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Simple suppression method of impact oscillations between a pantograph and an overhead rigid conductor line

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Abstract: The railway current collection system consists of a pantograph and a conductor line. In some cases, the pantograph separates from the conductor line. This phenomenon is called a contact loss. The system can be modeled as impact oscillations between a spring-supported mass and an oscillating plate. In the previous study, we investigated the effect of an additional mass spring system on the impact oscillations. When the frequency of excitation is near the second mode natural frequency, the impact oscillations are strongly restricted. In this paper, we propose the simple method to restrict the impact oscillations. In this method, an additional mass is replaced by the flexible beam. We theoretically and experimentally investigate the effects of additional beam on the restriction of the contact loss. It is theoretically clarified that the impact oscillations are strongly restricted when the frequency of excitation is near the second mode natural frequency. We conducted the experiments to verify the theoretical predictions. The experimental results show qualitatively good agreement with the theoretical ones.

Keywords: Impact Oscillation, Vibration Suppression, Railway system

1. Introduction

The railway current collection system consists of a pantograph and a conductor line. In some cases, the pantograph separates from the conductor line. This phenomenon is called a contact loss. The system can be modeled as impact oscillations between a spring-supported mass and an oscillating point. The frequency of excitation is equivalent to V/λ, where V and λ are a train speed and a main wave length of the wear. In the previous study, we investigated the effect of an additional mass spring system on the impact oscillations[1]. When the frequency of excitation is near the second mode natural frequency, the impact oscillations are strongly restricted. In this paper, we propose the simple method to restrict the impact oscillations. In this method, an additional mass is replaced by the flexible beam. We theoretically and experimentally investigate the effects of additional beam on the restriction of the contact loss. It is theoretically clarified that the impact oscillations are strongly restricted when the frequency of excitation is near the second mode natural frequency. We conducted the experiments to verify the theoretical predictions. The experimental results show qualitatively good agreement with the theoretical ones.

2. Results and Discussion

Figure 1 shows the analytical model of an impact oscillation between a spring-supported mass m_1 and a sinusoidal oscillating point. Spring constant is k. A mass is placed at the middle of the attached flexible beam (overall length l, flexural rigidity EI, mass per unit length ρ). Let $y = \delta \sin \omega t + d$ and v be the displacement of an oscillating point and a beam, where δ, ω, t and d are the amplitude of the sinusoidal wear, time , the frequency of excitation and static push up distance, respectively. *e* represents a coefficient of restitution between a sinusoidal point and a spring-supported mass. We discretized the governing equations considering first and second mode and derived the equations which govern the velocity the relation at the impacts. We numerically investigate the impact oscillations between a mass and an oscillating point. When ω is near the second mode natural frequency, impact oscillations are strongly restricted. The numerical value of second mode natural frequency can be easily adjusted up or down by varying the flexural rigidity *EI* and the overall length *l*. Next, we conducted the experiments to verify the theoretical predictions. We use the aluminium block as a main mass m_1= 367g. The first and second mode natural frequencies are 6.3Hz and 14.0Hz, respectively. Figure 2 (a) shows the times histories of *y* and *v*(0) at $\omega/2\pi$ = 13.5Hz. A mass collides two or three times during a period of *y*. When $\omega/2\pi$ is near the second mode natural frequency, the impact oscillations disappear. Figure 2(b) shows the restriction of the impact oscillaitons. The experimental results show qualitatively good agreement with the theoretical ones.

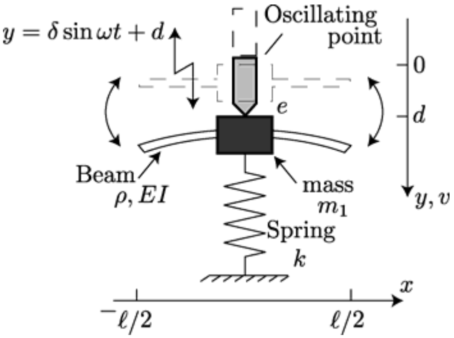

Fig. 1. Analytical model

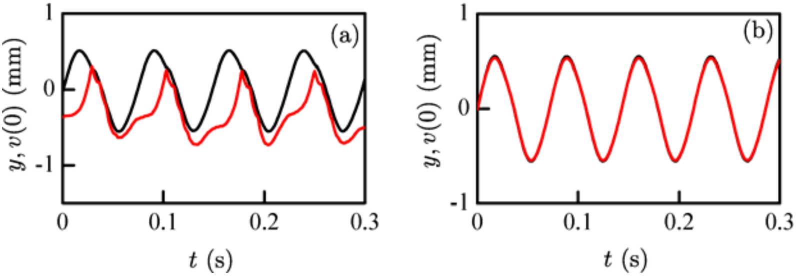

Fig. 2. Time histories of *y* and *v*(0) in Experiments. (a): $\omega/2\pi$ = 13.5Hz, (b) $\omega/2\pi$ = 14.0Hz. Black and red lines indicate *y* and *v*(0), respectively.

3. Concluding Remarks

In this paper, we propose the simple method to restrict the impact oscillations between a pantograph and an overhead rigid conductorl line. The flexural beam is attached at the mass in order to have excited states with infinite degrees of freedom. We numerically calculated the discretized equations which is obtained by two mode expansions. When the excitation frequency is near the second mode natural frequency, the impact oscillations can be strongly restricted. The experiments are conducted to verify the theoretical predictions. The observation in experiments show good agreement with the theory.

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References

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