Routine Test of Three Phase Induction Motor

Vishant Naik[1], Saurabh K Singh[2], Sahil Chawhan[3], Jatin Wankhede[4], Anand Nair[5] , Ankit Balpande[6]

[1,2]Asst. Prof. , Dept. of Electrical Engineering, S.B.J.I.T.M.R.Nagpur, Maharashtra, India
[3,4,5,6]Student , Dept. of Electrical Engineering, S.B.J.I.T.M.R.Nagpur, Maharashtra, India

---***---

Abstract- *Amongst many types of electrical motors, induction motors still enjoy the same popularity as they did a century ago. Several factors which include robustness, low cost and low maintenance have made them popular for industrial applications when compared to dc and other ac motors. Another aspect in induction motor drives which has been researched recently is the use of multiphase induction motors where the number of stator phases is more than three. Induction motor is one of the most important motor used in industrial applications. Induction machines are considered relatively reliable and robust due to their simple design and well-developed manufacturing technology. This paper aims to represent routine test performing in three phase induction motor. The computer based no load and blocked rotor test method are costlier and the electrical parameters cannot be visualized by Programmable Logic Controller (PLC) based method.*

KEYWORDS: Induction motor, No load test, Blocked rotor test, Vibration test, Temperature test, Phase sequence test, Insulation resistance test.

1. INTRODUCTION

The induction motor is one of the most important motors used in industrial applications. It is used to convert electrical energy into mechanical energy. Its low cost and high performance in addition to its reliability make them the most popular alternating current motors used in the industrial and commercial fields [1]. These motors have the flexibility of application fields; they can be used in low power applications such as household appliances or in large power applications such as petroleum industry. Despite the fact of high reliability of induction motors, the operating conditions may expose the machine into different fault conditions [4]. These faults may lead to machine shut down, thus causing industrial production losses. To protect the motor the faults must be detected in the initial stage. Early detection enables the maintenance engineers to take the necessary corrective actions as quickly as possible. The main reason for the motor faults is mechanical and electrical stresses [5].

The electrical stresses includes over-loading, single phasing, phase reversal, under voltage and overvoltage [3].

The testing of rotating electrical machine for constructional and electrical requirement can be verified without disassembling the machine.

Following tests are carried out on three phase induction motor to check the essential requirements which are likely to vary during production:

1) Measurement of winding resistance

2) Insulation resistance test

3) Vibration test

4) No load test

5) Blocked rotor test

6) Phase sequence test

7) Temperature test

These tests are carried out to prove conformity with the requirements of the standard. These are intended to prove the general qualities and design of a rotating electrical machine.

2. METHODOLOGY:

2.1 No load test

This test is intended to find out the no load current, loss, friction and wind-age loss.

2.2 Blocked rotor test

This test is intended to find out the voltage

2.3 Phase sequence test

Method – Phase sequence indicator meter

2.4 Measurement of winding resistance

Methods-

a] Megger

b] Wheatstone Bridge

c] Multimeter

d] Kelvin‟s Bridge

e] Kelvin‟s Double Bridge

2.5 Insulation resistance test

Method – Megger

2.6 Vibration test

Method – Vibration meter

2.7 Temperature test

Methods

a] Thermometer method
b] Temperature detector

2.1 NO LOAD TEST

The no load test on an induction motor is conducted to measure the rotational losses of the motor and to determine some of its equivalent circuit parameters. In this test, a rated, balanced ac voltage at a rated frequency is applied to the stator while it is running at no load. During this input power, voltage, and phase current are measured at the no load. The experimental setup of the no load test is shown in below fig. Fig.1.Circuit shown below is for no load test to obtain more reliable values ranges of both wattmeter should be 5A, 500 V for no load test. Similarly the range of Ammeter and voltmeter during no load test should be 5A, 500 V.

PROCEDURE:

To obtain on load current and its power factor angle θ no load test is performed at rated voltage and frequency. Let the readings of ammeter, voltmeter and no load power connected in the circuit be I_0, V_1 and P_0 respectively during no load test. Then,

$$\text{COS}\ \theta = \frac{P_o}{V_1 * I_0}$$

Hence, no load power factor angle θ can be calculated from the readings of wattmeter. No load current, I_0 has been directly measured by the ammeter.

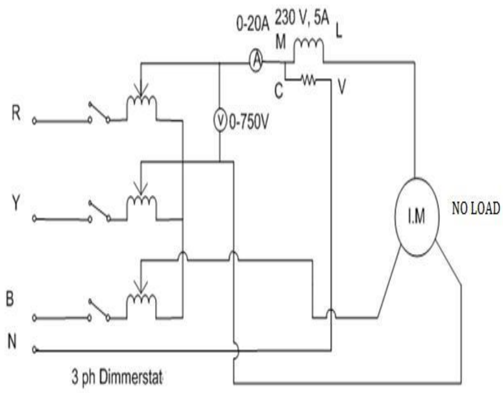


Fig 1.connection diagram of no load test

2.2 BLOCKED ROTOR TEST

In this test, the rotor of the Induction Motor is blocked. A reduced voltage is applied to the stator terminal so that the rated current flows through the stator winding. The input power, voltage and current are measured. The experimental setup of blocked rotor test is shown in below fig. fig.2. Circuit shown below is for Blocked Rotor Test to obtain more reliable values ranges of both wattmeter should be 10A, 250V for Blocked Rotor Test. Similarly the range of Ammeter and voltmeter during blocked rotor test, 10A, 250V.

PROCEDURE:

To obtain short circuit current and its power factor angle, block rotor test is performed on the motor. In this test, rotor is not allowed to move (blocked either by tightening the belt, in case provided or by hand) and reduced voltage (25 to 30 percent of the rated voltage) of rated frequency is applied to the stator winding. This test is performed with rated current following in the stator winding. Let the readings ammeter, voltmeter and power be I_{SC}, V_{SC} and P_{SC} respectively under block rotor condition. Then,

$$\text{COS}\ \theta = \frac{PSC}{V2 * ISC}$$

Short circuit current, I_{SC} observed during the block rotor test corresponds to reduced applied voltage, V_{SC}, which should be converted to rated voltage of the motor for plotting the circle diagram. The relation between the short circuit current and the applied voltage is approximately a straight line.
Thus, short circuit current, I_{SC} corresponding to rated voltage, V of the motor is given by,
Short circuit current, I_{SC} „ = $\frac{V * Isc}{Vsc}$

It may be remembered, that the power factor of the motor is quite low at no load as well as under blocked rotor condition. Thus, one of the wattmeter connected in the circuit will give negative reading in both the test, which may be recorded by reversing by terminals of the pressure coil or the current coil.

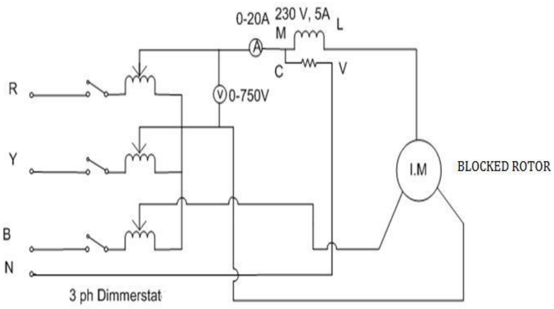


Fig. 2. Connection diagram of blocked rotor test

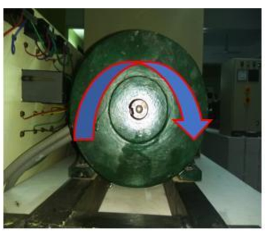
2.3 PHASE SEQUENCE TEST

It works on the principle of Induction Motor. The principle of rotating type phase sequence indicator is like that phase motor. Consider the working of a motor for a better understanding of these indicators.

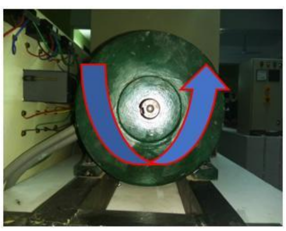
For this motors, we require three phase power supply, whereas thus three phase Power must be supplied in a sequence. Let us assume that the three-phase supply given to the motor has a phase sequence of RYB, then the motor will rotate in clockwise direction and if the phase sequence of supply is reversed, then the motor will rotate in antilock wise direction. This may cause severe problem to the load and entire system.

When a three-phase supply is given to the coils, then the coils will produce a rotating magnetic field, and this rotating magnetic field produces eddy EMF in routable aluminium disc.

The eddy EMF produces eddy current on the aluminium disc, due to the interaction of the eddy current with the rotating magnetic field a torque is produced which causes the aluminium disc to rotate. The clockwise direction rotation of the disc indicates the sequence as RYB, and the anticlockwise rotation of the disc indicates the change in phase sequence.



CLOCKWISE



ANTICLOCKWISE

The phase sequence meter is used for the direction of phase sequence in three phase circuit are different types of phase sequence indicator that are as follows:

Phase Sequence Indicator can be classified into two ways:

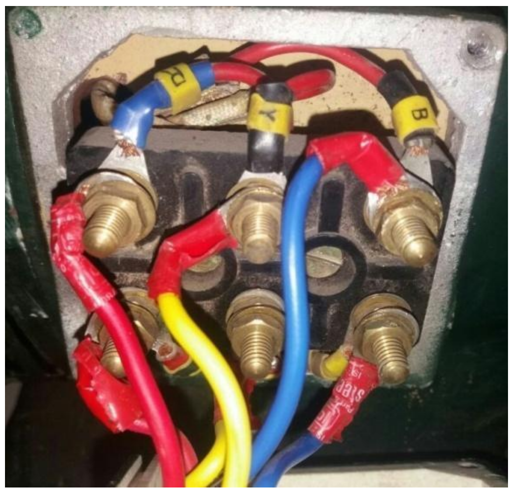
(a) Rotating Type
(b) Static Type

2.4 WINDING RESISTANCE TEST

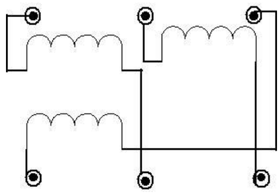
A typical 3-phase squirrel-cage motor has six connection leads in the electrical connection box for the three coils. If someone works with AC 3-phase motors, then it is important to know how to connect these motors in Star and Delta connection, and how to detect an electrical problem. There are basically 4 problems that the motor windings can suffer from:

- Broken coil (infinite coil resistance)
- Short-circuited coil (less than normal or zero coil resistance)
- Leaking coil to ground (current leaking from one coil to ground/neutral)
- Two or more coils short-circuited with each other (current leaking from one coil to another coil)

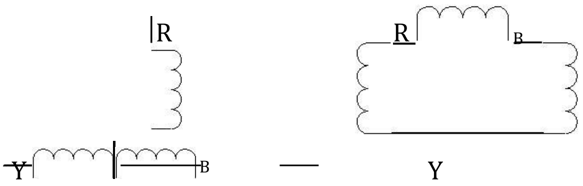
All of the above problems can be detected with a simple Ohm-meter. First of all, you need to understand how the coils are connected with the six motor leads that exist in the electrical connection box.



As you can see, there are indeed six leads arranged in two rows. Since each coil has 2 endings, it is easy to understand that these six leads can be separated in three pairs, and each pair is connected to one coil. It sounds logical to separate these 3 pairs in a vertical pattern, but that's not the way it goes. Instead, the pairs are in cross-pattern like this



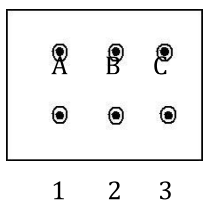
In a star connection, each one of the 3 phases (R-Y-B) is connected at one end of each coil. The other ends of the coils are connected together in a common point. A star connection can be easily accomplished simply by bridging one of the two horizontal rows in the connection box of the motor. The phases are then connected on the leads of the other horizontal row.



Star or Y connection Delta connection

Checking the coils of an unconnected motor

Being a motor unconnected, means that there are no Star or Delta bridges on its leads. This is the most straight-forward should resist current and keeps the current in its path along the conductor.case to understand. All you have to do is try to find the coil pairs in the electrical connection box. Let's give numbers to the 6 leads:



Suppose that you start from lead 1 and you want to find it's pair. You connect the first probe of the ohm-meter to lead 1, and then you connect the other probe of the ohm-meter to leads A, B, C, 2, 3 and ground (motor chassis).If the motor has no problem, then you must find infinite resistance between all leads and ground, except from one lead. This one cannot be lead A though, because -as we said- coils are connected in cross pattern.

Then, you repeat the same process but this time you connect the first lead of the ohm-meter to lead 2, and the second lead to leads A, B, C, 3 and ground. Notice that you do not need again between 2 and 1 since you've measured already before. Again, you must find infinite resistance between all leads and ground, except from one lead. This lead cannot be the one opposite to 2 (which is the lead B) and of course cannot be the lead that pairs with lead 1 (found from the previous measurement).

Finally, you repeat the same process with the first probe on lead 3, and the second probe on leads A, B, C and ground. Now, you know exactly which of these 3 leads pairs with lead 3. If for example you found that lead B pairs with 1 and lead C pairs with 2, then obviously lead A pairs with 3.

In short:

- You must find the same resistance between 3 pairs of leads ONLY
- These pairs must be in cross-pattern as explained before
- There must be absolutely no connection (infinite resistance) between all other combinations
- There must be absolutely no connection (infinite resistance) between the leads and the ground

2.5 INSULATION RESISTANCE TEST METHOD

Every electric wire in a system, motor is carefully covered with some form of electrical insulation. The wire itself is usually copper or aluminium, which is known to be a good conductor of the electric current that powers in equipment. The insulation must be just the opposite from a conductor: it

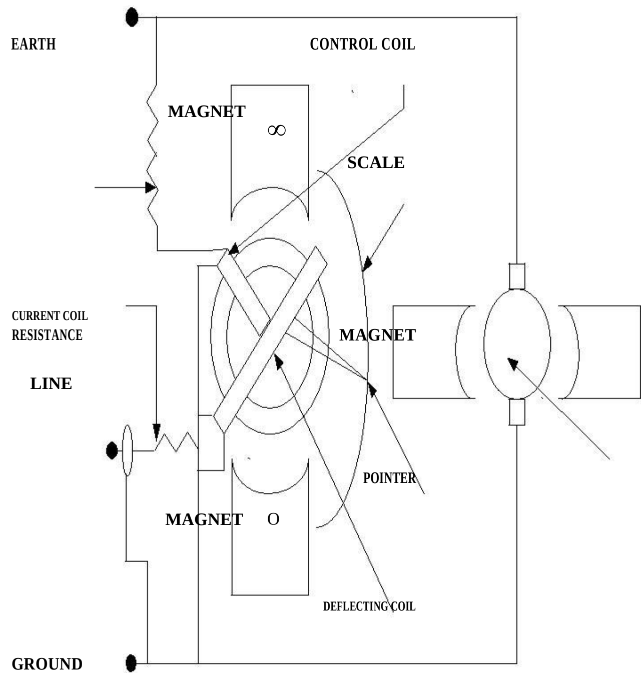


fig: Construction Of MEGGER

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 04 | April -2017 www.irjet.net p-ISSN: 2395-0072

Construction:

The important construction features of Megger consist of following parts:

1. **Control and Deflecting coil**: They are normally mounted at right angle to each other and connected parallel to the generator. The polarities are such that the torque produced by them is in opposite direction.

2. **Permanent Magnet**: Permanent magnet with north and south poles to produce magnetic effect for deflection of pointer.

3. **Pointer and scale**: A pointer is attached to the coils and end of the pointer floats on a scale which is in the range from "zero" to "infinity". The unit for this is "ohms".

4. **D.C generator or battery connection**: Testing voltage is supplied by hand operated D.C generator for manual operated Megger and a battery and electronic voltage charger for automatic type Megger.

5. **Pressure coil and current coil**: Provided for preventing damage to the instrument in case of low external source resistance

FACTOR AFFECTING INSULATION RESISTANCE READINGS

Current through and along insulation is made up partly of a relatively steady current in leakage paths over the insulation surface. Electricity also flows through the volume
of the insulation. Actually, our total current comprises three components:

1. Capacitance Charging Current

Current that starts out high and drops after the insulation has been charged to full voltage (much like water flow in a garden hose when you first turn on the spigot).

2. Absorption Current

Also an initially high current which then drops (for reasons discussed under the section Time-Resistance Method).

3. Conduction or Leakage Current

A small essentially steady current both through and over the insulation.

To understand insulation testing you really don"t need to go into the mathematics of electricity, Ohm"s law can be very helpful in appreciating many aspects. Even if you"ve been exposed to this law before, it may be a good idea to review it in the light of insulation testing.

Common sense tells us that the more voltage we have, the more current there"ll be. Also, the lower the resistance of the wire, the more current for the same voltage.

Actually, this is Ohm"s law, which is expressed this way in equation form:

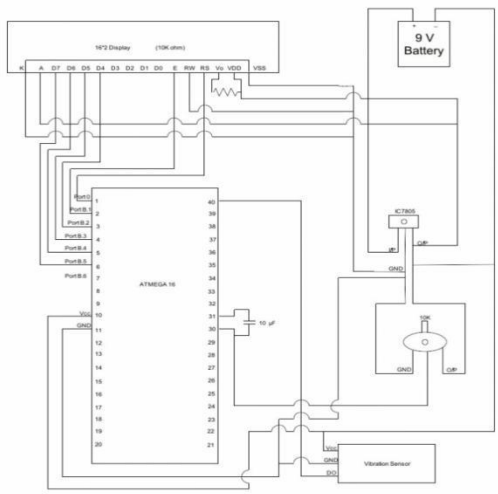
$$E = I \times R$$

where, E = voltage in volts
I = current in amperes

R = resistance in ohms

Note, however, that no insulation is perfect (that is, has infinite resistance) so some electricity does flow along the insulation or through it to ground. Such a current may only be a millionth of an ampere (one microampere) but it is the basis of insulation testing equipment. Note also that a higher voltage tends to cause more current through the insulation. This small amount of current would not, of course, harm good insulation but would be a problem if the insulation has deteriorated.

2.6 VIBRATION TEST

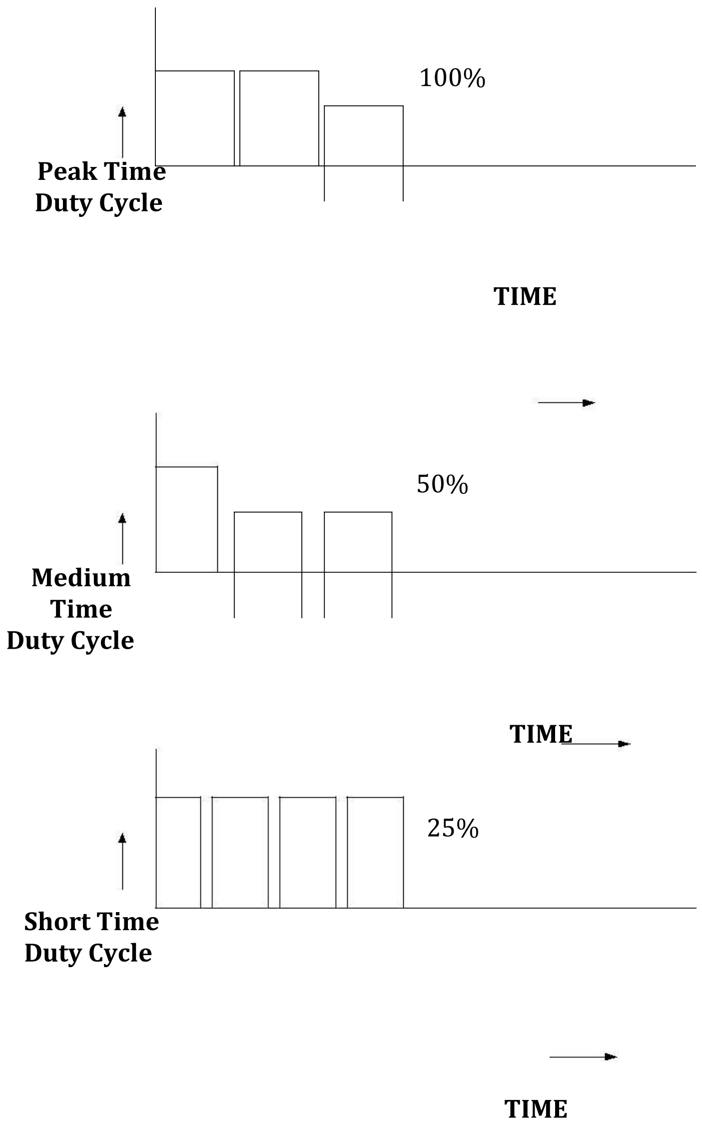


Connection Diagram

Vibration is the back and forth or repetitive motion of an object from its point of rest. When a force is applied to the mass, it stretches the spring and moves the weight to the lower limit. When the force is removed, the stored energy in the spring causes the weight to move upward through the position of rest to its upper limit. Here, the mass stops and reverses direction traveling back through the position of rest to the lower limit. In a friction-free system the mass would continue this motion indefinitely. All real systems are damped, that is they will gradually come to their rest position after several cycles of motion, unless acted upon by an external force. The characteristics of this vibratory motion are period, frequency, displacement, velocity, acceleration, amplitude and phase. Continued vibration of this spring mass system would only repeat the characteristics shown in this single cycle.

Vibration analysis is used primarily on rotating equipment such as steam and gas turbines, pumps, motors, compressors, paper machines, rolling mills, machine tools and gearboxes. Vibration analysis is used to determine the operating and mechanical condition of equipment.

Output Waveform:



VIII. TEMPERATUR TEST

Temperature is an important parameter in motor operation. Temperature can indicate any abnormality before any serious damage occurs. The two temperatures which are monitored at the bearing temperatures and the winding temperature. Abnormal winding temperature can cause damage to the insulation eventually leading to failure.

Bearing Temperature :

Bearing Temperature in motors is measured by temperature sensors which are machined in the bearing housing such that the tip of the sensor comes in contact with the bearing. These sensors are also connected to the temperature monitoring equipment
High bearing Temperature can be caused by improper alignment with the load, inadequate lubrication and even high ambient temperature.

3. Experimental Results

Output results of insulation resistance

Rating	Megger size	IR Value
745.7 watts	500 volts	25MΩ

Output result of no load and blocked rotor test

	Iph (A)	Vph (V)	(W)	Q (VA)	cos Φ	X1 (Ω)	X2 (Ω)	Xm	R1 (Ω)	R2 (Ω)
No-load	0.982112.58192.52 400.574					____	____	____	____	____
Blocked rotor test	4.2	20135.16829.050.16013. 05613.56						63.93	3.8	0.62

CONCLUSION:

In this chapter, a summary for the work that has been done in this project for achieving the objectives of the study is provided. Also conclusions from this work and suggestions for future work are presented. The rotor winding resistance shall be measured at the point of connection of rotor windings while the insusation resistance shall be measured between windings and frame..The vibration test is used to detect the vibration level of a particular motor. The no load test is intended to find out the no load current,core loss, friction and windage losses and the blocked rotor test is carried out to determine the copper loss of motor.(of rating upto 37kW).Also, temperature test primarily intended to determine the temperature rise at the bearing and the winding of the motor.

REFERENCES:

[1] G. K. Singh, "Multiphase Induction Machine drive research", Elsevier Journal, Electric Power System Research, Vol. 61, pp. 139-147, 2002.

[2] Emil Levi, "Recent Developments in High Performance Variable-Speed Multiphase Induction Motor Drives" Sixth International Symposium Nikola Tesla, Belgrade, Serbia. 18th – 20th October, 2006

[3] K. Gopalkumar, Mahopatra, "A novel scheme for six phase induction motor with open end windings." 28th Annual Conference of IEEE Industrial Electronics Society, Spain. 5th - 8th November, 2002.

[4] Hamid Toliyat, Emil Levi, "A novel concept of a multiphase, multi-motor vector controlled drive system supplied from a single voltage source inverter" IEEE Transactions on Power Electronics, Vol. 19, No. 2, pp. 320-335. March 2004.

[5] G. K. Singh, S. K. Lim, "A Simple Indirect Field-orien0ted Control Scheme for Multiphase Induction Machine", IEEE Transactions on Industrial Electronics, Vol. 52, No.4, August 2005.