

Delta Star Starter For High Starting Torque Squirrel Cage Induction Motor Drive Applications

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Abstract

The induction motor accounts for 70% of Industrial Electrical Energy Consumption. Up to 50HP drive applications, Squirrel cage Induction motor are most preferred one than Slip ring induction motor. The squirrel cage induction motors are rugged & maintenance free. Especially squirrel cage Induction motor selected for High starting torque application are purposely oversized to meet the starting torque requirement. This will lead to lightly load conditions during normal operation and poor operating efficiency. The motor load factor survey conducted on high torque applications such as long conveyor belts, Slurry agitator, Mixers reveals that in most of applications the squirrel cage induction motors are loaded up to 20 to 35% during running condition. An attempt was made to start the squirrel cage motor in Delta during starting and running in star for High starting torque applications. There is a reasonable reduction in power consumption during running condition due to reduction of losses and improvement in efficiency. This paper suggests methods to reduce energy consumption in Induction Motor having load factor less than 33% during normal running by going for a Delta Star Starter.

Keywords: *Over Sized Induction Motor, Delta Star Starter, Energy Management*

1. Introduction

The Star Delta Starters are commonly used for starting induction motor to minimise the starting current. The Star delta starter's applications are limited to low starting torque applications. For high starting torque applications, it is necessary to use Direct on line

starter for squirrel cage induction or Rotor resistance starter for slip-ring Induction motors. Especially industries availing High tension and extra high tension power supply at High Squirrel cage Induction motor is the commonly preferred drive up to 50HP application. The starting torque developed by the slip ring induction motor with rotor resistance starter is higher than the squirrel cage induction motor for a same size. Even though squirrel cage induction motor selected for high starting torque applications due to ruggedness, easy maintenance and relatively cheap compared to slip ring induction motor.

In general majority of LT Induction motor stator windings are connected in Delta connection. The reason for delta connection is to reduce the manufacturing cost of the motor. A delta connected induction motor deliver more output power than a star connected motor of same volume. The starting torque developed by the motor is directly proportional to the square of the supply voltage. In case of Delta connection, the 100% of supply voltage is applied to the each phase of the winding. In Star connection, only 58% of the supply voltage is applied to each phase of the winding. The starting torque in delta connected induction motor is three times than that of same motor connected in star connection.

2. Delta star starter

This is a special type of starter used to start the motor in Delta connection to develop high starting torque and to run the motor in Star connection to minimize the losses. The concept used in Delta Star Starter is just reverse in case of Star Delta Starter. In this type of starter, the Delta Contact is energized first

and starts the motor in Delta to meet the High Starting torque requirement of the application and then the Star Contact is energized & Delta contact is switched off to switch over to Star connection to meet the running torque requirement and reduce magnetization losses. This type of starter was tested with High starting torques applications such as Agitators, Mixers & Long conveyor belts and their energy performance are better than the Squirrel Cage induction motor using direct on line Starter.

3. Saving opportunity

Magnetization losses of Induction motor varies with respect to the applied voltage. The magnetization losses increase with increase in applied voltage to Induction Motor. The figure .1 shows that how the magnetization losses varies with respect to the motor voltage.

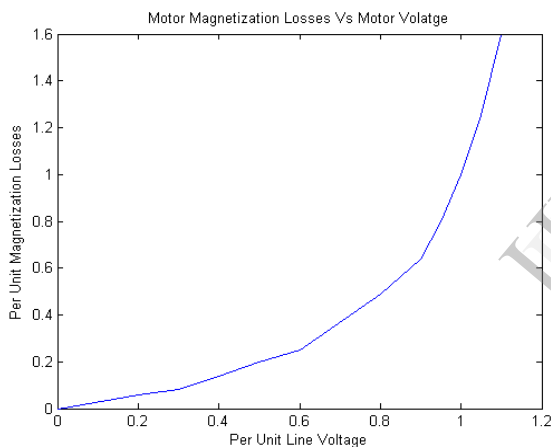


Figure 1. Induction motor core loss

The Squirrel cage induction motor selected for high starting torque application, leads to lightly loaded conditions during normal running. During this condition, when the load factor is less than 33% of its full load, it can be made to run in star connection to minimize the losses by installing Delta Star Starter. While converting delta to star connection in case of motor loaded less than 33%, the applied voltage across each phase of the winding is reduced to 58%. The reduction in applied voltage will result in reduction in magnetization current and in turn reduces the flux. In case of lightly loaded motor the flux utilization is less compared to the flux set-up. This reduction in voltage

will reduce the capacity to 33 % of its earlier capacity and results in reduction in magnetization loss. Thus it improves the Efficiency of the motor. The major factor governing the efficiency in this case is due to the reduction in magnetization loss. Especially up to 50 HP Standard Induction Motors, the Iron losses are reasonable amount of the total loss of the Motors during energy conversion.

4. High starting torque

While selecting the rating for a drive for a particular application, it is very important to consider the starting torque requirement. Especially in case of high starting torque applications like Agitators, Long Belt Conveyors the squirrel cage induction motor selected are oversized in order to meet the starting torque without appreciable increase in temperature during starting. This leads to lightly loaded conditions during running and poor operating efficiency. The possibility of over sizing induction motor for high starting torque application is very high in case of motor size less than 18.5 HP applications. The iron losses in induction motor up to 18.5 HP will be almost 50% of the total motor losses. An attempt was made in few Cement industries, to install Delta Star starter starters for high starting torque squirrel cage induction motors up to 50 HP size. Typical application is the slurry agitator, conveyor belt. In case of slurry agitator, the starting torque is very high and running torque is less. In these cases, the motor is started in delta for its initial starting torque requirement and it will bring to star connection after normal running. This Star Delta Star converter is ideal choice to save energy in case of lightly loaded motor, which is subjected to heavy load. The typical example is the Agitator, Aerator, Conveyor belt and mixers

Voltage optimization is possible for the Over Sized Induction Motor to improve its operating efficiency. The system voltage optimization will result in

Capacity Reduction: motor capacity is directly proportional to the square of the system voltage. Example 10% reduction in system voltage reduces the capacity by 19%.

Load Factor Improved: For the lightly loaded motors by reducing the system voltage, will result in reduction in capacity and improve the load factor compared to the earlier case.

Drop in Magnetization Loss: The reduction in system voltage will reduce the Magnetization losses. The

magnetization loss depends upon the square of the voltage.

Power Factor Improved: The Power Factor is the phenomena specifying the quality of flux utilization. In case of lightly loaded motors, effective flux utilization is less. Reducing the system voltage will reduce the flux & increase in the flux utilization, ultimately results in improved Power Factor.

Load Current drops: Due to the improved Power Factor, the load current will drop compared to the lightly loaded condition. This reduction in current will result in reduction in stator & rotor copper loss.

Improved Efficiency: Thus the entire above factor will ultimately results in improved efficiency compared to the earlier case.

6. Case study

The proposed delta star starter was installed with slurry agitator in a wet cement plant and its performances were observed. The drive for the slurry agitator is designed based on the starting torque requirement. In case of cement industry for constant speed, less than 50 HP applications squirrel cage Induction motors are preferred because of less maintenance & considering the environmental factors. Initially Direct On-line starter is installed to meet-out the starting torque requirement. The power measurement made in the slurry agitator drive indicates that, it is lightly loaded during running conditions. The reason for the light load is, design based on the starting torque requirement and the selection of squirrel cage motor for this application. It was recommended to install Delta Star Starter to reduce energy consumption during running. Delta star starter was installed at 6 Nos. of slurry agitator motors in a wet cement plant, which is subjected to high starting torque. The slurry agitator runs for 16 hours per day for 330 Days in an year.

7. Observations

Rated Capacity is 37.0 KW .Actual Load, when running with DOL Starter 10.5 KW. Actual load, when running in Delta Star Starter 9.5 KW

8. BENEFITS

The annual saving in energy consumption per annum is 31680Kwh

9. Limitation

This practice is applicable up to 50HP standard induction motor. The reason for the capacity limitation is the iron loss will be a reasonable magnitude of the full load copper loss up to 50 HP standard induction motor. In case of higher HP motor, the iron loss is 5 to 15 % of the full load copper loss, so the reduction in iron loss by star conversion is negligible. Adopting this technique for Energy Efficient motor is limited, since the iron loss also partially varied by varying the magnetic saturation, hence even during lightly loaded condition it operates at maximum efficiency due to the optimal design and improved magnetic material used.

10. Conclusion

The performance of Delta Star Starter was analyzed experimentally in laboratory and also tested in real drive applications. The operating efficiency improved 5 to 15% depending upon the size of the applications. Smaller capacity motor, the saving potential is high compared to larger size, since iron losses is a reasonable amount of total copper loss of a motor. They operate normally with out affecting the process. The Delta Start Starter is ideally suited for High Starting torque application, where squirrel cage induction motor is selected up to 50HP capacity. The Delta Star Starter also improves the power factor & reduces the demand on power supply system.

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