

Efficiency improvement in Electrical Utility: A Review

Yogesh Katdare¹, Aditya Bhosale², Akshay Repal³, Aniruddha Khedekar⁴, Siddhesh Salunke⁵

¹Assistant Professor, VPM's MPCOE, Velneshwar, Maharashtra, India

^{2,3,4,5}Student, VPM's MPCOE, Velneshwar, Maharashtra, India

Abstract - *the thermal power plant plays a leading role in power generation world. This study paper covers some facts about measure and improving efficiency of power plant equipment. And the scope of study analysis shows the technical efficiency of power plant to understand any improvement in efficiency due to modernization and renovation process in thermal power plant. It is very well-known that in thermal power plant such problems in rotating mechanism, boiler, and electrical equipment occur while doing power generation. Apart from these, heat energy also wasted in the form of leakage or exhaust of steam turbine. So this waste of energy must be utilized for improving the efficiency of power plan which can be achieved by re-designing some devices like impeller, steam vessels etc. This satisfactory design also includes estimation of cost, selection of proper ratings motors and alternator, proper selection of physical place of equipment etc. Overview the thermal power plant is very important for its better functioning and maintenance.*

1. INTRODUCTION

In thermal power plant, most popular electrical machine is three-phase squirrel cage induction motor, which is used for boiler feed pump, condensate extraction pump, cooling tower fan. It is popular in many industries because of its rugged construction and reliability. Voltage levels of such three-phase induction motors are 3.3KV, 6.6KV, 11KV. The efficiency of motor is affected by few losses which include resistance losses, mechanical losses due to friction, losses due to dissipation of magnetic energy in core and different losses depending upon type of material used and large amount of variations in load. In order to make motor more efficient losses must be controlled. Following are some standard methods which are being used for improving efficiency of motor.

1.1 CONVENTIONAL METHODS

1. Mechanical protection—

The purpose of yoke of a motor is to provide mechanical protection to the stator and rotor windings. It is also responsible for the interface for installation through feet. The motor frame plays critical role in its thermal performance because it is responsible for transferring the heat generated inside the motor out to the frame surface where air blown by the fan will promote heat dissipation. This will reduce heat losses. [8]

2. Reduced stator losses—

Stator which is major component of the motor is cause of 60% losses so, in order to reduce these losses, mass of Stator winding must be kept larger as the increase in the mass will reduce the electrical resistance. Motors that are highly efficient contain 25% extra copper as compared to motor that are designed for standard efficiency models. [8]

3. Reduced rotor losses—

Rotor losses are also major amount of losses taking place in the motor, which are caused due to rotor current (i.e. rotor copper losses). Slip is the difference between speed of the magnetic field and the actual speed of the rotor at a given load. Where slip is obtained by subtracting speed of motor at full load from speed of motor at no load and divided by speed of motor at full load. Rotor losses are reduced by using high conductivity material for rotor. Copper must be largely used because copper has high conductivity but copper must be die-cast as recently process has developed for die casting of copper. [8]

4. Core losses—

Core magnetic losses consist of hysteresis losses, Eddy current losses and saturation of magnetic core. These losses can be minimized by using good quality of materials and quality control to improve efficiency. Also reduce the effect of hysteresis and saturation steel containing small amount of silicon to be used in lamination instead of lower cost carbon steels. In this way core losses can be removed. By reducing the thickness of lamination and increase the length of lamination, can minimize the flux density also and core losses. By ensuring proper insulation between the sheets of lamination used eddy current losses can be largely minimized.[8]

5. Installation place—

This is another basic method which is adopted to keep minimum gap between any walls positioned near the back of the fan cover to allow air intake. Periodically checking is done for any air blockage that can reduce the cooling system performance. Motor surrounding is also kept clean. This will result in having more lives span. [8]

1.2 MODERN METHODS USED

1. Variable frequency drive—

Variable frequency drive is a device used to control speed of 3 phase induction motor. Speed control is achieved by varying voltage and frequency of motor supply. VFD is basically a power electronics device consisting of 3 stages, viz. rectifier, dc link and inverter. By adjusting frequency of switching devices of inverter by PWM technique, voltage frequency can be adjusted. In short, VFD converts fixed frequency fixed voltage supply into variable frequency variable voltage. By doing this, soft starting of 3 phase induction motor is achieved along with its smooth operation during running (full load) condition. VFD is also popularly called by some more names like, variable speed drive, adjustable speed drive, soft starter etc.

Use of VFD offers various advantages like energy saving, increased reliability, soft starting, speed variations, extended machine life, less maintenance, high power factor, slip power recovery, etc. Energy conservation achievement is the highest priority based reason because of which use of VFD is increasing in modern industries. As per the paper [11] presented by Mr. Ankur P Desai, it can be concluded that if the net head increases then a flow of pump can be control with throttling. To minimize this extra head the motor draws more power. A variable frequency drive is useful in the pumping system. A variable frequency drive reduces the flow then motor consume very less power. So more amount of energy can be saved with the help of variable frequency drive. VFD is also used for soft starting and therefore motor draws very less current and it also provides a smooth stopping of motor. Therefore the losses occur in the motor can be minimized. [11]

Ultimately VFD is a power conversion device which converts electrical power of fixed voltage and frequency into variable voltage and frequency. The electrical power in many industries is consumed by electrical motors. That Power consumed by the electrical motors can be saved by using variable frequency drive. According to the paper [2] presented by Prasad Bhave, it is studied that energy conservation of induction motor is archived by using variable frequency drive at some limit. It is found that in variable torque type of load 20% reduction in speed of induction motor reduced about 45% energy consumption. Similarly, for constant type of load application 20% reduction in speed reduces about 20% energy consumption. Variable frequency drive consists of power electronic devices to vary the frequency of supplied power to the motor. Alternating current passed through the stator winding produced magnetic field that rotates the motor at synchronous speed. This speed can be measured by the line frequency by the number of magnetic poles in the motor winding. Rotor speed slightly behind the rotating field called as slip. This small slip generates an induced current and the resulting the magnetic field in the rotor produces the torque. As an induction motor rotate near synchronous speed, the most effective and energy efficient way to change the motor speed is to change the frequency of the applied voltage. Therefore speed can be controlled by the changing supply frequency of motor. A life of mechanical equipment increases because of soft starting and stress on motor also reduces. A source voltage is constant when input current is less than output current. Power consumption depends on the motor speed. Variable frequency drive provides more efficiency and also improves power factor. According to affinity laws and equations energy can be saved when speed of the induction motor can be controlled by using variable frequency drive. So, large amount of energy can be saved by reducing a little amount of speed. [2]

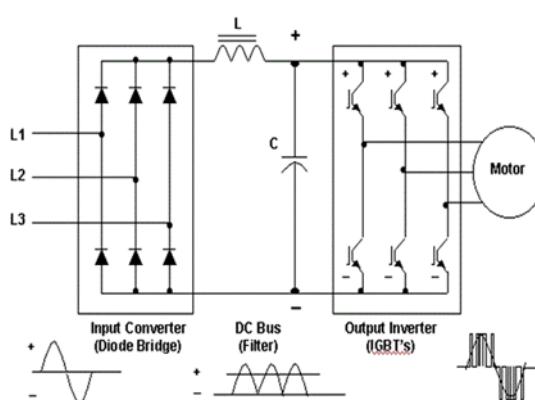


Fig. 1 Variable frequency drive circuit diagram

A Variable frequency drive is a new technology to minimize the use of electric power. A variable frequency drive is an adjustable speed drive used in electro-mechanical drive systems to control AC motors speed and torque by changing motor input frequency and voltage. In the paper [4] presented by Nasir Khalid, it has been put forward that last few years the cost of electric power has increased expressively. Many researchers and manufacturers have been trying to find ways to minimize the use of electric power. The energy can be saved by using variable frequency drive. In thermal power plant mostly main motor running at constant speed can conserve energy when they are operated on VFD. Such energy cost savings are generally used in centrifugal fan and pump application. [4]

2. Impeller trimming -

Impeller trimming is done to match operating Point, which is done by reducing the impeller diameter which in turn results in reduction of circumferential speed at outlet of centrifugal pump of impeller. High discharge flow due to impeller has larger diameter than impeller with smaller diameter. Energy required is more for high discharge flow therefore for required operating specification it is advisable to use impeller trimming method which ultimately improve pressure distribution of impeller outlet, decreases shaft power and conserve electrical energy required for pump. [6-7]

The paper [9] presented by T N Raval, presents an idea about impeller trimming. According to this paper, pump requires more power to run and it produces more head which is more than its required value if impeller diameter is higher than required value. To overcome this difficulty diameter of impeller can be reduced by matching desired value of head and discharge can be attained. It should be noted that geometric and kinematic similarity condition may not be preserved completely after trimming of pump impeller and impeller inlet to outlet diameter ratio may get change. As the blade angle varies with radius of impeller outlet diameter then there is no chance of matching kinematic similarity. It also found that with decrement of impeller diameter, clearance between the impeller and fix pump casing can be increased. Because of such effect paper concludes that pumps impeller diameter can be trim up to 75%. [9]

Valve opening of pump also affects the loading of motor because ultimately that load must be driven by motor, so sometimes improper openings of valve may create overloading problem of motor. According to the paper [10] presented by L M Tsang, it can be concluded that impeller trimming is used to limit the motor loading and also used to reduce the head. When the valve at the pump outlet is not fully open but the current has already reached to its rated value, so further opening of the valve will cause overload. To maintain such a head of pump at the rated current the valve may be either fully open or partially closed with impeller being trimmed. It is impossible to make a single trimming due to some factors and therefore only trial and error method is employed. [10]

Impeller trimming assists to improve efficiency in pumping system. This is beneficial because improving pumping efficiency ultimately results in improving efficiency of motor by reducing its load as well as hydraulic and mechanical efficiencies also improve. The paper [12] presented by Wen-Guang Li, focuses on some facts about efficiency improvement in pumping system by impeller trimming. As per this paper, Impeller trimming improves efficiency and this improving efficiency effect is most likely related to improvement in hydraulic and mechanical efficiencies. If the flow rate or head of the pump exceed system requirements, the impeller should consider to be trimmed. Impeller trimming is a proper method to alter performance of centrifugal pump with constant speed to meet the demand on the specified flow rate and head of the pump. Benefits of impeller trimming are reducing maintenance and operation costs, vibration and wear in pipeline, relief of noise. [12]

3. De-staging of impeller -

Pump contains different stages within the piping system where force is applied to the water. Each stage consists of one impeller as well as accompanying diffusion component. The term of multistage is mostly used in centrifugal pump. In thermal power plant it is necessary for water to be moved in large distance within high pressure. At that situation the only way to achieve higher pressure is use of series impeller. Multistage impellers are mounted on the same shaft and flow of water from one stage to another stage flow series to achieve the height. Another advantage of multistage pump is when the power of pump is more than required load that time de-staging of impeller method is used. In this method as per required discharge flow impellers are removed from multistage pump so that load on the motor decreases and there is considerable energy saving. [6-7]

De-staging of impeller is required mainly in service application equipped with multistage pump where the required differential pressure may decrease (or increase) in the future for some reasons: the system pressure requirements may change, the pumped liquid properties may change. According to the paper [5] presented by Gopikrishna Balakrishnan, It can be concluded that differential pressure of multistage pump can be reduced by deactivating one, or more, of its stages. When an impeller is replaced by its de-staging parts, stage deactivation can be achieved. According to the affinity laws, reduction of pressure can be achieved by reducing the speed [5]

According to the paper [13] presented by 'Vishnu R Nair, Energy conservation and ultimately efficiency and economy improvement is the main aim in all industries. In many industries electricity is consumed by different auxiliaries. The power consumption by these auxiliaries are very high due to bad design of equipments or poor operation. The efficiency can be improve either by improving equipment's design or operating the equipment to maximum efficient position. If there is large capacity pump is already installed but after some time load requirement is reduced, so instead of replacing pump de-staging of pump is used to meet that requirement. De-staging method is simple to implement and it can fulfill the requirements satisfactorily. De-staging of pump refers to removal of one or more impeller from the multistage pump to reduce the energy added to the system fluid, which in turn reduces no of stages, which directly lowers amount of energy being used and lowers both head and pressure of the pump. [13]

4. CONCLUSION

To improve the efficiency of Thermal power plant it is essential to improve the efficiency of motor. The different methods are discussed in this paper. Mainly efficiency improvement methods are briefly classified into two categories viz. Conventional methods and modern methods. Out of which conventional methods are not widely used because these methods depend on commissioning factors. It is beneficial to use modern methods i.e. VFD and redesigning of mechanical parameters such as impeller trimming and de-staging of pumps. By adopting these methods it is possible to get required discharge flow of water required for generation which in turn results in decrement in the load on motor and efficiency of motor can be improved.

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