Dynamic response analysis of discrete supported electromagnetic railgun

Jinguo Wu[1], Qinghua Lin[2], Baoming Li[2], Shaobo Wen[1] and Dan Chen[1]

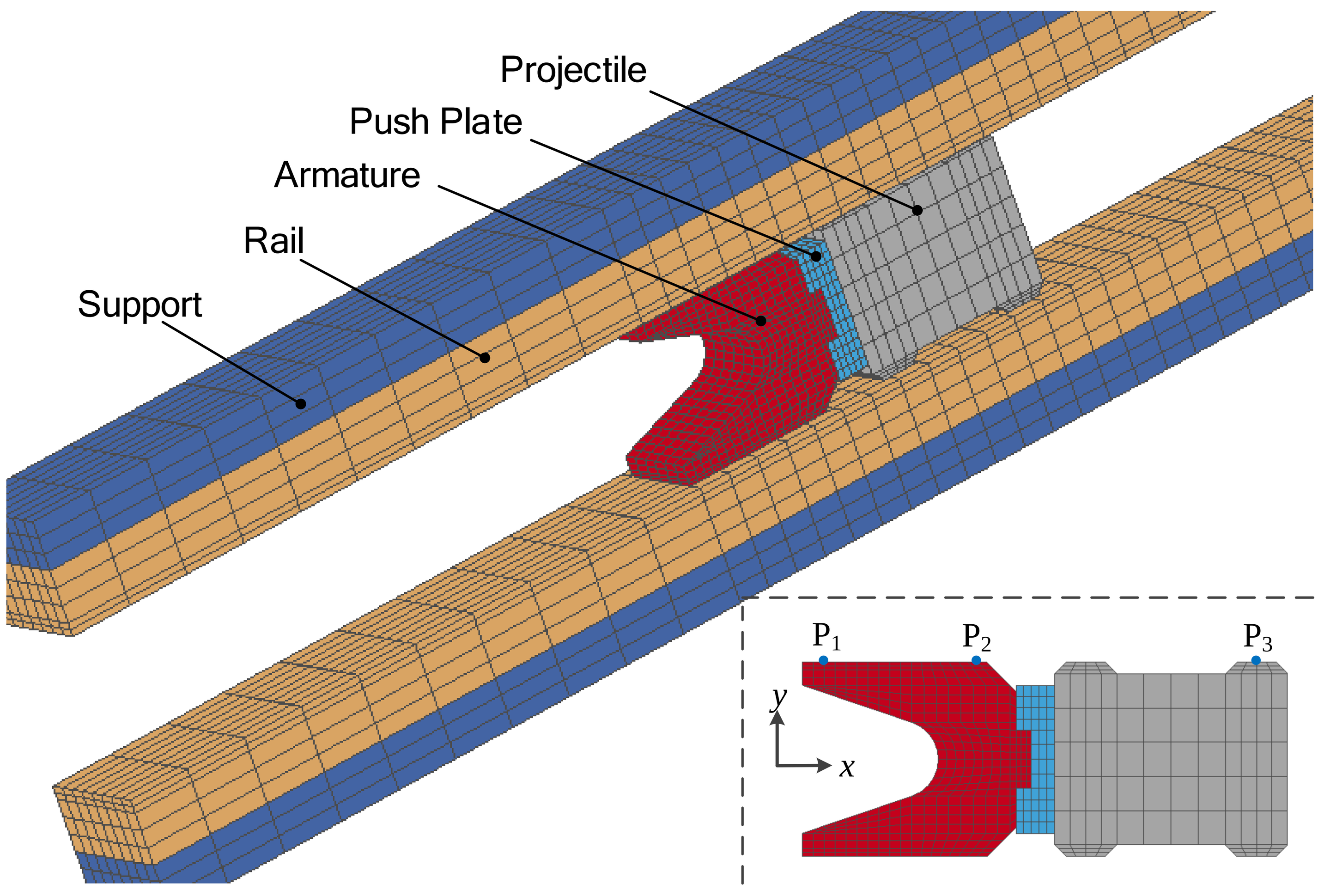
1 Nanjing Institute of Technology, Nanjing, China; 2 Nanjing University of Science and Technology, Nanjing, China

*E-mail: wujg8848@163.com

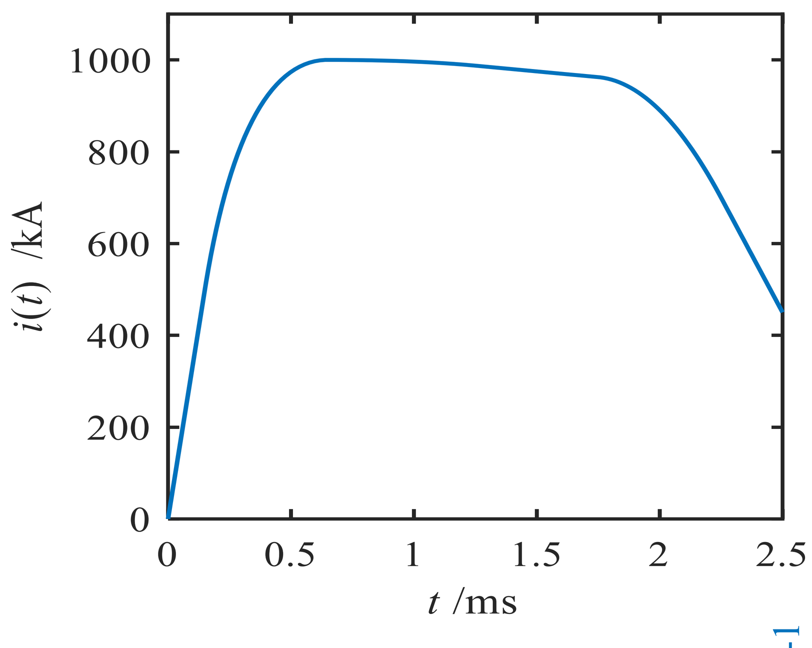
Abstract

In order to analyze the dynamic deformation of rails subjected to transverse moving magnetic pressure, a 3D simulation model consisting of the launcher and integrated launch package was constructed and solved with dynamic finite element method. Critical velocity effects of rail dynamics were obviously observed in the simulation results. The effects not only enlarge the rail deflections but also affect the contact status between the armature and rails. To mitigate this problem, discrete supports with different stiffness were applied in the simulation. By locally enhancing the stiffness of support, especially for the part of rails where the critical velocity happens, the dynamic responses can be effectively controlled.

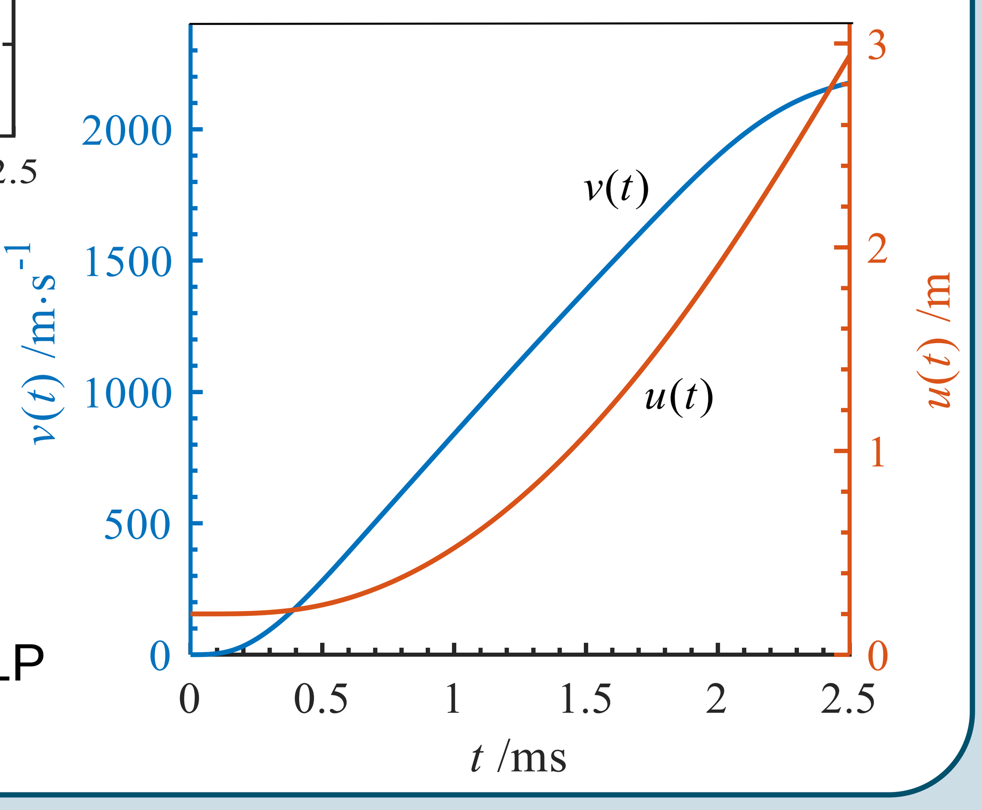
FEM model



↑ Fig.1. FEM model of the launcher and ILP

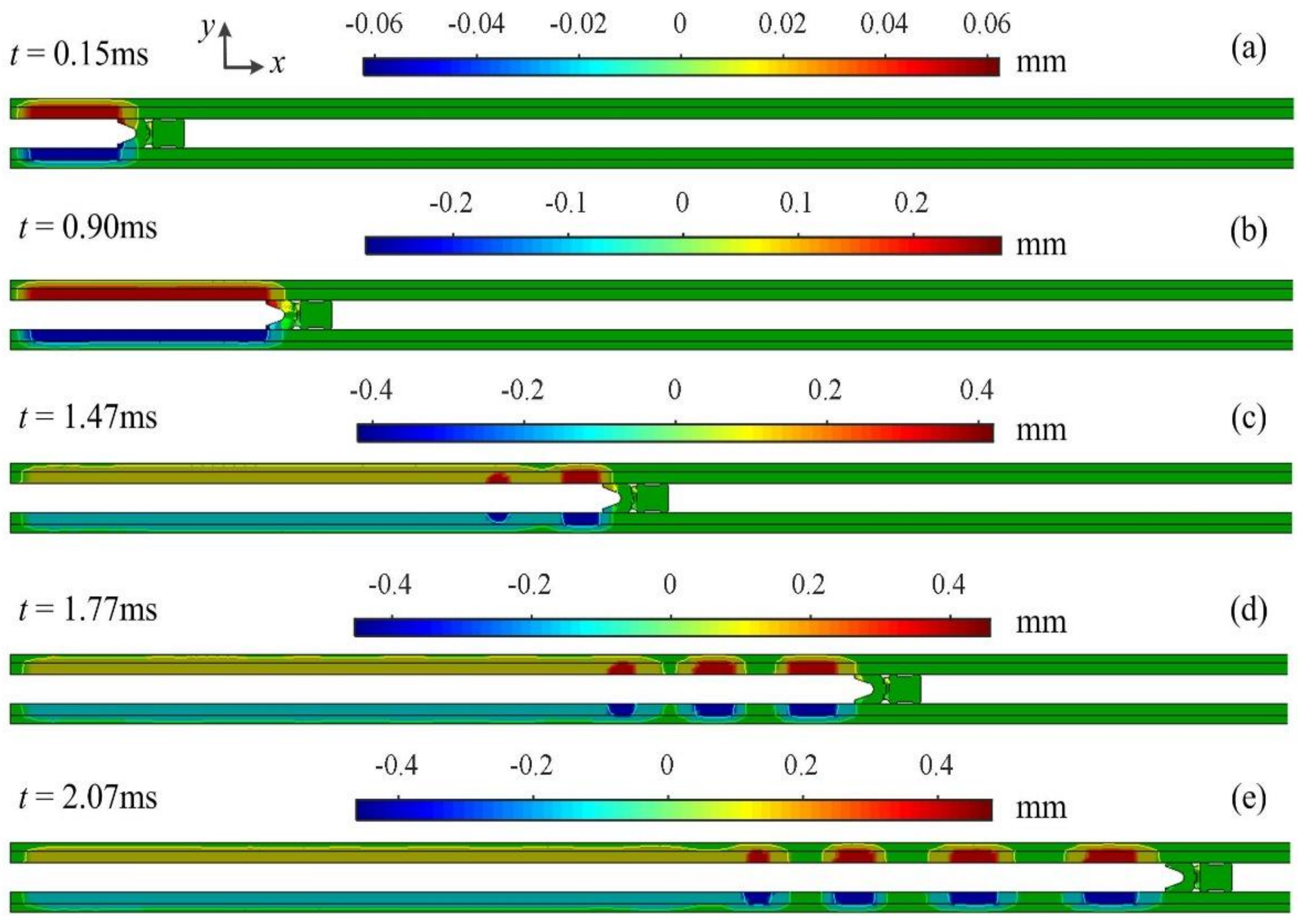


← Fig.2. A typical current profile

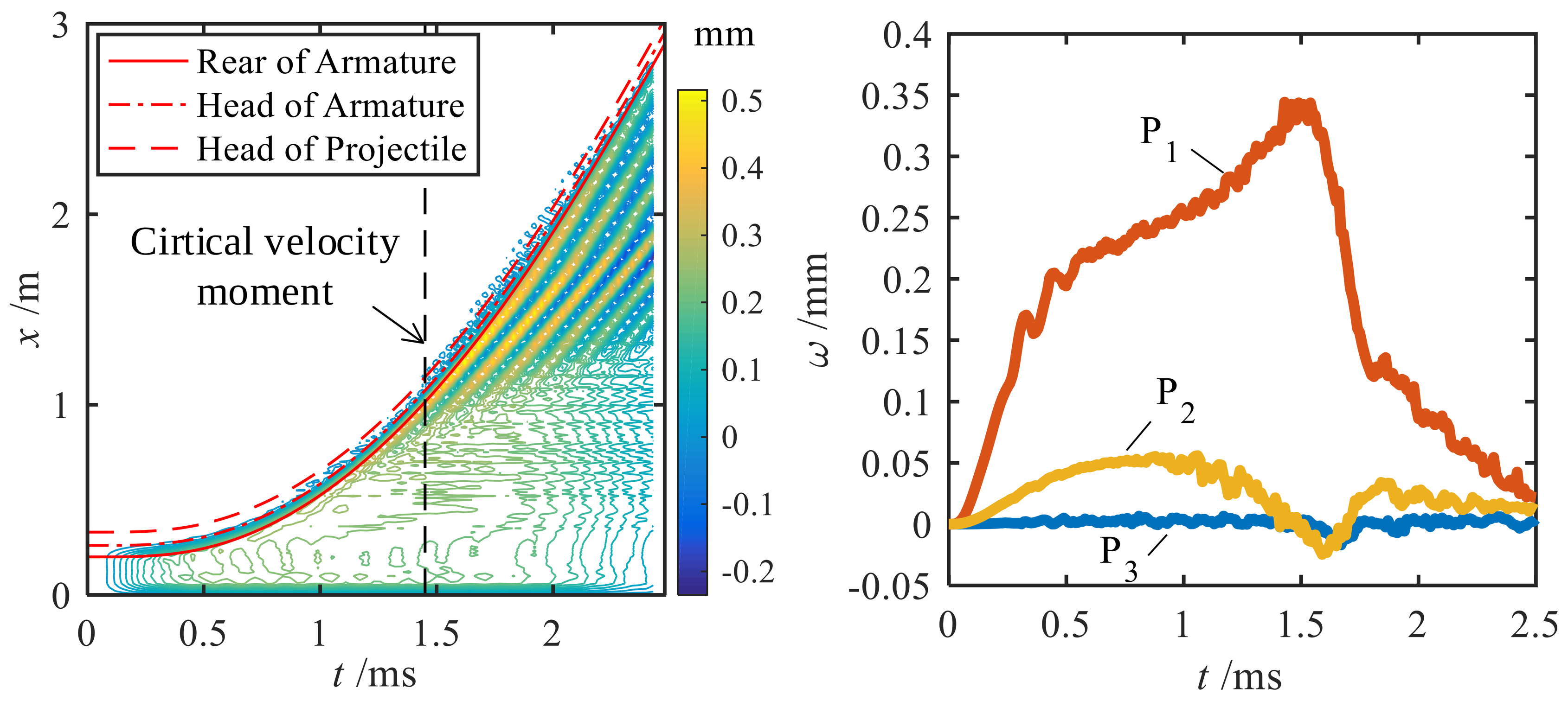


→ Fig.3. The velocity and displacement of ILP

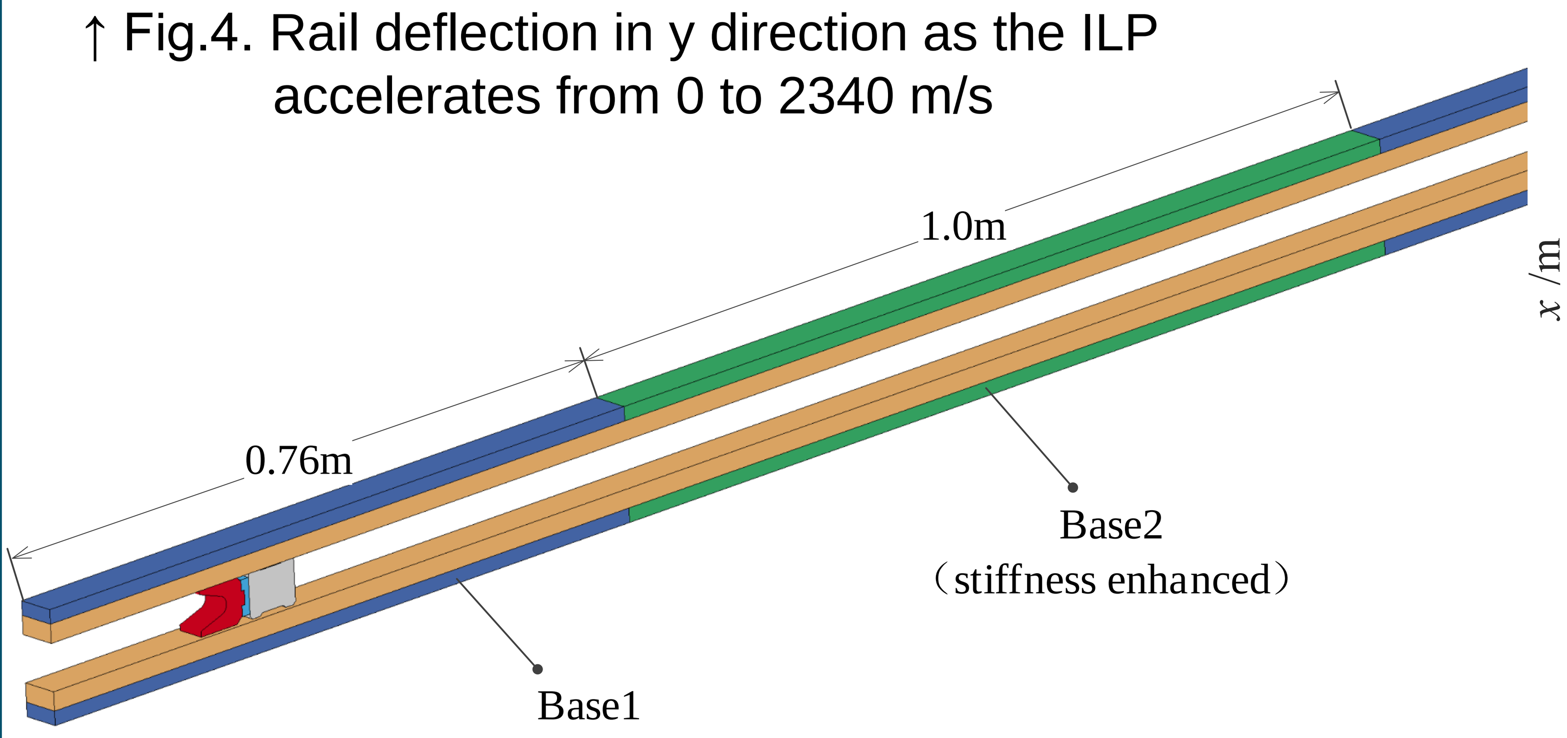
Results



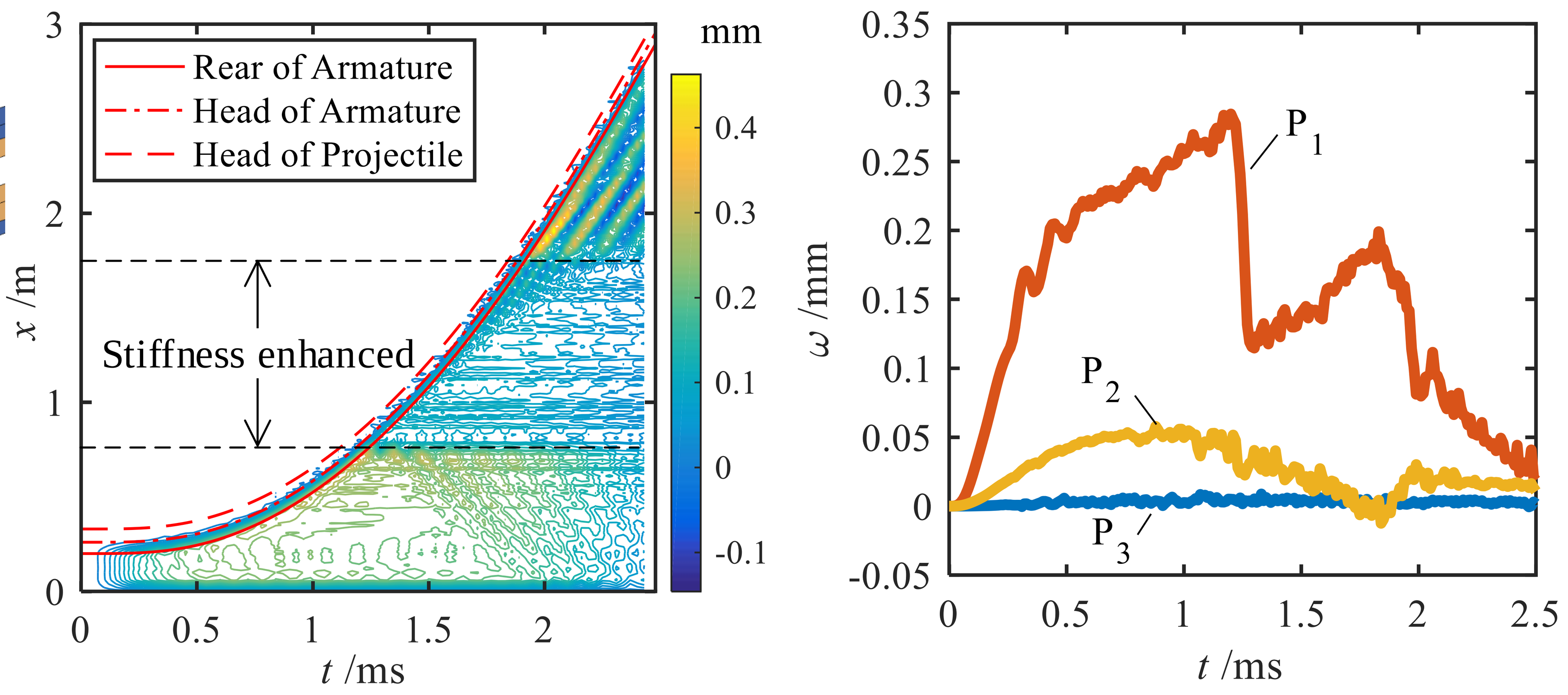
↑ Fig.4. Rail deflection in y direction as the ILP accelerates from 0 to 2340 m/s



↑ Fig.5. Deflection of the rail and displacement of the interface points under uniform support



↑ Fig.6. Illustration of launcher with discrete supports



↑ Fig.7. Deflection of the rail and displacement of the interface points under discrete supports

Conclusion

- Critical velocity effects which is represented by the fluctuation of rail deflection will enlarge the dynamic responses of rails.
- As the ILP arrives to the critical velocity, lateral vibration is more obvious on the rear part of ILP and the rails will squeeze the head of the armature.
- The dynamic responses can be effectively controlled by applying discrete supports, especially enhance the stiffness of support for the part of rails where the critical velocity happens.

1. Wu J G, Tang B, Lin Q H, et al 2016 3D numerical simulation and analysis of railgun gouging mechanism Defense Technology 12 90-95.
2. Wu J G, Lin Q H, Wan Gang, et al 2017 3D Numerical Research of Railgun Gouging Mechanism Based on Material Point Method Explosion and Shock Waves 37 307-14.
3. Nechitailo N V and Lewis K B 2006 Critical Velocity for Rails in Hypervelocity Launchers International Journal of Impact Engineering 33 485-95.
4. Achenbach J D and Sun C T 1965 Moving load on a flexibly supported Timoshenko beam International Journal of Solids and Structures 1 353-70.
5. Tzeng J T. 2003 Dynamic Response of Electromagnetic Railgun Due to Projectile Movement IEEE Transactions on Magnetics 39 472-75.
6. Tzeng J T and Sun W 2007 Dynamic response of cantilevered railguns attributed to projectile/gun interaction-theory IEEE Transactions on Magnetics 43 207-13.
7. Daneshjoo K, Rahimzadeh M, Ahmadi R, et al 2007 Dynamic Response and Armature Critical Velocity Studies in an Electromagnetic Railgun IEEE Transactions on Magnetics 43 126-31.
8. Johnson A J and Moon F C. 2007 Elastic Waves in Electromagnetic Launchers. IEEE Transactions on Magnetics 43 141-44.