STUDY ON THE DESIGN FOR TOUCH FREE LINEAR EDDY CURRENT BRAKE

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Abstract-This paper describes braking performance of a touch free linear eddy current brake operated electrically at rail high-speed transportation systems. The eddy current brake systems have to be equipped with the favorable circumstance of the maximum braking force and deceleration at the given volume or mass, high braking forces rate, attraction forces as small as possible and stable construction. In order to design eddy current brake magnet satisfying the above-mentioned performance, the characteristic of eddy current brake according to the design parameters is analyzed by using 2-demsional FEM. From the results, the optimized eddy current brake system is designed to obtain the maximum braking force and deceleration.

Introduction

The design parameters including the number of poles, magnetomotive force and slot width have influence on the braking force characteristics [1,2]. Therefore, it is necessary to know exactly on which the parameters has an effect in order to design the optimal eddy current brake. According to the variation of the parameters, the detail design is carried out and then the effects of braking performance with thermal characteristic are analyzed by using 2-D FEM. To improve the accuracy of 2-D analysis, the equivalent stack length is calculated using magnetic scalar potential.

The electromagnetic equation for time varying field problem with vector potential is as follow [3].

$$\nabla \times \left(\frac{1}{\mu}\nabla \times \vec{A}\right) = \vec{J_0} + \sigma\left(\vec{v} \times \vec{B}\right) \quad (1)$$

In order to calculate the equivalent stack length, the governing equation is the equation (2). From the equation (3), the equivalent stack length w' can be calculated, where flux, ϕ, and coenergy, W_m, are obtained by solving the equation (2).

$$\nabla \cdot (\mu \nabla \Omega) = 0 \quad (2) \qquad w' = \frac{\gamma\phi^2}{2W_m\mu_0} \quad (3)$$

The initial model is 6-pole whose magnetomotive force per slot is 33600[AT]; airgap is 7[㎜]; the pole pitch is 180[㎜]; rail width is 74[㎜]. The velocity is limited from 50[㎞/h] to 350[㎞/h]. The slot dimension of eddy current brake magnet varies with the number of pole. But the total length of magnet is almost same.

Conclusion

Fig. 1 shows the average braking force and attraction force with slot width in 6-pole model. The x-axis represents slot width/pole pitch. From this feature, the ratio of 35/180 in x-axis produces the peak value of braking force. Fig. 2 shows the average braking force of re-designed model in accordance with the

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variations of the number of the pole with 4-pole, 6-pole, 8-pole and 10-pole. In the case of constant current density, as the number of pole is decreased, attraction force and braking force are increased. But the decrease in the number of pole enhances the increase in the load of the wheel which is, in turn, caused by attraction forces acting on them. In another case of constant MMF, the 8-pole has not only the maximum braking force but also the lower attraction force. Fig. 4 shows the thermal analysis results according to number of the pole. As the number of the pole is increased, the temperature rise in the magnet coil is decreased when the current density is kept to constant. Fig. 3 shows that the mechanical stack length over 110[㎜] saturates the equivalent stack length. Thus, the stack length appropriates to be designed below 110.

The above described analysis results might be used for the design of the eddy current brake system.

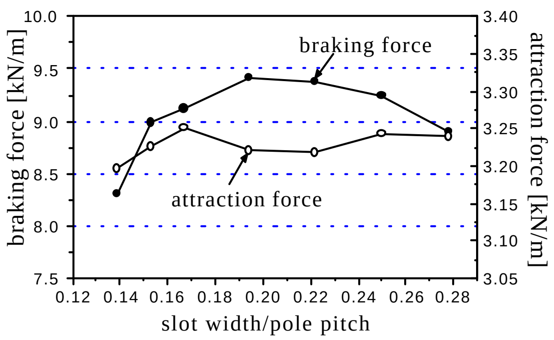

Fig. 1 Braking characteristic according to slot width /pole pitch

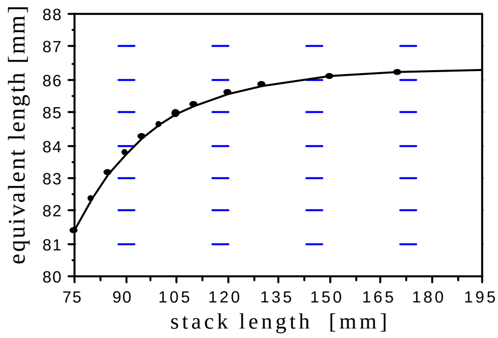

Fig. 3 Equivalent stack length according to variation of the mechanical stack length

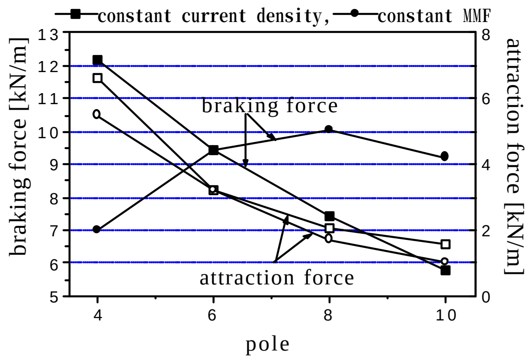

Fig. 2 Braking characteristic vs. number of poles

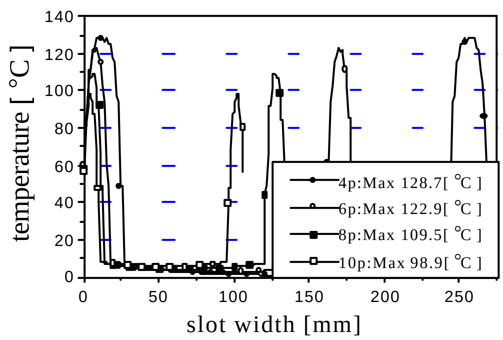

Fig. 4 Temperature distribution in the magnet

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