Development of an Eddy Current Rail Brake Derived from Linear Motor Technology

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Eddy current rail brakes characteristically guarantee the generation of a stable braking force that is not affected by the conditions of the rail tread surface, as they function without contacting the rails. There are several problems, however, in the application of the eddy current rail brake system. These include a rise in rail temperature when eddy current rail brakes are used, and ensuring the supply of power to energize the brake when the main circuit of the car has failed. For these reasons, the system has not yet been commercialized in Japan. Given this situation, the Railway Technical Research Institute (RTRI) is aiming to solve these problems with the eddy current rail brake system by applying linear motor technology acquired during the development of Maglev systems.

Concept of the linear motor rail brake system

The linear motor rail brake system uses the armature of linear induction motors (LIMs) in place of the excitation pole of the conventional system and generates braking forces by dynamic braking operation, as shown in Fig. 1. This system has the following advantages.

1) For the same braking force, the LIM rail brake does not raise the rail temperature as much as a conventional eddy current brake.
2) The power required for excitation is secured from the kinetic energy of the vehicle.

Figure 2 shows the arrangement of the power supply system. When triggered by a brake command, the inverter starts using the voltage of the auxiliary power circuit and increases the output DC voltage immediately thereafter by relying on the generated power. After reaching a preset DC voltage, it maintains the DC voltage required for its rated operation while maintaining the braking force by controlling the power to balance the power generated and that required for excitation. This method is called the "dynamic braking with zero electrical output." Figure 3 shows the basic energy flow using this control method.

Estimation of the system characteristics with a conceptual model

RTRI calculated the characteristics of the system against the car running speed when it is controlled to keep the generated output power constant, as in the case of dynamic braking with zero electrical output (Fig. 4). Figure 4 shows that the output power and braking force are kept constant when the frequency is approximately constant, irrespective of the running speed.

A prototype of the armature for rail brakes

Given the need to generate power and maximize the braking force density in a limited space, together with the restricted space available for installation, RTRI is now discussing the adoption of a ring-wound armature for rail brakes. To examine the feasibility of this option, therefore, RTRI had a prototype ring-wound armature for the rail braking application manufactured and examined its electromagnetic characteristics in a lock test system with a static tester (Fig. 5). This moves forward the magnetic field alone in the static condition to generate a thrust force in the rails. When the speed of the magnetic field is converted into the car running speed, the value of the thrust force thus obtained gives the characteristics of the braking force when the car is actually running. By repeating various tests, RTRI confirmed that unnecessary magnetic fields, which were expected to occur with a ring-wound armature, did not occur much, with the thrust force (braking force) reaching a peak when the speed of the magnetic field was approximately 100 km/h.

Future development

Through various studies of element technologies for the eddy current rail brake system derived from linear motor technology, the feasibility of the functions and performance proposed by RTRI has been confirmed. In the near future, RTRI will develop rail brakes to be mounted on test bogies and carry out running trials.

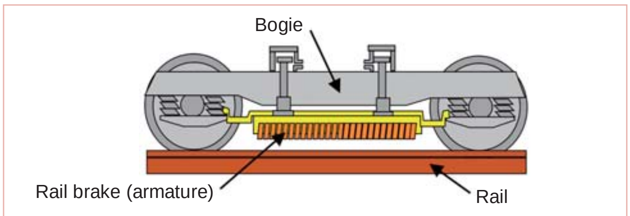

Fig. 1 Schematic of a LIM rail brake

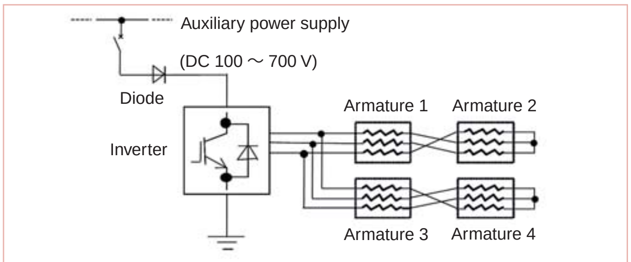

Fig. 2 Example of a power supply system for a LIM rail brake

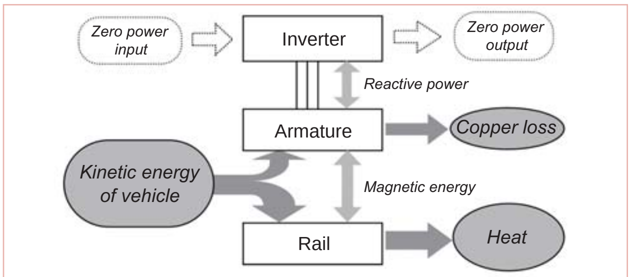

Fig. 3 Energy flow of the dynamic braking with zero electrical output

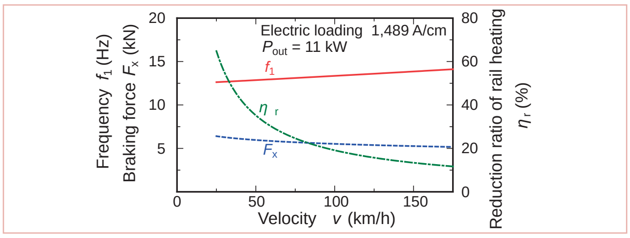

Fig. 4 Velocity characteristic curves of the LIM rail brake under the condition of constant current and constant power generation

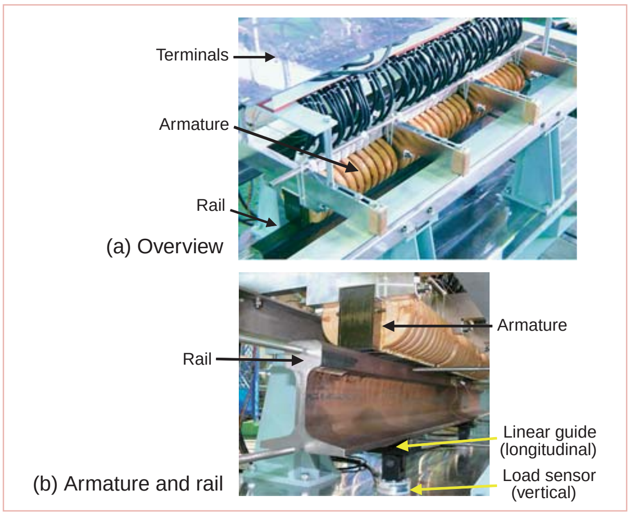

Fig. 5 Testing armature for the lock test