Advanced Science and Technology Letters
Vol.47 (Healthcare and Nursing 2014), pp.379-382
http://dx.doi.org/10.14257/astl.2014.47.86

Design of Roof Type Dynamic Braking Resistor for Railway Carriage by using Thermal Analysis

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Abstract. For train's safe operations, a braking system is needed to control the velocity easily and fastly. The braking system is classified into mechanical braking which transforms kinetic energy into heat and an electric braking which transforms power energy into heat. A regenerative braking system dissipates the regenerative energy generated by electric bracking in the load resistor and suppresses over voltage of power electronics system. In this paper, a method to design the braking resistor of roof type electric braking system using for railway carriage is proposed by using thermal analysis. By thermal analysis, the shape and arragement of an element which is main part of a braking resistor is designed.

Keywords: Roof type, dynamic braking resistor, railway carriage, thermal analysis, computational fluid dynamics, heat transfer.

1 Introduction

For train's safe operations, a braking system is needed to control the velocity easily and fastly. The braking system is classified into mechanical braking which transforms kinetic energy into heat and an electric braking which transforms power energy into heat [1]. A braking resistor is used to suppress the voltage surge and absorb the regenerative power. In an inverter operation, inertia energy of motor and load is transformed to electric energy by speed reduction, and is regenerated to inverter [2]. By dissipation of regenerated energy into heat, the efficiency of speed reduction by inverter is increased. A regenerative braking system dissipates the regenerative energy (regenerativ voltage) generated by electric bracking in the load resistor and suppresses over voltage of power electronics system. This system is necessary for control of train velocity, and the dissipation of regenerative power generated by velocity reduction of high-speed trains. Many researches related with development of regenerative braking system for magnetic levitation and high-speed trains are proposed [3-5]. Regenerative braking system is classified into a roof type and an under type according to arranged

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ISSN: 2287-1233 ASTL
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position at train. The roof type regenerative braking system is more popular than the under type because of easy installation, small space, light weight, high efficiency of natual cooling.

In this paper, a method to design the braking resistor of roof type electric braking system using for railway carriage is proposed by using thermal analysis. By thermal analysis, the shape and arragement of an element which is main part of a braking resistor is designed.

2 Configuration of Roof Type Dynamic Braking Resistor

A braking resistor of roof type electric braking system is positioned on the upper side. Inertia energy of the motor and load is transformed to electric energy, and is regenerated in inverter as shown in Fig. 1. This regenerated energy is dissipated to heat, so efficiency of speed reduction by inverter is increased.

The braking resistor of roof type electric braking system is consisted with an element, an out frame to seperate resistor from outside, and an insulator to insulate the element from the out frame as shown in Fig. 2. In this configuration, the element has sheet plate shape to release the heat generated by regenerative braking and to increase the resistance. High resistance can be achieved by a serial welding of each element.

3 Requirement of Roof Type Dynamic Braking Resistor

The requirement of roof type dynamic braking resistor is to preserve the efficiency of regenerative braking to minimize the velocity reduction time. So, it is required that the heat generated by a regenerative braking is dissipated and the temperature rise in a braking system is minimized.

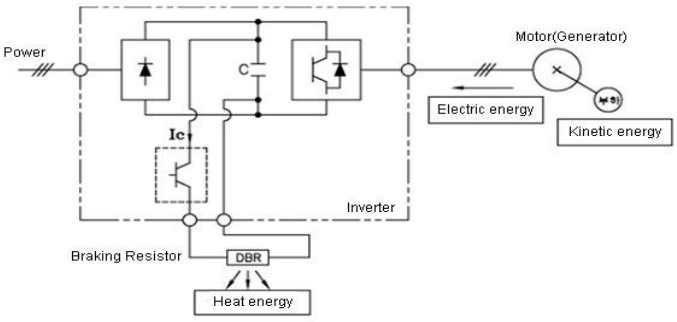

Fig. 1. Operating principle of regenerative braking by inverter.

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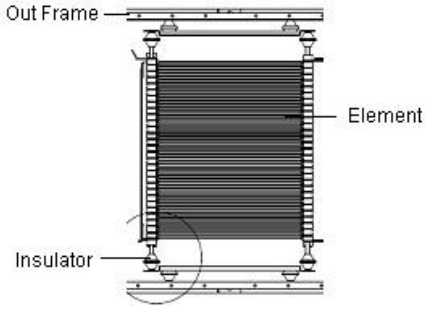

Fig. 2. Configuration of dynamic braking resistor.

4 Thermal Analysis

Thermal analysis is used to design the shape and arragement of an element which is main part of the braking resistor using for dissipation of the heat generated by the regenerative braking. In the thermal analysis, the temperature rise of an element acting as a resistor is calculated according to the current flow induced by the voltage generated in the regenerative braking process. In this analysis, natual cooling condition is used for the resistor. Thermal analysis is conducted with computational fluid dynamics (CFD) software. The analysis model is simplified to 2-dimension as shown in Fig. 3.

5 Results and Discussion

To satisfy the design specifications of dynamic braking resistor using for high-speed train, the shape and arrangment of the element is designed with thermal analysis and design results are listed in Table 1. The temperature rise and the heat dissipation of the element according to time step are shown in Fig. 4.

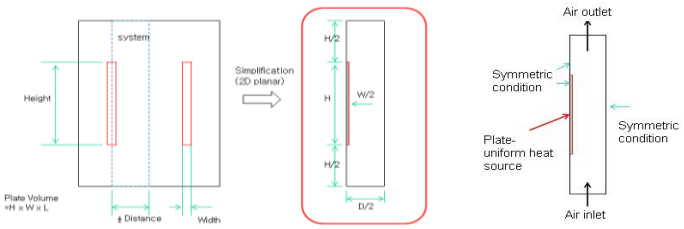

Fig. 3. Thermal analysis model and boundary conditions.

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Table 1. Designed values of roof type dynamic braking resistor.

Item	Value	Unit
Element Thickness	0.7	mm
Element height	40	mm
Space between elements	10	mm

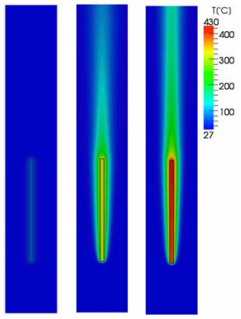

Fig. 4. Temperature characteristics of element according to time step; (a) t=0 sec, (b) t=20 sec, (c) t=100 sec.

6 Conclusions

In this paper, a method to design the braking resistor of roof type electric braking system using for railway carriage is proposed by using thermal analysis. By thermal analysis, the shape and arragement of an element which is main part of a braking resistor is designed.

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