Research on a Method for Adjusting Preloading Parameters of Urban Rail vehicle doors

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Abstract. The passenger compartment door is an important facility for ensuring the safe operation of urban rail vehicles.There are a large number of doors in the passenger compartment of urban rail vehicles, with a large effective opening and uniform distribution, which requires high reliability to ensure the safety of passengers.According to the statistics of faulty components in the application site and maintenance operations, a large proportion of passenger compartment doors have faults. If a single urban rail door fails, it will cause the entire train to be unable to be put into operation. The adjustment of door parameters is related to the safe operation and life safety of urban rail vehicles, and operators must be required to have professional skills and proficiency.Aiming at the mechanical parameters which lead to the high fault rate of passenger compartment door,this paper proposes a method of adjusting the preloading parameters of urban rail doors based on self-developed laser adjustment equipment, which provides theoretical and practical basis for the adjustment of passenger compartment doors.

Keywords: Urban rail vehicles; passenger doors; preloading parameters adjustment.

1. Introduction

Urban rail transit vehicles have an important positive impact on modern and convenient travel. According to the characteristics of urban rail vehicle operation services, urban rail vehicles have a high daily operating density, a large number of trips[1], and multiple passenger compartment doors to achieve efficient service for urban travel.In order to facilitate passengers' comfortable and safe riding, the opening and closing frequency of passenger compartment doors is relatively high. The design of passenger compartment doors not only considers aerodynamic effects, such as effectively reducing air resistance, having sufficient sealing[2], isolating external noise, and reducing air conditioning energy consumption,etc. ,but also needs to have sufficient strength and safety to ensure the safe operation of the vehicle and the personal safety of passengers.

According to statistics, from June 2023 to December 2024, out of 263 incidents of passenger compartment door malfunctions reported by a certain subway company, 141 were resolved by adjusting the door parameters, without the need for additional spare parts. These types of faults include "excessive gap when closing the door", "air leakage during operation of urban rail vehicle"[3], "jamming and abnormal noise when opening and closing the door", "whistling sound when the door is in operation", etc. The reason for causing door faults is that the door is a moving part, and the opening and closing of the door is frequent. During long-term use, the mechanical dimensions related to the door are prone to change. Therefore, the mechanical size adjustment of doors is a skill that must be mastered in the maintenance work of urban rail vehicles. Improving the inspection process and efficiency of doors is related to the safe operation and production efficiency of urban rail vehicles.

This article focuses on the commonly used external electric sliding doors in urban rail vehicles as the analysis object. Based on a self-developed laser positioning and adjustment tool, an improved method for adjusting the preloading parameters of urban rail doors is proposed, which can quickly locate the position of the door pre load parameters, reduce operation time, improve maintenance efficiency, and thus improve production and operation efficiency to a certain extent.

2. Analysis of the Significance and Current Situation of Adjusting the Preloading Parameters of Urban Rail Doors

2.1 The significance of adjusting the preloading parameters of urban rail doors

The basic structure of the external electric sliding door for urban rail vehicles is shown in Figure 1.The preloading parameters of urban rail doors refer to the difference in size between the upper and lower openings of the door leaf, requiring the upper openings of both sides of the doors to be 2mm~5mm larger.The door drive device is located at the upper part of the door leaf, and the preloading parameters can ensure that the door leaf is parallel to the vehicle floor when the door is closed in the passenger state, ensuring the sealing and safety of the running train. When abnormal situations occur in the door and after related maintenance operations, it is necessary to adjust the preloading size, mainly by rotating the eccentric bolts on the door frame connecting plate on each door to achieve individual adjustment of each door leaf. The general preloading parameters may have the following two situations.

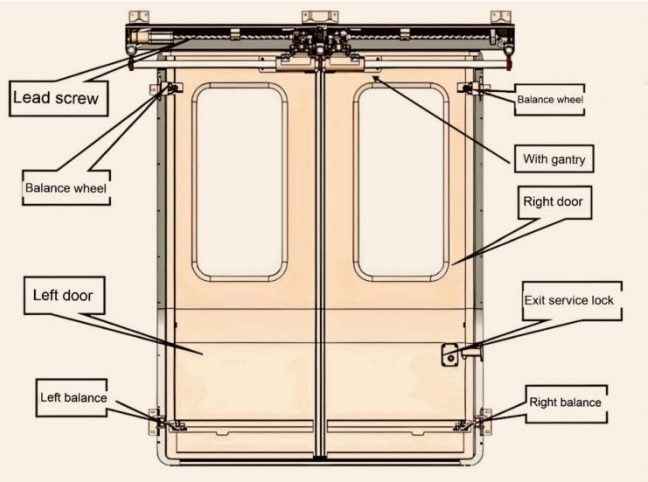

Fig. 1 Structural composition of the external electric sliding door

The preloading parameter of the car door is too large, that is, the preloading parameter is greater than 5mm. During the process of opening and closing the door, there is a difference in force between the upper and lower parts of the door leaf, causing it to tilt and form a larger V-angle. According to the analysis of the wear of the screw rod, the possible reason is that the worn side door leaf is preloaded too much during the movement process, and when the screw rod is locked, one side of the screw rod is subjected to a large load, which exacerbates the wear of the single-sided screw rod. This situation will reduce the overall service life of the car doors, increase the maintenance costs and manpower of urban rail vehicles.

The preloading parameter of the car door is too small, that is, the preloading parameter is less than 2mm. During the process of opening and closing the door, the gap between the doors is similar to a small V-angle. When the car door is closed in this situation, the gap between the doors cannot be fully compressed, resulting in faults such as "air leakage during operation", "whistling sound during operation", "loud noise and vibration", which are extremely detrimental to passenger safety and comfort requirements.

2.2 Current situation of adjusting preloading parameters for urban rail doors

For the external electric sliding doors used in urban rail vehicles in China, the existing door preloading parameter adjustment technology needs to meet the following conditions:

(1) Measure the horizontal distance between the door frame at 10cm below the upper edge and 10cm above the lower edge of the door when the door is at the forefront of the slide, and calculate the difference. The difference requirement is that the lower edge reading of the single-sided door should be 1-2.5mm larger than the upper edge reading. If the gap is too large, it will cause the car

door to close loosely or scrape against the vehicle body. At present, due to the lack of a horizontal reference point, only the operator uses a steel tape measure to measure the corresponding door frame in the horizontal direction, which seriously affects the measurement accuracy. At the same time, when locking the eccentric bolt for adjusting the preloading, it is easy to drive the preloading value of the door leaf. Therefore, it is necessary to re measure and adjust it. If the parameters are still not qualified after adjustment, they will continue to be adjusted. There will be a repeated process of "adjustment measurement adjustment", which generally requires more than three cycles of adjustment and takes about 15 minutes, seriously affecting production efficiency and the accuracy of door parameter measurement.

(2) The preloading parameters of the door on both sides must range from 2 to 5mm.The current practice is to use a steel tape measure to measure the left and right doors separately. During the measurement process, the operator visually judges whether the measured points are horizontal. There are many measurement points, many operators, and low efficiency, which can easily lead to long measurement time and low measurement accuracy.

3. Improvement Method of Adjusting Tooling Based on Preloading Parameters of Urban Rail Doors

3.1 Introduction to the tooling for adjusting the preloading parameters of urban rail doors

The overall structure of the urban rail door preloading adjustment tool developed in this paper includes two cross laser scribing pens arranged symmetrically on the left and right side, and a bracket with fixed laser scribing pens on the same parallel plane. The fixed bracket is installed on the slide and can be adjusted left and right on the horizontal plane of the slide. The slide is installed on a level ruler, and the level ruler and above are installed on a height adjustable tripod as a whole. The actual vehicle door preloading parameter adjustment tool is shown in Figure 2.

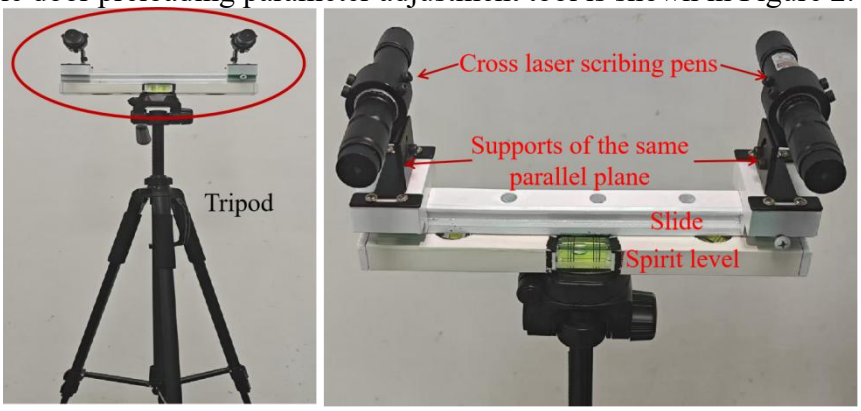

Fig. 2 Physical picture of door preload adjustment tool

During the use of the tooling, the cross laser pen can freely adjust the top and bottom angles in the vertical plane, and the laser scribing pen bracket can also be freely adjusted for left and right spacing on the horizontal slide according to needs. After adjusting in both directions, it can be locked by itself. The level ruler and tripod are securely installed, and the levelness of the level ruler can be adjusted and locked. The height of the tripod is adjustable and can be adjusted to the carrying height and usage height according to usage needs. The height adjustment range is 70cm-160cm. The entire fixture weighs about 0.5kg, equivalent to half the weight of a laptop, making it extremely convenient for maintenance personnel to carry and use.

3.2 Improvement method for adjusting preloading parameters of urban rail doors

A new method for improving preloading parameters is designed by using the preloading adjusting tool for urban rail doors. The steps are as follows.

(1) Preliminary adjustment of door preloading tooling. The positionof the preloading adjustment tool for the door requires it to be at the intersection of the centerline of the car door and the centerline of the car body; Adjust the levelness of the door preloading fixture to ensure complete levelness; The height adjustment of the laser part of the door preloading tool is required to be at the center of the vertical height of the car door. The above adjustment positions are shown in Figure 3.

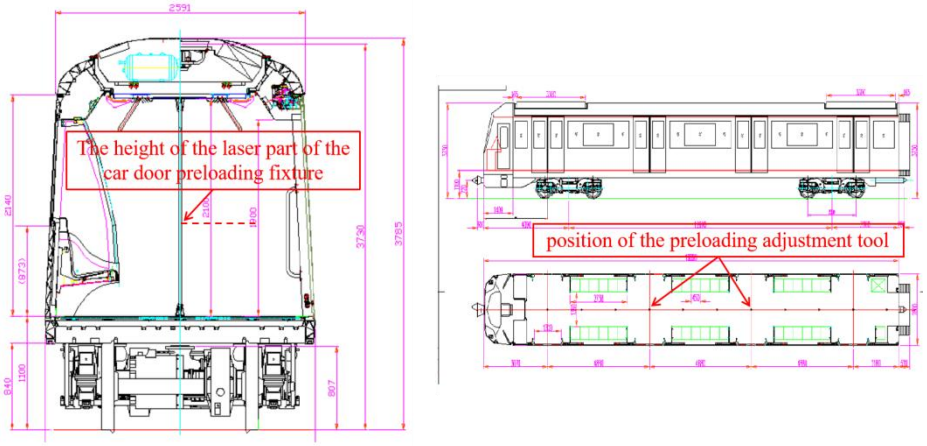

Fig. 3 Position setting diagram for preloading adjustment tool of urban rail doors

(2) The reference points for the left and right car doors should be set at 10cm below the upper edge of the door and 10cm above the lower edge of the door.

(3) Push the car door to the front end of the straight road, use the car door preloading adjustment tool to draw laser lines, aligning the upper and lower horizontal laser lines with the reference points of the left and right car doors. At this point, the vertical laser can be visually compared with the car door preloading status.

(4) The operator adjusts the preloading eccentric bolt according to the laser lines on the left and right doors and the actual state of the car door, quickly narrowing down the parameter range, as shown in Figures 4 and 5 .

Fig. 4 Rapid positioning of laser preloading tooling

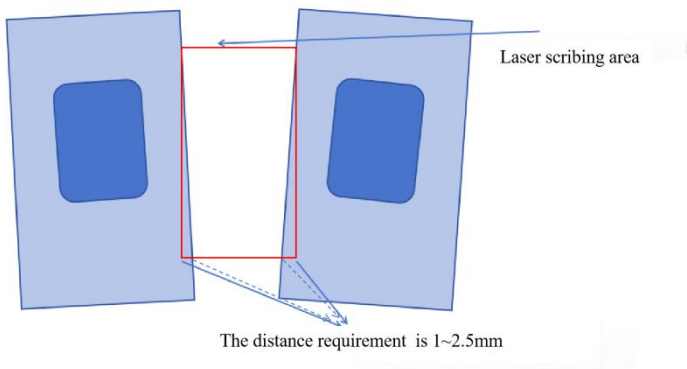

Fig. 5 Schematic diagram of adjusting parameters using the door preloading adjustment tooling

(5) Use a vernier caliper to measure the distance between the reference point under the car door and the vertical laser line, which should meet the process requirements of 1-2.5mm.

(6) After adjusting the car door, the operator tightened the torque of the door preloading eccentric bolt.

Through the development and use of the vehicle door preloading parameter adjustment tool, the maintenance operation method is improved, the operation efficiency is enhanced, and the preloading parameter adjustment operation is visually controllable. Moreover, the parameter adjustment method based on the urban rail vehicle door preloading parameter adjustment tool does not require any proficiency from practitioners, and even new operators can quickly and accurately meet the operation standards.

4. Comparison of methods for adjusting door preloading parameters

The traditional urban rail door preloading parameter adjustment operation does not require the setting of preloading parameter adjustment fixtures, which can save about 30 seconds of preparation time. When the operator adjusts the parameters, they use a steel tape measure to measure the horizontal distance between the two reference points of the same door leaf and the corresponding door frame, and calculate the difference until the difference reaches the requirement of 1-2.5mm. This completes the adjustment of the preloading parameters for one side of the door leaf. The same measurement method was used on the other side, and the final pre load parameter values of the doors on both sides reached the requirement of 2-5mm. The traditional car door preloading parameter adjustment workflow and the improved workflow are shown in Figure 6.

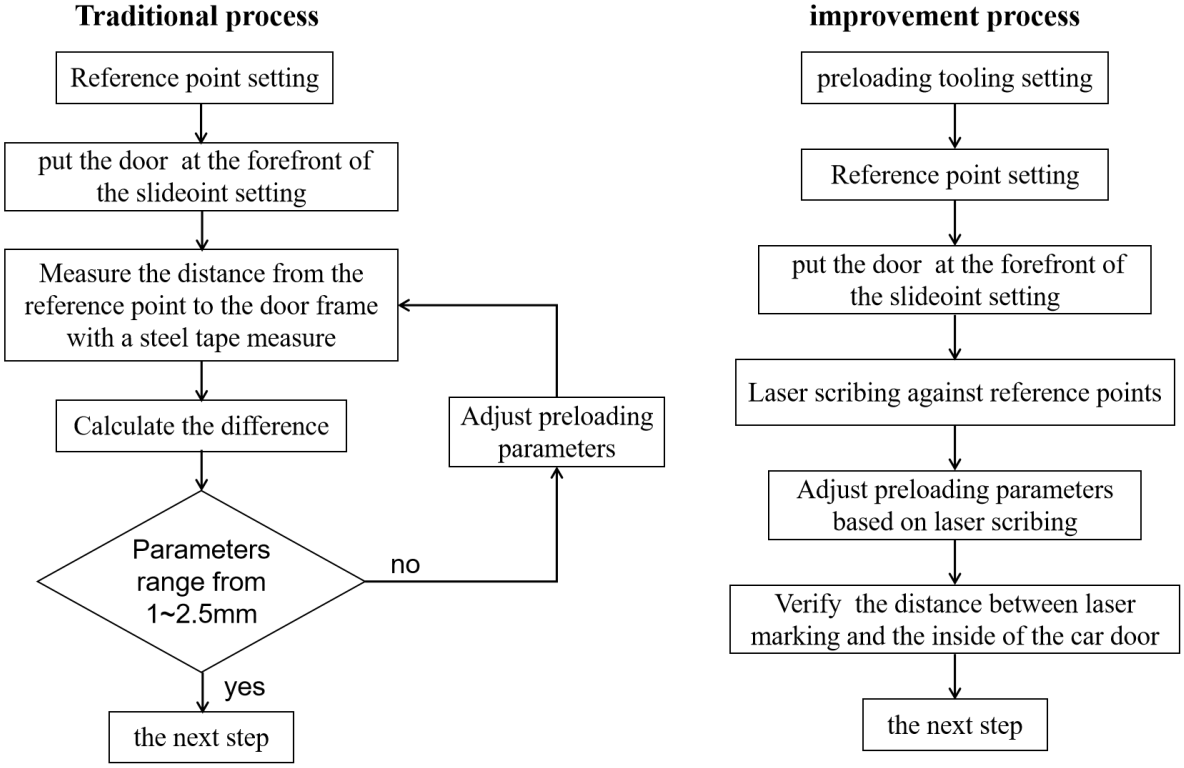

Fig. 6 Comparison of preloading parameter adjustment process for urban rail doors(left: traditional method, right: improved method)

In Figure 6, the traditional manual measurement of adjustment tasks is greatly affected by the factors of the operators, with multiple measurement points and the need for operators to move high, low, left, and right multiple times. Additionally, the reference point of the door frame is not fixed, and the measurement of horizontal distance relies entirely on manual visual judgment, resulting in

significant errors. This may lead to long adjustment times for preloading parameters during the installation and adjustment of door mechanical parameters, as well as increased product quality and maintenance costs in the later stage. If the door malfunction of a vehicle that is currently responsible for transportation tasks is adjusted, it may cause certain economic losses and social impacts.

After using the urban rail door pre load adjustment tool, the process of repeated "measurement adjustment measurement" can be effectively solved, shortening the initial 15 minutes to complete the preloading adjustment work within 3 minutes. At the same time, the laser line serves as a static reference point, making the entire preloading adjustment operation visually controllable. Even new workers can proficiently operate after completing one or two full operations.

5. Summary

Due to the short distance between railway vehicle stations, frequent opening and closing of train doors, and the large number of passenger compartment doors, the number of passenger compartment door failures accounts for more than 30% in daily maintenance and operation, seriously affecting the use of urban rail vehicles and the economic benefits of enterprises. Increased daily maintenance downtime reduces vehicle turnover efficiency, while also increasing labor intensity for operators and maintenance costs for the enterprise.

This article proposes an improved method for adjusting the preloading parameters of urban rail doors based on the urban rail door parameter adjustment tool, which effectively improves the accuracy and efficiency of mechanical assembly and adjustment of urban rail doors, extends the maintenance interval of key moving parts of vehicles, not only helps enterprises save operating costs, but also improves the safety of vehicle operation to a certain extent, and effectively serves the urban rail transit transportation industry.

Acknowledgment

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