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Experimental Research on Aircraft Landing Gear Drop Test Based on MRF Damper

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Abstract

In this paper, the aircraft landing gear drop test based on MRF damper was conducted on the test platform. The parameter configuration of the buffer system and the parameters of the test platform were analyzed to study their influences on the performance of the landing gear. First, the initial pressure of the accumulator was calculated; next, a test plan was designed, then parameters such as drop height, drop mass, the initial pressure of the accumulator, and active current were selected to establish different conditions. Reasonable parameters of the landing gear were obtained through two drop tests and the analytical comparison of the performances. This research serves as a reference for in-depth researches on MRF damper performances and the application in practice.

***Keywords**:* MRF damper; landing gear; drop test

1. Introduction

With the improved of performances and the development of the research on MRF, MRF technology is widely used in aerospace and aeronautics, machining, automobile engineering, medical appliance and civil engineering. For example, many new parts for increasing the performances of vehicles have been developed, typical examples are MRF dampers, clutches and brakes, etc. In the future decades, MFR-

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based devices will have a broad market prospect, while MRF damper has become a major application of MRF technology.

MRF damper is generally used in the landing gear because it features fast response, simple structure and continuous maneuverability.

Compared with the oil-pneumatic damper landing gear, the MRF-damper-based aircraft landing gear has significant advantages and favorable buffer characteristics. Researchers home and abroad have done researches aiming at applying MRF technology in the aircraft landing gear[1,2].

The aircraft landing gear is a very important part of aircraft. In the process of landing, the majority of impacting energy is absorbed by the landing gear. And it is significant to conduct researches on the application of MRF damper to landing gears under impact load.

With this objective in view, a MRF damper is installed on a landing gear. Then a drop test was conducted. The parameter configuration of the buffer system and the parameters of the test platform were analyzed to study their influences on the performance of the landing gear. This research serves as a reference for in-depth researches on MRF damper performances and the application in practice.

The Landing gear drop test is a dynamic test of simulating aircraft landing impact. The situation of landing gear is obtained by measuring various parameters such as displacement, load, acceleration, force and stain. The more parameters are measured, the more clearly it simulates the situation at landing. In this drop test, the focus was on the performances of the MRF landing gear. Different current values and equivalent weights (load basket and balancing weight) were configured to analyze the landing gear shock absorption performance.

2. Drop Test Devices

The newly developed MRF damper (multi ring groove) is shown in Fig.1.

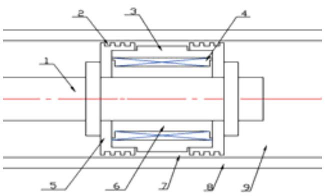

Fig.1 Structure of MRF Damper
1.piston rod 2 .rectangular groove 3.load barrel
4.coil 5.magnetic conductive disk 6.magnetic conductive ring
7.damping channel 8.cylinder 9.MR Fluid

Fig.2 Drop Test Platform and Landing Gear Assembly

MRF damper is a single piston-cylinder structure, with a diaphragm as the compensator.

The device on the landing gear drop test platform is for measuring the parameters in the implementation of the controlled drop test and for measuring the resultant parameters in the landing gear drop test[4].

The Drop test platform consists of the drop test pillar, load basket, landing gear, extending-retracting mechanism, motion mechanism, and ground impact platform, etc. The drop test platform and the landing gear assembly are shown in Fig.2.

3. Landing Gear Drop Test

Before initial test, the accumulator charge pressure must be calculated. Appropriate values of the accumulator inflation pressure must be configured so as to obtain the optimum efficiency and maximum service life. If the inflation pressure is too high, it will cause the high stiffness of the accumulator, as a result, the liquid can not enter the accumulator and the shock absorption effect can not be obtained. Moreover, when inflation pressure comes close to the pressure limit, the diaphragm of the accumulator may burst, significantly affecting the safety of the system safety; Conversely, if the accumulator inflation pressure is too low, the accumulator's interior pressure is far below the working level, and the accumulator cannot function as a device for energy storage and liquid storage, causing, in serious cases, damages to the damper due to the collision between the piston of damper and the cavity.

The relationship between the air chamber V and pressure p complies with the gas equation $pV^n = C$, where n is the state index. According to Boyle's law,

$$p_0 V_0^n = p_1 V_1^n = p_2 V_2^n = C \tag{1}$$

In the adiabatic process of the accumulator, $n = 1.4$.

From equation (1), we obtain:

$$V_0 = \frac{V_W \left(\frac{1}{p_0}\right)^{\frac{1}{n}}}{\left[\left(\frac{1}{p_1}\right)^{\frac{1}{n}} - \left(\frac{1}{p_2}\right)^{\frac{1}{n}}\right]} \tag{2}$$

Where: p_0: pre-charged pressure, V_0: pre-charged nitrogen volume at p_0, p_1: minimum work pressure,

V_1: nitrogen volume at p_1, p_2: maximum work pressure, V_2: nitrogen volume at p_2, $V_W = V_1 - V_2$.

After calculation, we choose $p_0 = 4Mp_a$ and $p_0 = 5Mp_a$ as the initial pressures, and did individual tests.

In order to study the shock absorption performance of the MRF landing gear, a test plan is designed to conduct the two tests and compare the results.

Test One: in the drop test, the equivalent drop mass was 300 kg ,the inflation pressure of the aircraft wheel was 1.0 Mp_a, the initial inflation pressure of the accumulator was $p_0 = 5Mp_a$, the values of currents were 0A, 0.1A, 0.2A, 0.3A, 0.4A, and 0.5A, and the drop height of load barrel were 20mm, 30mm, and 40mm.

Test Two: the equivalent drop mass was 300 kg , the inflation pressure of the aircraft wheel was 1.0 Mp_a, the initial inflation pressure of the accumulator is $p_0 = 4Mp_a$, reducing the initial inflation pressure by 1 Mp_a when compared with Test One. Since the accumulator piston displacement increases as same exciting current is applied, the maximum parameter of the exciting current in Test One was set at 0.5A , then raised to 0.6A. The drop height of load barrel was kept unchanged.

4. Test Results and Analysis

Based on the results of the tests, an analysis was carried out concerning the relationship between piston displacement, current and drop height.

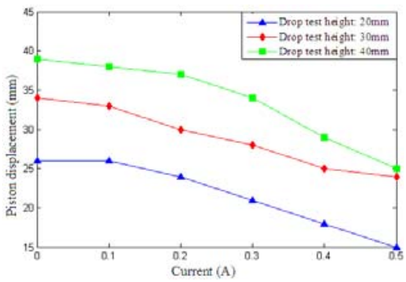

Fig.3 Piston Displacement Curve of Buffer System at 5MPa

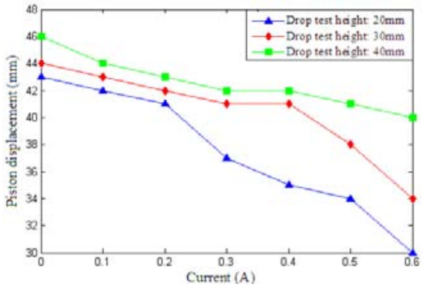

Fig.4 Piston Displacement Curve of Buffer System at 4 MPa

As shown in Fig. 3 and Fig. 4, under 5 MPa and different drop heights, the changing trend of the piston displacement at different current values are basically the same, and the curves change smoothly, the spacing between the curves is in uniform. While under 4 MPa and different drop heights, the changing trend of piston displacement at different current values fluctuates, and the spacing between curves changes dramatically .

An Analysis of the relationship between the efficiency of the landing gear and currents then follows. It can be seen from Fig.5 that the landing gear efficiency drops with the current increases and reaches the maximum value at about 0.1A; and the landing gear efficiency rises with the drop height increases before arriving maximum value, and then drops. It reaches the maximum at 30mm and drops at 40mm.

As shown in Fig. 6, at drop heights of 30 mm and 40mm, the landing gear efficiency rises with the drop height increments and reaches the maximum at the current value of about 0.4A; the landing gear efficiency first rises then drops with different current values and reaches the maximum at 0.2A and a drop height of 20 mm.

Comparing the data in the two landing gear efficiency figures, we reach a conclusion that under a system initial inflation pressure of 5 Mp_a and different drop heights, the landing gear efficiency changing trend can be roughly predicted, while under 4 Mp_a, the landing gear efficiency changing trend stay stable at current 0.4A.

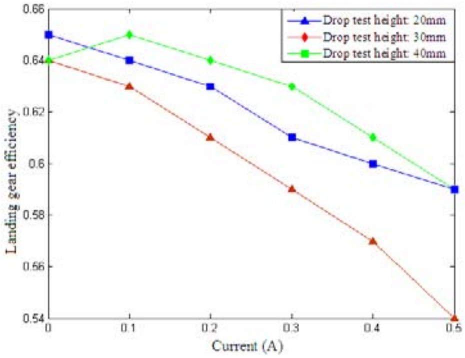

Fig.5 Landing Gear Efficiency in Test One

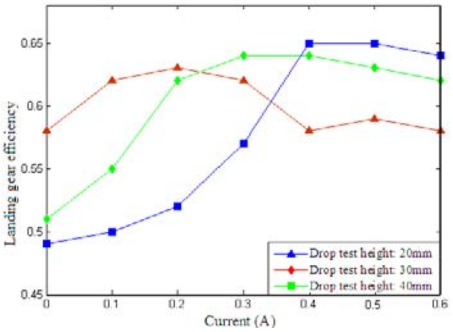

Fig.6 Landing Gear Efficiency in Test Two

It is true that the damper efficiency increases with current increments, yet it does not mean that the higher the co-efficiency, the better. Generally the co-efficiency is kept between 0.65 ~ 0.85.

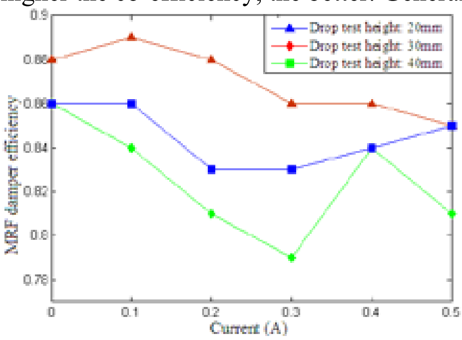

Fig.7 Total Work of Damper in Test One

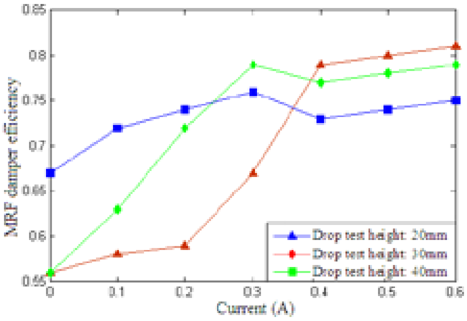

Fig.8 Total Work of Damper in Test Two

From Fig. 7, it can be seen that the landing gear efficiency stay at upper limit and work at about 0.85, yet the landing gear seems rigid in this case. But the landing gear efficiency can be in a reasonable range when the drop height is 30mm. In this situation the landing gear has a surplus in its stroke. In this case, it would be better to keep the co-efficiency at the lower limit. In this way, the damper can work at milder conditions.

That is why in Test Two, when the initial inflation pressure of accumulator decreases, the damper works under milder conditions, as is shown in Fig. 8. Under such conditions, The efficiency of the damper increases gradually with current increments and the curve stays stable at around 0.4.

5. Conclusion

In this research, drop tests of MRF landing gear are conducted. Comparative studies were done to analyze the performance of the MRF landing gear and the MRF damper. The conclusions are follows:

1) The MRF damper in Test One seems too rigid; the landing gear efficiency changing trend can be roughly predicted under different drop heights. The landing gear efficiency is at its highest when the drop height is 30mm and the efficiency is in a reasonable range.

2) The MRF damper in Test Two seems softer. The efficiency of damper increases gradually with current increment. Moreover the curve changes tend to stay stable when current is about 0.4A, and the changing trend of landing gear efficiency stays stable at this current.

References

[1]D C Batterbee1, N D Sims1, R Stanway and Zbigniew Wolejsza ,Magnetorheological landing gear:1,Smart Mater. Struct. 2007(16): 2429-2440.

[2] Jia yuhong, Wu xiaojuan. MRF damper application in landing gear[J]. aircraft design,2007, 27(2):41-45.

[3] Zhang Daqian, Lu Wei. The present situation and development of chinese drop test measurement and test system [J]. Journal of Shenyang Aerospace University, 2002,19(2):10-12.

[4] Liu Hui. The semi-active control technology applies in Landing Gear Shock Absorption System [D] Nanjing: Nanjing University of Aeronautics and Astronautics, 2003.