Structure Design and Simulation of Portable Intelligent Gauge Calibrator Based On ANSYS

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Abstract: Gauge industry is an indispensable part of China's railway inspection industry. There are some problems in the traditional gauge industry, such as large volume and low intelligence. In view of the above key points, this paper designs a new portable intelligent gauge calibrator, which greatly reduces the volume of the device. Through the upper computer operating the internal control unit of the device, the automatic measurement of the instrument is carried out. The structure of the new gauge calibrator is analyzed and demonstrated by ANSYS simulation software.

1. Introduction
The total length of traditional gauge calibrator is generally more than 1.6 meters, which can not be disassembled and has a large weight, which is difficult to carry. Therefore, nowadays, the verification of gauge mostly adopts the process of factory sending for inspection. The manufacturer will send the gauge to the measuring institution, and then return it after verification. Due to the objective factors such as freight transportation and manpower allocation of measurement institutions, the verification period of a single batch of track gauges is usually about one week. As the gauge is one of the national compulsory inspection items, it needs to be sent for inspection every three months, which is a waste of manpower and time cost for the manufacturers who use the gauge.\cite{1}
On the other hand, it can be seen from Figure 1 that most of the traditional gauge calibrators are designed with mechanical structure, which is low in intelligence. In daily use, most of the calibrators use manpower to read and adjust the scale, which is easy to produce errors, which will affect the accuracy of the experimental results.

In view of the above problems, we redesigned the structure of the gauge calibrator. Without changing the verification process of the traditional gauge calibrator, we greatly reduced the volume of the gauge calibrator and enabled it to be disassembled, so as to realize the outward carrying of the gauge calibrator and make the on-site verification possible. At the same time, the use of Mechatronics design reduces the degree of human intervention in the verification process and makes the verification results more credible.

2. Structural design
The overall inspection process of the new type gauge calibrator is similar to that of the traditional gauge calibrator. The general structure is shown in Figure 2 below. Because the platform structure needs to be portable, the total structure is divided into two parts: superelevation measurement platform and horizontal measurement platform, as shown in Figure 3 and Figure 4.
In the process of measuring the track gauge, the upper computer drives the nut on the motor screw rod group of the horizontal platform platform for axial displacement. At the same time, the movable side head clamping groove on the guide rail is driven to move synchronously by the connecting piece 1, and then the movable side head clamping groove is connected with the vernier on the grating ruler through the connector 2 to keep the synchronous displacement of the whole mechanism. In the same way, the superelevationatform is connected with the ejector rod on the ejector unit through the connector 3, so that the two keep the consistency of longitudinal movement, as shown in Figure 5 below.

Finally, the readings on the gauge and grating ruler are read and recorded to complete the whole detection process. The whole detection process is basically similar to that of the traditional gauge calibrator, and the leveling link of the platform itself is added.
3. Static analysis of platform connector

In this chapter, ANSYS simulation software is used to analyze the structure of the core parts of the two, mainly for the structural strength analysis of the grating ruler connector of the horizontal measurement platform. [4-5]

This simulation mainly uses mechanical meshing in ANSYS, and the material settings of its main components are shown in Table 1.

| Part name  | Material name  | Density (g / cm$^3$) | Poisson's ratio | Elastic modulus (Mpa) |
|------------|----------------|----------------------|----------------|----------------------|
| Screw      | 304 stainless steel | 7.93                | 0.31           | 193000               |
| Nut        | 304 stainless steel  | 7.93                | 0.31           | 193000               |
| Main structure | Structural steel   | 7.85                | 0.30           | 206000               |
| Connector  | Al-6061-T6          | 2.703               | 0.33           | 69000                |

3.1. Simulation of horizontal platform connector

In order to facilitate the simulation, the simplified model is shown in Figure 6. This paper mainly analyzes the horizontal platform connector of green part.
After gridding, the number of nodes is 35625 and the number of elements is 21025. Tetrahedral mesh is adopted, and the mesh model is shown in Figure 7.

In the analysis, the influence of structural damping and inertia is not considered. After adding boundary conditions according to the actual situation, the stress-strain results are shown in Figure 8 and Figure 9.
The maximum deformation and the maximum stress point appear at the interconnection of the connector. The maximum deformation is 0.0003 mm and the maximum stress is 61.059 MPa.

3.2. Simulation of superelevation platform connector

In order to facilitate the simulation, the simplified model is shown in Figure 10. In the same way, the connection parts of the green part of the superelevation platform are mainly analyzed.

In the analysis, the influence of structural damping and inertia is not considered. After adding fixed constraints at the bottom, the load and boundary conditions are added according to the actual situation. The stress-strain results are shown in Figure 12 and Figure 13.
The distribution of maximum stress and maximum strain is the same, the stress is 2.0134 MPa and the strain is 0.00003mm.

According to the query data, the compressive yield limit of al-6061 is $\sigma = 55.2$MPa, and the safety factor is $n = 2$, so the allowable stress is:

$$[\sigma] = \frac{\sigma}{n} = \frac{27.6}{2} = 13.8\text{MPa}$$

According to the fourth strength theory, $\sigma_{1max}=19.116$MPa, $\sigma_{2max}=2.0134$ MPa, all less than the allowable stress, so no plastic deformation occurred during the operation of the device. Since the readings of the device are carried out when the device is still, the deformation has no effect on the detection results of the device.

### 4. Summary

In this paper, a new type of portable intelligent gauge calibrator is designed to make up for the shortcomings of the traditional gauge calibrator, such as large volume and mass, difficult to carry and
difficult to carry out on-site measurement. At the same time, through the mechanical and electrical integration transformation on its original structure, it makes up for the deficiency that is greatly affected by human factors. The feasibility of structural design is proved by static analysis with ANSYS simulation software.

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