Analysis of Temperature Distribution in Power Converter for Switched Reluctance Motor Drive

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Abstract — This paper presents the 2D thermal model of power converter in Switched Reluctance motor drive. The mesh structure is given that large grids are used in radiator, while small grids are used in gasket and power electronic components because there is large heat flux density. The thermal distribution of equivalent thermal model with the maximum temperature part is also presented. The relationship between the space of two rows component and the maximum temperature on the power converter, the relationship between the thickness of radiator bottom and the maximum temperature on the power converter, and the relationship between the height of the radiator fins and the maximum temperature on the power converter are also given.

I. INTRODUCTION

Switched Reluctance motor drive has the well applied foreground [1][2]. Enhancing the reliability, reducing the noise and vibration [3][4] contribute to generalize the applications of Switched Reluctance motor drive in industries. Temperature rise of Switched Reluctance motor drive causes less reliable. Temperature rise of switched reluctance motors due to electromagnetic losses [5][6]. In this paper, the finite element method was used to solve the thermal model by using FEM software Flux. The thermal model was divided into three layers from top to bottom, including power electronic devices, the gasket and the radiator.

II. STRUCTURE OF THE POWER CONVERTER

As shown in Fig.1, the main circuit topology of power converter in Switched Reluctance motor drive is three-phase asymmetrical half-bridge circuit. Two parallel power MOSFETs are used as one main switch, and two parallel fast recovery diodes are adopted as one freewheeling diode.

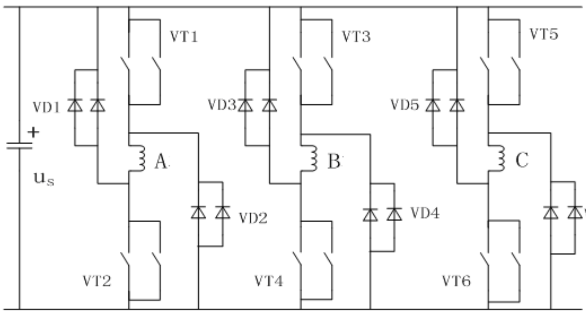

Fig. 1. Main circuit topology of the power converter

The structure of the power converter main circuit is given in Fig.2. The voltage PWM control is adopt for output torque and rotor speed regulation of the drive. The conducted signals of the main switches, VT1, VT3 and VT5 are modulated by PWM signal. The conducted signals of the main switches, VT1, VT3, VT5, VT2, VT4, and VT6 are based on the rotor position.

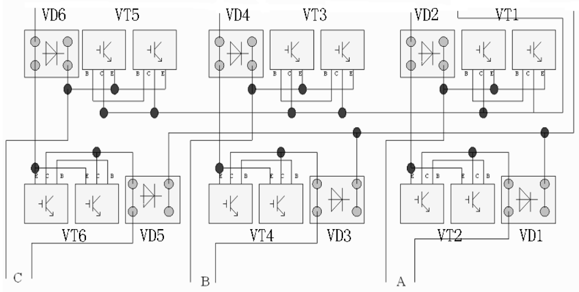

Fig. 2. Structure of the power converter main circuit

III. 2D THERMAL MODEL

The 2D thermal model can be considered as a slice of 3D model, but the slice can not load heat convection completely, therefore a new equivalent transformation was proposed to build equivalent fins for 2D thermal model, which should meet the following relations between 3D thermal model and 2D. Firstly, the volume of the radiator is equal. Secondly, the capacity of heat convection is equal. The 2D thermal model used equivalent transformation is shown in Fig. 3.

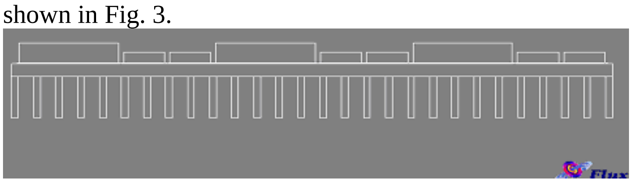
Fig. 3. Equivalent 2D thermal model

The mesh structure is shown in Fig. 4, which indicates that large grids are used in radiator, while small grids are used in gasket and power electronic components because there is large heat flux density.

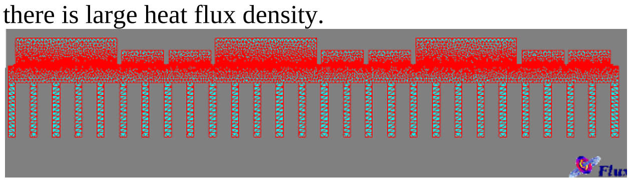
Fig. 4. Mesh structure of 2D thermal model

IV. CALCULATED RESULTS

Fig.5 shows the thermal distribution of equivalent thermal model with the maximum temperature 28.404℃ in main switch VT_6.

There is a minimal value of the maximum temperature on power converter while the space of two rows component is changed shown in Fig.6. The minimal value of the maximum temperature on power converter is 28.139℃, while the space of two rows component is 31mm. While the space is greater than 31mm, the maximum temperature will ascend with the space increased, because with the power electronic components closed to the edge of the radiator, the thermal resistance of the radiator is increased. On the contrary, while the space is less than 31mm, the maximum temperature ascend with the space reduced, because the thermal coupling of the power electronic components becomes strong.

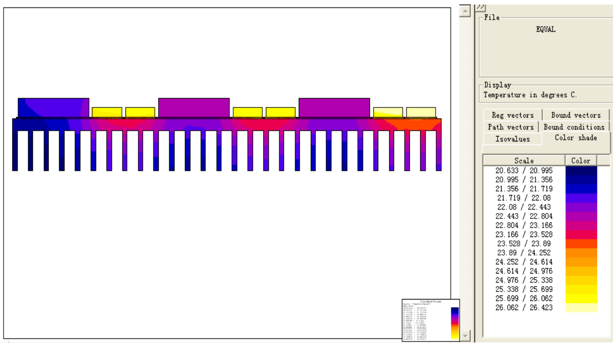

Fig. 5. Thermal distribution of equivalent 2D thermal model

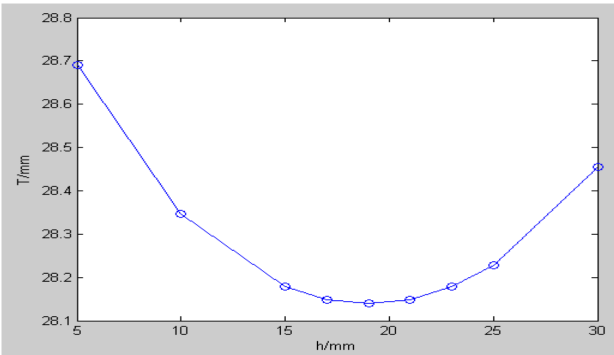

Fig. 6. Relationship between the space of two rows component and the maximum temperature on the power converter

There is a minimal value of the maximum temperature on power converter while the thickness of radiator bottom is changed shown in Fig.7. The maximum temperature drop while the thickness of radiator bottom is reduced because the thermal resistance of the radiator is decreased. But while the thickness is reduced to some extent, the maximum temperature will ascend because cooling effect depended on the cooperation of the bottom and fins becomes weak.

There is a minimal value of the maximum temperature on power converter while the height of the radiator fins is changed shown in Fig.8. The maximum temperature drop with exponential function while the height of the radiator fins increases. However, the volume and the weight of the radiator are increased while the height of the radiator fins is enlarged. Therefore, the radiator fins can not be designed too high.

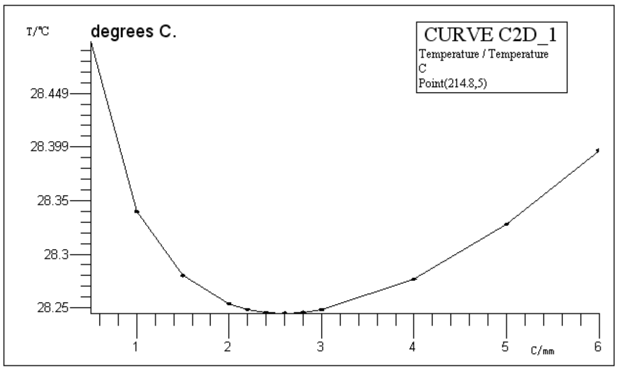

Fig. 7. Relationship between the thickness of radiator bottom and the maximum temperature on the power converter

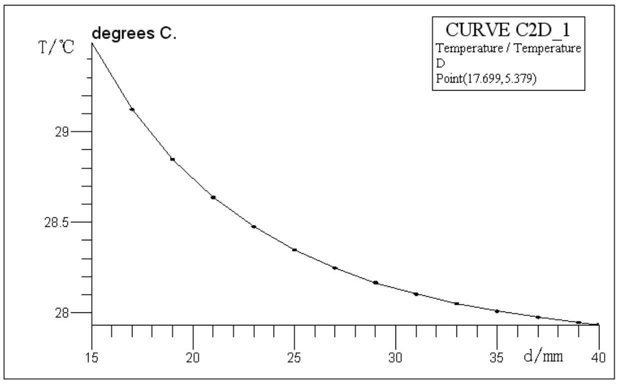

Fig. 8. Relationship between the height of the radiator fins and the maximum temperature on the power converter

V. CONCLUSION

The 2D thermal model of the power converter in Switched Reluctance motor drive can be considered as a slice of 3D model. It contributes to analysis the temperature rise effectively and rapidly.

VI. ACKNOWLEDGMENTS

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VII. REFERENCES

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