Comparative study of 3 phase starter

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Abstract- This paper presents a comparison between the Direct-On-Line (D.O.L.), Star-Delta, and Soft starter induction motor starting method. The purpose of this paper is to find out the most reliable and practical starting method which has the less power quality problems. These three basic starting methods which differ in their respective wiring connection are the most applicable and widely-used starting method in the industrial area due to its economic reasons. The three different starting method are being compared to conclude the most suitable and applicable starting method which causes the least severe power quality events.

Keywords – Direct-on-Line (DOL) starter, Star-delta starter, soft start, squirrel cage, wound rotor, induction motor.

I. INTRODUCTION

A 3-phase induction motor is theoretically self starting. The stator of an induction motor consists of 3-phase windings, which when connected to a 3-phase supply creates a rotating magnetic field. This will link and cut the rotor conductors which in turn will induce a current in the rotor conductors and create a rotor magnetic field. The magnetic field created by the rotor will interact with the rotating magnetic field in the stator and produce rotation. Therefore, 3-phase induction motors employ a starting method not to provide a starting torque at the rotor, but because it reduce heavy starting currents and prevent motor from overheating, Provide overload and no-voltage protection. There are many methods in use to start 3-phase induction motors. Some of the common methods we are using is Direct On-Line Starter (DOL), Star-Delta Starter and Soft Starter.

II. CAMPARATIVE STUDY

A. *Direct-on-Line (DOL) Starters*

This is by far the most common starting method available on the market since it is a very compact and a very cheap starting solution. The starting equipment consists of only a main contractor and a thermal or electronic overload relay. The disadvantage with this method is that it gives the highest possible starting current. A normal value is between 6 to 8 times the rated motor current but values of up to 14 times the rated current do exist. There is also a magnetization peak that can be over 20 times the rated current since the motor is not energized from the first moment when starting. The exact values are dependent on the design of the motor. In general, modern motors have a higher inrush current than older ones because of the lower resistance in the windings. During a direct on line start, the starting torque is also very high, and for most applications it is higher than necessary. This will cause unnecessary high stress on driving belts, couplings and the driven application.

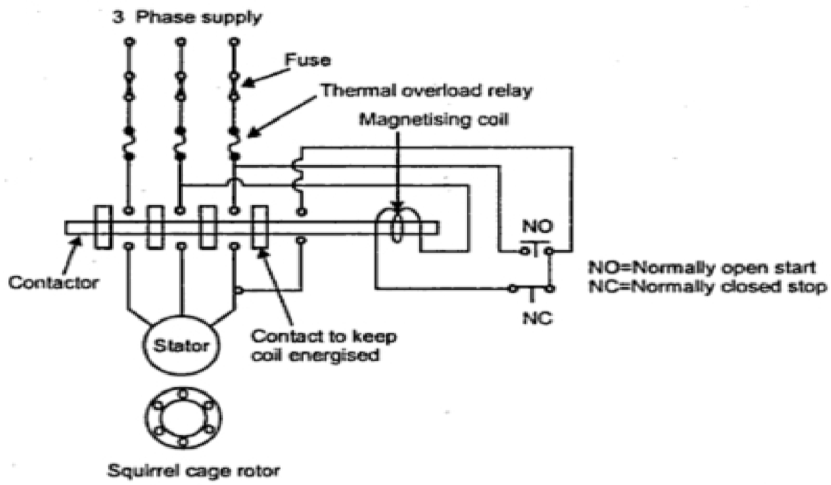

Figure 1 : Direct On-line Starter

Naturally, there are cases where this starting method works perfectly fine and there is no need to use any other starting method. If starting DOL, the only possible way to stop the motor is to make a direct stop.

B. *Star-delta starter*

A star delta starter usually consists of three contactors, an overload relay and a timer. This starting method can only be used with a motor that is delta connected during continuous run.

The basic idea behind a star-delta starter is that during the first part of the acceleration, the motor windings are connected in star, giving a reduced current. After a preset time, the connection will change to delta which will give the full current and also the full torque.

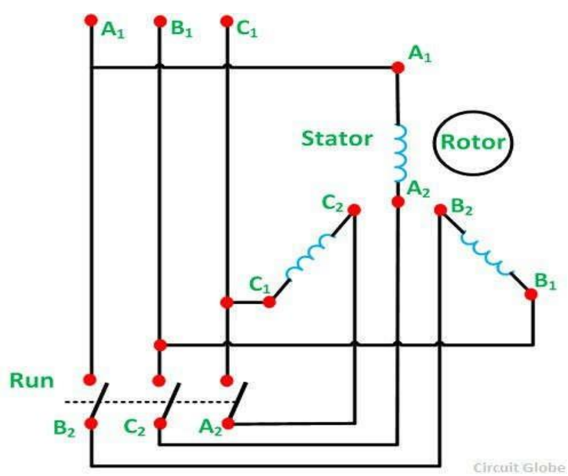

Figure 2 Star-delta starter

When used in delta, the voltage across each motor winding is same as the network voltage. The motor current will split between two parallel windings with the factor 1/√3 compared to the line current. If the impedance in each motor winding is Z, then the sum of impedance for the parallel windings is Z/√3. When the motor is star connected (Y- connected) the motor windings become serial connected. The resulting impedance will then be √3*Z, resulting in an impedance which is ((√3*Z)/(Z/√3) = 3), 3 times the impedance when delta connected. As the voltage level is the same, the resulting current when Y-connected will be 1/3 of the current when delta connected. So when starting using Star-Delta start, the star connection results in a current of 33% compared to a delta connected motor.

As the main voltage is the same the motor feels a star connection as a voltage reduction, as because the voltage across each motor windings will be $1/\sqrt{3}$ of the main voltage. This lower voltage will also result in a torque reduction. The torque will be reduced with the square of the voltage, $[(1/\sqrt{3})^{*} (1/\sqrt{3}) \approx 0{,}33]$ ending up being 33% of the toque available when delta connected. However, this is only a theoretical value. A more true value is 25% as there are additional losses as well as other efficiency data valid when used star connected. This works well in an unloaded or very light loaded start, but it will not be possible to start heavier applications. A big problem with star-delta starters appears when starting for instance pumps. The motor will accelerate to about 80- 85% of the rated speed before the load torque is equal to the motor torque and the acceleration ceases. To reach the rated speed, a switch over to delta position is necessary, and this switch over will very often result in high transition and current peaks. In some cases the current peak can reach a value that is even higher than for a DOL start. Also, just as with a DOL start, the only way to stop when using a star-delta starter is to make a direct stop.

C. Soft starter

A soft starter does not change the frequency or the speed like a drive. Instead it ramps up the voltage applied to the motor from the initial voltage to the full voltage. Initially, the voltage to the motor is so low that it is only able to adjust the play between the gear wheels or stretching driving belts etc. to avoid sudden jerks during the start. Gradually, the voltage and the torque increase so that the machinery starts to accelerate. One of the benefits with this starting method is the possibility to adjust the torque to the exact need, whether the application is loaded or not. Using a soft starter will reduce the starting current and thereby avoid voltage drops in the network. It will also reduce the starting torque and mechanical stress on the equipment, resulting in reduced need for service and maintenance. Just as for a drive, the soft starter can perform a soft stop, eliminating water hammering and pressure surges in pumping systems and avoiding damage to fragile material on conveyor belts.

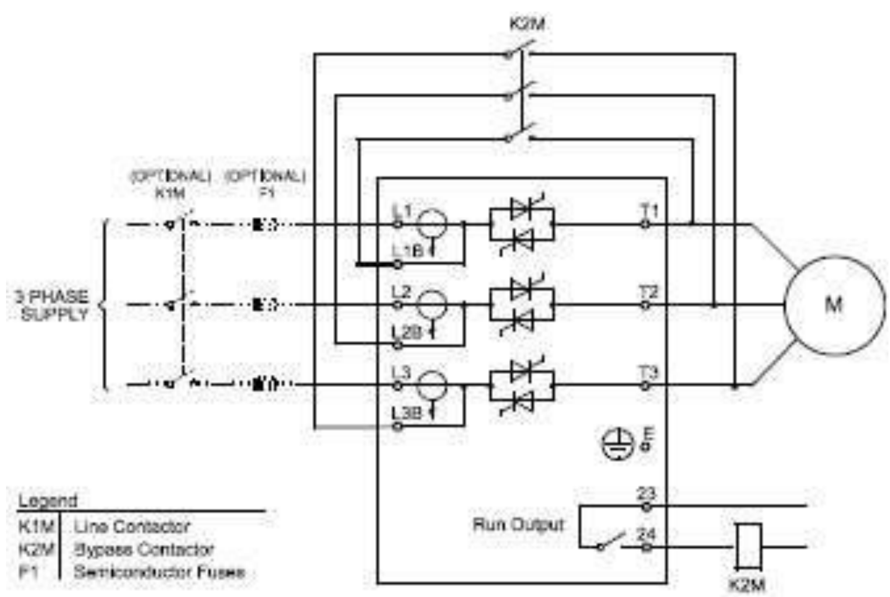

Figure 3 : Soft Starter

A soft starter consists of only a few main components. These are the thyristors that can regulate the voltage to the motor and the printed circuit board assembly (PCBA) that is used to control the thyristors. In addition to this, there are the heat sink and fans to dissipate the heat, current transformers to measure the current and sometimes display and keypad and then the housing itself. It is more and more common to offer integrated by-pass contacts in the main circuit minimizing the power loss in normal operation. Depending on the model of the soft starter, it can be equipped with a built-in electronic overload relay (EOL) eliminating the need for an external relay, PTC input, fieldbus communication possibilities etc.

Advantages of Soft Starter over other methods:

1. The inrush current is reduced so that voltage drops on the network are avoided.
2. The torque is reduced which will decrease the mechanical stresses on the equipment and lead to a reduced need for service and maintenance and also to a longer life of the equipment.
3. By using a stop ramp, water hammering is avoided in pump systems, which will further reduce the stress on the equipment.

Comparison between different starting methods

The table below describes which **problems are prevented**, using the most common starting methods.

Type of problem	Type of starting method (Status of problem prevention)			
	Direct on line	Star-Delta start	Drives	Soft starter
Slipping belts and heavy wear on bearings	No	Medium	Yes	Yes
High inrush current	No	Yes	Yes	Yes
Heavy wear and tear on gear boxes	No	No	Yes	Yes
Damaged goods / products during stop	No	No (at loaded start)	Yes	Yes
Water hammering in pipe system when stopping	No	No	Yes	Yes (Eliminated with Torque control Reduced with voltage ramp)
Transmission peaks	No	No	Yes	Yes
Estimated average installation cost	1	3	>12	6

III CONCLUSION

From the above survey we can able to conclude that the best method for starting the induction motor is soft start method. In this method we found that various problems are can be prevented with soft start. Soft start method can prevent the problems like damaging of goods or product while stopping the motor, heavy wear and tear of various parts, hi inrush current, transmission peak value, slipping of belt and bearing on start, etc.

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