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New electric opening function and mechanism design of large passenger aircraft door

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ABSTRACT
Aircraft door is an important part of aircraft.To the main opening mode of large passenger aircraft door that requires human strength and contact, presents a motor-driven and automated opening mode of aircraft door.Research was performed aiming at the fact that the traditional aircraft door can only be opened manually . Putting forward an addition of electric control system on aircraft door.The main content of the research is to design a electric control system based on the existing opening mode of C919 aircraft door,and conduct an aircraft opening design on structure,motion,dynamics and control methods.
Keywords – Electric door opening, Incomplete gear transmission,Luluo polygon

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I. INTRODUCTION

Intelligent technology has made remarkable achievements in the field of aircraft design and manufacturing. As an important component of the aircraft, the cabin door of civil aircraft can be simply classified according to the cabin floor: the cabin door above the floor, the cabin door below the floor. The cabin door above the floor is our main research, including boarding door, service door and wing emergency door. The boarding gate is located on the left side of the front of the cabin for passengers to board. The opposite is the service gate for dining cars, food, etc. The rear of the cabin is called the rear boarding gate or rear service gate. The door in the middle of the cabin is called the wing emergency door. These cabin doors are collectively referred to as cabin emergency exits, which are used as escape routes in case of emergency evacuation. Therefore, the cabin door is very important, responsible for the function of passengers in and out of the cabin. The structural design of cabin door opening mechanism is developing towards intelligent and unmanned operation on the premise of ensuring the safety of strength, stiffness, air tightness and aerodynamic shape.

At present, the new corona virus is spreading in various countries in the world. The key of epidemic prevention and control is to block or minimize the spread of pathogens among people. Non-contact unmanned operation is the development. As one of the main transportation for people, the opening and closing of the cabin door is mainly through the manual operation of the flight attendants, which increases the hidden danger for the spread of the virus. In order to effectively eliminate this hidden danger, the control circuit is added on the basis of the original door mechanism to form a remote door opening and closing system, which avoids the contact between personnel and the door and effectively reduces the spread of virus.

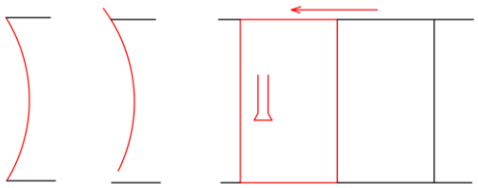
II. AIRCRAFT DOOR OPENING PROCESS

Cabin door is a kind of active component, which is used for entering and exiting the cabin area. At present, the boarding gate of the major large commercial airliner mainly has three open sports forms. The first is the internal retraction and torsion opening mode adopted by the boarding door of Boeing B737 aircraft. Pull the handle out of the groove outside the aircraft, connect the handle to the door driving mechanism, turn the external handle 180 degrees clockwise to unlock the door, push the handle back into the groove, push the door to the front side outwards by using the auxiliary handle of the door until the door is locked by the locking mechanism. Generally speaking, the movement direction is the initial movement of the hatch door as Turn inward and turn an angle, then turn outward and open about 180 ° . The second is the lift translation and outward opening method adopted by

the boarding gate of Airbus A320 aircraft, namely, the cabin door is initially moved upward and then opened in the forward direction. The third is the boarding door opening method adopted on Boeing B767 aircraft, which is rowed upward into the cabin ceiling to leave clear opening space. The above three types of hatch, due to the success of Boeing and Airbus commercial aircraft, have been proved to be excellent designs to meet the airworthiness and customer's two-way requirements during their service. The development of aviation industry promotes the improvement of airworthiness clauses, and at the same time, the revised airworthiness clauses and market demand also promote the innovation of aviation industry. The gate opening mode used by Boeing B737 and B767 has been reduced to a small number. At present, the lift translation open hatch, which is widely used in Airbus family aircraft, has been proved to be the most advanced and most market approved design.

The opening process of the passenger cabin door can be divided into three stages: one is the lifting unlocking stage, the other is pushing to the scheduled track stage, and the third is the translation stage.

The main content of this study is to design a set of aircraft door system which can realize electric unlocking based on the reference to the existing mature side open gate scheme, and optimize the design of the opening part of the aircraft hatch. A set of electric control opening mode is designed, which can use electric control switch without manpower, so that the staff can reduce the contact of aircraft handle when opening the hatch door and avoid cross infection. This design is to analyze the existing door mechanism system, and then to verify the feasibility of the scheme.

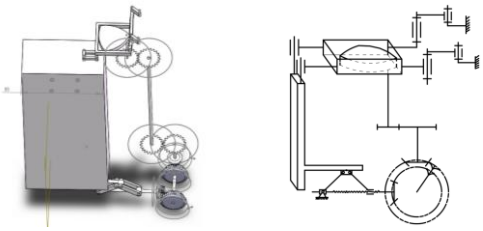


(a) (b)

Fig.1: Door opening process. (a) Door lifting process. (b) Door translation process.

The cabin door body is an arc-shaped plate structure, and the upper and lower parts are folding plates, which can be folded inward. The cabin door body is connected with the fuselage through a mechanism installation box, two upper and lower hinges and two torsion pipes. The hinge of the door is very long, which is called hinge arm. The hinge arm is fixedly connected with two torsion pipes through bolts and splines, and plays the role of supporting the cabin door in the non locking state. Two torsion pipes are used as the rotating shaft, one of which is installed in the cabin door, which is called the door torsion pipe. The cabin door body can rotate around this shaft and move upward. The other one is installed on the body structure, which is called the fuselage torsion tube. The hatch rotates around the axis of the fuselage torsion tube to open or close the whole hatch. The mechanism installation box is located in the middle of the hatch, which is an integral box type component, and the hatch is fixed on it by bolts. The mechanism mounting box is installed on the torsion tube of the door through two bearings, so that the door can rotate around the torsion tube.

III. DESIGN AND ANSLYSIS OF AIRCRAFT DOOR OPENING MECHANISM

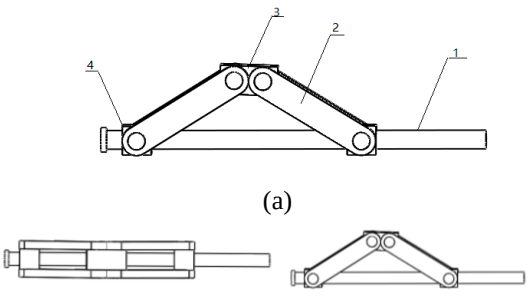


(a) (b)

Fig.2: Structure view. (a)Structural model diagram. (b)Concise machine draft.

The mechanism is mainly composed of the following parts: Luluo triangle structure, Jack like lifting mechanism and gear transmission. The jack is used as the lifting mechanism of the cabin door, and the mechanism composed of Luluo triangle structure is used as the pushing and translation mechanism of the cabin door. The whole mechanism has three positions: locking position, pushing track position and full open position.

3.1 Lifting mechanism



(a)

(b) (c)

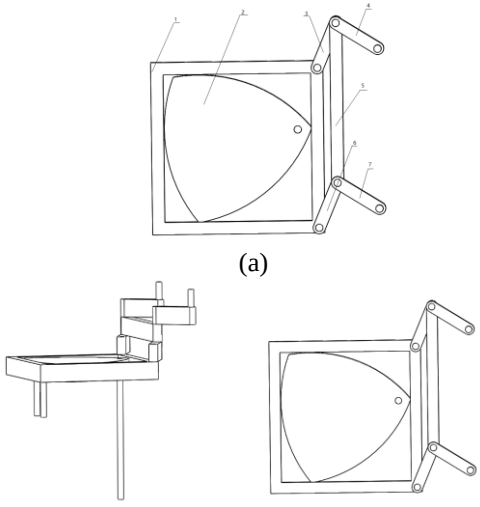
1-screw rod. 2-connecting rod.3-platform.4-slider.
Fig.3: Lifting mechanism. (a)The scissor jack. (b)Top view. (c)Front view.

The structure shown in Fig.3 (b) and Fig.3 (c) is the lifting mechanism of the cabin door. The rotation of the gear drives the rotation of the jack shaft to make the left and right slide blocks of the Jack move to the middle, so as to achieve the lifting effect of the jack. According to the lifting of the jack, the safety pin on the side of the cabin door moves out of the locking position following the opening track.

The principle of the jack used here is similar to that of the shear Jack. The shear jack is also called the support jack. It is composed of the upper support rod and the lower support rod made of metal plate, and its working principle is different. The cross section of the upper strut and the cross section of the lower strut at and near the tooth is a rectangle with an opening on one side, and the metal plates on both sides of the opening are bent inward. The teeth on the upper support rod and the lower support rod are made of metal plates bent on both sides of the opening, and the tooth width is greater than the metal plate thickness. It is composed of a base, a pair of lower support arms, a pair of upper support arms, saddle, plane bearing, nut, cradle, pin shaft and screw rod. The edges of a pair of upper support arms are turned inward into stiffeners, and their ends are gear meshed. The edges of a pair of lower support arms are turned outward into stiffeners, and their ends are gear meshed.

Scissors jack is based on the geometric principle of isosceles triangle two waist unchanged, shorten the bottom edge will enhance the high line. It adjusts the bottom edge of the upper and lower isosceles triangle through the screw rod and nut to raise and lower the height. Just like the tool ladder in daily life, the smaller the angle between the two arms of the ladder, the higher the ladder. Similarly, the larger the angle between the two arms of the ladder, the lower the ladder.

3.2 Pushing and translation mechanism



(a) (b) (c)

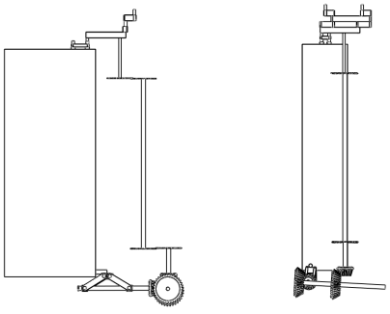
1-square frame.2-Luluo triangle.3-quadrilateral connecting rod.4-fixed rod.5-quadrilateral connecting rod.6-quadrilateral connecting rod.7-fixed rod

Fig.4: Pushing and translation mechanism. (a)Luluo triangle structure. (b)Side view. (c)Top view.

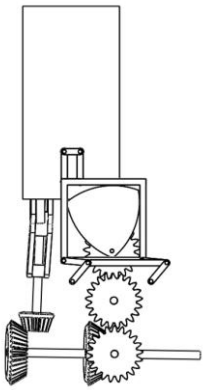
The pushing and translation mechanism is replaced by Luluo triangle structure, which respectively takes the vertex of the regular triangle as the center of the circle and its side length as the radius as the arc. The curved triangle composed of these three arcs is called Luluo triangle. The characteristic of the Luluo triangle is that it has the same width in any direction, that is, it can rotate freely between two parallel lines whose distance is equal to the radius of its arc, and it always keeps in contact with both lines. It is installed on the upper part of the cabin door to complete the pushing and translation action. Because when the Luluo triangle rotates in a square whose side length is its width, four-points contact with the four sides of the square at any time, and the position of the contact point is constantly changing. As shown in Fig.4 (b), fix an angle of Luluo triangle to make it rotate eccentrically around the fixed point.

As shown in Fig.4 (c), this is the trajectory of the door driven by the Luluo triangle. Luluo triangle is fixed for eccentric rotation, rotating a certain angle, and the upper right corner of the outer square frame of Luluo triangle is connected with the aircraft door. In Fig.4 (c) the trajectory is the movement of the cabin door connected by the outer frame driven by the Luluo triangle. This trajectory is just right to meet the needs of the door's launch and translation.

3.3 Gear transmission



(a) (b)



(c)

Fig.5: Gear transmission. (a)Front view. (b)Side view. (c)Top view.

Fig.5 (a) is the front view of the gear transmission, and Fig.5 (b) is the side view of the gear transmission. The middle and lower part of Fig.5 (b) is the driving shaft, which drives the two half gears to rotate. The purpose of making the pinion and the big gear into half teeth is to ensure the working order of the mechanism. Firstly, the rotation of the small teeth drives the operation of the jack to make the cabin door lift first. After the rotation of the small half gear is completed, the large half gear starts to rotate, making the upper Luluo triangle start to do eccentric rotation, which is the movement of the cabin door with pushing and translation. The successive meshing of the big and small half gears makes the jack and Luluo triangle move successively to achieve the mechanism movement of lifting first and then doing pushing and translational motion.

IV. CONCLUSION

4.1 Advantages of the lifting mechanism

The scissor jack has the advantages of simple structure, stable support, safe and reliable structure, small lifting height and large lifting weight, so it is very suitable to be used as the lifting mechanism of aircraft door.It has no leakage problem of hydraulic jack, and all kinds of structural problems caused by the change of ambient temperature will not appear.

4.2 Advantages of the mechanism doing pushing and translational motion

Luluo triangle is a kind of triangular eccentric wheel, which can drive the square frame to complete the trajectory movement of the half square by the eccentric rotation of the triangle. The trajectory coincides with the trajectory of the pushing and translation process when the aircraft door is opened. The most outstanding advantage of the mechanical structure is its simple structure, which can effectively realize the pushing and translation of the aircraft door.

4.3 Advantages of the gear transmission

As shown in Fig.5 (a) and (b), the transmission group is only driven by one motor, and the half gears are used to do successive mesh to realize the movement of lifting first and then doing pushing and translational motion. The design is simple, convenient and easy to implement. It can complete the movement of lifting the door first and then do pushing and translation with a simple mechanical structure.

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