FLANGE-CLIMB DERAILMENTS OF FREIGHT TRAINS ON CURVED TRACKS DUE TO ROLLING

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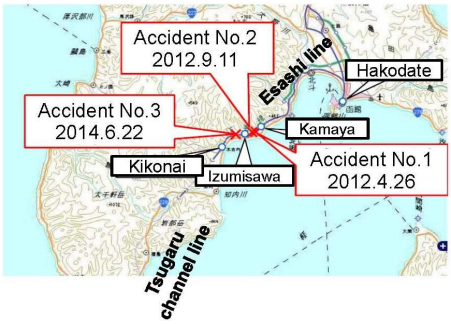
EXTENDED ABSTRACT

1. INTRODUCTION

A series of three derailment accidents of freight trains, composed of container-carrying wagons, occurred in 2012-2014 on Esashi Line, which is the main line between Honshuu and Hokkaido islands. These accidents have the common situation that outside wheels of the freight wagons running through relatively sharp curve (300-350mR) at near balancing speed of each curve (around 60km/h) derailed by flange climbing. As the probable causes of these accidents were difficult to conclude and considered to be related to complex combination of the factors, such as vehicles, tracks, loading freights, JTSB carried out running tests on the accident sites and running simulations of curving of freight trains by using SIMPACK[1][2].

Table 1 Outline of accidents in Esashi line

	No.1	No.2	No.3
Date	2012.4.26	2012.9.11	2014.6.22
Track	300mR(c=100)	300mR(c=100)	350mR(c=90)
Derailed vehicle	18th/20	9th/21	20th/21
Derailed axle	3rd (Front axle of rear bogie)	3rd	3rd
Speed (balance)	57km/h (59.8km/h)	59km/h (59.8km/h)	63km/h (61.2km/h)



2. SIMULATION AND ANALYSIS

2.1 SIMULATION MODEL

Multibody simulations by SIMPACK were carried out, considering the conditions of suspension, loading freight, track irregulality, running speed, etc. The simulation model is 46 degree of freedam of the car body of a freight wagon with empty/half-loaded/full -loaded containers, as shown Fig.1. The car body can twist at the center of body flame with actual stiffness. The simulation model have been verified by the comparison between running tests around the accident sites and simulation results.

The characteristics of vertical dampers, which are different between “empty” and “loaded” conditions, is considered in the simulation. The track irregularity is given according to the measured data just before the accidents.

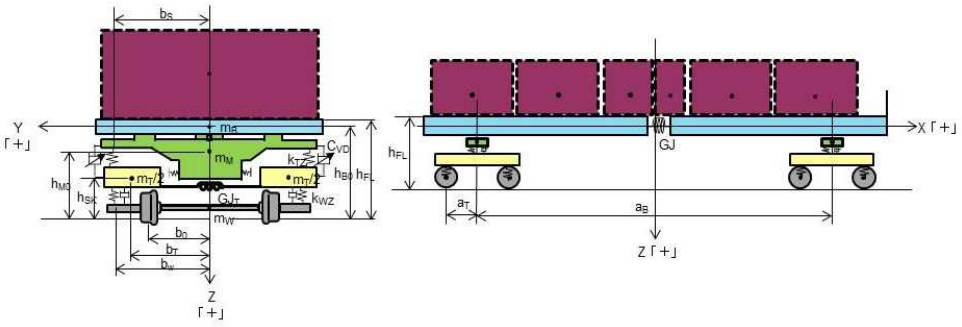


Fig. 1 Simulation model

2.2 SIMULATION RESULTS

Fig.2 shows the results of SIMPACK simulation around the accident No.2 site. The continuous rolling oscilation was produced in 300m radius curved section, and the outside wheel of 3rd axle is climb up just at the accident site. At this point the derailment coefficient Y/Q is also increased up to around 1.5.

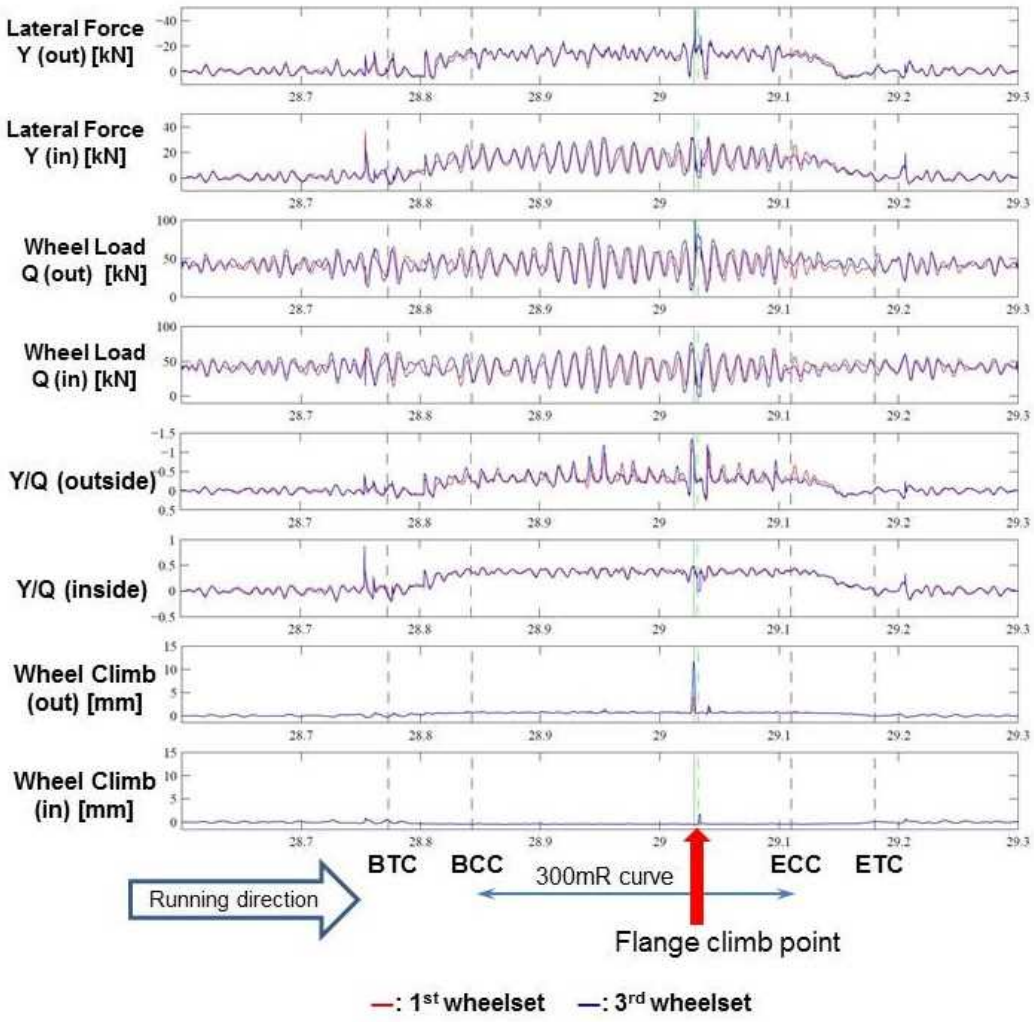


Fig. 2 Simulation result

- The outside wheel of 3rd axle (= front axle of rear bogie) climbing up just at the accident No.2 site on 300mR curved track -

The rolling oscilation is produced by insufficient damping of vertical dampers, whose damping factor is different between “loaded condition” and “empty condition”. So in the case of light loaded condition, such as the accident No.2 condition, large rolling oscilation may be produced, compared with “loaded” or “empty” conditions, as shown Fig.3.

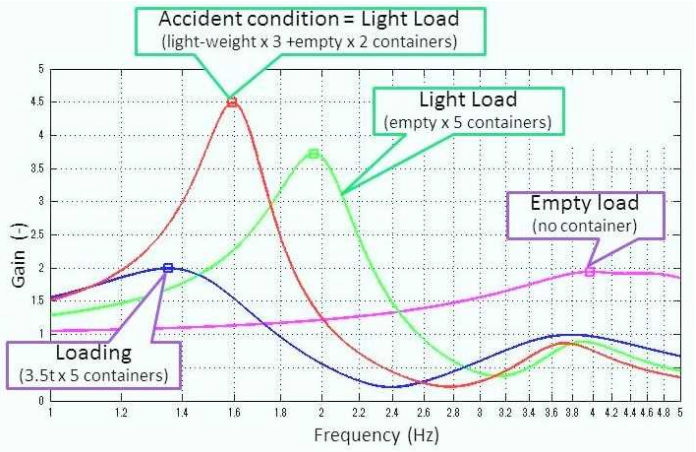


Fig.3 Response amplitude of body-rolling oscilation against track twist irregularity input

3. CONCLUSIONS

After the simulation under various conditions, flange-climb phenomena have been successfully realized at accident sites. Under some conditions the continuous rolling oscillations are produced in freight wagons which are running through curves, and the outside wheel is climbing up the rail combined with some track irregularities. According to the results of simulations and additional considerations, JTSB conclude that the accidents happened during the rolling osclasions of freifht wagons, which were produced by the following probable causes[3].

The probable causes are the combination of the following factors;

1) insufficient damping of bogie vertical dampers under intermediate loaded condition of container-carrying wagons,

2) relatively high gravity center of loaded freight containers,

3) relatively large track irregularities of the combination of „twist” and „alignment”.

As the causes for each accident were described in each investigation report, these accidents were caused by complex combination of the above factors, although their effected levels were different among accidents.

4. POSTSCRIPT

According to the results of these accident investigations, the JTSB expresses its opinion to the Minister of Land, Infrastructure, Transport and Tourism, towards the improvement of safety for the freight train operation[1].

5. REFERENCES

[1] **JTSB**; Index of summaries of the accident reports of No.1, No.2, No.3 in Esashi line and the safety recommendation (in English)
http://www.mlit.go.jp/jtsb/Safety_Recommendation_Railway.html

[2] **JTSB**; Investigation report RA2015-9-2 of the accident No.2 in Esashi line
http://www.mlit.go.jp/jtsb/railway/rep-acci/RA2015-9-2.pdf (in Japanese)

[3] **JTSB**; Animation of rolling and flange climb in SIMPACK simulation
http://www.mlit.go.jp/jtsb/video/railway/2012019-1.wmv (rolling)
http://www.mlit.go.jp/jtsb/video/railway/2012019-2.wmv (slow; flange climb)