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Research and development of on-line measuring device for anchor chain length

Wang Hairong¹, Li Cunjun¹, Li Liang¹, Zhao Hua¹ and Zhao Jianbo²

¹Zhoushan Institute of Calibration and Testing for Quality and Technology Supervision, Zhoushan Zhejiang 316000, China

²School of Mechanical Engineering, Jiangsu University of Science and Technology, Zhenjiang Jiangsu 212003, China

whrio@126.com, licunjun@sina.com, 359318649@qq.com, 284515112@qq.com, zhaojianbo1992@126.com

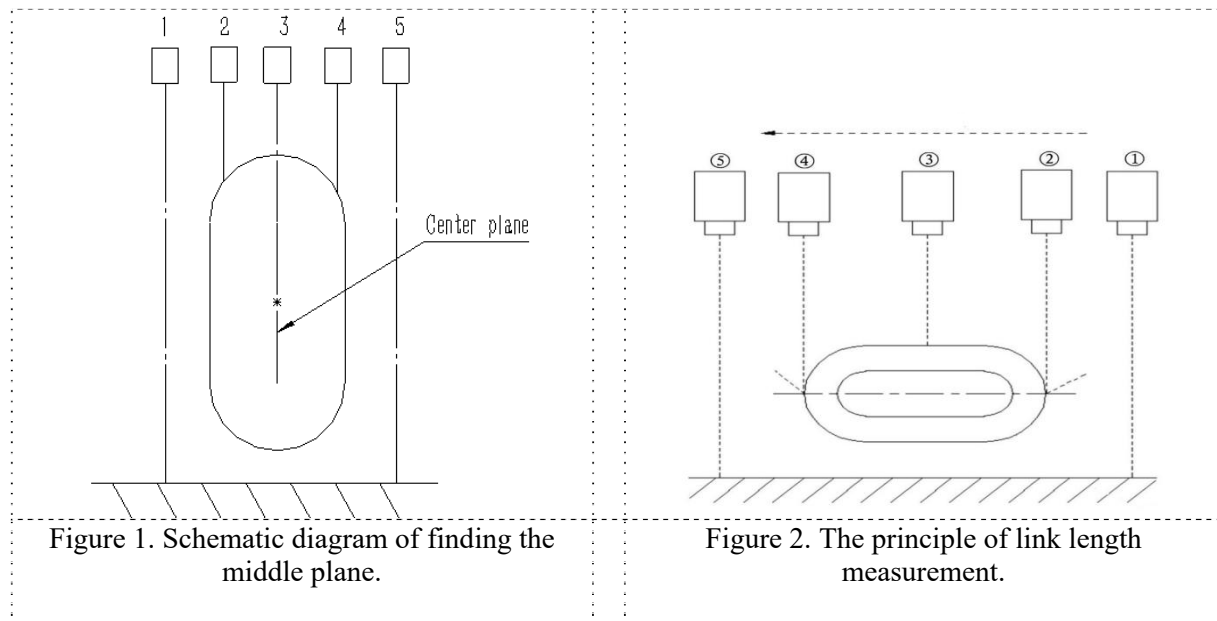
Abstract. In order to realize the automatic online measurement of the anchor chain length, this paper proposes a measuring device with simple structure and high measurement accuracy. According to the structural characteristics of the existing anchor chain tensile testing machine, the structure spliced with AL plates is designed and it has good mechanical properties. The measurement method combining the laser ranging sensor, the laser sensor and the magnetic grid sensor realizes the on-line measurement of the anchor chain length and effectively improves the measurement accuracy. The platform has been successfully installed in Zhoushan, China.

1. Introduction

ISO 1704-1973 and ISO 20438 stipulate that the five-ring length must be measured during the tensile test, and that the national classification societies have five-ring length inspection requirements, some foreign classification societies have also proposed the requirements for automatic online measurement of five-ring length ^[1].

At present, most of the chain link length measurement is manually measured using an ultra-long vernier caliper, which not only has low measurement accuracy, but also is time consuming, laborious, and unsafe. The use of the vision measurement system ^{[2][3]} can effectively improve the efficiency, but since the resolution of each camera is limited, in order to ensure the measurement accuracy, the method needs to arrange a plurality of cameras, so the cost is high. In order to improve measurement accuracy, reduce the workload of workers and improve work efficiency, we need a device with high reliability, high precision, simple structure, easy implementation, and automatic on-line measurement. Based on the original test bench, this paper uses a combination of laser ranging sensor, laser sensor and magnetic grid sensor to design an automatic online length measuring device that meets the above requirements. After stress and deformation analysis, the structure is optimized according to the analysis results.





2. Measuring principle

2.1. Determination of the center plane

As shown in Figure 1, the motor control slider module sweeps the entire anchor ring from 1 to 5 and finds the longest end of the chain through the reading of the laser displacement sensor.

2.2. Anchor chain single loop length measurement process

As shown in Figure 1, when the laser sensor moves from ① to ②, the emitted laser light is scattered by the ring crown, so the laser sensor does not receive the reflected laser. At this time, the output signal of the laser sensor is abrupt, and the measurement and control computer records the position of the magnetic scale read head at this moment, and the value is X_i ; When the laser sensor moves from ③ to ④, the emitted laser light is reflected back to the laser sensor via the reflector. At this time, the output signal of the laser sensor is abrupt, and the measurement and control computer records the position of the magnetic scale read head at this time. The value is Y_i . The length of each single loop of the anchor chain is calculated by $Y_i - X_i$, and the length of the five loops can also be measured.

3. OVERALL STRUCTURE DESIGN

The length measuring device works on the guide rail of the 12000KN tensile test platform. According to the structural characteristics of the platform and the measurement requirements, it adopts a "convex"-shaped overall structure and as shown in Figure 3 it is driven by a stepping motor to move on the guide rail.

As shown in Figure 3 the main body of the device is made up of aluminum plates, and its load is its own gravity. The frame structure with thin plate splicing can meet the strength requirements; the range sensor group mounted on the stepper motor driven module is the core measurement part of the entire device. It is equipped with adjustable devices that can be adjusted according to different anchor chain specifications. The laser ranging sensor is in the same plane as its measurement center, and the length of the anchor chain can be measured on the largest plane it determines; The magnetic grid type sensor group adopts an air spring structure to realize two working states of telescopic expansion, which can ensure the shrinkage of the small roller and the magnetic scale and have a certain preload, and finally utilize the elephant head part (One button can be self-locking, press again to release the rebound); The device wheel provides power to the entire device and advances along the rail for automatic measurement.

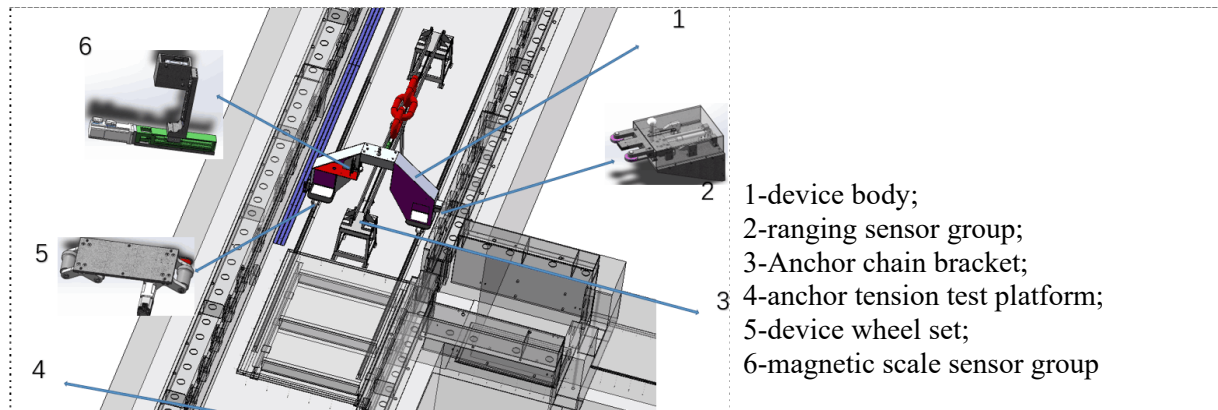


Figure 3. Device for measuring length.

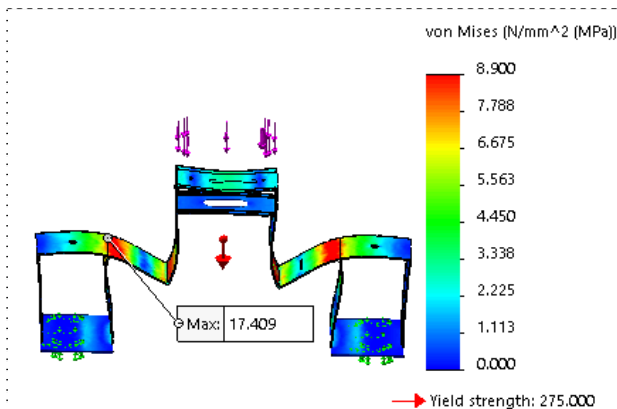


Figure 4. Stress pattern.

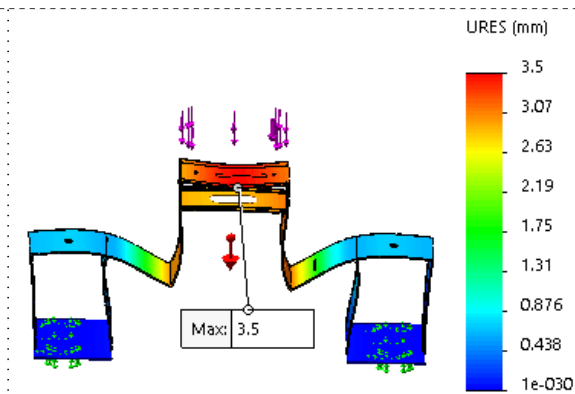


Figure 5. The deformation figure.

4. OVERALL STRUCTURE DESIGN

In the actual working process, the main load is the gravity of the main body of the device, so only the strength and deformation of the device body need to be analyzed.

4.1. Load constraint processing

Since the force receiving surface is the contact surface of the wheel set and the main body of the device, during the constraint setting process, an independent area is defined on the bottom surface according to the actual wheel set installation position, and Fix this area [4][5].

4.2. Finite element analysis

In order to simulate the situation that may occur during the actual test (falling object), after comprehensive consideration, add 500N uniformity on the top surface for analysis. The yield strength of the AL alloy is 185MPa. From the figure, the maximum stress is 17.409MPa when the additional force of 500N is added. The yield strength of the material is much larger than the stress value obtained by the analysis, so the strength requirement is met. For the amount of deformation, the maximum deformation is 3.5mm when 500N additional force is added. As shown in Figure 5, it is necessary to optimize the structure to reduce the amount of deformation.

4.3. Structural optimization

Through analysis, it is necessary to optimize the structure to reduce the amount of deformation when the strength requirement is met. Combined with the existing structure, the specific measure is to increase the ribs in the area with large deformation. After changing the 3D model of the device, the analyses of the strength and deformation of the model are as follows:

Table 1. Stress and deformation under different applied forces.

	Stress(Mpa)		Deformation(mm)	
	Before the change	After the change	Before the change	After the change
500N	17.408	11.524	3.5	0.114
3000N	71.546	54.683	15.2	0.476

From the above table, after adding ribs, applying additional forces of 500N and 3000N, the stress and deformation of the device are significantly reduced.

5. Conclusions

The length measuring device makes full use of the existing 12000KN tensile test platform, designs an on-line measuring device, uses a laser ranging sensor to find the middle plane, and then uses a laser sensor to capture the end of the link, and the magnetic scale records the length of the anchor chain.

Acknowledgments

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