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A NEW MULTIFUNCTION TORQUE STANDARD MACHINE AT NIM

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Abstract – The paper describes a new multifunction torque standard machine at NIM. National institute of Metrology has established a multifunction torque standard machine. It has three main functions. One is hydraulic torque wrench calibration. The second function is torque multiply calibration. The third function is reference torque standard machine. This paper introduces the structure and the working principle of the equipment, performance parameters and the uncertainty evaluation.

Keywords: torque calibration; hydraulic torque wrench; torque multiply calibration; reference standard machine.

1. INTRODUCTION

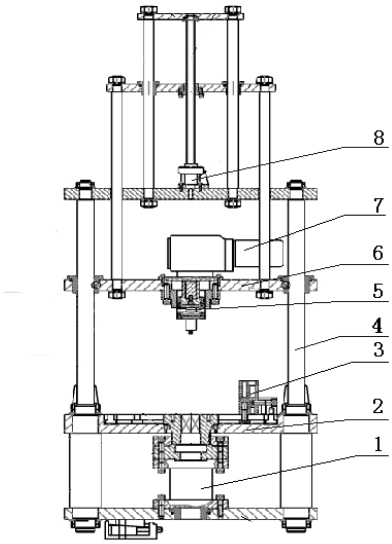
Recently, with the development of manufacturing industry, the requirement of bolt assembly quality become more and more strictly. So the requirement of various types of torque tools calibration has become more and more. Such as hand torque wrench, hydraulic torque wrench, electronic torque wrench, torque multiply. Especially the demand for hydraulic torque wrench calibration and torque multiply calibration has increased due to the rising number of large torque applications. Last year we have established a multifunction torque standard machine. It has three main functions. One is hydraulic torque wrench calibration. The second function is torque multiply calibration. The third function is reference torque standard machine. The relative expanded uncertainty of this torque standard from 100Nm to 1000Nm is better than 5×10^{-4}（k=2）, and from 1000Nm to 30000Nm is better than 5×10^{-3}（k=2）.

2. STRUCTURE AND WORKING PRINCIPLE OF 30kNm MULTIFUNCTION STANDARD TORQUE MACHINE

2.1 Main structure and working principle

30kNm multifunction standard torque machine use reference structure, the mechanical structure shown in figure 1. The machine mainly consists of 30kNm standard torque sensors, working platforms, lifting platforms, 1000Nm standard torque sensors, loading mechanism, lifting mechanism.

The bottom of 30kNm torque standard machine is a fixed basis of 30kN • m standard torque sensor, the torque transducer is mounted at the bottom of the machine. And also is installation location for the three pillars, on the top of the 30kNm torque transducer is work surface. The 30kN m standard torque sensor as a hydraulic torque wrench, torque multiplier calibration standard sensor, above the work surface is lift platform. This platform can be lifted by lifting mechanism，we can move up and down lift platform, height of the need to adapt to different calibrated tools. Rotation loading mechanism is installed on the lifting platform, constituted by a servo motor and reduction gear, 1000N • m standard torque sensor installed in the rotating shaft, used as a multiplier input torque, but also in the (100 ~ 1000) N• m range segment to achieve high-precision reference torque standard machine functions.



1. 30kNm standard torque transducer 2.working platform 3. Reflect block 4. Guiders 5.1kNm standard torque transducer 6.lifting platform 7.add mechanism 8. Lifting mechanism

Fig.1. Standard torque equipment

2.2 Design and features of the work surface

When we calibrate hydraulic torque wrench, torque multiplier, torque sensors, the installation point need to be provided. But different torque tools have different shape and size. So the work surface needs to adapt too many different

tools. It needs to provide flexible installation point. As the fig 2 shown we use of radioactive and circular T-slot design and Flange holes. This approach can provide three kinds of accuracy diameter flange mounting, and many mounted point with different angle. With the special design of the work surface, we can mount the torque tool in the plat. Such as hydraulic torque wrench, torque multiply, torque transducer, torque wrench.

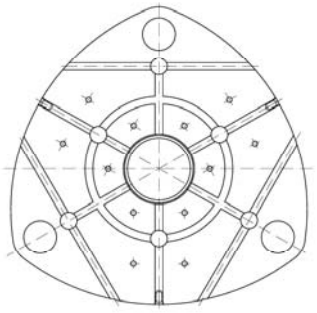


Fig.2. diagram of the work surface

2.3 Design of the Reaction plate

When we calibrate the hydraulic torque wrench and torque multiply, we need the reaction force point. So we design a special reaction force support module. As we have said that different brands, different models, different range of tools have different dimensions, they have different reaction force arm. Include the length and height. So the module design is also the focus of the machine. As shown in Figure 3, we design the reaction force support module; this support module can be used individually or in combination use, with the work surface installation location, can provide different kinds of reaction force support.

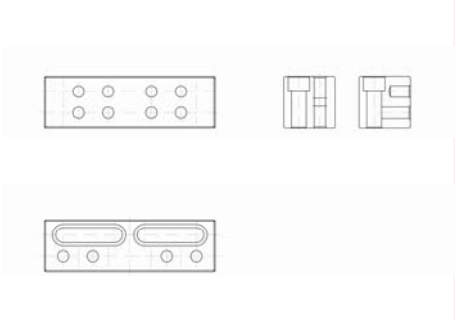


Fig.3. diagram of the Reaction plate

2.4 Design of the loading mechanism

Need to provide a standard input torque during the torque multiplier and torque sensor calibration, this standard machine achieve input torque by standard torque transducer and loading mechanism, the loading mechanism is consisting of servo motor and reducer. Also has an angle sensor, it can measure the rotate angle of the main shaft.

2.5 Design of the lifting mechanical

In order to adapt different tools, such as torque multiplier to the height (100 to 500) mm, the torque sensor with the height of the coupling is not the same value. So the space between work surface and lifting platform needs can be adjusted. The space can be adjusted from 200mm to 900mm. the lifting mechanism is consisting of servo motor and reducer.

3. ELECTRICAL CONTROL SYSTEM OF 30kNm MULTIFUNCTION STANDARD TORQUE MACHINE

The new multifunction standard torque machine's control system is computer and PLC control system. We can see the diagram of the control system from Fig.4.

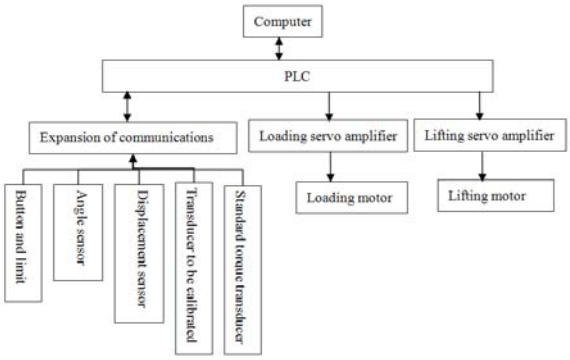


Fig.4. control system

With the control system realize the control of the servo motor. The working state in various parts of the machine under operation condition can be displayed on the computer screen in real time. Using displacement transducer detects the lifting platform position. Using angle encoder detects the rotation angle of input shaft. The control system has three control modes.

3.1 Torque control

Torque control uses the signals of standard torque transducer as feedback signal. The signals of torque transducer amplified by the torque meter and transmitted through the serial port to control system. Torque control with PID control; continue to monitor the set torque value, so a long time to keep the torque within the set range, the fluctuations in the torque value can be stabilized within ± 0.02Nm.

3.2 Angel control

Use the absolute rotary optical angle encoder as spindle angle detecting sensor; we can get the angle signal of spindle at anytime. Absolute rotary optical encoder has an absolutely unique for their every position, well anti – interference. Before each angle position control, the target angle sensor value should be written to coordinate; Rotation range of ± 450 °, corresponding to the encoder readings ± 180 000.

3.3 Manual control

Use the wireless remote control button box or PC software interface manual control button, we can directly control

spindle and platform lift, rotate and lift speed variable speed, rotation angle and height can be display on the PC.

4. PERFORMANCE TEST

After the machine was build. We have done some performance tests. According to machine functions, the tests are divided into hydraulic torque wrench calibration test, torque multiply calibration test, reference torque machine performance test.

4.1 Hydraulic torque wrench calibration

The test of hydraulic torque wrench calibration. We select a hydraulic torque wrench made by HYTRC; the model is HY-AVANTI8; serial number 095350967. Table 1 is the result of calibration.

Table 1

Oil pressure (bar)	Output (Nm)	output (Nm) 1	2	3	Avery (Nm)	error (%)	repeatability (%)
110	1668	1659.9	1657.6	1658.2	1658.6	-0.6	0.1
220	3405	3380.0	3373.4	3395.8	3383.2	-0.6	0.7
290	4487	4485.5	4489.2	4508.0	4494.2	0.2	0.5
400	6198	6179.5	6220.2	6220.8	6206.8	0.1	0.7
510	7872	7930.2	7974.1	7993.8	7966.0	1.2	0.8
620	9510	9590.9	9636.5	9655.3	9627.7	1.2	0.7
690	10519	10600.0	10648.6	10698.6	10649.1	1.2	0.9

We can see from the table 1 that the maximum devotion of actual output torque and its pressure to the torque table is 2.7% and the maximum repeatability is 2.7%, were better than the target of 5% which was given by the tool. The uncertainty of hydraulic torque wrench calibration is better than 0.5 %(k=2).

4.2 Torque multiply calibration

The characteristic of torque multiply calibration is that we need input torque and output torque. A torque multiply has a Magnification, But with the tools to keep using its input and output torque ratio changes, so the need for periodic calibration, the input torque of the machine up to 1000Nm output Maximum torque 30000Nm. we select a torque multiply, Its theoretical maximum output torque is 8000Nm, by the calibration of nominal input torque, the maximum output torque is less than 7000N • m, the test results shown in Table 2. The uncertainty of torque multiply calibration is better than 0.5 %(k=2).

Table 2

Input torque (Nm)	Output torque (Nm)	Actual output (Nm) 1	2	3	Avery (Nm)	error (%)	repeatability (%)
40	538	513.5	510.3	507.3	510.4	-5.1	1.2
100	1320	1262.1	1260.1	1240.0	1254.1	-5.0	1.8
160	2181	2078.8	2113.7	2109.2	2100.6	-3.7	1.7
220	3147	2924.6	2930.9	2968.6	2941.4	-6.5	1.4
280	3921	3766.6	3639.7	3580.6	3662.3	-6.6	5.1

4.3 Reference torque machine performance test

The reference torque machine performance test using TT1 high accuracy torque transducer and a precision digital measuring instrument DMP40, load points covering the full range of the 1000Nm reference function from 100Nm to 1000Nm. Firstly we mount the TT1 transducer as the working status. Then pre-load three times, the first and second times directly added to the rated load, the third times a gradually imposed. After the preload is complete, apply the test load step by step. Three times on the original installation location, and then will be calibrated torque sensor around its axis followed by rotation to the initial position of 120 º, 240 º azimuth, each rotating step by step pre-load rating, Progressive Loading measurement. Torque Repeatability is calculated according to equation (1). We can see the results in Figure 5.

$$R = \frac{\sqrt{\frac{\sum_{j=1}^{n}\left(X_j - \overline{X}\right)^2}{n-1}}}{\overline{X}} \times 100\% \qquad (1)$$

Where: X_j is the measured value of the j on the original installation location, $\overline{X}$ is the average value of three times measurements on the original installation location; n is the measurements number of original installation location, n = 3.

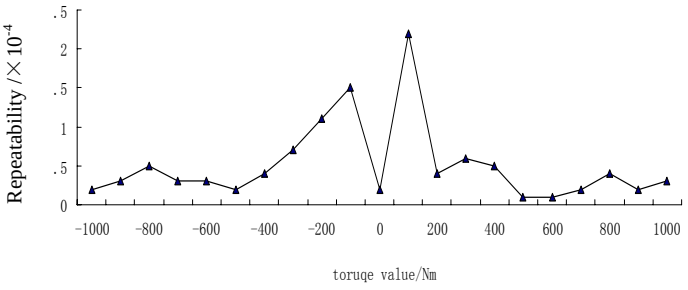


Fig.5. Repeatability of torque value

5. CONCLUSION AND OUTLOOK

30kNm torque standard machine using reference style has three main functions. Hydraulic torque wrench calibration, torque multiply calibration and torque transducer calibration. Through performance test prove the torque standard machine has well performance. The repeatability from 1000Nm to 30000Nm is better than 3×10^{-3}, the relative expanded uncertainty is better than 5×10^{-3} (k=2). The repeatability from 100Nm to 1000Nm is better than 2.2×10^{-4}, the relative expanded uncertainty is better than 5×10^{-4} (k=2).

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