A study on critical speed of high-speed train using measured wheel profiles

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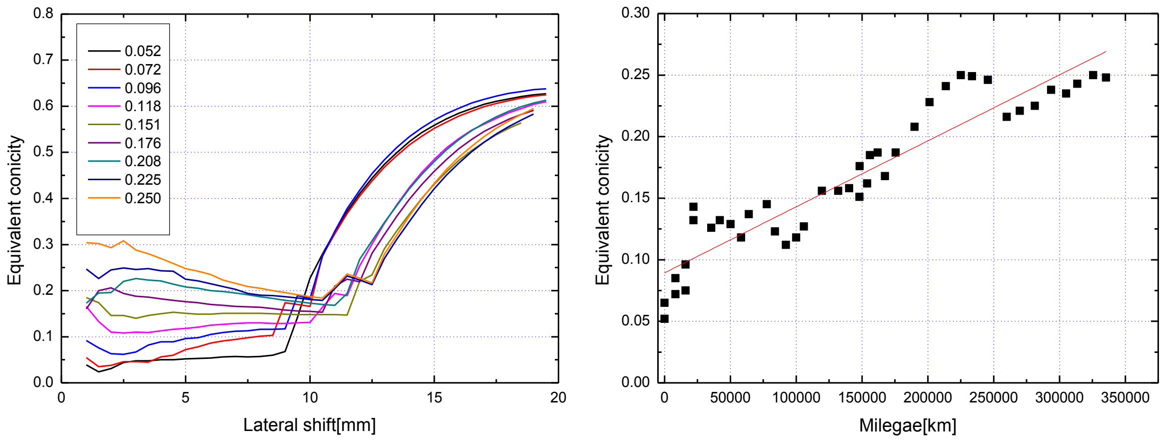
Abstract

This study describes the critical speed of KTX-sancheon, the Korean high-speed train, using measured wheel profiles. The critical speed of KTX-sancheon power car was analyzed using VAMPIRE[1], the railroad dynamic software. In this analysis two types of wheel/rail contact data were investigated. One is contact data from linear creep model[2] and the other is data from measured wheel profiles.

Lots of wheel profiles of KTX and KTX-sancheon were measured using CALIPRI[3] as mileage increased. The mileage was between 0km and 335,500km. The wheel profile of KTX and KTX-sancheon is XP55(1/20) accoriding to French standard NF F01-115. The equivalent conicity was calculated using measured wheel profiles and new UIC60-20 rail and displayed in Fig. 1(a). The conicity of new wheel is 0.052 and it was according to lateral shift. The worn wheel conicity of 335,500km is about 0.25. The conicity of 5mm lateral shift is displayed in Fig. 1(b). It shows that the conicity increases according to mileage.



(a) Calculation of equivalent conicity

(b) Equivalent conicity according to mileage

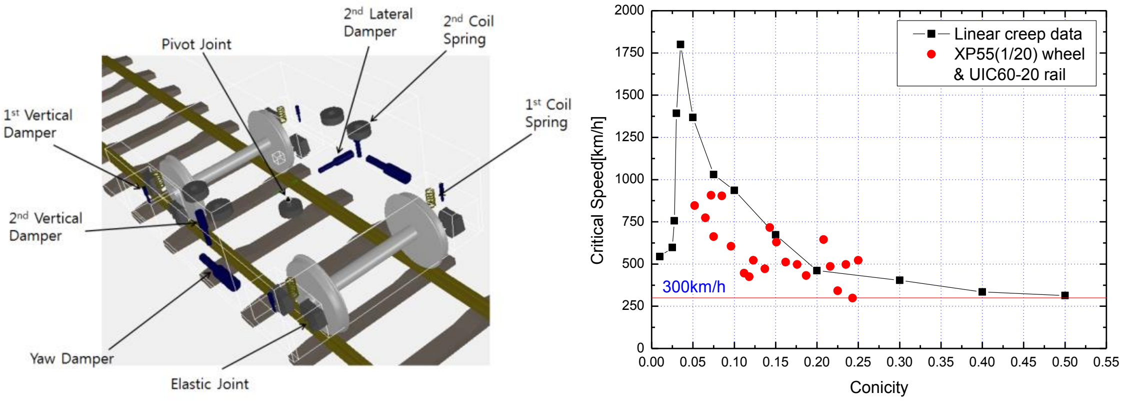
Figure 1: Equivalent conicity

The critical speed of KTX-sancheon power car was calculated using VAMPIRE. The vehicle has two motor bogies and the bogie model is shown in Fig. 2(a). There are coil spring, vertical damper and elastic joints for the primary suspensions which connect the axle box and bogie. Secondary suspensions are consisted of coil spring, vertical damper, lateral damper and yaw damper. The specification of suspension is in Table 1.

Two types of wheel/rail contact data were used in the critical speed analysis. One is linear creep model from Kalker[2]. This model assumes that creep force is linear as the creepage increases. The calculation results of critical speed is shown in Fig. 2(b). The critical speed is high at the conicity near 0.05, which means new wheel condition. But it decreases as the conicity increases. In real situation, the creep force saturates at the high creepage and the contact data has non-linear characteristics. Many non-linear contact data were generated using the measured wheel profiles and the critical speed was calculated. The critical speed using non-linear contact data is less than that of linear contact data as in Fig. 2(b).

Table 1: Suspension specification

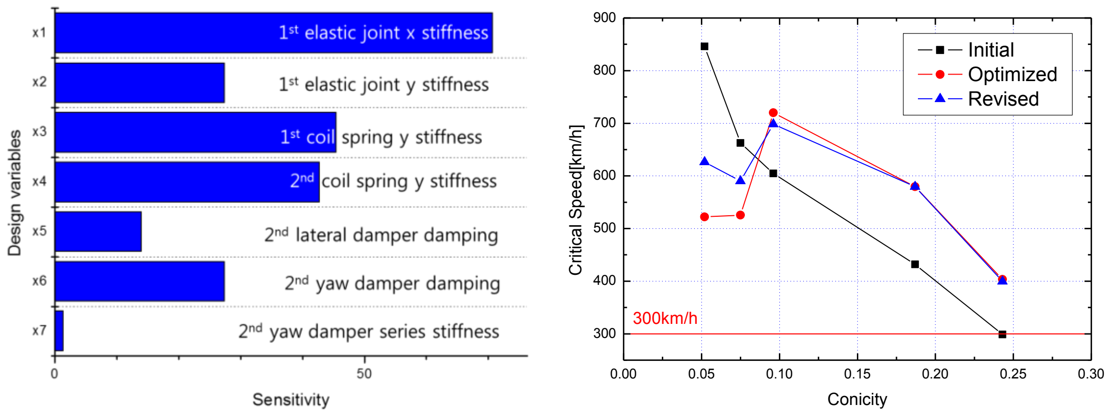
	KTX-sancheon power car	
Weight	56.183 ton	
Primary suspension	Coil spring	0.75 MN/m
	Vertical damper	0.01 MNs/m
Secondary suspension	Coil spring + Elastic bearing	0.634 MN/m
	Vertical damper	0.02 MNs/m
	Lateral damper	0.1 MNS/m



(a) Bogie model (b) Effect of conicity on critical speed

Figure 2: Critical speed analysis

Sensitivity test and optimization were performed to increase the critical speed of KTX-sancheon Power car at high conicity. The critical speed can be more uniformly distributed all of the conicity with results of optimization and revision as shown in Fig. 3.



(a) Sensitivity test (b) Increased critical speed at high conicity

Figure 3: Optimization of suspension

Acknowledgement

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References

[1] DeltaRail Group Limited, VAMPIRE Pro V6.20 Users' Manual, 2013.

[2] J.J. Kalker, "Review of Wheel/Rail Rolling Contact Theories, The General Problem of Rolling Contact," Applied Mechanics Division, vol.40, pp.77-92, 1980.

[3] http://www.nextsense.at/en/calipri/