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Investigation on the effect of anti-braking system on nose landing gear shimmy

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Introduction

This paper establishes a mathematical model describing the braking and shimmy of landing gear, and models the moment generated by braking process as a function of the adhesion coefficient and the torsional shimmy speed. The study on the influence of anti-braking system on the shimmy region and oscillation characteristics of nose landing gear is carried out, which provides a reference for the design and structure optimization of aircraft nose landing gear.

Dynamic modeling

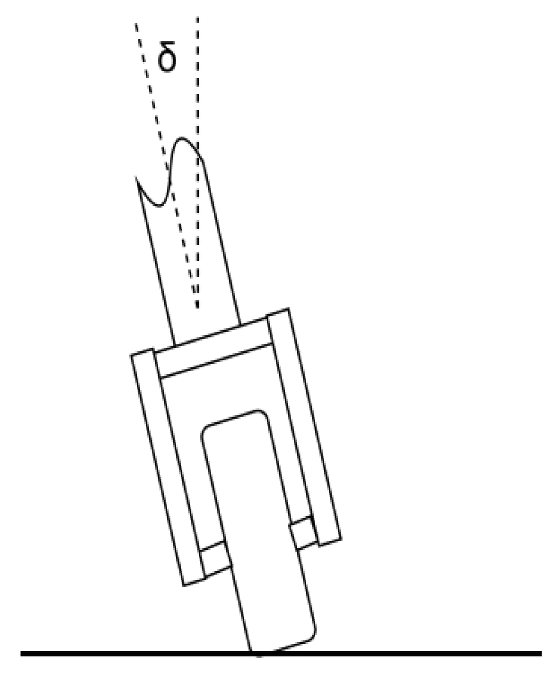


Fig. 1. View of nose landing gear structure in front view

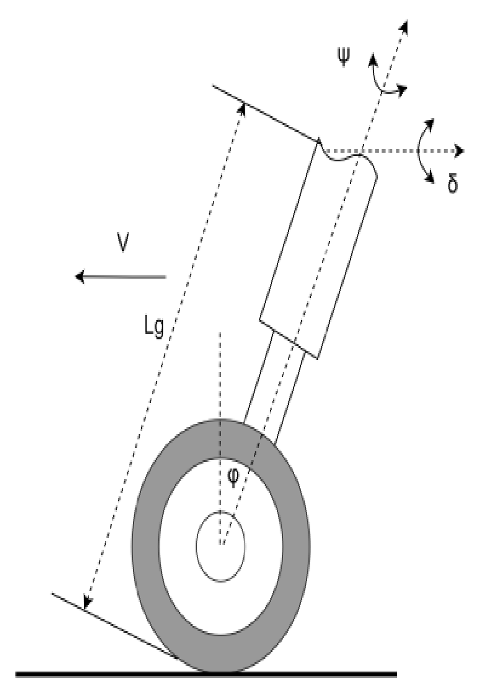


Fig. 2. View of nose landing gear structure in side view

Figure 1 and Figure 2 shows the structural diagram of the nose landing gear. The nose landing gear is connected with the fuselage and has a certain front rake angle φ with the ground. When the aircraft taxis on the runway, the load imposed by the fuselage on the landing gear will cause the landing gear to produce torsional shimmy(shimmy angle ψ) around the strut axis and lateral shimmy(shimmy angle δ) around the fuselage axis. Under the joint influence of the two shimmy and the ground, the contact part between the tire and the ground will produce lateral deformation(deformation λ).

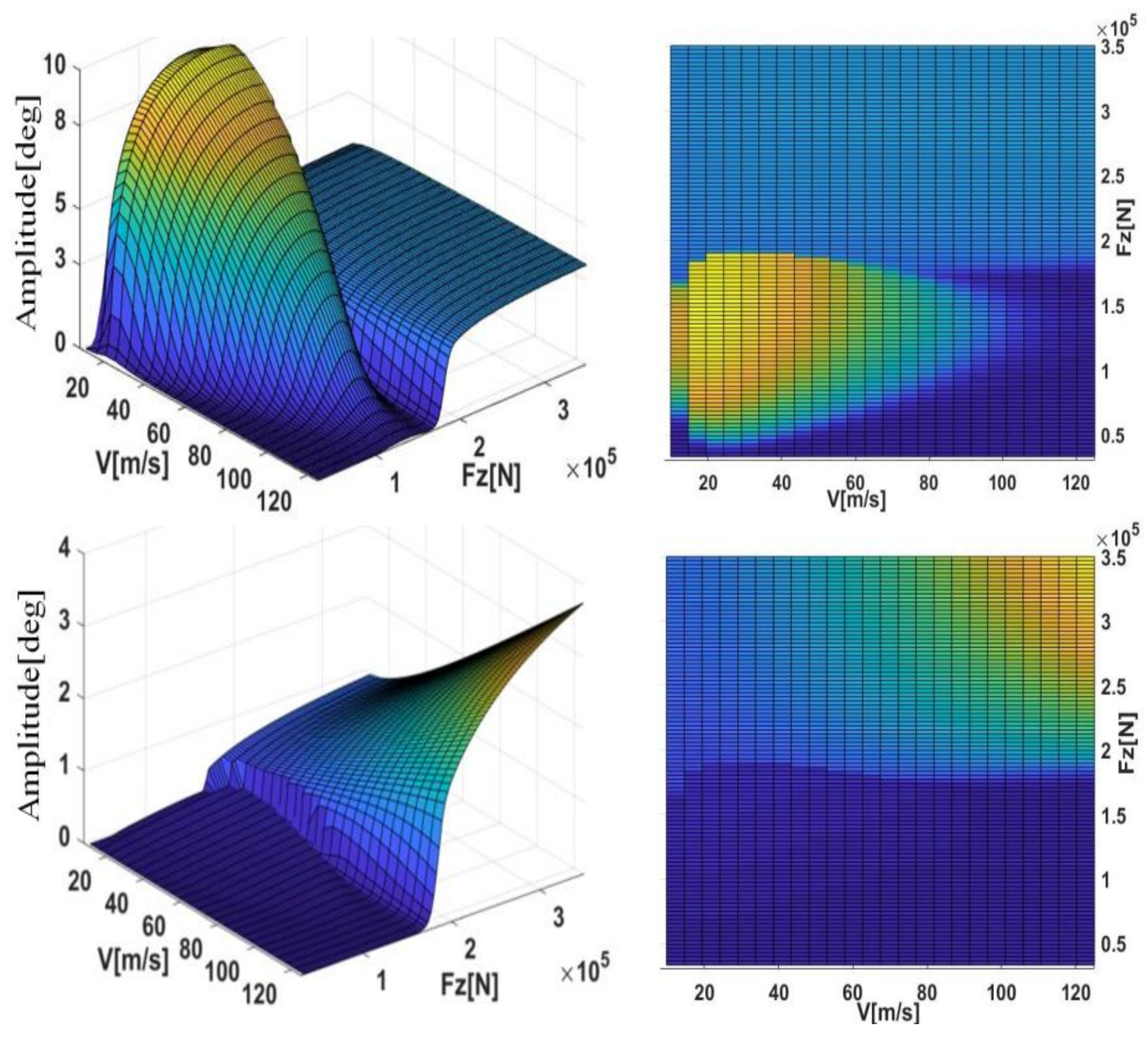
The dynamic model of torsional and lateral shimmy can be expressed as equations (1) to (3).

$$I_z\ddot{\psi}+k_\psi\psi+c_\psi\dot{\psi}+M_{F1}+M_b+\frac{c_\lambda\dot{\psi}\cos(\varphi)}{V}-F_z\sin(\varphi)e_{eff}\sin(\psi\cos(\varphi))=0 \quad (1)$$

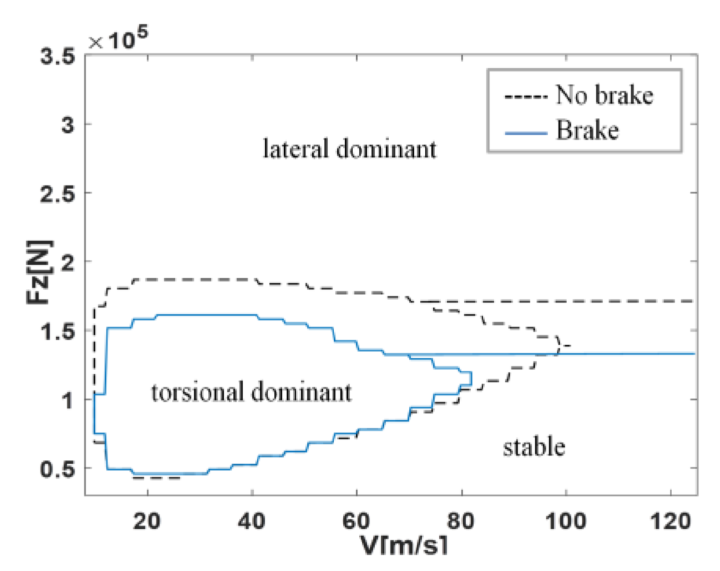
$$I_x\ddot{\delta}+k_\delta\delta+c_\delta\dot{\delta}+M_{\lambda\delta}-F_ze_{eff}\sin(\psi\cos(\varphi))=0 \quad (2)$$

$$\dot{\lambda}+\frac{V}{L}\lambda-V\sin(\psi\cos(\varphi))-L_g\dot{\delta}\cos(\delta)-(e_{eff}-h)\cos(\psi\cos(\varphi))\dot{\psi}\cos\varphi=0 \quad (3)$$

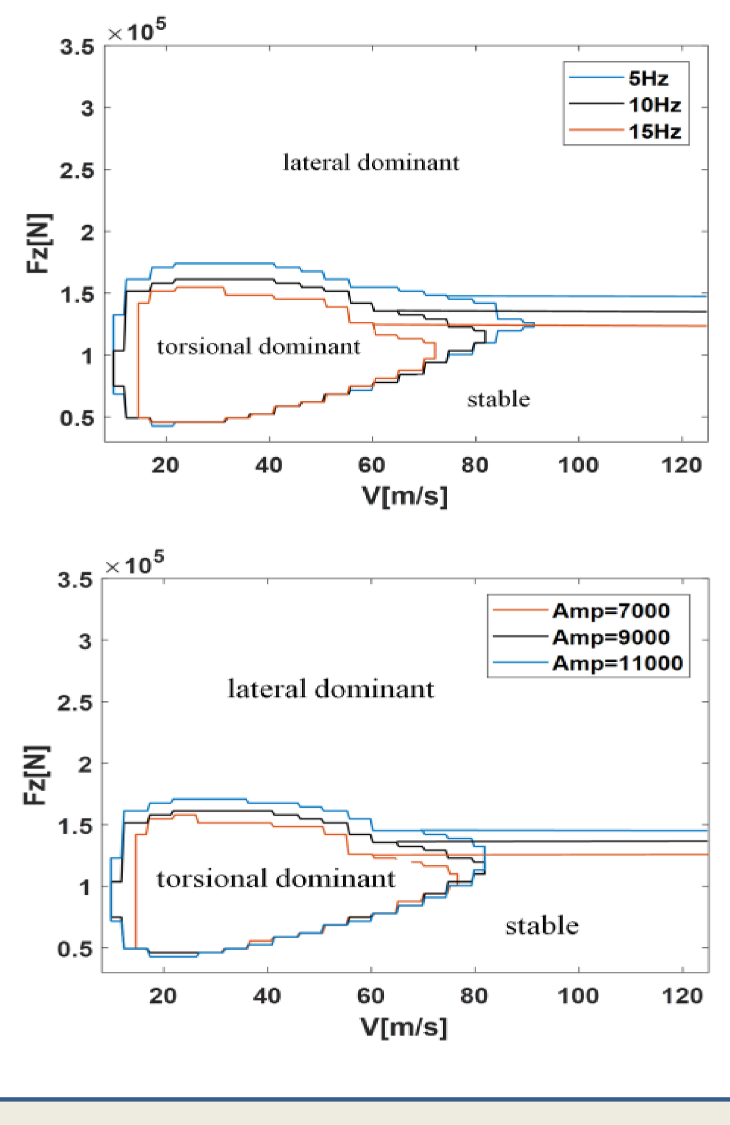
Numerical simulation



The maximum torsional and lateral shimmy amplitudes of the landing gear strut under different horizontal speeds V and loads F_z are calculated using MATLAB software. The dark blue area is the stable region without shimmy. the maximum torsional and lateral shimmy amplitudes of the landing gear strut under different horizontal speeds V and loads F_z are calculated using MATLAB software. The dark blue area is the stable region without shimmy.



It can be seen that the braking system will reduce the area of the stable region and the torsional region, and increase the area of the lateral region. The impact on the torsional region is particularly significant, with an area change of 35.3%. The influence on the area of stable region is small, only 9%.



It can be seen from these figures, taking 10Hz as the reference braking frequency, when the braking frequency increases to 15Hz, the torsional and stable domain area decrease, and the lateral domain area increases. When the braking frequency is reduced to 5Hz, the result is just the opposite. By the way, taking amp=9000 as the benchmark braking amplitude, when the braking amplitude increases to 11000, the torsional domain and stable domain area increase, and the lateral domain area decreases. When the braking amplitude decreases to 7000, the result is just the opposite.

Conclusion

■ The implementation of anti-skid braking system will reduce the area of torsional shimmy region and stable region in the whole parameter space, and increase the area of lateral shimmy region.

■Increasing the braking frequency will further reduce the area of the torsional and stable regions, and increase the area of the lateral region. The effect of increasing the braking amplitude on the shimmy region is opposite to that of increasing the braking frequency.

■Increasing the braking frequency can effectively suppress the increase of torsional shimmy, but the effect on restraining the amplitude of lateral shimmy is limited.

Information

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