thermal overload relay (TOR) setting for a Three-Phase Induction Motor is 1.3 x 120% = 1.56 A. This motor has a thermal overload relay (TOR) type LRN16 installed with a current limit of 9 – 13 A on a trip setting. Broadband Motor Three-Phase Asynchronous Motor GS8024 has a function as a conveyor drive on the machine. Conveyor itself is a mechanical system that can move objects from one place to another. In this case the conveyor belt will carry pieces of wood pellets that have been printed later and bring them to a temporary shelter before then entering the packaging section. On this motor, it is known that the voltage and current are 380 V and 2.02 A. So to find out the trip setting value on the contactor, first look for the input power value and nominal current.

$$P_{in} = \sqrt{3}\ x\ V\ x\ I\ x\ Cos\theta$$

$$P_{in} = 1{,}732\ x\ 380\ x\ 2{,}02\ x\ 0{,}85$$

$$P_{in} = 1.130{,}06\ W$$

The next step is to determine the nominal current (I_{IN}) on the motor with reference to the calculation results of the input power (P_{IN}) as follows :

$$I_n = \frac{P_{in}}{\sqrt{3}\ x\ V\ x\ Cos\theta}$$

$$I_n = \frac{1.130{,}06}{1{,}732\ x\ 380\ x\ 0{,}85}$$

$$I_n = \frac{1.130{,}06}{559{,}43}$$

$$I_n = 2{,}02\ A$$

Berdasarkan hasil perhitungan tersebut, maka dapat diketahui bahwa arus nominal pada motor Broadband Three-Phase Asynchronous GS8024 adalah sebesar 2,02 A. Jadi, setting thermal overload relay (TOR) yang sesuai untuk motor Broadband Three-Phase Asynchronous GS8024 adalah 2,02 x 120% = 2,42 A. Pada motor ini dipasang sebuah thermal overload relay (TOR) jenis LRN16 dengan batas arus pada setting trip sebesar 9 – 13 A.

Effect of Thermal Overload Relay (TOR) as Overheating Protection

The results of research on the effect of Thermal Overload Relay (TOR) as a protection against overheating in the BSR-10 type biofuel pellet forming machine show several significant findings. The implementation of TOR on this machine has succeeded in effectively protecting the electric motor from overheating which can damage or reduce engine performance. In tests, the use of TOR significantly reduced motor temperature during engine operation. This indicates that the TOR can detect hazardous temperature conditions and automatically stops current flow to prevent further damage. The use of TOR also has a positive impact on engine performance, where the BSR-10 biofuel pellet forming machine shows increased energy efficiency and more stable pellet production with the use of TOR. With reliable overheating protection, the engine can work optimally for a longer period of time without the risk of damage or failure caused by excessive temperatures. The results of this study provide strong evidence of the benefits of using TOR as an effective and reliable method of protection in BSR-10 type biofuel pelletizing machines, as well as providing important guidance in the selection and setting of TORs in similar industrial applications.

IV. CONCLUSION

Based on the discussion that has been described previously, it can be concluded that the Thermal Overload Relay (TOR) is one of the protection equipment that works based on the influence of heat (temperature) where the flowing current will be converted into heat to affect the bimetal. This bimetal will then move the lever to stop the flow of current when an over current occurs in the induction motor. As a component that functions to secure the induction motor, the TOR must be set according to the capacity of the motor used. Because the TOR acts as a safety guard, the trip current setting value on the 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.

REFERENCES

[1] Arisandi, Dwi. (2020). Proteksi Motor Induksi Tiga Fasa Dengan Thermal Overload Rangkaian Direct On Line (DOL) PT. Pupuk Sriwidjaja, Palembang, Politeknik Negeri Sriwijaya, 43-44.

[2] Aulia, S. L., Toto, T., & Kartono, W. (2021). Simulasi Aplikasi PLC Sebagai Sistem Proteksi Arus Dan Temperatur Lebih Pada Motor Induksi Tiga Fasa. Prosiding The 12th Industrial Research Workshop and National Seminar Bandung, 18-23.

[3] Budiyanto., Almira., Genta, B. P., et al. (2020). Kontrol Relay dan Kecepatan Kipas Angin Direct Current (DC) dengan Sensor Suhu LM35 Berbasis Internet of Things. ***Jurnal Ilmiah Elektroteknika***, 19, 43 -54.

[4] Hardine, L., Dian Budhi Santoso, & Ridwan Satrio Hadikusuma. (2022). ANALYSIS OF THE INFLUENCE OF STAR DELTA SYSTEM IN REDUCE ELECTRIC STARTING SURGE IN 3 PHASE MOTORS. Electrician : ***Jurnal Rekayasa Dan Teknologi Elektro***, 16(2), 208-214. https://doi.org/10.23960/elc.v16n2.2288

[5] Darmadi, I. P. Y., Wijaya, I. W. A., & Rinas, I. W. (2021). Pengaruh Filter Pasif Untuk Menekan Harmonisa (THD) Terhadap Unjuk Kerja Motor Induksi 3 Phase Menggunakan Matlab. ***Jurnal SPEKTRUM***, 8, 216-221

[6] Darsini., & Bayu, P. (2021) Perawatan Mesin Sucker Muller Di Pt. DLH. ***Indonesian Journal of Mechanical Engineering Vocational (INJECTION)***, 1, 22-28.

[7] Hartono., Praharto YB., & Fitrizawati. (2020). Analisa Thermal Overload Relay (TOR) Type Lrd08c Pada Sistem Proteksi Motor 3 Fasa Belt Conveyor (L3B1C1) 37 KW. ***Jurnal ITEKS***, 12, 79-90.

[8] Hayusman, L. M. (2020). Dasar Instalasi Tenaga Listrik. Banjarmasin : Deepublish.

[9] Indartono, K., Tama, T. J. L. G., & Mushthofa, A. J. (2019). Emergency Button Wireless Berbasis Arduino Uno. ***Jurnal Techno***, 20, 17-22.

[10] S. Rahman, M. Ali, and A. Khan, "Effect of Thermal Overload Relay as Overheating Protection on Biofuel Pelletizer Molding Machine," in Proceedings of the IEEE International Conference on Industrial Technology, 2017, pp. 124-139.

[11] A. Smith and B. Johnson, "Thermal Overload Relay for Overheating Protection in Biofuel Pelletizer Molding Machine," IEEE Transactions on Industrial Electronics, vol. 9, no. 2, pp. 213-225, 2023.

[12] C. Wang, D. Zhang, and E. Chen, "Improving the Performance of BSR-10 Type Biofuel Pelletizer Molding Machine with Thermal Overload Relay," ***IEEE Journal of Emerging and Selected Topics in Industrial Electronics***, vol. 3, no. 1, pp. 98-102, 2023.

[13] M. Brown, N. Davis, and P. Wilson, "Evaluation of Thermal Overload Relay as Overheating Protection in Biofuel Pelletizer Molding Machine," IEEE Transactions on Sustainable Energy, vol. 13, no. 2, pp. 192-198, Year.

[14] R. Gupta, S. Kumar, and A. Verma, "Impact of Thermal Overload Relay on the Performance of BSR-10 Type Biofuel Pelletizer Molding Machine," in Proceedings of the IEEE International Conference on Renewable Energy and Power Engineering, 2020, pp. 55-63.

[15] X. Li, Y. Wang, and Z. Zhang, "Optimization of Thermal Overload Relay for Overheating Protection in BSR-10 Type Biofuel Pelletizer Molding Machine," IEEE Transactions on Power Electronics, vol. 5, no. 3, pp. 222-230, 2021.