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Research on Landing Impact Characteristic Of Multi-Wheel Bogie Landing gear's Truck

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Abstract : Taking the four-wheel bogie landing gear as an example, the force status of truck-like landing gear during the landing impact was analyzed and the simulation model of four-wheel bogie landing gear was established. Firstly, a landing gear prototyping model was established using CATIA and imported to LMS Virtual.lab. Secondly, dynamic analysis of the landing impact was simulated with the established model. Finally, with the help of LMS Virtual.lab's parametric design ability, the effects of landing approach and truck pitch angle on the landing performance, truck motion and truck beam strength were studied. These conclusions will be useful to the design and analysis of the truck.

Key Words : Multi-wheel bogie landing gear, Landing impact, Landing approach, Truck motion characteristic

1. Introduction

With the development of aviation industry, the weight of the aircraft is increasing gradually. When the aircraft weighs more than 40 tons, the load on the main landing gear is quite huge. So multiple wheeled landing gear were often required to reduce the pavement pressure and meet the requirement of airport runway strength[1]. Multi-wheel landing gear is widely used on large aircraft. In order to smooth the tire force and decrease truck's pitch motion, snubber[2] is arranged between truck beam and main buffer. Snubber's main function is to dissipate rotational kinetic energy and make the pitch motion convergence as soon as possible.

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Landing performance includes the overload of landing gear during landing impact, the reprint load and wheel load distribution, etc. [3]. Taking four-wheel landing gear as an example, this paper analyzes some factors that influence landing impact characteristics, and provides some references for the design of multi-wheeled landing gear.

2. The virtual prototype model of multi-wheel landing gear

In order to conduct simulation analysis of landing gear using virtual prototype, firstly, 3D model of landing gear is established in the CATIA environment. Then multibody dynamic model is built in LMS Virtual lab [4-5]. At last, simulation is conducted using the established model. The force of main buffer can be obtained from references [6-8]. The four wheeled landing gear model built in CATIA environment is shown in figure 1.

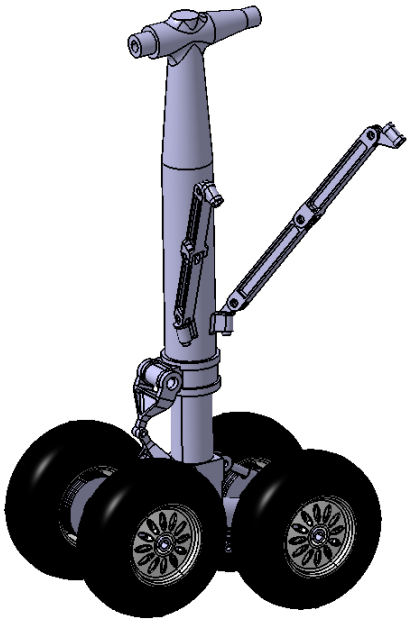

Fig.1 Virtual prototype model of truck-like landing gear

3. Simulation analysis of landing performance

3.1. Influence of main wheel landing sequence on landing

Landing approach of multi-wheel truck landing gear includes three types: the front wheel landing first, the rear wheel landing first and level landing. When the initial pitch angle is small, front and rear wheels do not bounce after the landing. Load stroke curves of three different ways are shown in Figure 2.

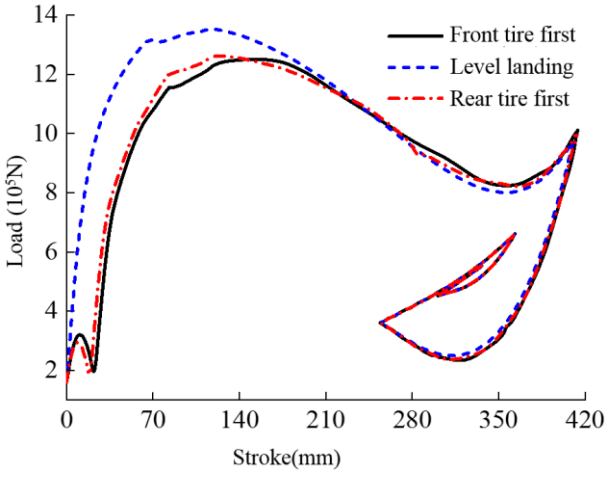

Fig.2 Load stroke curves of shock strut under different landing approaches

From figure 2, it can be seen that the main buffer's load in the level landing situation is the largest in the three landing ways, and rear tire landing first is the smallest. But the maximum stroke is very close. In the front and rear tire landing first situation, the buffer's load is increasing at first and then decreasing in the initial stage. However, the buffer's load of level landing is increasing as the stroke increases. The difference between the two situations is caused by the freedom of truck beam, which changes the velocity of the oil in the buffer.

Table.1 Effect of landing sequence on landing performance

Landing sequence	Front tire landing first	Level landing	Rear tire landing first
Overload	1.5034	1.6246	1.5176
Front tire drag force(N)	106566	178481	231098
Rear tire drag force (N)	222892	178604	100123
Total drag force (N)	576015	714187	576271
Max stress of truck (MPa)	474	509	490

Table 1 shows the load during the landing process. It can be seen that the overload of landing gear, drag force of front and rear tire in which front tire lands first are the smallest in the three situations. However, level landing is the largest. When the front tires land first, the drag force decreases the rotating velocity of the truck beam. The maximum drag force in the front tire landing first situation is smaller than the other two situations. The maximum stress appears in level landing, and the minimum stress appears in the front tire landing first. Thus front tire landing first helps to decrease the maximum stress in the process of landing impact. The maximum truck pitch angle in front tire landing first is restricted by the drag force and its structure, however, the pitch angle in rear tire landing first is only restricted by its own structure.

3.2. Influence of truck pitch angle on landing performance

Taking the rear tire landing first as an example, we analyzed the influence of initial truck angle on landing performance. Load stroke curves of different truck pitch angle during landing are shown in figure 3.

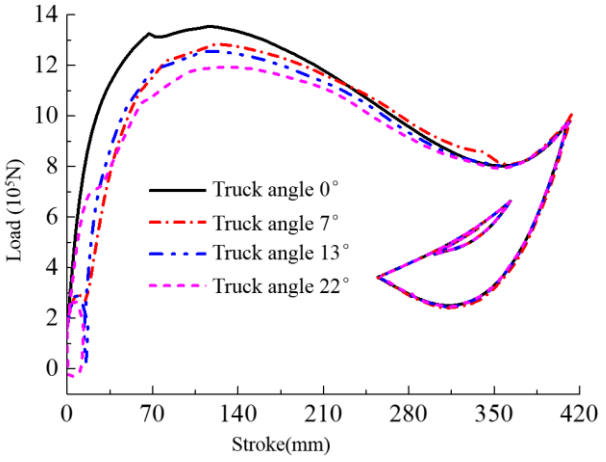

Fig.3 Load stroke curves of shock strut during landing with different truck angle

As can be seen from figure 3, the maximum load buffer decreases with increasing the truck pitch angle. In the initial stage of landing, with the increase of the pitch angle, buffer load stroke curve gradually formed a loop. This is because the oil in snubber strokes, unstrokes and strokes again as the rear tire impact, then rebound into the air and both the front and rear tire impact [9]. When the truck degree of freedom exists, the truck rotation and the initial oleo stroking occurs before the front gear makes ground contact when the front and rear tires do not touch the ground at the same time.

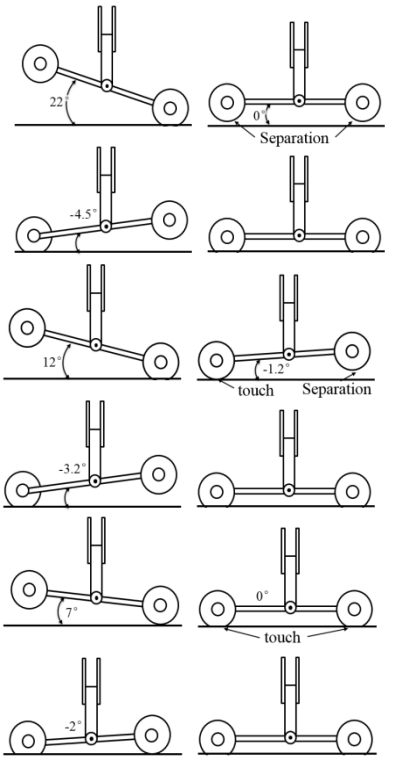

Fig.4 Truck motion under different pitch angle

The motion status during landing impact can be divided into three types, which can be seen in figure 4. When the initial truck angle is small, the front and rear tire will not leave the ground after the rear tire making ground touch. When the initial truck angle is larger than 22 degree, the front and rear tire will leave the ground after the rear tire making ground touch. If the initial truck angle is in the middle range, only the rear tire will leave the ground and the front tire will stay on ground.

Table. 2 Effect of truck pitch angle on landing performance

Initial truck angle(deg)	0	7	13	22
Overload	1.6246	1.5422	1.5100	1.4331
Front tire drag force (N)	178481	224971	220531	199415
Rear tire drag force(N)	178604	215576	240915	239606
Front tire vertical load (N)	362635	449942	441061	398831
Rear tire vertical load (N)	346185	203932	204936	215351
Total drag force(N)	714187	605662	574238	514962
Load of snubber(N)	342	149567	181552	214016
Max stress of truck(MPa)	509	496	479	468

The results shown in table 2 indicate that the overload of main landing gear, drag force and maximum stress decrease as the initial truck angle increases. But, the total force of snubber increases when the initial truck angle increases. Increasing the initial truck angle is beneficial for improving the strength of the structure. It can be seen from table 2 that the front gear vertical load is larger than the rear gear vertical load. This is because that the rotation of truck beam increases the vertical velocity of the front gear.

Considering the effect of initial truck angle on landing performance and truck beam strength, increasing the initial truck angle helps to improve the safety of main landing gear, but not conducive to a smooth landing. Therefore, designing a reasonable

snubber is one effective method to reduce bounce characteristics of the landing.

4. Conclusions

From the previous analysis, the following conclusions can be obtained:

(1) In the three landing sequences, the max drag force, landing gear overload and stress of the truck beam occurred in level landing situation, which means the higher demands on the structure strength are needed. The maximum truck angle is not restricted by the drag force when the rear tire lands first. So, the way that rear tire lands first is better than the two other ways in general.

(2) With the increasing of the initial truck pitch angle, the overload of main landing gear and maximum stress decrease, but the times that tire rebound into air increases. To achieve better landing performance, it is helpful to design the snubber reasonably.

(3) The variation trend of truck beam's maximum stress is as the same as the main landing gear vertical load. In the initial design stage, the overload and strength of landing gear can be considered as one unified factor, to improve the efficiency of design.

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