Design and Calculation Analysis on a New Type of Aircraft Hydraulic Chocks

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Abstract: In order to facilitate the rapid drainage of airport apron in the special weather (such as heavy rain and snow), the apron is usually designed to have a certain slope. However, this slope leads to a difficult problem that chocks are not easy to take out when the airplane leave airport. In order to solve this problem, a hydraulic chocks design scheme is firstly proposed. The aircraft hydraulic chock involves two systems, which are named the slider system and the rod system. Taking Boeing 737-800 as an example, this paper firstly makes reasonable assumptions. And then uses a hydraulic chocks to analyze the aircraft's stress situation. Through the calculation and analysis of the scheme, the feasibility of the scheme is verified, it also completely solve problem that chocks are not easy to take out. At the same time, the use of the hydraulic wheel block also avoids injury to personnel and waste of time.

1. Introduction

At present, the design of the domestic airport apron needs to meet a certain slope, which is to strengthen the rapid drainage in the rain and snow weather. This slope can avoid gathering water apron, which is good for the airplane to slide. The design of this slope usually needs to consider the local rain and snow amount and relevant design specifications. Taking Hefei as an example, the design slope of the airport apron is design slope is \( \alpha = \arctan 0.05 \). However, the aircraft needs to release the pressure of brake system after aircraft stop slide. The purpose is to release the huge amount of heat which generate by using the brakes. At the same time, it result the displacement of the aircraft after setting brake. The displacement can lead to collisions between aircraft and boarding bridge and other injuries to personnel. In order to avoid collisions and the injuries, it is required to adopt a measure that enables the aircraft to stop slide after the aircraft arrival the apron stop line. At present, metal or rubber chocks are used as shown in figure 1 and figure 2.

A new type of aircraft hydraulic chock is designed, which aim is to solve the problem when the flight need takeoff. It makes use of the characteristics of the knob-type hydraulic pump which can rapidly relief pressure. Meanwhile, it also utilize lever principle which can reduce the pressure of the hydraulic pump. The force of chock was calculated and analyzed [1-4] in detail when the airplane stop slide.
Take Boeing 737-800 aircraft as an example, through the calculation and analysis, it is found that the design of the hydraulic chock achieves the purpose of quickly and easily removing the chock when the aircraft is ready to take off.

2. Design method of hydraulic chock
The design of the aircraft hydraulic chock involves two systems, which are named the slider system and the rod system. The slider system is composed with slider 1, slider 2, slider 3 and a stop block, which supports aircraft in quiescent condition when the aircraft need to stop movement. At the same time, when the hydraulic pump releases pressure, the relative position of the slider changes, thus relieving the slider pressure. The function of the stop block is to avoid the problem that the wheel block is out of control when the hydraulic system fails. After the pressure of the hydraulic pump is released, a gap is created between the tire and the slider 1, so as to facilitate removal of the chock. The rod system includes a metal rod 1, a metal rod 2, a metal rod 3, a metal rod 4, a knob type hydraulic pump and a plurality of metal steel pipes. The main function of the rod system is to support the slider system and the second function is to reduce the pressure of hydraulic pump through lever principle. At the same time, it also reduce the weight of the hydraulic pump. Structure of airplane hydraulic chock is shown in figure 3 and amplification figure is shown in figure 4.
3. Force analysis of hydraulic chock

3.1. Force analysis of slider 2
When the aircraft stop on the airport apron and the brake is released, the force of the tire acting on the slider 1 forces the slider 1 to generate a perpendicular force on slider 2 which name N1. At the same time, the slider 3 is pressed by the slider 2 and it also generate a perpendicular force on slider 2 which call N2. Besides, the slider 2 also receive own gravity G2, the friction forces f1 and f2, the rod 1 thrust F. Force analysis of the slider 2 as shown in figure 5, the slider 2 remains stationary under these forces.

3.2. Force analysis of slider 1
After the commander guide the aircraft on stop line, the service personnel start to inform the cockpit to release the brakes. And then the slider 1 receive a force N3 from tire. Besides, the slider 1 also receive own gravity G1, friction forces f1’ and f3, the force N1 from slider 2. The slider 1 remains stationary under these forces. Force analysis of the slider 1 as shown in figure 6.
4. **B737-800 case calculation and analysis**

At present, the apron design slope is about 3°. Take Hefei airport for example, design slope is \( \alpha = \arctan 0.05 \). Slider size and angle are shown in figure 7.

Considering the computational problems, simplifying assumptions are made as follow.

1. As the maximum takeoff weight of the B737-800 aircraft is 78245kg\[5\], the maximum takeoff weight of the B737-800 aircraft can be set at 80000kg;

2. As the aircraft tire pressure and the pressure between the slider is far greater than the chock gravity and friction, so the calculation ignores the chock gravity and friction.

4.1. **Tire force calculation**

When the chock is squeezed by the tire, B737-800 aircraft remain static under the action of gravity \( G_0 \) and supportiveness.

The gravity \( G_0 \) include the weight of B737-800 aircraft and the supportiveness include ground support force \( N_8 \) and the chock resistance \( N_3 \). Force analysis of the tire as shown in figure 8.

The tire force is decomposed along the \( N_3 \):

\[
G \cos \alpha = N_3 \sin 30^\circ
\]

Put \( G = 8000(\text{kg}) \) and \( \alpha = \arctan 0.05 \) into (1)
\[ N_3' = 4000 \text{ (kg) } \]

![Figure 8. Force analysis and calculation of the tire](image)

4.2. Slider 1 force calculation

The slider 1 force is decomposed along N4. The following formula can be obtained according to figure 7 and simplified assumptions:

\[ N_4 = N_3 \cos 30^\circ \]  \hspace{1cm} (2)

Put \( N_3' = N_3 = 4000 \text{ (kg) } \) into (2);

\[ N_4 = 2000 \text{ (kg) } \]

4.3. Slider 2 force calculation

The slider 2 force is decomposed along F. The following formula can be obtained according to figure 7 and simplified assumptions:

\[ F = N_1 \cos 60^\circ + N_2 \cos 60^\circ \]  \hspace{1cm} (3)

Put \( N_1' = N_2 = N_4 = 2000 \text{ (kg) } \) into (3);

\[ F = 2000 \text{ (kg) } \]

It can be concluded from the calculation that the B737-800 aircraft can remain static on the airport apron as long as there is a 2,000 kg force on the rob 1. Moreover, the power of the knob type hydraulic pump can be further reduced by adjusting the position of the fulcrum.

5. Conclusion

The design starting point is the problem that the chock is very difficult to remove when the airplane is ready to takeoff. Through the analysis of the reasons for the problem, a device was designed, which can quickly remove the chock when the aircraft need depart airport. This paper also takes 737-800 as an example, the function of chock confirmed by the calculation and analysis.

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