Research on the Motor of Variable Frequency Compressor of Inverter Air-condition

Qian Wang and Zhexiang Zou

ABSTRACT

Compared Inverter air conditioner with the traditional fixed-frequency air-conditioning, with a stable temperature regulation, energy-saving effect is obvious, low running noise and a series of advantages, so more and more sought after by the majority of users. However, the ordinary motor as the inverter air conditioner compressor running under the influence of variable frequency power supply can not start even under high frequency blocking caused by the motor burned and other issues.

In this paper, considering the operation of air-conditioning compressor, the paper puts forward the method of "using higher magnetic density materials and reducing the harmonics with closed slot", and using the Ansoft Maxwell V12.1 Software Rmxprt and Maxwell 2D modules to establish the frequency of the permanent magnet synchronous motor model to study the inverter air conditioner motor to run at different speeds can still achieve a smooth temperature regulation, high efficiency, energy-saving effect.

INTRODUCTION

As we all know, inverter air conditioner is the traditional air conditioning compressor with frequency control device, a dedicated inverter air conditioner compressor. Frequency conversion compressor can be divided into two parts, one is the inverter; the other is the compressor. Motor as an important part of the compressor, it should also be able to adapt to the inverter control to achieve energy efficient results.

By analyzing the influence of variable frequency power supply and frequency conversion device on the motor, this paper compares the advantages of permanent magnet synchronous motor and permanent magnet brushless DC motor in the compressor application.
In the end, a permanent-magnet synchronous motor with closed slot is used as a variable-frequency motor, which can not only overcome the shortcomings of traditional fixed-frequency motor starting performance, electromagnetic noise and low efficiency, but also can achieve flexible start, low voltage operation, and with the load to adjust the speed of freedom, thereby greatly improving efficiency.

**VARIABLE FREQUENCY POWER INFLUENCE ON THE MOTOR**

Variable frequency power supply will increase such as fixed-rotor copper loss, core loss, stray losses and other losses. But also affect the saturation of the main magnetic circuit, a serious impact to the motor performance.

In the general three-phase asynchronous motor plus frequency power, The motor cannot be below 30HZ 70HZ or more cannot work properly, Especially in the 70HZ above, the motor will be severe vibration and fever[1]. So there is a variable frequency power supply motor must be redesigned. According to the influence of variable frequency power supply on the performance of the motor, the design parameters of the motor should be different from the design parameters of the general motor. The main considerations are as follows:(1) rated power Pn should be appropriate amplification of 5% to 10% Pn.(2) the choice of the nominal frequency fn;(3) the rated voltage Un about 15% Un about;(4) efficiency, torque, the maximum torque multiples can be set according to actual requirements;(5) fixed-rotor slot type selection.

Therefore, the frequency conversion motor design does not need to consider the electrical machinery starting question.

Efficiency and power factor can be maintained at different levels of high speed, thereby increasing the power density. Usually the stator is designed to be deeper and narrower, the rotor slot design is closed slot, in order to increase the slot leakage resistance, reduce the harmonic current and its impact, improve the motor performance. Design should be achieved:

\[ x'_{1\sigma} + x'_{2\sigma} = 0.2 \sim 0.25 \]  

**MODELING OF INVERTER AIR-CONDITIONER MOTOR**

According to the advantages of the permanent magnet synchronous motor, the motor type is selected, the basic parameters of the motor of the inverter air conditioner compressor are calculated, and the calculation process is described in detail.

Air conditioning compressor to achieve efficiency in the winding area to improve the international community there are two main technical direction, respectively, a good low-speed performance of the concentrated winding motor and high-speed performance better distribution of the winding motor[2].

The distributed winding motor is less efficient than the concentrated winding motor at low to medium speed, but higher than the concentrated winding motor at low speed. Therefore, to improve the efficiency of the distributed winding motor, it is necessary to improve the motor efficiency at the time of low speed operation.

In this connection, you can take the following measures:(1) reduce the air gap, increasing the air gap flux density, expand the motor stator slot area, reduce the number of turns and coil resistance; (2) the motor flux density uniformity, to avoid
local magnetic flux concentration caused by excessive iron loss; (3) Increase the saliency ratio to utilize the reluctance torque[3].

ANALYSIS AND SIMULATION OF VARIABLE FREQUENCY AIR-CONDITIONER
Frequency Conversion Motor Performance Curve after Modeling RMxpert Model

As shown in Figure 1, under the same load condition, the frequency increases, the voltage increases, and the current decreases. Therefore, when the air conditioner is in low speed, the current is large and the torque is large. The motor usually uses low frequency output under heavy load.

The attenuation of the field winding current can also be seen from Figure 1. It can be approximated that: When the excitation current begins to decay, the damping winding current attenuation has been completed, so the damper winding is like an open circuit. When calculating the field winding, the influence of the damper winding can be neglected, and only the armature winding is considered. In this case, magnetic flux is forced to close along the leakage magnetic path of the armature winding which is generated by the non-periodic component of the field winding current. As shown in Figure 1, the current in the figure is the steady-state excitation current generated by the DC excitation power supply. A periodic component superimposed on it, is caused by the non-periodic component of the armature's sudden short-circuit current, when the field current decays to zero, the armature current decays to its steady-state short-circuit value.

As shown in Figure 2 for the modeling of the motor characteristic curve, theoretically, inverter air conditioner can be a dedicated motor for a long time running. Under the torque characteristic curve Characteristic Torque is shown in Figure 2, Modeling the motor operating at different frequencies can get different torque, and the maximum torque is obtained at the time of adjusting the temperature. Stable at room temperature at a certain temperature, the torque decreases and remains constant.

![Figure 1. Load Current.](image1)

![Figure 2. Torque characteristic curve.](image2)
Model Partitioning, Magnetic Flux Distribution and Magnetic Flux Density Distribution

As can be seen from the distribution of the magnetic field lines of the motor as shown in Figure 3, a closed magnetic field line appears in the loop of the stator winding, and the control of the magnetic flux density, as shown in Figure 4. Magnetic flux density of the local magnetic flux is relatively large, Magnetic flux density is small where the magnetic flux is relatively small[4].

![Figure 3. Distribution of magnetic field lines of inverter air conditioner motor.](image1)

![Figure 4. Distribution of flux density of inverter air conditioner motor.](image2)

In contrast to the color distribution as shown in Figure 4, red represents the maximum flux density, blue indicates minimum. Among them, the distribution of the four magnetic colors of red, magnetic flux density is relatively large; according to the winding circuit settings, magnetic flux density on the loop is relatively large, so here the magnetic flux density on the map that is red; on the contrary, not in the magnetic flux loop on the composition of the motor, the magnetic flux density is relatively small, here from the magnetic flux density diagram shown as blue.

CONCLUSION

In this paper, considering the operation of air-conditioning compressor operating conditions, proposed a "high density and the use of close-slot weakened harmonic" approach to study the motor.

The simulation results show the flux linkage curve, the torque characteristic curve and the magnetic flux density distribution of the motor and the distribution of the magnetic field lines of the motor. So that the study of permanent magnet synchronous motor can be obtained from the simulation diagram of inverter air conditioner motor static and the process of transient operation, as well as the motor flux density distribution, torque and back-EMF and other characteristics, we can see that the impact of reducing the harmonic motor can get maximum torque, low purpose.

REFERENCES

1. Matsui N., Takeshita T., Yasuda K. A New Sensorless Drive of Brushless DC Motor [J]. Proceedings of Power Electronics and Motion Control, 1992,(1.1): 430-43
2. Albert Qiu, Hassan Kojor, Bin Wu. Sensorless Control of Brushless DC Motor for More Electric Aircraft [J]. IEEE Transactionson Power Electronics, 2003, 9(3): 27-29.
3. A wide-angle wave control method of reducing torque ripple for brushless DC motor [J]. Journal of Shanghai University (English Edition), 2007, 11(3): 300-303.
4. Huang Keyuan, Luo Derong, Huang Shoudao. Design of Three-phase Variable Frequency Motor for Inverter Air Conditioner Compressor [J]. Hunan University.