Performance Characteristics Comparison of Electric Vehicle Driving Motor with Slot Water Jacket and Oil Spray Cooling

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Abstract
The energy densities of electric driving motors are continuously increasing to improve the performance of electric vehicles. This has led to high heat generation from such electric driving motors which limits to achieve higher torque rating and power output using conventional water jacket cooling. The direct liquid cooling is emerging technique to achieve the desired thermal management of electric driving motor with increasing energy densities. In the present study, the performance characteristics of electric vehicle driving motor with slot water jacket cooling and that with oil spray cooling are numerically compared. The coupled numerical model is developed to simulate the temperatures and torque rating of electric motor with both direct cooling strategies under various conditions of speed. The oil spray cooling shows superior performance characteristics of electric vehicle driving motor compared to slot water jacket cooling. The maximum temperature of windings is lower by 17.12 ℃ for oil spray cooling compared to slot water jacket cooling. The oil spray cooling shows enhancement in torque rating of electric vehicle driving motor compared to slot water jacket cooling owing to decrease in temperature.

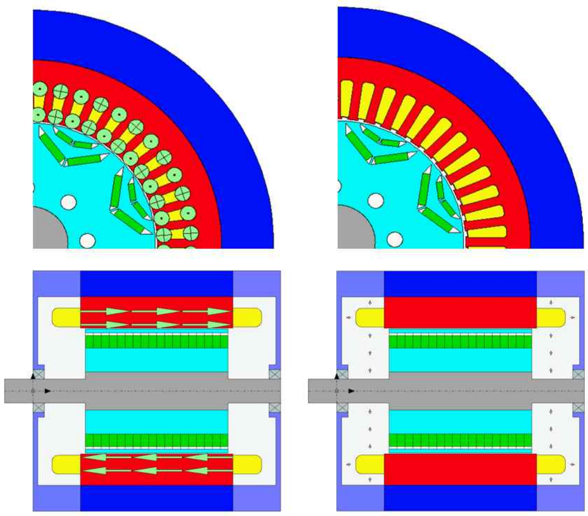
1. Introduction

The direct liquid cooling is getting increasing attention for thermal management of electric vehicle driving motor owing to the high thermal resistance of conventional water jacket cooling [1]. In open literature, the direct liquid cooling for electric driving motor is categorized into slot jacket cooling and spray cooling. The oil has property of higher electrical resistivity which enables the advantage of direct spray on electric driving motors whereas, water could be preferred as best coolant for slot jacket cooling of electric driving motor [2, 3].

2. Numerical model

A 125-kW electric vehicle driving motor with two direct liquid cooling strategies is considered as computation domain to study its performance characteristics. The configurations of two direct liquid cooling strategies as slot water jacket cooling and oil spray cooling are shown in Fig. 1. The spray cooling is conducted through nozzles using transmission oil as coolant. The performance characteristics are simulated at coolant temperature and flow rate of 40 ℃ and 6 LPM considering variation of speed in range of 2000 rpm to 10000 rpm.

3. Results and discussion



[Fig. 1] Electric vehicle driving motor with slot water jacket cooling and oil spray cooling

The temperatures of various components of electric vehicle driving motor with oil spray cooling are lower compared to that with slow water jacket cooling. The maximum winding temperatures are evaluated as 173.43 ℃ in case of slot water jacket cooling and that as 156.32 ℃ in case of oil spray cooling. The improvement in cooling performance of electric vehicle driving motor with oil spray cooling over slot water jacket cooling has resulted in enhancement of torque rating.

4. Conclusion

The electric vehicle driving motor with two direct liquid cooling strategies namely slot water jacket cooling and oil spray cooling are compared based on performance characteristics. The temperatures and torque rating of electric vehicle driving motor are simulated using coupled numerical modeling under various speed conditions. The temperatures of electric motor decreases and torque rating of electric motor improve for oil spray cooling over the slot water jacket cooling.

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