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Breaking simulation of railway vehicle under low friction coefficient conditions considering wheel slide re-adhesion control

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Abstract

In the railway system, the contact between wheel and the rail of railway vehicles has a strong influence on the running safety. But the friction coefficient between wheel and rail are decreased by water film on the top of the rail caused by rain. Under low friction coefficient conditions, wheel slide occurs when the vehicle is breaking, and braking distance may be increased. This is a serious safety risk to the operation of railway vehicle. Therefore, understanding of adhesion of wheel and rail is important.

The water film on the rail is partially removed by passing wheel, so the thickness of water film for the trailing wheel is considered to be thinner than that for the leading wheel. A numerical model of the friction coefficient between wheel and rail in wet conditions is constructed and the relationship between the thickness of water film, the friction coefficient and the vehicle speed[1]. Recently, a developed numerical model has been proposed and a scale model experiment was performed[2, 3].

However, the way to use the results of these research for actual vehicle control has not yet been proposed. In this research, we built a multibody dynamics simulation model of a railway vehicle with wheel slide re-adhesion control and have carried out breaking simulations under low friction coefficient conditions.

We used Simpack to build a model of vehicle and do multibody dynamics simulation.

Modelling targets are 2-car EMU actually in use in some part of Japan. The modelling target EMU consists of two types of control motor cars. Both cars have one trailer bogie on drivers' cab side and one electric motored bogie on the other side, and have break control units for each bogie.

Figure 1 shows the model of an electric motored bogie and figure 2 shows the model of a vehicle. The number of bodies are 17 and the degree of freedom is 52.

Wheel slide re-adhesion control is implemented based on the specifications of the break control unit of the modelling target train.

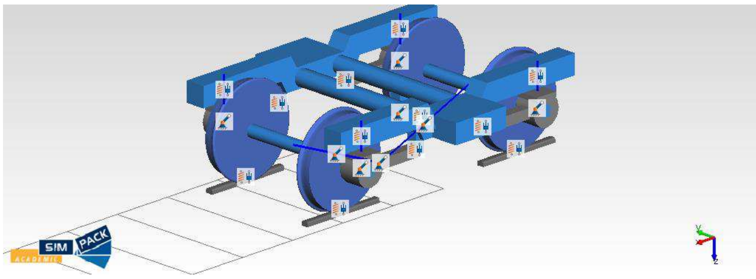

Figure 1: Simulation model of a bolsterless bogie (electric motored)

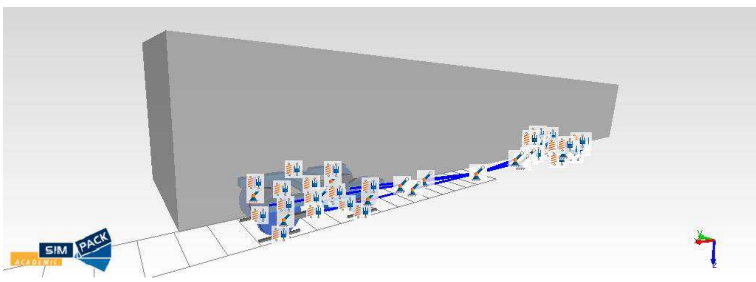

Figure 2: Simulation model of a vehicle

To confirm the function of the wheel slide re-adhesion control, breaking simulation was performed on straight and flat track. At the start of this simulation, vehicle speed was set to 110 km/h, the maximum speed of the modelling target train. 5 seconds after the start, breaking torque start to be applied to each axle so that the vehicle decelerate in 3.9 km/h/s.

Friction coefficient between wheel and rail depends on the axis. (See Table 1) These figures are provisionally defined only to confirm the function of the re-adhesion control and do not reflect research findings mentioned above.

Table 1: Friction coefficient between wheel and rail in the simulation

Axle number	Friction coefficient
1st	0.1
2nd	0.105
3rd	0.3
4th	0.3

Simulation result of angular velocity of wheel sets is shown in Figure 3. Negative angular velocity means the vehicle is running forward. Both 1st and 2nd axle started to slide immediately after breaking torque applied but didn't lock. From this figure, we can say that the wheel slide re-adhesion control is working well in this simulation.

Looking more closely, the changes of angular velocity near the start of slide are similar to the result of breaking test in real vehicle, but the change of angular velocity of 2nd axle during the re-adhesion control working is not similar to that.

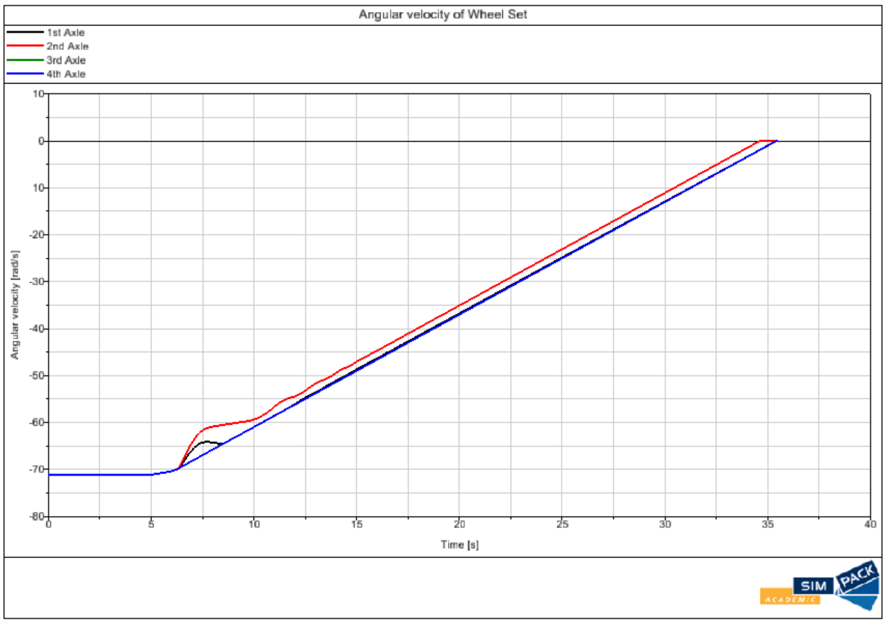

Figure 3: Angular velocity of wheel sets

After this, we are going to reflect the previous work findings to the MBD simulation model, and study the best way of breaking under wet conditions.

References

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[2] Wang, Y.; Lin, S.; Suda, Y.: Experiment validation of the brake control of railway vehicle based on the wheel-rail adhesion characteristics. Proceedings on J-RAIL2021, SS9-2-2, 2021

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