Mechanical Performance Analysis of a Switch-and-Lock System for Shinkansen

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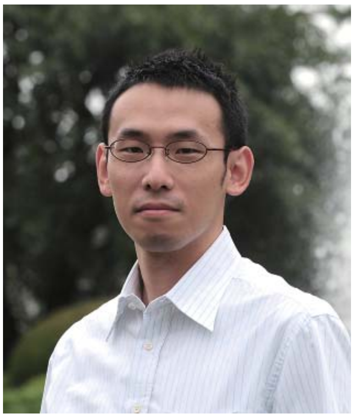


In the development and redesign of the switch-and-lock system (composed of an electric switching machine and switching equipment) to ensure its safety and reliability, it is important to check a number of mechanical properties including the force required to bring about switching (referred to here as the switching load) and performance in the detection of foreign matter captured between the tongue rail and stock rail. To this end, we are currently implementing performance confirmation testing on actual switch-and-lock systems combined with turnouts, which requires tremendous amounts of time and money. Furthermore, it is very difficult to perform tests for all combinations of switch-and-lock systems and turnouts due to the sheer numbers involved. In redesigning and developing more efficient switch-and-lock systems to meet today's needs for reduced costs and streamlined maintenance work, it is essential to improve the efficiency of the development process (Fig. 1). Against this background, we are now working on the development of a dynamic model to estimate switching loads while aiming to establish a technique to analyze and evaluate the mechanical performance of switch-and-lock systems to replace such measurement tests.

Figure 2 shows the composition of a Shinkansen switch-and-lock system. The system adopts a setup that makes use of an electric point machine and plural escape cranks (to switch plural spots of tongue rails). This type of switch-and-lock system has the characteristic of being subjected to shock from high-speed trains by the escape cranks (rather than directly by the point switch machine) in order to ensure a high level of safety. This switch-and-lock system involves switching equipment including signal links that mediate between the electric point machine and the tongue rail, meaning that the switching load is affected by the dimensions and configuration of this switching equipment (e.g., the diameter and length of signal links and switch adjusters).

We have therefore developed a model to estimate the transmission of switching loads in switching equipment (Fig. 3). The model is made up of elements corresponding to signal links, switching adjusters and escape cranks. In its development, we assumed that the dimensions and configuration of the signal link and the switching adjuster affect the elastic and damping coefficients, while those of the escape crank affect the transmission torque, which changes depending on the contact condition.

As an example of the model's application, Fig. 4 shows the switching load calculated using the model after redesign of the configuration of the escape crank on the end side. It turns out that the maximum switching load is reduced by using the redesigned crank as compared to the conventional one. This finding corresponds with the test results obtained from actual systems.

These results suggest that measures can be implemented to cope with switching disability (a type of failure that occurs when the switching load is larger than the switching power of the electric point machine) by redesigning switching equipment. In the future, we plan to promote the development of a dynamic model that considers the effects of friction force and tongue rail elasticity, and to improve the simulation precision of the dynamic model. We will then propose an analytical means for dealing with problems caused by increased switching loads.

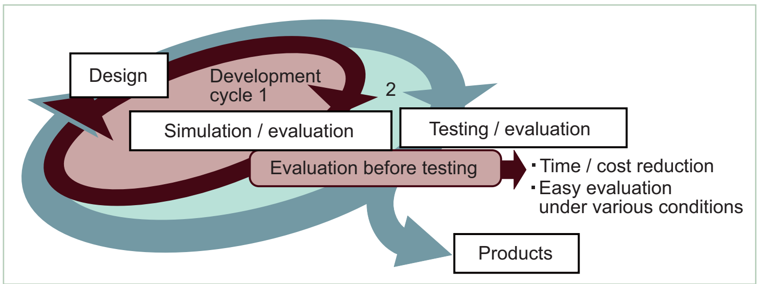
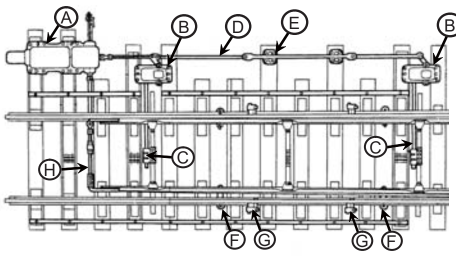


Fig. 1 Development process of switch-and-lock system (proposed)



A	Electric switching machine
B	Escapement crank
C	Switch adjuster
D	Rod
E	Rod carrier
F	Roller
G	Circuit controllers (contact detect type)
H	Front rod

Fig. 2 Composition of Shinkansen switch-and-lock system

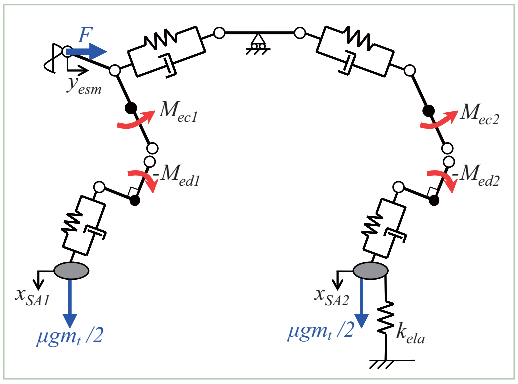


Fig. 3 Switching loads transmission model

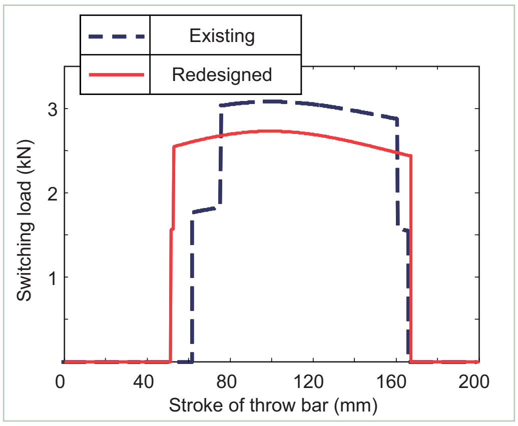


Fig. 4 Result of switching load calculation