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Induction Motor with two Rotors

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Abstract: The current paper concentrates on the cooling conditions of high-slip induction motors. So when such motors operate at low speed they have bad cooling. The suggested design may solve this problem. An additional rotor fixed on the motor shaft with special and simple design gives better cooling conditions. An additional rotor (fan-rotor), coaxial located with the main rotor, is packed free to the motor shaft by the means of bearings. And it is able to rotate around the main shaft independently on the main rotor. The torque in the additional rotor is produced by both the leakage magnetic flux of the projective part of the stator winding (the end of turns) and by the main rotor flux. Thus the additional rotor gives intensive cooling for the motor either it works with high speed or with low speed.

Key Words: Induction Motors, High-Slip, Double-Rotor, Intensive Cooling

Introduction

Electrical motors and drives enter in all fields of today industry (Norman S. Nise, 2000; Addasi E.S., 2000; R. Lalalou, 2001). Induction motors are the most widely used motors (Lukhachov V.L., 2002 and P.C. Sen, 1997). And the most used of them is with conventional design. But in some cases, industry has machines and mechanisms with special requirements.

Textile machinery now has the motor and starter built in as integral parts. Individual drive is more costly than group drive. However, it has a number of advantages: such as facility for overtime working and freedom from complete stoppage, minimum transmission loss and power consumption. The absence of line shafting makes the work place cleaner, giving better lighting and environment.

Normally a considerable amount of cotton fluff is present in textile mills. It has a tendency to accumulate on the fan cover grids and in ventilation passages. This leads to overheating and burning out of motors. For applications such as spinning, doubling, ring frame, draw frame, fly frame, etc., where a moderate amount of fluff is present, totally enclosed fan cooled motors with clean flow construction are used. For loom and carding application, totally enclosed surface cooled motors are used. For motors in bleaching and dyeing departments, are should be taken against the ingress of water, steam and alkaline fumes. For group drives, the motors may be located outside the processing rooms and drip proof enclosures may be used for the motors.

It is necessary to use specially designed motors for textile applications. The motors should be in compact frame sizes, should withstand temperature and ventilating conditions, high ambients, frequent starts and stops or duty cycles, should have protection against single-phase burn outs and thermister protection against overheating. The kW rating of the motor required for the particular application to suit a specific duty should be decided by considering:

1. highest loading when handling heaviest material with fastest delivery speed;
2. heating of the motor under worst conditions and
3. torque requirements by the machine under all conditions of loading.

In all equipment the used motor must be not overheated, otherwise its life will be shorter. This problem appears more if the used motor has a self-cooling system (with a fan fixed on its own shaft) and it works with low speed. In this case cooling conditions become worse. In industry there are many solutions for such problem.

For example, induction motor with two rotors (Potent USSR, 1957) was designed to solve the problem of motor heating, when it operates at low speed. This design recommends manufacturers to add to the induction motor an additional rotor, which should be coaxial located with the main rotor and under the stator, so it interacts with the main magnetic field of the machine.

But this design has a serious disadvantage; the main rotor becomes smaller because of the additional one. And so the induced torque on the motor shaft will decrease (if use the same stator).

Other solution of this problem is recommended in (Potent USSR, 1985): in this case the motor has an additional rotor (fan-rotor), which is located under the projective part (frontal part) outside of the magnetic core of the stator winding. But here the main disadvantage of this solution is that it can not be used for motors with power more than 800 W. That because with increasing the motor power, the relative leakage flux of projective part of the stator winding decreases, so the induced torque in the additional rotor decreases. Therefore, the cooling conditions will be worse.

Suggested Double-Rotor Design: The figure shows the main components of the suggested double-rotor design of the induction motor, where

1. the stator (as for other conventional induction motors);
2. the main rotor (with squirrel cage);
3. the projective part of the main rotor outside of the stator;
4. the additional rotor (the fan-rotor);
5. blade (impeller) of the fan;
6. and 7. the bearings of the additional rotor;
8. hole for cooling;
9. the motor housing (enclosure);
10. cooling air flow,
11. projective part of the stator winding (end of turns).

From the figure it is clear that the fan-rotor (4) is coaxial located with the main rotor and is packed free to the motor shaft. The fan-rotor is located under the projective part (the frontal part or the end of the turns) of the stator winding. Its form is like a cup and is made from a ferromagnetic material. Inside this cup enters a part of the main rotor. Where the main rotor projects outside the stator core (Fig. 1).

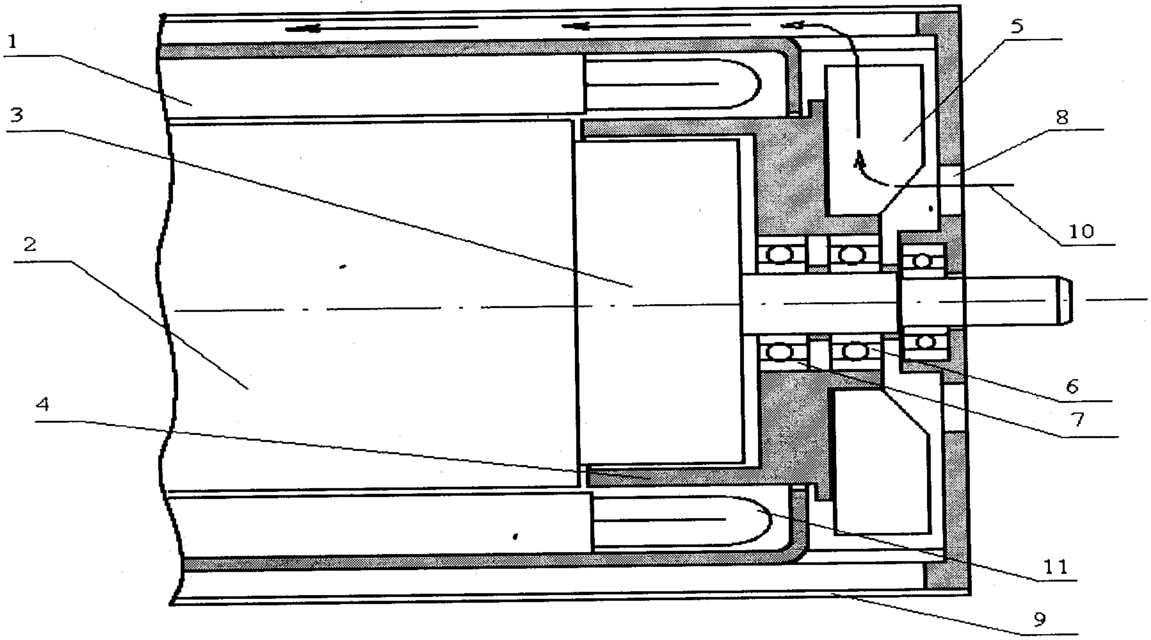

Fig.1: The Special Induction Motor with a Special Additional Rotor and a Projective Part of the Main Rotor

The induced torque in the fan-rotor is produced by both the leakage flux of the stator and the main rotor magnetic field. The magnetic field of the main rotor, at any slip, rotates synchronously with respect to the stator magnetic field. It is important here to mention that the induced torque in the fan-rotor is directly proportional to the slip.
Thus the principle of operation of this motor is as follows: the main rotor rotates with some slip, value which depends on the load. So a current flows through the rotor winding (the squirrel cage). Therefore, a magnetic field is produced by this current, which rotates synchronously with the stator magnetic field. The rotor current is direct proportional to the slip and thus the rotor magnetic field is proportional to the slip. And so the induced torque of the additional rotor is proportional to the main rotor slip. Therefore, as larger the motor load as more the slip and as larger the torque of the fan-rotor and the cooling is more intensive. Also the leakage flux of the stator winding participates in production of the torque in the additional rotor. But as larger the motor, as less its effect.
Therefore, the suggested motor design gives more intensive cooling for the high-slip induction motor with any horsepower, because the fan-rotor torque does not depend only on the leakage flux. But it is mainly produced by the main rotor flux, which will be larger as the slip larger. With a good design the suggested motor may work without overheating even with locked main rotor.
In addition, the fan-rotor does not occupy any place under the stator, so the main rotor size does not affected by the additional rotor. Therefore, the torque on the motor shaft does not decreased by adding the fan-rotor.

Conclusion

The suggested design of the self-cooling, high-slip induction motor provides good cooling conditions for all operation cases: at no-load or with load, at high-speed or at low speed operation. The suggested motor design with additional rotor does not require a place under the stator, so it does not affect the main rotor size and so on the motor power or torque. The suggested design is applicable not only for small motors but for high-slip induction motors with any horsepower. Both the stator leakage flux and the main rotor magnetic flux produce the additional rotor torque.

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