ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)
Vol 5, Issue 10, October 2020

Optimizing Electrical Energy Consumption in Steel Industry

[1] Ashit Prasad, [2] Ram Ranjan Choudhary, [3] Anup Prasad

[1][2][3] Research & Development Centre for Iron and Steel, SAIL, India
[1] ashitpd@sail-rdcis.com

***Abstract*— Electric motors are used in a variety of applications in metal industries. These motors are classified as Alternating Current (AC) and Direct Current (DC) motors depending on the type of input supply to the motor. AC motors are further classified as Synchronous motors and Asynchronous motors. In industries such as Steel, the synchronous motors are generally High Tension (HT) motors such as exhauster that has the advantage of providing power factor correction. The slip ring induction motors are generally used where high starting torque is required such as in crane application, wagon tripler, etc. The squirrel cage induction motors are used in applications such as pumps, conveyors, ventilations fans, etc. Moreover, with the advent AC drives, these motors have replaced the slip ring induction motors and DC motors. DC motors have few applications in the industries and because of the high cost of maintenance involved, the trend is to phase out the DC by AC inverter drive system.**

***Keywords*— Optimizing Electrical Energy, Electrical Energy Consumption, Steel Industry**

I. INTRODUCTION

Electric motors are used in a variety of applications in metal industries. These motors are classified as Alternating Current (AC) and Direct Current (DC) motors depending on the type of input supply to the motor. AC motors are further classified as Synchronous motors and Asynchronous motors. In industries such as Steel, the synchronous motors are generally High Tension (HT) motors such as exhauster that has the advantage of providing power factor correction. The slip ring induction motors are generally used where high starting torque is required such as in crane application, wagon tripler, etc. The squirrel cage induction motors are used in applications such as pumps, conveyors, ventilations fans, etc. Moreover, with the advent AC drives, these motors have replaced the slip ring induction motors and DC motors. DC motors have few applications in the industries and because of the high cost of maintenance involved, the trend is to phase out the DC by AC inverter drive system.

These motors driven by electric power to produce the mechanical power required for running of the equipments are therefore the workhorse of the industry. The specific power consumption is therefore an importance techno-economic parameter for any metal industry such as steel. In SAIL steel plant it ranges around 400-500kWh/T of saleable steel depending upon the efficiency of the plant. The specific power consumption can be optimized with the use of energy efficient motors and proper monitoring of the motors with respect to its health through analysis of current, voltage, vibration, temperature, etc. Electrical energy conservation and condition monitoring of the motors are thus two facets of the same coin which eventually helps reducing the input cost of production in any energy intensive industry

II. ELECTRICAL ENERGY CONSERVATION – *AVENUES*

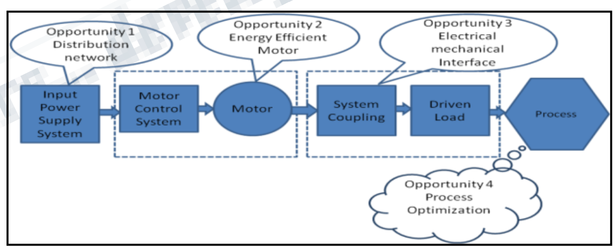

Figure 1

Energy management of the motor driven system is of utmost importance in order to reduce costs by improving equipment efficiency. As shown in Figure 1, ample opportunities exist for electrical energy conservation in any motor driven system. Generally, the opportunity 2 i.e the use of energy efficient motors instead of standard motor is not stressed upon much. The energy efficient motors operate with efficiency that is typically 3-4% higher than standard motors. They help in conservation of electrical energy especially in case of continuous duty cycle operation such as pumps, conveyors, etc. The motor efficiency has a significant role in deciding the kW rating of the motor and determining the operating cost of the motor. A higher efficiency motor will produce the same shaft output power

ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)
Vol 5, Issue 10, October 2020

but draw less input power (kW) than a standard efficiency motor. Thus if the efficiency is higher, the capacity (kW) rating of the motor will be less than the standard motor. The operating cost of the higher efficiency motor will also be less as it will draw less power (kW) for the same shaft output power required by the driven load. Normally, the initial cost of the higher efficiency motor is 15-30% more than the standard motor but this is compensated by the reduced running cost. The payback period of replacement of a standard efficiency motor with higher efficiency motor can be from few months to 2-3 years depending on the running hours of the motor.

Energy Efficient Motors are manufactured with higher quality material and technique, they have higher service factor and bearing lives, less waste heat output and less vibration. Energy efficient motors are built with high grade silicon steel and the watt loss is reduced by 50% as compared to low carbon electrical steel used in standard efficiency motor. Typical values of watt loss/ kg in silicon grade steel is 3.3watt/kg as compared to 6-6.6watt/kg in low carbon steel. Lower watt loss means lower magnetising current and hence low iron loss. The other design factors which reduce the losses in energy efficient motors are the use of bigger copper conductor to reduce winding resistance, longer core length of the motor for improved power factor, low loss fan design for effective cooling, etc. Moreover, the standard motors are designed for maximum efficiency at minimum 75% of the full load whereas the energy efficient motors have a flat efficiency curve with load i.e it can be provide maximum efficiency from even 50% of the load. It would therefore be appropriate to select an energy efficient motor if the operational duty in unknown as it would give a better efficiency even if the system is working at lower loads. The operational hours for which the motor is running is also important for calculating the energy savings. An energy efficient motor would give more benefit if it is replaced with standard motor of continuous duty. As an example, replacing a 15kW standard motor with energy efficient motor, having higher efficiency of around 2% (90.6% Vs 88.7%) and working hour of 8000hr/annum would save around 2800kWh/annum.

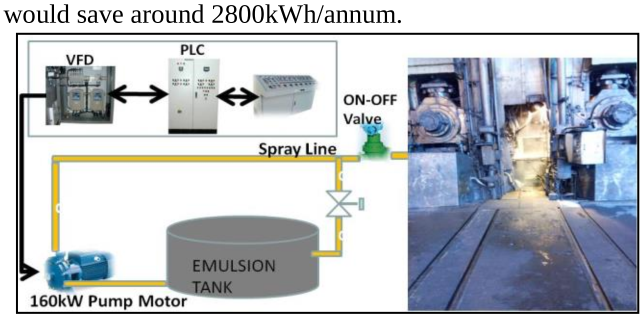

Figure 2

Again in any motor driven system, the avenue of electrical energy conservation through process optimization is of utmost importance. This is shown as opportunity 4 in the above figure. In process optimization, the one aspect which is often neglected is the workload on continuous duty motors. One such example is the pumping systems in any industry which accounts for nearly 25% to 50% of the total electrical energy usage in industrial facilities. Significant opportunities exist for electrical energy conservation through smart design, retrofitting, and operating practices. In particular, the many pumping applications with variable-duty requirements offer great potential for electrical energy savings. As per Affinity law, Flow through pump is proportional to the speed, Pressure is proportional to square of the speed and Power is proportional to the cube of shaft speed. One such example of the use of Affinity law is in Bokaro Steel Plant, Tandem Cold Rolling mills, emulsion system which is meant for cooling of work rolls only during roll bite to prevent heating of rolls. This requires flow control of emulsion during threading and intermittent stoppages of mill. In old cold rolling mills the emulsion flow management system was based on the mechanical scheme which resulted in considerable wastage of electrical energy. A scheme for emulsion management , as shown in Figure 2, was designed and implemented where the emulsion pump speed is controlled with the mill speed during cold rolling. Emulsion Management is through automatic changeover of the motor speed to around 25% of the rated rpm during mill preparation & intermittent delay, 75% of the rated rpm during threading and up to 150mpm and 100% of the rated speed during normal running condition of the mill. This has resulted in electrical energy conservation of 972kWh / day with 60 coils rolling per day.

III. CONDITION MONITORING OF MOTORS – *METHODS*

The condition monitoring of motors is yet another important aspect of optimization of the motor driven system. The monitoring of the health of its equipment in any process is of utmost importance because it prevents uncalled for stoppages in production lines. Sometimes, through proper monitoring of these motors we can get signal when to replace the inefficient equipments in general and motors in particular. This monitoring can also help in planning for repair or replacement of defective parts of these motors. The mechanical faults due to vibrations, bearings, etc gets reflected in the current waveform only when appreciable damage to the motor is done. As the locations of the some of these motors are unmanned, especially in steel Industries, the continuous physical monitoring of these motors is not possible. The online condition monitoring of motors from

ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)
Vol 5, Issue 10, October 2020

remote locations can be done through current signature analysis, shaft voltage, rotor magnetic flux, temperature of winding, vibration monitoring etc. Current Signature Analysis (CSA) is important in tool in preventing faults such as broken bars that cause rotor core damage due to temperature increases and arcing , premature degradation of bearings, rotor eccentricity issues due to unbalanced magnetic forces. Any disturbance as a sequel to above will manifest itself as an electrical signal in the stator current. Current Signature Analysis determined from the spectrum of the signals embedded in the stator current and by understanding induction motor and load dynamics it is possible to determine the nature of rotor problems. As soon as the amplitude exceeds a certain empirically determined threshold , relative to the amplitude of the fundamental, it indicates a failure condition may be likely. Similarly, the purpose of shaft monitoring is to indicate the presence of high levels of voltage or current on the motor or generator shaft in order to detect poor grounding shaft performance prior to bearing failures. Vibration monitoring is also one of the important tools for checking the health of the rotating equipment such as motors. Vibration is often the result of components that are imbalance, misalignment, worn, loose or improperly driven. To monitor the vibrations, velocity, acceleration and displacement can be measured. Temperature of the windings of stator and rotor helps in analysing the load conditions, the cooling efficiency and any insipient fault that may occur due to insulation failure. With the advent of Industry 4.0 at present the condition based monitoring has moved forward with the development of some smart sensor which captures the data of the motor and transmits it for analysis. The Figure 3 depicts how the IOT based sensors are installed to transmit and analyse the data. Most of the automation companies have developed IOT based sensor like SMART sensor (ABB) and Mind sphere (Siemens) which monitor the health of motor from remote locations and do the analysis of its health and give the timely feedback to the customer for doing the predictive maintenance.

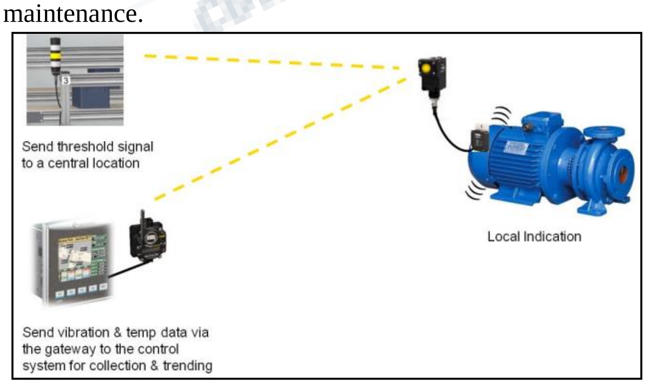

Figure 3

IV. CONCLUSIONS

Thus, the use of energy efficient motors, condition monitoring of these motors and other associated electrical equipments leads to electrical energy conservation, plant availability and reduction in cost of operations in any industry. It can be said that the use of large scale energy efficient motors of continuous duty cycle will result into energy savings, reduction in maintenance cost. Acknowledging the need for energy savings in view of energy scarcity, a 3% increase in motor efficiency on an average rating could bridge the supply demand gap. Indirectly, it will help reduction in fossil fuel use and reduction in emission of green house gases. Another pertinent aspect is the online condition based monitoring of at least the critical motors. This is required to be done to prevent such uncalled for failures, The offline instrument generally used for motor health diagnostics does not see the trend of vibrations or rise in bearing temperature. A general trend therefore is the need to shift from preventive maintenance to predictive maintenance.

REFERENCES

[1] The complete guide to Energy efficient motors : International Copper Promotion Council
[2] Electrical Machine Design : A K Sawhney
[3] IRIS – Monitoring

