F17/1685/2015

ASSIGNMENT: INDUCTION MOTOR APPLICATION

INDUCTION MOTOR IN CENTRIFUGAL WATER PUMP

Construction and ratings of motor

The motor was a squirrel cage rotor, three phase induction motor.

(The nameplate was covered with rust, information obtained from the technicians)

120A, 460V, 60HZ

DUTY: CONT. 40 DEGREES CELCIUS

SERVICE FACTOR: 1.15,

NEMA DESIGN: B, FRAME: 449-TS,

DATE-CODE: K92

CLASS INSUL: F, RPM: 2555

ORD. NO: 1RA04492DY62,

TYPE: RG, 20KG MASS

BRAND: SIEMENS

<u>**Description of Application**</u>

The induction motor was mounted at the back of the pump casing. In this, the rotor through a shaft was connected to the pump. There were bearings at the shaft. An impeller was then mounted onto the shaft. The impeller stays inside the pump casing where it's completely sealed in that you cannot see any of its components.

The centrifugal pump had two ports, an inlet and an outlet. The inlet was horizontal while the outlet was arranged vertically. The inlet allowed water in while the outlet allowed water out of the pump chamber. This gives the suction line at the input and a discharge line at the output.

The impeller was always submerged in water, otherwise it could not be able to draw sufficient amount of water to pump. This condition of lacking enough amount of water could lead to cavitation, where there was a low pressure build up in the pump chamber. In this case the water would actually start to boil inside the chamber as a result of low pressures caused by the high speed moving streams of air. This was a dangerous phenomenon that could destroy the impellers.

The pump casing had a volute, running around the circumference the former. The volute had an increasing diameter from inside innermost of the pump all the way up to the discharge. The change in diameter allowed more water to flow hence an increase in flow rate.

The impeller had curved vanes that run from the center all the way out to the outer edge. The water was allowed to move onto the surface of these vanes. Then vanes then rotated providing the water with a centrifugal force.

As the water entered through the inlet into the pump chamber, the torque of the impeller pushed the water towards the edge and was collected by the volute and found its way up.

The working principle of the impeller is that when it begins to spin, it creates a low pressure cavity inside the chamber. The low pressure cavity pulls the water by suction into the chamber through the inlet. The spinning water causes it to have a tendency of trying to move away from the center. This will be the radial force of the water. The water will also have a tangential force due to the rotating impeller vanes. The resultant of the two is a force that makes the water to move at a spiral trajectory. The volute shape matches this and as the water collects in the volute, it slows down and kinetic energy is converted into static pressure. The pressure that pushes the water and gives it a flow rate that allows it to move through the piping at the discharge or outlet.

The torque that does all the work comes from the induction motor. The power from the motor rotor gets transferred to the pump shaft through mechanical coupling.

Mechanical coupling

Mechanical coupling was the means by which power was transferred between shafts. Diaphragm type of coupling was used in this case. The coupling style was applied in that it could absorb misalignments between the two shafts and its ability to support large torque transfer at high speed with minimal slip. The special diaphragm shape had no movable parts hence had minimal wearing friction, with no need of lubrication. The method had minimal noise, backlash and was well balanced. The low backlash nature was a good feature of the coupling since backlash causes poor power factor of operation.

Power factor correction

Power factor improvement was done using capacitor banks arranged in either star or delta arrangement. The KVAR supplied by the capacitor was a leading one to counter the lagging KVAR of the induction motor. The power factor correction was done to reduce the wasted current since at low power factor the current drawn and KVA intake is high for a low amount of real power consumed by the motor. This correction was done by connecting the capacitors in parallel to the motor. Using a delta connection we connected from each tip of the delta connection to any of the phases going into the inputs of the motor. The capacitors were arranged in parallel so as to make sure the arrangement was reliable, in that any failure of the capacitors would not stop the working of the motor. Overall the amount of current flowing from the distribution line was reduced and hence reduced the cost of bills.

Protection of motor

The motor was protected from overload of currents by use of circuit breakers. In case of short circuit, the motor draws a lot of current which can burn out the windings. To prevent this, the motor circuit breaker limits the amount of current the motor draws from the mains. Indeed this current is high at starting of the motor therefore the circuit breaker was at a threshold value higher than starting current value. This was protection against:

- Phase to phase short circuit
- Winding to phase short circuit
- Winding to neutral

Speed control and Braking

The motor operated at constant speed since there was always water when switched on to start.

Braking could be done by counter current application. In this case the torque developed was in opposite direction to the rotation direction. This would develop heating which subsided after a while.

Safety devices

The motor's casing is earthed to protect against electrocution in case of leakage in current. The casing had also allowance to screw the motor to the ground and hold it firmly to the ground to avoid vibrations at high speed.

The casing was strong enough so as not to have any danger of exposure of the high speed moving motor. The connection wires into the stator were well insulated to prevent electrocution or unnecessary short circuit between phases.

Reasons for choice of these motor and its advantages

The cage rotor in this particular application was cheap, rugged and very maintenance-free. It's made of two major parts; the rotor and the stator. The stator is stationary without any wear and tear. The rotor only wears out its bearings which can be replaced.

The coupling method also allowed minimal movement between shafts hence low friction between parts.

The motor is self-starting; by simply applying a voltage to the three terminals, torque is induced and the machine starts working immediately. This reduces complexity of maintenance and operation.

The motor has a high starting torque which makes it more useful since the pump starts its operation with water already on the curved vanes of the impeller. This means the starting load must be high to support this initial propulsion.

The motor is also simple in its construction. This makes it cheap to maintain and has a longer life of service due to less movable or detachable parts.

With the three phase motor, if one of the phase undergoes failure, the motor continues to operate until the other phase fault is corrected.