The Study of Starting Methods of Squirrelcage Asynchronous Motor

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Abstract. Base on the analysis of the starting problem of the asynchronous motor, this article elaborates various starting methods of the squirrelcage asynchronous motor and all the advantages and disadvantages corresponding different methods.

Keywords: Squirrelcage asynchronous motor.

1. The starting problems of asynchronous motor

The motor has developed with the development of production which promotes the continuous growing of social productivity. There are two kinds motors coexisting in various production fields throughout the development process of the motor, the Dc motor and the Ac motor. As its outstanding superiority in speed adjustment, Dc motor was used in electric drive for some time, however, the high failure rate of brush and steering detemines its limitation in using environment and the developments of voltage class, rated speed and unit capacity are also influenced, which cannot enough adapt to the development needs of modern production facing high speed and large capacity. However, the Ac motor, especially the three-phase squirrelcage asynchronous motor with the advantages of simple structure, easy for manufacture, low price, more durable and reliable operation, are well used in many industry fields and play more and more vital role.

The Ac motor exist many obvious advantages comparing with the Dc motor, but the asynchronous motor have many disadvantages at the start-up process. After connecting to power, the Ac motor' starting current becomes very large, it ususlly can reach to 10-20 times of the rated current without adopting any start device during accelerating to the steady state from quiescent state, and the impact of the torque is very great when the three-phase asynchronous motor start. Higher current when the motor start can cause serious impact of the power grid and large voltage drop, drastically reduce the power quality and influence the normal operation of other equipment. And the large impact of the torque will bring the mechanical impact which influences the motor and the useful life of electric driving equipment. Therefore, we always hope to get enough large starting torque under smaller starting current, the starting question of asynchronous motor has become an important topic of the electrical industry.

2. The starting methods of the squirrelcage asynchronous motor and its advantages and disadvantages

2.1 The reduced-voltage start

The reduced-voltage start is an effective method to decrease starting current. First, the motor is connected with lower voltage and then increasing the voltage to the voltage rating regularly after its rotate speed raises. We can see from the formula 1 that the starting current can decrease in proportion by reducing the voltage U_1 that is at the expense of starting torque. The starting torque is proportional to the voltage U_1 squared and owns a faster rate of decline than starting current. This starting method is mainly used in the producing machinery that the starting torque of the loads are not large.

$$I_2^{'} = \frac{U_1}{\sqrt{\left(r_1 + r_2^{'}/s\right)^2 + x_k^2}} \tag{1}$$

Where the U_1 is the voltage virtual value of the power, x_k is the total equivalent impedance, r_1 and r_2 are respectively the single phase resistance of the stator and rotor on the side of the stator, $I_2^{'}$ is the equivalent current of the rotor and s is the slip ratio.

1. The star-delta start.

This method is just applied to the Ac motor under rated condition whose stator winding is delta connection. The stator winding is star connection when the motor starts so that the starting voltage is down to $\sqrt{1/3}$ of the rated voltage and up to the standard of starting with reduced-voltage. The stator winding is changed to delta connection after the motor' speed rise to some preset value. Now, the voltage value of the motor can only be adjusted from $\sqrt{1/3}U_H$ to U_H and the change is discontinuous, the cost of this method is the lowest due to just need one switch.

2. The autotransformer start.

The starting method that the stator of the motor is connected to the power grid through the autotransformer whose voltage can be multi-adjusted is called the autotransformer start of the squirrelcage asynchronous motor. Comparing with the first method, this method has two obvious advantages: First, the voltage can be adjusted multi-level, and the impact to system is small; Second, the starting current applied on power grid can diminish to IS/n (n is the step-down ratio of transformer). But the cost and weight of the auto-transformer are larger than start-delta type switch.

2.2 The adjustable resistance starts

The adjustable resistance start is that add a resistance in series with each phase stator winding and limit the starting current realizing the voltage-reduced start by using the voltage drop of the resistance, the resistance is not short-circuited with a switch until the motor' speed is up to some preset value. Under this starting method, the starting current of the motor can be controlled very well except the resistance need consume energy and losing heat alse increases the total cost.

2.3 The variable frequency start

The variable frequency start is using the transducer for decreasing the voltage and frequence of the power and effectively decreased the starting current on the premise that can achieve enough starting torque. At present, it becomes more and more popular using the transducer on starting control. The advantage of the variable frequency start is owning reliable performance and applying to the variable speed control of motor. Its disadvantages are, besides their inherent high price and complicated primary loop and control circuit that the maintenance is difficult, that cannot give full play to the frequency control function of inverter.

2.4 The soft start

The soft start usually can be achieved by using the power electronic equipments which is called soft starter. Due to the flexibility of electronic device, we can control the voltages of the motor to get better start-up characteristic for various requirements. The soft starter concatenated between the power and controlled motor is used to control the conduction angles of the thyristor internal the motor and has a gradual increase from scratch in input voltage of the motor with a preset relation of function, until soft start is terminated and giving the motor full voltage, which is the so-called soft start. The starting torque and speed of motor keep increasing during the soft start.

Generally speaking, the soft start has the following starting methods.

Slope boost soft start. This starting method is the easiest one without the current loop control and just need adjust through the conduction angles of the thyristor to make it become some functional relationship with time. Its disadvantage is that sometimes too large impulse current makes the thyristor damage during the moter's starting process due to unlimited current, which has a big impact on the power grid and are rarely used actually.

Slop constant-current soft start. This starting method' starting current is increased on the initial stage of the motor start until starting is over. During starting, the speed that current increases can be set according to motor' load. The starting torque is large and starting time is short when the current

increases by a fast speed. This start method is most-used method, specially apply on the starting of fans and pump load.

Step soft start. The so-called step start is asking the starting current reach to the preset values quickly in the shortest time, and through changing the preset values we can achieve the result of quick start.

Pulsing soft start. At the phase of starting, the thyristor will fall after breakover with a larger current at a moments notice, it will rise linearly according to the previous preset values and is connected to the constant-current starting. This starting method is less used in generally load, it ususlly applys to the occasions that is overloads and need to overcome bigger static friction

Comparing with the traditional starting methods, the soft start has the following different points.

Without impulse current. The soft starter makes the the starting current of the motor up to preset values from zero through increasing the conduction angles of the hyristor when the motor starts.

Contant-current start. The soft starter can introduce the closed-loop control of current to make the motor keep contant-current during starting process and make sure the motor start steadily.

It can adjust to the best starting current according to the situation of load and the choice of the relay protection characteristics of the power grid.

3. Conclusion

Through the above-mentioned discussion, the start control has experienced the electronic soft starter from the traditional direct start, star-delta start and autotransformer start. when the direct start of the motor cannot meet the requirement in engineering applications, the first consideration is the electronic soft start. It is the history stage of scientific and technological progress, and it also is the inevitable process laying a good foundation for intelligent control system in the furture.

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