



Numerical investigation on wheel-turnout rail dynamic interaction excited by wheel diameter difference in high-speed railway

Key words: Wheel diameter difference; Turnout; Wheel-rail contact behaviour; Dynamic performance of wheel-rail system; High-speed railway

Cite this as: Rong Chen, Jia-yin Chen, Ping Wang, Jing-mang Xu, Jie-ling Xiao, 2017. Numerical investigation on wheel-turnout rail dynamic interaction excited by wheel diameter difference in high-speed railway. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 18(8):660-676. <http://dx.doi.org/10.1631/jzus.A1700134>

Introduction

- ✓ The severe wheel wear caused by the continuous operation of high-speed railway, machining and turning repair errors cause wheel anomalies.

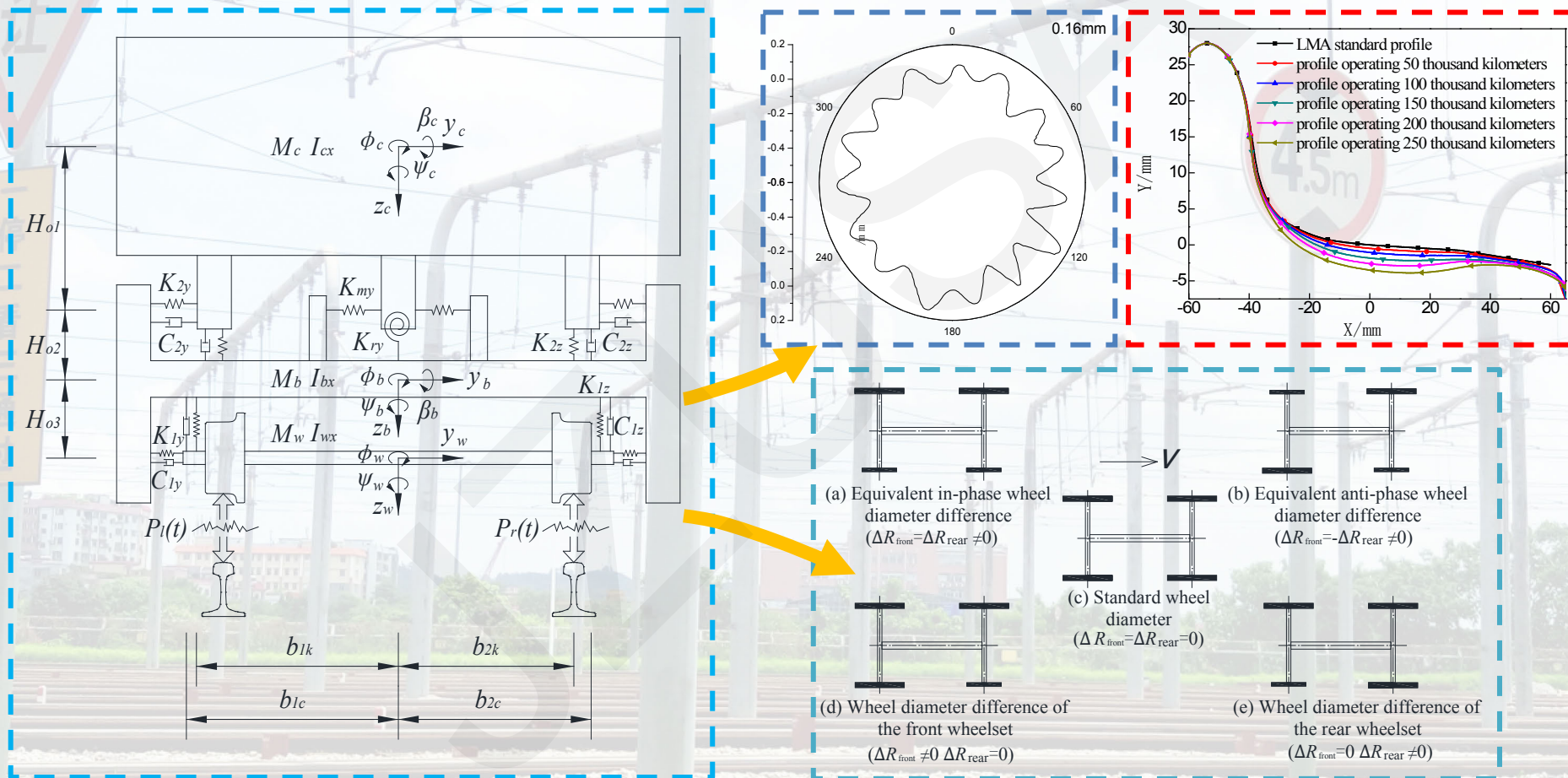


Figure 1. Wheel anomalies caused by wheel wear, machining and turning repair errors, (a) vehicle multi-body dynamics model, (b) polygonal wheel, (c) wheel with concave wear, (d) wheel diameter difference

Introduction

✓ No transition curve or rail cant are provided in the turnout design.

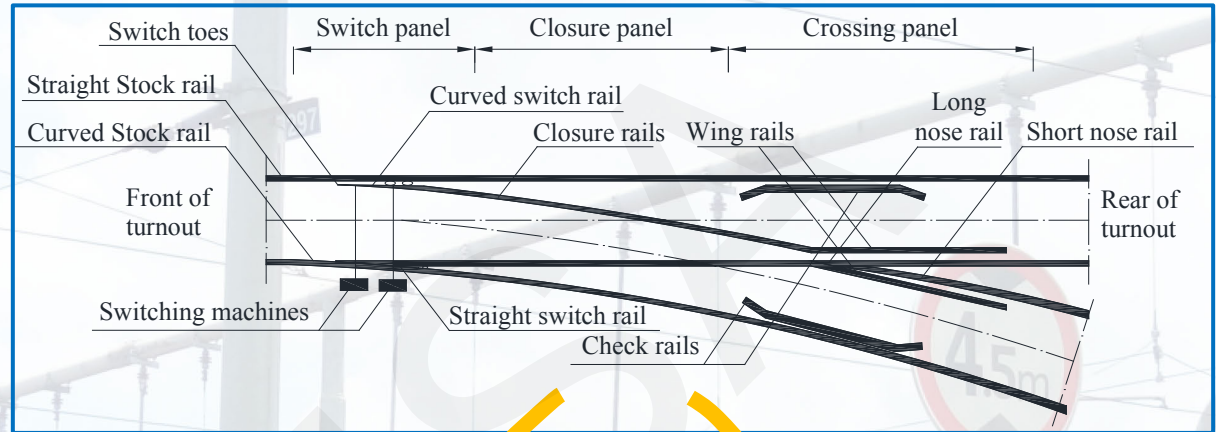
✓ Multiple wheel-rail contacts.

✓ Severe wear of switch rail and stock rail.

✓ Complex structure.

✓ Severe diseases.

✓ Difficult maintenance and higher cost.



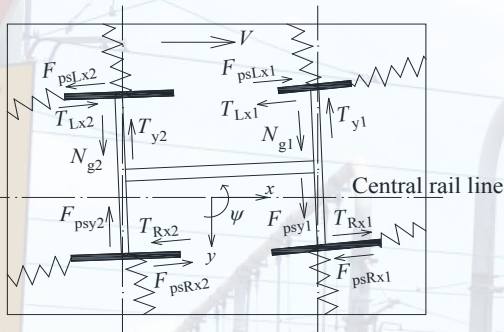
■ Dynamic interaction between the train and turnout is more complex than that on tangent or curved tracks and severe impact loads can occur, generating serious damage of the contact surfaces and transmission of noise and vibrations to the environment.

Innovation

Wheel diameter difference

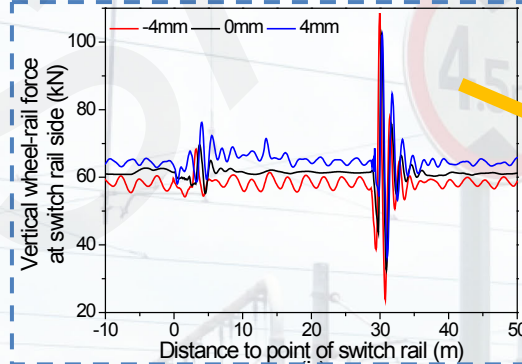
The wheel turnout –rail interaction is aggravated.

Turnout

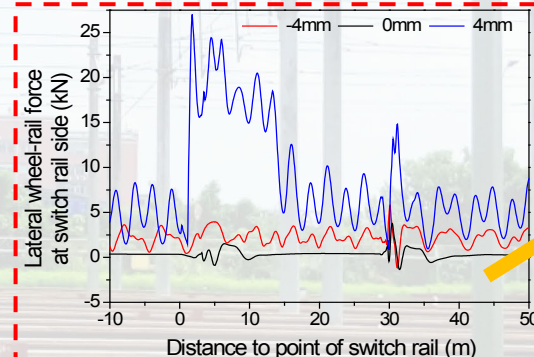
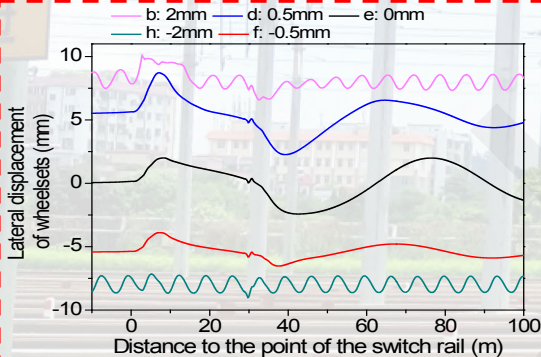


✓ Wheel diameter difference cause large lateral displacement of wheelset.

✓ Wheelset motion can be controlled at equilibrium positions or gradually become unstable decided by the type and amplitude of wheel diameter difference.



✓ Strong wheel-turnout rail dynamic interaction when trains pass turnouts



✓ Dynamic failure of turnout structures

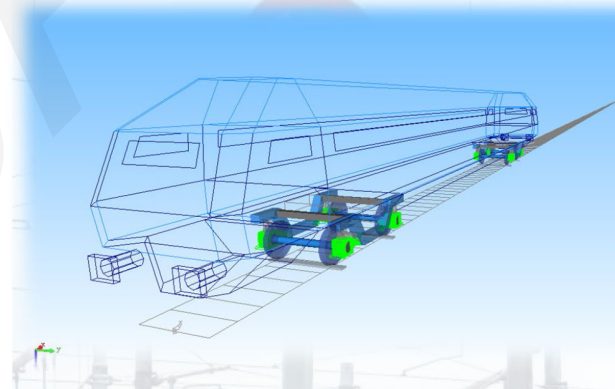
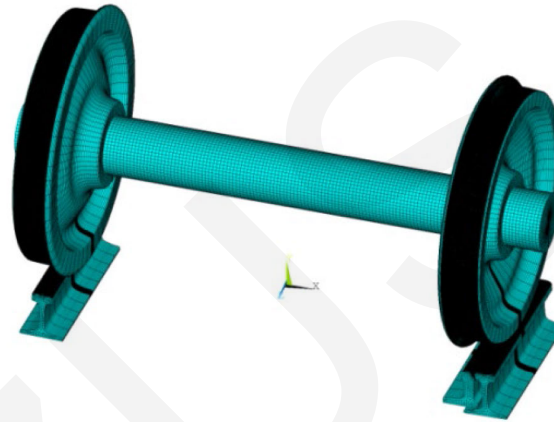
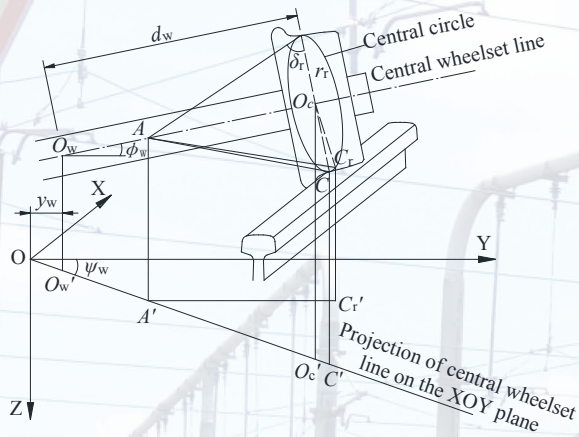
- The obtained research findings mostly focused on the interval line.
- Based on the numerical simulation, the wheel-turnout contact behavior and wheel-turnout rail dynamic interaction are investigated.

Method

Contact geometric relationship

Nominal contact behavior

Dynamic performance



Wheel-rail contact points' trace principle

Wheelset-turnout contact finite element model

Vehicle-turnout rigid multi-body coupled dynamics model

Evaluating indicator:

- Distribution of contact points
- Roll angles of wheelsets
- Variation of wheel-rail contact point positions along the longitudinal direction
- Contact pressure
- Size of contact patch
- Vertical/ Lateral wheel-rail force
- Lateral wheelset displacement
- Multi-point wheel-rail contact
- Sperling riding comfort index
- Wear index

Conclusion

- Wheel diameter difference can greatly disturb the positions' variation of wheel–rail contact points.
- Wheel diameter difference changes the wheel load transition position, causing significant change of the nominal contact behaviour in switch rail. What's more, it may optimize the contact position on wheel-rail surface and decrease the contact pressure.
- Effect of wheel diameter difference on wheel-turnout rail dynamic interaction can be divided into three according to its amplitude. It is recommended to control it to within 2.5mm to avoid severe wear, but limit it to 2mm for in-phase wheel diameter difference to ensure the vehicle riding comfort.