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Common Faults and Maintenance of Three-phase AC Asynchronous Motors

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ABSTRACT

Application of three-phase AC asynchronous motor in industrial applied in many aspect following function that need to use. In operation use, many troubles may cause motor equipment not to operate or break down by the motor itself or caused by a system including protection, control system, interlocking device, and others causes. Aiming at the actual situation that three-phase AC asynchronous motors are widely used and have a high failure rate, this paper focuses on analyzing the common failures and abnormal phenomena of three-phase AC asynchronous motors and their main causes. This Research Method is reinforced by the actual monitoring of the locality where the equipment is installed. At the same time, some specific preventive measures and treatment methods are proposed to timely discover and eliminate the potential accidents of motors as much as possible and ensure the safe operation of motors. In conclusion, the aspects that need to be considered are one by one. There are 2 general classifications to determine possible faults, the first is about the operating conditions that the equipment motor should monitor and take the scheduled data to know about the actual conditions including power quality, temperature rise, vibration analysis, and physical abnormalities during the operation of the unit.

Introduction

The three-phase AC asynchronous motor is the most common electrical equipment in industrial and agricultural production. Its function is to convert electrical energy into mechanical energy (Braunovic et al., 2017). It plays a huge role in industrial and agricultural production and brings great convenience to people's lives. It is also the most used motor. It has a simple structure, easy start-up, small size, reliable operation, strong and durable, and easy maintenance and repair (EKO, 2020). To ensure the safe operation of asynchronous motors, electrical workers must master the basic knowledge about the safe operation of asynchronous motors, understand the safety assessment of asynchronous motors, and do their best to discover and eliminate the hidden dangers of motor accidents promptly to ensure the safe operation of motors (Bhattacharyya et al., 2011). Electric motors are exposed to many kinds of disturbances and stress. Part of the disturbances is due to imposed external conditions such as over- and Under-voltage, over- and under-frequency, harmonics, unbalanced system voltages, and supply interruptions, for example, autoreclosing that occurs in the supplying network (Risdiyanto et al., 2013). Other possible causes of external disturbances are dirt in the motor, cooling system bearing failures, or an increase in ambient temperature and humidity. Stress factors due to abnormal use of the motor drive itself are frequent successive startups, stall, and overload situations including mechanical stress. The above stress and disturbances deteriorate the winding insulation of the motor mechanically and by increased thermal aging rate, which may eventually lead to an insulation failure. (ABB Distribution Motor Handbook Section 8.11 Motor Protection et al.,2011)

1. Select the type of motor according to the surrounding environment where the motor is installed.

There are two common types of motors: protective and enclosed. The protective type has better ventilation performance and is low in price. It is suitable for dry environments with less dust. If there is a lot of dust and water droplets splashing, a closed motor should be used. In addition, there is a sealed motor that can work in water. Electric submersible pumps use this type of motor (Popa et al., 2006).

2. Select the power of the motor according to the load conditions.

The power of the motor should generally be 1.1 to 1.5 times the power of the production machinery. If the power is too large, it will not only increase investment but also reduce mechanical efficiency and increase production costs. If the power is too small, the motor will be subjected to excessive load for a long time, which will cause the temperature to rise too high and damage the insulation, shortening the service life of the motor. (Tri Ananda, 2024).

The grounding of the motor is an important link, but some units often ignore this point, because the motor can run without obvious grounding, but this buries unsafe hidden dangers to production and personal safety. Once the insulation is damaged, the shell will generate dangerous voltage to the ground, which directly threatens personal safety and the stability of the equipment. (Khayam et al., 2017). Therefore, the motor must be safely grounded. The so-called motor grounding is to connect a metal part of the electrical equipment that is not charged under normal circumstances to the earth through a grounding device, and the grounding of the motor is the grounding of the metal shell. In this way, even if the equipment is grounded and the shell is short-circuited, the current will diffuse hemispherically to the earth through the grounding, and the current will form a voltage drop when it flows to the earth, thus ensuring the safety of the equipment and personnel (Lai et al., 2022).

To prevent the motor from burning out during operation, in addition to taking necessary technical protection measures before the operation, the most effective and practical way to prevent it is to perform correct technical maintenance. There are mainly 6 points:

1. Always keep the motor clean. When the motor is running, dust, water stains, and other debris are not allowed within at least 3 meters of the air inlet to prevent them from being sucked into the motor, forming a short-circuit medium, or damaging the insulation layer of the wire, causing a short circuit between turns, increasing current, and increasing temperature, which can burn the motor. Therefore, it is necessary to ensure that the motor has sufficient insulation resistance and a good ventilation and cooling environment to keep the motor in a safe and stable working state during long-term operation.
2. Keep the motor working at the rated current. The main reasons for motor overload are excessive load, low voltage, or mechanical jamming. If the overload time is too long, the motor will absorb a large amount of active power from the power grid, the current will increase sharply, and the temperature will rise accordingly. Under high temperatures, the insulation of the motor will age and burn out. Therefore, when the motor is running, it is necessary to pay attention to check whether the transmission device is flexible and reliable, whether the concentricity of the coupling is standard, and the flexibility of the gear transmission. If jamming is found, the motor should be stopped immediately to find out the cause and eliminate the fault before running again.

Ensure the normal operation of the starting equipment The technical status of the motor starting equipment plays a decisive role in the normal starting of the motor. The practice has shown that the vast majority of burnt motors are caused by the abnormal operation of the starting equipment. For example, the starting equipment starts with a phase loss, the contactor contacts arc, spark, etc. The maintenance of the starting equipment is mainly cleaning and tightening (RASYID, 2020). If the contactor contacts are not clean, the contact resistance will increase, causing heat to burn the contacts, resulting in phase loss and burning the motor; the iron core of the contactor suction coil is rusted and dusty, which will cause the coil to be loosely attracted, and strong noise will occur, increasing the coil current, burning the coil and causing failures. Therefore, the electrical control cabinet should be located in a dry, ventilated, and easy-to-operate location, and dust should be removed regularly. Frequently check whether the contactor contacts, coil cores, and various wiring screws are reliable and whether the mechanical parts are flexible so that they are kept in a good technical state, thereby ensuring smooth starting without burning the motor (Sheng & Wang, 2015).

This research tries to analyze and prove that the results of many conditions and also treatment for Three-phase induction motor can perform and indicate the preliminary actual condition of each motor.

Research Method

Actual Monitoring and Visual Examination

This research strengthens with actual monitoring of local where equipment is installed, the purpose of this method is to know the actual condition of equipment including:

a. Cleanliness of body motor and cooling way

b. Terminal box condition regarding corrosion or mechanical damage
c. Grounding connection
d. Appearance of noise at bearing and cooling fan
e. Cable condition including connection and conduit protection

Equipment Monitoring with Measurement Tools

Thermal Imaging Camera

Actual measurement of temperature when equipment is running is very necessary related to the temperature rises. Abnormal temperature can be defined by a Thermal imaging camera scanning at body motor and also the terminal connection.

Vibration Analyser

Measurement of vibration rotating equipment holds a main role in knowing the actual vibration that is generated when the unit running. Taking data using a Vibration analyzer can define the value of the vibration and also can make a preliminary diagnosis from the measurements.

Power Analyser

During equipment running, monitoring electrical parameters is helpful also to know about the health level of rotating equipment. The value of current for each phase (ampere), active power, and also reactive power can be monitored by Power Analyser tools.

Assessment Test 3 Phase Asynchronous Motor and MCC Equipment

Assessment Test of rotating equipment during stop condition is necessary to know the condition of the motor after running during unit power plant operation. Not only the rotating equipment that needs to be assessed, but supporting equipment also needs to be assessed to make sure no abnormal condition can affect the motor to operate or break down.

Insulation Resistance (IR) and Polarisation Index (PI) Test

The insulation Resistance Test (IR) aims to know about of insulation winding condition that works to protect the winding short with the body or grounding point. The Polarisation Index or PI Test defines fouling conditions that may arise because of environment or residue during operate a winding motor. An insulation Resistance test was also done at the cable power of the motor to avoid any ground leaking condition.

Winding Resistance (WR) Test

Winding Resistance (WR) Test used to measure the value of each phase (separate) winding motor and/or in Y or Delta connection. This assessment test is very useful to define the stability of resistance value.

Contact Resistance Test of MCC (Contactor and Primary Contact)

Contact resistance test of MCC Equipment to measure the value of resistance for each power contact that transferred big ampere to the motor still in below maximum standard value.

Results and Discussion

Actual Monitoring and Visual Examination

An environment that places rotating equipment is not limited only to indoor areas with clean conditions, there are many motors installed in dirty and open areas that may affect the equipment's performance. The deposit of dust usually collected at the fin of the airway body motor that causes heat produced during operation cannot be released.

Equipment Monitoring with Measurement Tools

Thermal Imaging Camera

Monitoring of actual temperature motor during running conditions is necessary to map the highest temperature at the surface area of the motor. Areas that show the highest temperature need to be analyzed and made sure still in standard or already over. Increasing the temperature of the motor can increase the friction of the bearing with the housing bearing and also cause by winding temperature that is loaded.

Regarding the Insulation Class of Motor, in general use minimum standard of Insulation Class is an F Grade. It means that the temperature working of the motor is not more than 155°C in the highest value. Of attached picture shows that during actual monitoring activity, measurements are at the surface area of the body motor with record the highest value.

Table 1
of NEMA Standard for Motor Insulation Class

NEMA Motor Insl. Temperature Ratings		Temperature Rise			
		1.0 SF Motors			1.15 SF Motors
Class	**Temp.**	**Ambient**	**Hotspots**	**Rise @1.0**	**Rise @1.15**
A	105	+40	+5	60	70
B	130	+40	+10	80	90
F	155	+40	+10	105	115
H	180	+40	+20	125	Not Defined

Figure 1
Actual Measurement of Body Motor

Not only actual temperature measurement of the motor, but other equipment that support unit of the motor can operate normally also must do actual monitoring. It's to ensure that the motor operates in a safe condition. The Motor Control Centre also called MCC plays a critical role in supplying power to the motor, The current that is transferred goes through the motor flowing from the MCC part, and the power cable produces excess heat that must be monitored during unit operation. Many factors can affect excess heat increase during unit operation that may initial dangerous conditions if not measure the actual condition.

Figure 2
Actual Monitoring Measure Temperature MCC

Figure 3
Excess heat causing damage to part of MCC Equipment

Vibration Analyser

Measure the vibration value of rotating equipment including 3 3-phase motors is necessary to know the actual condition of the motor following bearing condition, rotation, lack of lubrication, and other abnormalities. The vibration of the motor can be measured using a vibration motor and also a vibration analyzer to deeply analyze the actual condition that happens at the motor. The results of vibration measurement can refer to the ISO 10816 standard.

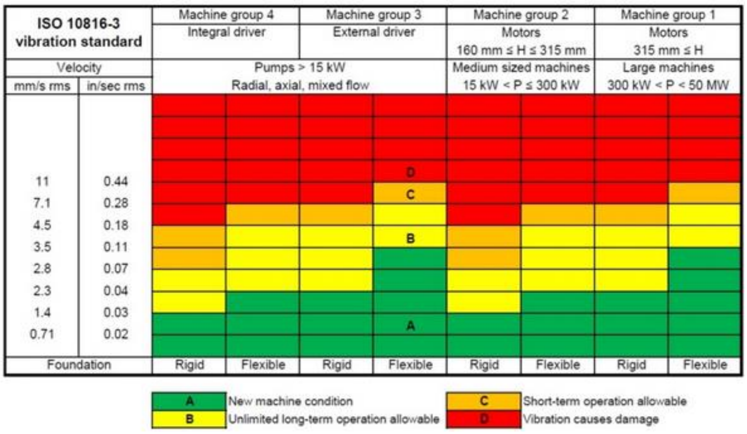

Figure 4
Standard ISO 10816 Vibration Rotating Equipment

Power Analyser

During motor operation, analysis of power that consumes the equipment is necessary to assure that power quality and balance of each phase can define and not excess than 10% of each phase. It is strongly connected with the temperature increase of winding and also excess power that may cause the equipment to break if running in an unbalanced condition.

Assessment Test 3 Phase Asynchronous Motor and MCC Equipment

Insulation Resistance (IR) and Polarisation Index (PI) Test

Insulation Resistance (IR) and Polarisation Index (PI) Test is a basic assessment for electrical motors and generators to define the condition before the equipment operates. Insulation Resistance will indicate with Ohm value in minimum value is Megaohm (MOhm) and/or GigaOhm (GOhm) that show that insulation paper and insulation coating of winding in good condition.

Table 2
of Reference Insulation Resistance Value

Guidelines for DC Voltages to be Applied During Insulation Resistance

<100	500
1000-2500	500-1000
2501-5000	1000-2500
5001-12000	2500-5000
>12000	5000-10000

*Rated line-to-line voltage for three-phase AC machines, line-to-ground voltage for single-phase AC machines, line-to-ground, voltage for single-phase machines, and rated direct voltage for DC machines or field winding.

The Polarisation Index (PI) Test is a motor and generator winding assessment test that equipment injected with DC voltage in 10 minutes and calculates the IR value in 60 seconds and 10 minutes. The value of the PI Test in scale or index number is the bigger the number indicating that the winding condition is in optimal condition.

Table 3
of Reference Polarisation Index Value
IEEE 43-2000

Explanation The Ratio of Values Polarization Index	
Polarization Index Value	Insulation Condition
<1.0	Dangerous
1-1.4	Poor
1.5-1.9	Questionable
2.0-2.9	Fair
3.0-4.0	Good
>4.0	Excellent

Winding Resistance (WR) Test

The winding Resistance Test is a non-destructive test applied to equipment motors generators and also transformers that are defined in Milliohm (mOhm). The value of each phase is not allowed more than 10% between each phase to avoid winding overheat during the equipment operation. It is related to excess heat that is produced during equipment operate can affect the winding insulation condition.

Contact Resistance Test of MCC (Contactor and Primary Contact)

Contact Resistance Test is an assessment test that is applied to electrical equipment that relates to contact open–close, including disconnecting switches, breakers, contactors, fuses, and others.

Contact Resistance test of MCC can applied to contactor and primary contact to avoid any improper closing contact. Frequency failure operation of MCC during start-stop equipment induction motor has a big contribution. This means this assessment test during unit equipment test is necessary to define the condition of MCC before the motor operates.

Contact Resistance test can assess the use microohm meter with injected high current to the contact pole 50A or 100A following standard. During unit powerplant stop, implementation of Contact Resistance test to assess MCC of each motor with large capacity found that after at least 1 year of equipment running contact resistance value of contactor has the possibility of failure of open-close or in operation condition.

Table 4

Motor	**R (μΩ)**	**S (μΩ)**	**T (μΩ)**	**Max Differential**
CEP 1A	85.8	96.8	84.1	126,15
CEP 1B	60.2	54.3	57.3	81.45
FDF 1A	59.8	103	68.8	**89.7**
FDF 1B	77.0	68.2	71.5	102.3
CCWP 1A	70.8	93.2	85.2	106.3
CCWP 1B	63.5	78.4	88.7	95.25
SAF 1A	79.3	100	95.4	118.95

SAF 1B	103	86.9	98.2	130.35

The table found that Force Draft Fan (FDF) 1B has a differential more than 1.5 times or more than 50% above another value for each phase following the standard.

As per **IEEE 450-2010:**

1. Define a minimum deviation of **50%** between phases.
2. In this case, simply multiply the lowest value by **1.5** and this will determine the maximum limit for other phases.

In case the contact resistance value of the contactor is unbalanced, it is necessary to do further inspection with an open contact surface area to inspect the actual condition. Found that in Force Draft Fan 1B contactor in each contact already worn and arching or spark footage during unit operates off to on condition or reverse. It means that contact resistance can define the condition of the surface contact area contactor with the value result.

Figure 6
Condition of the arching chamber and the surface of the contactor

Conclusion

Common failures of a 3-phase asynchronous motor or induction motor have many aspects that need to be considered one by one. There are 2 general classifications to define fault possibility, the first is about the operating condition which the equipment motor must monitor and take data scheduled to know about the actual condition including the power quality, temperature rises, vibration analysis, and physical abnormalities during unit operation.

The second is about non-operate or offline assessment tests when the unit is in stop condition or during a powerplant scheduled outage. Assessment tests also can define the healthiness of equipment motors such as Insulation Resistance, Winding Resistance, Polarisation index, and mechanical parameters including bearing, housing bearing clearance, greasing, and drain line condition.

Not only focused on the equipment of motor, supporting system or equipment also need to do actual monitor and offline assessment to avoid trouble that can be affected to the motor when operating condition. MCC unit has a vital role for equipment motors that many parts of MCC must check and assess during unit stop operation. One example of an assessment test that can to prioritized to maintain the reliability is Contact Resistance measurement of the power contactor, breaker, and also the primary plug that takes responsibility for transferring the power or current from the Main Power or Incoming to the motor directly.

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