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Generator flow field and temperature field analysis

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Abstract: In this paper, the flow area of the generator and the solid area of the generator are taken as the research object. According to the theory of fluid mechanics and heat transfer, the CFD software Fluent is selected as the calculation tool, and the direct coupling simulation analysis method is adopted to determine the boundary conditions and carry out the ship power generation. Numerical simulation of fluid-solid coupling. The 1/8 circumference of the motor is intercepted as a simulation model. Firstly, the simulation is carried out for the fluid field. According to the simulation results, the wind resistance of each air path in the motor and the total pressure drop of the motor are adjusted, and then the coupling simulation calculation of the fluid field and the temperature field is performed. The calculation results of the temperature field are evaluated.

1 COUPLED FIELD ANALYSIS METHOD

The parameters of each physical field can be obtained with a direct coupling analysis method, which analyzes the coupled field for only once.[1]. A calculation model is needed, and the parameters of the flow field and physical field of the marine generator can be directly calculated to achieve direct coupling [2].

2 FLUID-SOLID COUPLING SIMULATIONBOUNDARY CONDITION

The analysis of the physical model and the pre-processing content such as meshing can be finished after the entire calculation process and the boundary conditions is determined. The calculation model and boundary conditions also need to be determined. Each calculation model corresponds to different control equations. The correct choice of control equations plays the most critical role in the accuracy of the calculation results. Therefore, the correctness of the choice of control equations is very important. This example intercepts the motor circumference 1/8 as a simulation model.

For numerical solutions, the biggest feature of the analytical method is that there must be clear boundary conditions. Only when the boundary conditions of the computational model are given, the calculation results have a unique solution, and the control equations can be solved. It can be seen that the correct choice of boundary condition selection has a crucial impact on the calculation results. Therefore, in this case, we must choose a clear calculation model and boundary conditions to ensure that the calculation results are indeed reliable and unique [3]. The fluid-solid coupling analysis of marine generators in this example considers the following boundary conditions:

a) Speed entry boundary conditions:

The boundary of the air inlet is defined as the speed entry boundary condition:

Inlet air temperature: T = 273K + 45 = 318K (45 ° C is the air inlet temperature)

b) The simulation boundary conditions are set as shown in Table 1 below:

Table 1. Simulation boundary conditions

Inlet air temperature		45°C	
Total air volume requirement		≥4.45 m3/s	
Thermal conductivity of various parts of the motor	Winding copper core	380 w/mk	
	Winding insulation	0.2 w/mk	
	Iron core (silicon steel sheet laminated structure)	Circumferential and radial	50 w/mk
		Axial	20 w/mk
	Metal material such as shaft	30/mk	

3 RESULTS

3.1. Flow field analysis

The cooling fluid inside the generator is ambient air at 45 °C around the generator at this time, and the cooling system is a free circulation system [4].

(1) The simulation results of the motor fluid field are shown in Table 2.

Table 2. Generator fluid field simulation results

Name	parameter
Total air volume	4.46m3/s
Stator back air volume	2.89 m3/s
Air gap air volume	0.62 m3/s
Rotor vent air volume	0.95 m3/s
Motor inlet and outlet wind pressure	2220Pa

3.2. Temperature Field

Firstly, the simulation analysis is carried out on the fluid field. According to the simulation results, the wind resistance of the wind path and the total pressure drop of the motor are adjusted. Then the coupling simulation calculation of the fluid field and the temperature field is carried out, and the calculation results of the temperature field are evaluated. [5] [6].

(1) The temperature field distribution of each part of the motor is shown in Figures 1, 2, 3 and 4 below.

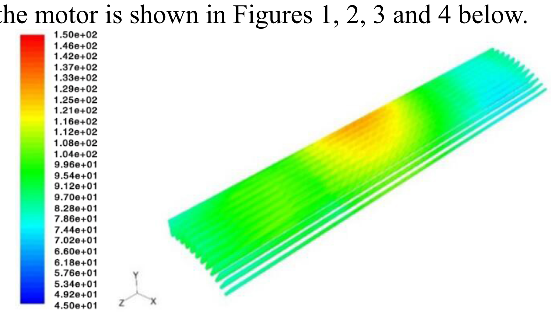

Figure 1.Temperature field distribution diagram of stator winding

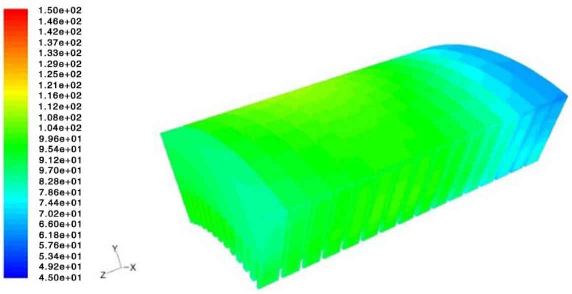

Figure 2. Motor stator core temperature distribution diagram

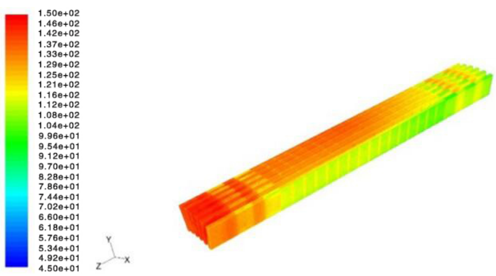

Figure 3.Temperature field distribution diagram of rotor winding

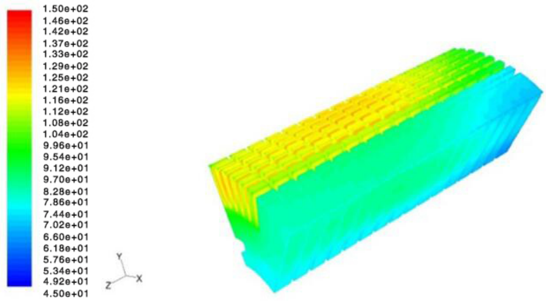

Figure 4.Temperature field distribution diagram of rotor core

(2) The temperature field data of each part of the motor is shown in Table 3.

Table 3. Generator temperature field simulation results

Part Name	Temperature range / °C	Maximum temperature rise / k	Average temperature / °C	Average temperature rise / k
Stator winding	75.2~130.3	85.3	102.1	56.0
Stator tooth core	71.0~126.7	81.5	102.2	55.9
Stator yoke core	64.2~120.4	74.5	96.5	51.2
Rotor winding	113.5~150.0	103	135.1	88.9
Rotor core	60.0~126.3	82.4	89.3	42.3

4 DISCUSSION AND ANALYSIS

(1) Through using the numerical simulation calculation method, the temperature rise value of the stator coil of the generator and the wind speed value of the air outlet outlet are approximately close to the actual measured results of the real machine, which proves the applicability of the numerical simulation method in the analysis of the air-cooling of the generator-class air-cooled electric machine.

(2) When the generator is actually running, the air flow field at the inlet of the stator air sump changes very sharply，the tooth speed is greater than the yoke wind speed, and the windward wind speed is also greater than leeward wind speed. The surface of the stator wind ditch share the same the variation law of the heat dissipation of the generator .

(3) The relationship between the pressure drop of air flowing through different regions of the stator air sump is: P inlet > P tooth > P yoke > P outlet, among which the inlet loss of the stator airbag accounts for the largest proportion of the total loss of the ventilation channel, which indicates the necessity and importance of stator inlet flow channel optimization.

(4) The magnitude of the thermal resistance between the stator coil and the core has a crucial effect on the heat dissipation of the stator winding, therefore, increasing the coefficient of thermal conduction, appropriately reducing the thickness of the insulation, ensuring the coils that are in good contact with the surface of the core, and using the measures of a larger groove aspect ratio will all have a certain effect on lowering the temperature of the stator coil.

5 CONCLUSIONS

It can be seen from Table 3 that the temperature of each main component of the motor meets the design requirements. The highest temperature is located inside the rotor winding, and its maximum temperature reaches 150°C, which meets the design requirements. At the same time, due to the large air volume of the shaft centrifugal fan actually selected by the motor, it reaches 5.6 m^3/s, which is greater than the 4.46 m^3/s used in the simulation calculation. Therefore, the comprehensive income, temperature rise has a margin.

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