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Research paper

Numerical analysis of the external wind path for medium-size high-voltage asynchronous motors

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HIGHLIGHTS

- The reasonableness of the motor cooler thermal physical model was verified.
- The characteristics and efficiency curves of the external fan were calculated.
- The coupling heat transfer analysis was applied to the cooler of YKK series motor.
- Finding the optimum operating point of the external fan.
- We improve the cooling performance through optimizing the structure of the motor cooler.

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ABSTRACT

In this study, we apply the theory of Computational Fluid Dynamics (CFD) and Numerical Heat Transfer (NHT), to improve the cooling capacity of the motor's external wind path by using a YKK450-4 800 kW medium-sized high-voltage asynchronous motor as an example. According to the actual size of the motor cooling system, we establish the external fan zone and cooler zone model. By changing the external fan inlet velocity, a series of differential pressure, flow rate and fan moments were obtained; thus, we calculated the characteristics and efficiency curves of the external fan for the fluid field and the heat transfer of these two areas. First, we used the coupling iteration analysis for the external fan wind path and cooler wind path to obtain the optimum operating point of the external fan. Using this operating point as a base, we explored the impact of the cooler structure on fluid flow. We optimized the structure of the motor cooler such that the temperature decreased by 3.3 °C in the outlet cooler internal wind path, thus proving that cooling performance was improved; we therefore provided a theoretical basis for the future design of wind paths.

1. Introduction

The YKK series motor is a closed cage rotor with an air–air cooler. The external wind path of the YKK medium-sizes high-voltage asynchronous motor comprises an external fan and cooler. As the YKK series motor is an enclosed AC asynchronous motor, the heat generated by the motor under normal operation cannot be directly cooled by outside air, so the temperature of each portion of the motor increases [1]. The role of the cooler is to generate the cold and hot air to exchange heat by the condenser [2,3]. The cooler takes away this heat such that it can maintain an average temperature rise and maximum temperature for the safe operation of the motor [4,5]. For medium and large motors, friction drag loss accounts for a large proportion of the total loss in the motor [6]. Thus, choosing an external fan is important for improving the efficiency of the motor.

Currently, there are three main research methods for such external fans. The first method use a path method [7]; the second method is uses the finite volume method (FVM) [8–10]; the third method uses wind tunnel experiments [11,12]. In the actual production of the motor, the production cycle and production cost should both be considered. If using the first algorithm, it can accurately calculate existing motor, once the motor structure is changed, this method cannot accurately be analyzed. If the third method is used, only a single wind path can be tested, i.e., we cannot test for the coupled analysis of the full wind path. Using the second method (i.e., FVM), we can repeatedly change the structure

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of the design model for numerical analysis and calculation until the parameters required are satisfied. Then, we can produce physical prototypes for testing, not only shortening the production cycle but also reducing cost. Therefore, in this study, we use the second method to analyze the cooler and external fan. Using YKK450-4 800 kW medium-size high-voltage asynchronous motor as an example and applying the theory of Computational Fluid Dynamics (CFD) and Numerical Heat Transfer (NHT), we created a three-dimensional model of the cooler and external fan. Next, we applied the numerical analysis method to calculate it. Finally, in this study, we contrast our numerical analysis results and experimental data, concluding the rationality of our numerical analysis.

2. Physical and mathematic model of the external wind path

Fig. 1 depicts the ventilation structure of the motor. In the figure, the dashed arrows represent the direction of external wind path flow fluid, whereas the solid arrows represent the direction of internal wind path flow fluid. Fig. 2 shows the motor physical map.

2.1. Physical model of the fluid flow of the external wind path

2.1.1. Physical model of the external fan

In this work, we used a centrifugal fan as the external fan, which consisted of nine blades. Towing to the large changes in the sectional area near the inlet and outlet of the fluid field of the actual external fan, establishing the fluid field with a certain length of the inlet and outlet cross-sectional area remaining the velocity same, we can ensure that the fluid flowing pattern develops fully. The physical model of the external fan can be seen in Fig. 3.

2.1.2. Physical model of the cooler

In this work, there were 713 cooling pipes, each with a diameter of 20 mm. While modeling the entire cooler, computer memory requirements were relatively high. Therefore, according to its symmetrical structure, one-ninth of the cooler model was created, thereby reducing the amount of calculation required. The physical model of the cooler is shown in Fig. 4(a). We changed the number of

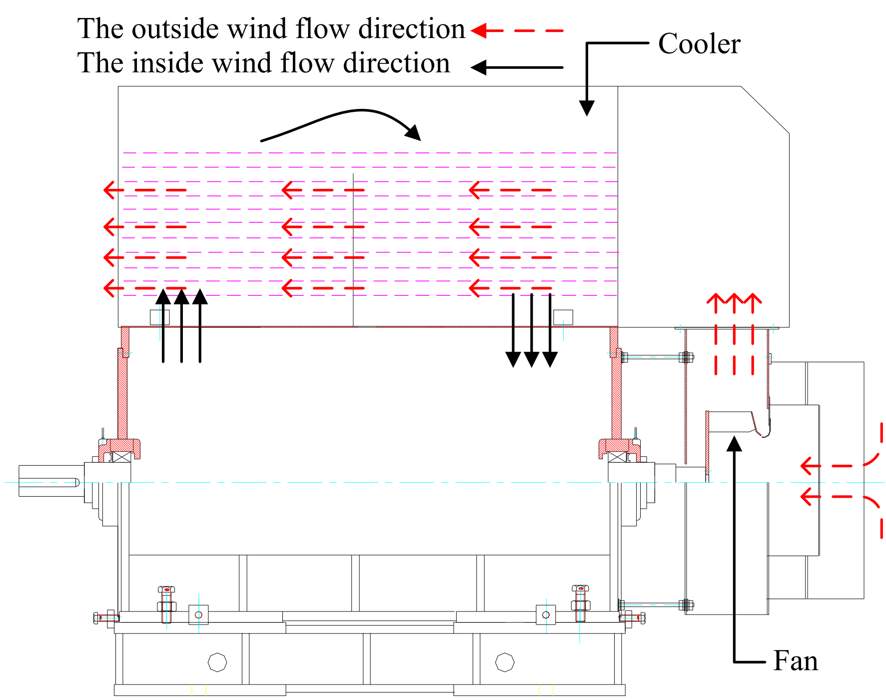

Fig. 1. Ventilation structure of the motor.

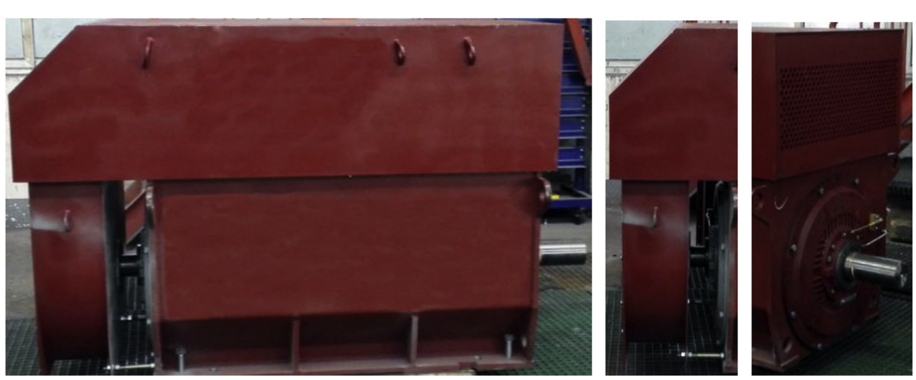

Fig. 2. Motor physical map.