

## Design of Universal Measuring Equipment for Bogie Frame

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**ABSTRACT:** The performance parameters of the bogie which directly affect the quality and safety of train operation should be detected during maintenance, especially the structure parameters of bogie frame after many operation years. Based on the related research of the bogie frame measuring requirement, a universal measuring equipment is designed for metro overhaul. The function, basic principle, structure and software design of the universal measuring equipment for bogie frame parameters are described, and the summary meanwhile prospect are given.

**Keywords:** bogie frame, measuring equipment, measuring jig, data management

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### I. INTRODUCTION

With the continuously rapid development of the economy in our country, the quickening process of urbanization, the increasing of population, the urban public transport is challenged by these situations severely. And urban rail transit such as subway and light rail has become the first choice to solve traffic jam and problems of urban public transport because of its convenience, large passenger flow, low energy consumption and less pollution. Running in the city, subway also faced with special circumstances in reality, for example, frequent start-stop, the great number of passengers as well as the small horizontal curves of route. And especially during the rush hours, remaining high load even over load, the bogie is under too much pressure. As the carrier of passengers, the running stability and safety of bogie has become one of the main basis to judge vehicle quality. To ensure its good condition, to detect and control the deformation, cracks and other hidden dangers in time, is an essential task in the maintenance of the bogie frame. So, it is strongly necessary to measure the bogie periodically, especially the bogie frame.

#### 1 Bogie Frame Measuring Equipment

##### 1.1 Bogie frame overview

A bogie is a mechanism that carries the weight of a vehicle body and transfers its weight as even as possible to the track. The bogie can be divided into two types of power bogie and trailer bogie. The metro bogie generally consists of wheel sets, axle box, primary and secondary suspension, bogie frame, braking equipment and carbody connecting parts.

Metro car uses two-axis bogie, and equipped with two sets of wheels. Metro bogie is a very rigid frame, in which the structure design of primary suspension and secondary suspension are to ensure the ride comfort, curve through, safety and running in the linear orbit of the dynamic [3]. The primary suspension is a flexible device that connects the wheel set and the frame, and the secondary suspensions is located between the frame and the body. The bogie frame which urban rail transit vehicle features: used air-spring as secondary suspension and rubber spring as primary suspension. This kind of structure increases the lateral flexible, reduces the wearing between wheel and rail, which improves the running quality.

Bogie frame is the mounting foundation, which makes several components of the bogie as a whole. The frame must have enough strength in order to bear and pass various forces and load, of which the quality should meet the structure and shape requirements of components assembly (such as braking device, suspension dampers, axle box, etc.). The components need high quality in position accuracy to insure the safety, which should be detected and controlled in the whole life cycle[4-7].

Each bogie frame of new cars should be detected with special equipment by vehicle suppliers before acceptance test, the numbers of dimension chains and tolerances up to hundreds, and should be adjusted correctly according to the measuring results. Metro operator which takes charge of maintenance can only measure few dimensions with simple measuring implement, basically do not have the professional equipment for measuring bogie frame during overhaul, which fails to evaluate on maintenance quality and life situation perfectly. With the rapid development of urban rail transit industry in China, Metro operators have the prominent demand of tracking the status of the bogie frame. To design a detecting device for this demand is urgent. Because of the particularity of urban rail transit industry, the structure of bogie frame is various with different speed levels or manufacturers. According to this situation, put forward the general idea of universal bogie frame measuring equipment for research is imperative.



Figure 1 Metro Bogie Frame

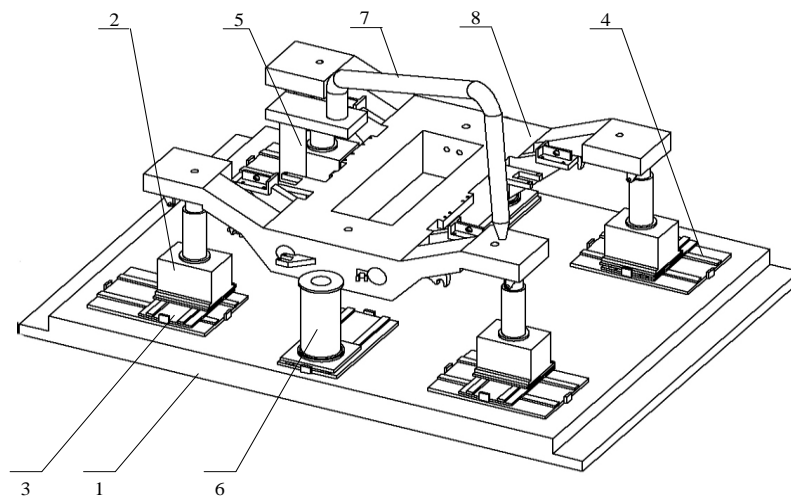
### 1.2 Function of Measuring Equipment

In order to meet the requirements of bogie frame measuring, this paper provides a kind of universal metro bogie frame measuring equipment which is suitable for almost all types of metro vehicle. This equipment includes measuring jig, articulated arm measuring device, and data manage software. It can be applied in detecting the bogie whatever the bogie frame is placed upwards and downwards. When supports the frame safely and steadily, this measuring jig can ensure that all the key dimensions are achieved in the measurable ranges of articulated arm.

### 1.3 Main Structure of Measuring Jig

The basic principle of the measuring jig is to place the measured bogie frame steadily on several supporting bases ,including the bases of primary suspension, secondary suspension and articulated arm measuring device. The supporting bases can be adjusted by the longitudinal and transverse slide guiding rails in order to adapt and support different scale of frames. A iron ruler mounted on each base is helping to adjust precisely. After fixing all the supporting bases on right position, operating person could place the frame on the platform steadily, then use articulated arm to measure all dimensions. The structure of measuring jig is shown in the figure 2.

Measuring jig includes iron platform and supporting base. The structure area of iron platform satisfies the operation and standing space. The supporting base for positioning and supporting can adapt various types of metro bogie frame, and leave the 10% margin in order to adapt new type frame in the future whenever the bogie frame is placed upwards and downwards to set. When frame placed upwards ,using the primary suspension spring mount base as contacting surface; When frame placed towards, using the secondary suspension spring mount base as contacting surface.

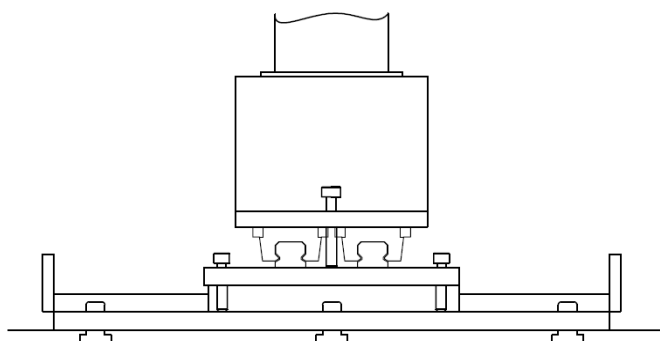


1-iron platform 2- primary suspension supporting base 3- lateral slide rail 4- longitudinal slide rail  
5- articulated arm supporting base 6-secondary suspension supporting base  
7- articulated arm measuring device 8- bogie frame

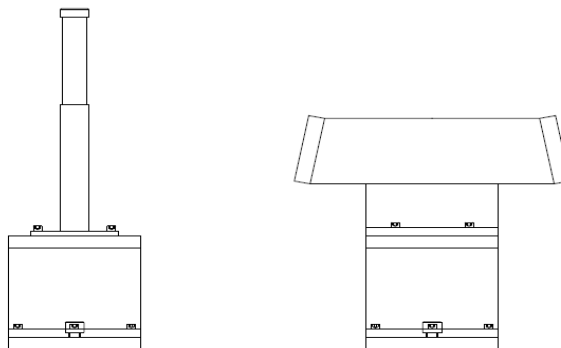
Figure 2 Main Structure of Bogie Frame Measuring Jig

Primary suspension supporting base comprises a two-layer slide elements both longitudinal and lateral (see figure 3), and with a supporting column. By adjusting manually the two-layer slide element can adapt variety with dimensions of bogie frame, and a ruler can promote the precise alignment of fixing. The column of the supporting is composed of two sections (see figure 4), the upper column with several types to be adapted to the different types of the primary suspension supporting bases. Secondary suspension supporting base is the main supporting and positioning parts when the frame placed downward. It comprises of a lateral slide device and a supporting column, by adjusting the slide to support various types of frame.

The articulated arm supporting base is used for supporting the articulated arm measuring device, and the top plate processing flange hole is connected with the measuring machine base. Considering the measure range of the articulated arm, the top plate of the supporting base designed as a rotating construction. In order to extend the measuring range to reach all the position on frame, the rotating top plate can be across above the center of the frame when the supporting is approaching the frame.



**Figure 3** Slide Elements on Primary Suspension Supporting Base



**Figure 4** Primary Suspension Supporting Base with Different Upper Column

## **II. ARTICULATED ARM MEASURING DEVICE**

### **2.1 requirement of Measuring Machine**

Universal measuring equipment is utilized for bogie frame measurement by metro operator, to diagnose whether there is deformation presence after years running. Key dimensional characteristics is located everywhere as horizontal or lateral plane, even inner cylindrical which is not easily to measure with traditional frame-type coordinate measuring machine. Furthermore, traditional frame-type occupies more space to accommodate the size of bogie frame. Therefore, an articulated arm measuring device is chosen as the core measuring device which operated more flexibly and lightly.

The articulated arm measuring device consists of three rigid arms, six flexible joints and one touching probe, see figure 5. Joint between each two arms can rotate freely in space. And the vertical rotation angle sensors fitted at joints can measure exact position of each arm and the probe in space. The articulated arm measuring device is normally six-joint, with manually measuring operation. The main advantages are as below:

- Flexible movement, easy to touch blind area, especially with complex structure.
- Larger range, compact size and light weight.
- Portable system, less complex and space-free.
- Good measuring efficiency, manually supported and route-free [8].

To be clear, when measuring a fixed space point, the measuring arm has infinite combinations, and the error of each rotation angle may lead to the decrease of the accuracy, but the degree of decreasing still acceptable for metro vehicle maintenance application. To reduce possible measuring error, an advanced articulated arm measuring device is chosen in this project, which can directly measure after switch on, with measuring diameter of 4.5m, measuring accuracy and repeatability of the point is less than 0.1mm.

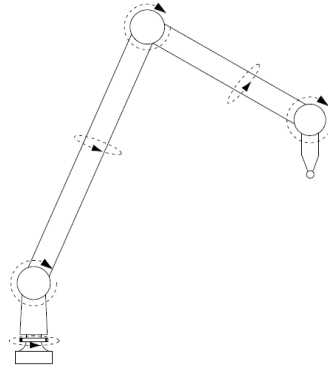


Figure 5 The Main Structure of Articulated arm measuring device

**2.2 data acquisition system**

The data acquisition system mainly picks the data from the angle sensors with multi-parameters acquisition function. The integrated, intelligent sensor and fieldbus technology are used to set up intelligent data acquisition unit in each joint and arm body, which consists of single chip microcomputer, angle sensor, temperature sensor and strain sensor, etc. Each unit can complete the multi-sensor data acquisition task independently, and all data acquisition units are linked on bus. The three-coordinate measuring equipment runs under the PC configuration, hosted by laptop for data acquisition and coordinate measurement. Via the RS485-USB adaptor on the measuring machine base, communication is directly built up in more convenient way through a USB cable between laptop and data acquisition system [9].

**III. DATA MANAGEMENT SOFTWARE**

**3.1 overall design ideas**

Because of the massive measuring points of bogie frame, in order to facilitate the use of operators, the data management software for measurement is designed when using this measuring jig. The function of the software is to instruct the workers to measure the corresponding positions according to the requirements, import the measurement results produced by the measuring machine, store and analysis the historical data. The software is compiled in C # language, the concrete flow chart is as follows:

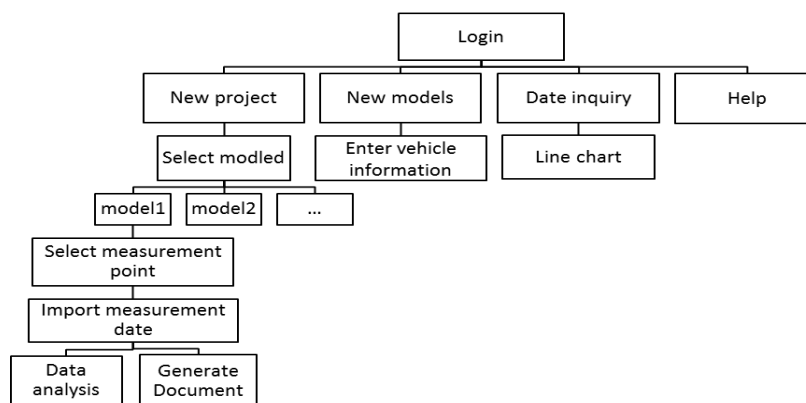


Figure 6 Data Management Software Bock Diagram

Figure 7 is the software interface. When create a new project, selected the dimensions to be tested, the software will prompt the corresponding measuring points on the diagram. After measurement with articulated arm, the measurement results should be imported in this software which can be determined qualified or not. Each time the data is stored in this software platform. The software can also query the analysis results of each measuring batch, including the values of the most, the average, the variance and the qualified rate, as well as the

number of the problem frame and corresponding measurement value.

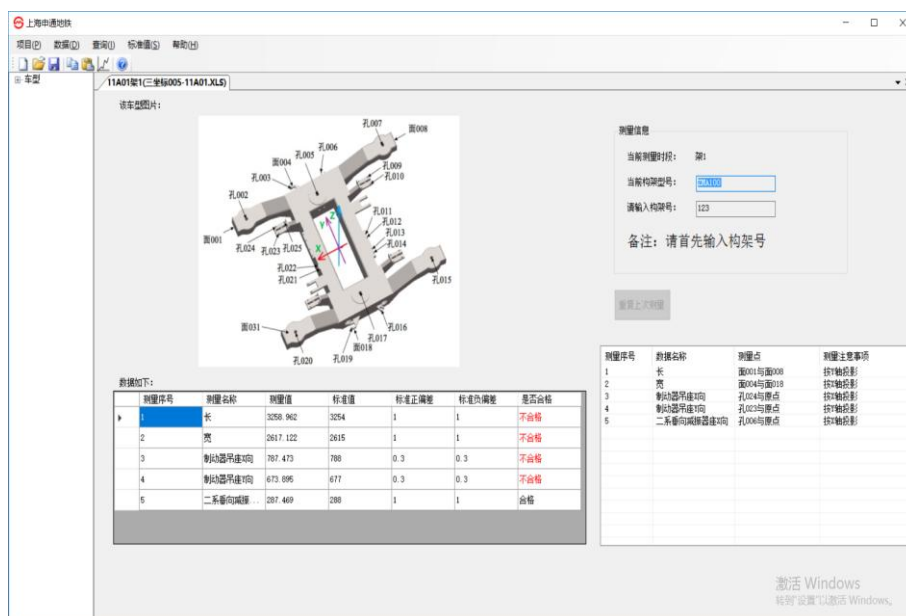


Figure 7 Software Interface

#### IV. CONCLUSION

Based on maintenance requirements of bogie frame, a universal measuring equipment is designed for metro operator. The equipment's capabilities include supporting and adapting various types of metro bogie frame, supporting measurement machine and data management, which utilize the mature and advanced technology of articulated arm measuring device. The system has been put into use in Shanghai metro, nowadays all types of metro frame can be measured to provide a evidence for safety assessment of the running gear after overhaul.

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\*Song Jian. "Design of Universal Measuring Equipment for Bogie Frame." International Journal of Research in Engineering and Science (IJRES) 5.8 (2017): 09-13.