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CALIBRATION OF REFERENCE TORQUE WRENCH AT NIM

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Abstract – The paper describes two kinds of reference torque wrench, which were developed by our institute, and introduce the calibration methods by different torque standard machine. The experiment between two kinds of reference torque wrench has been done. The result was discussed in the paper.

Keywords: reference torque wrench, calibration method, torque standard machine.

1. INTRODUCTION

Verification regulation of calibration instrument for torque wrenches of china issued in 2013. In this verification we propose to calibrate the calibration instrument for torque wrenches by using reference torque wrench. The reference torque wrench is defined as a high accuracy torque wrench. With the reference torque wrench we can calibrate the torque meter at location. And don't need to disassemble the torque transducer. So the reference torque wrench can evaluate the whole performance of torque meter. SI traceability system of torque wrench in China can be seen in Fig. 1.

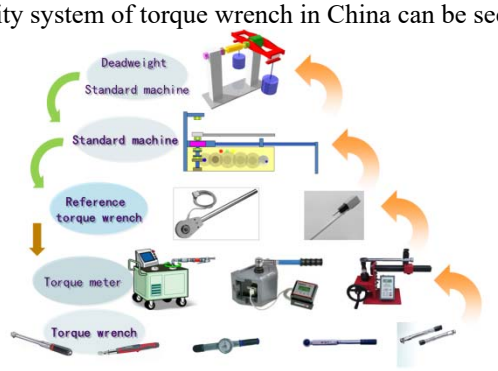

Fig. 1. SI traceability system of torque wrench

Table 1 shows the calibration ranges for reference torque wrench by using the torque standard machine.

Table 1. Different standard torque machine.

Torque standard machine	Reference torque wrench
4000Nm torque standard machine	10Nm~4000Nm, 1×10^{-3}
30kNm torque standard machine	10Nm~1000Nm, 1×10^{-3}
1000Nm torque standard machine	1Nm~1000Nm, 1×10^{-3}

2. TWO KINDS OF REFERENCE TORQUE WRENCH USING AT NIM

The researcher at NIM developed two kinds of reference torque wrench. Show in Figs. 2(a, b).

Fig. 2 (a). STW series reference torque wrench

(b). CNJ series reference torque wrench

These two kinds of reference torque wrench have good performance, consistent with the provisions of Verification regulation of china and DKD-3-7.

2.1. The performance of STW series

Main performance of the first kind of reference torque wrench is shown in Table 2.

Table 2. Main performance of STW series.

level	Technical indicators					
	Zr(%FS)	b(%)	bl(%)	b'(%)	Sb(%)	$\delta_{(\%)}$
0.1	±0.01	0.06	0.05	0.05	±0.1	±0.1

The symbols according to the verification regulation of reference torque wrench of china refer to the DKD-3-7 specification.

2.2. The performance of CNJ series

The performance of the second kind reference torque wrench is shown in Table 3.

Table 3. Main performance of CNJ series.

level	Technical indicators					
	Zr(%FS)	b(%)	bl(%)	b'(%)	Sb(%)	$\delta_{(\%)}$
0.1	±0.01	0.07	0.06	0.08	±0.1	±0.1

The Characteristic of these two kinds of torque wrench fits with the requirement of reference torque wrench.

3. CALIBRATION EQUIPMENT

In the development process of the reference type torque wrench, we have done a lot of experiments. One of the problems is how to scientific and accurate calibration reference torque wrench. Here introduce these experiments.

3.1. First experiment

The 4kNm equipment involves three standard torque transducers, which can be changed very convenient. The measuring range of standard is from 10Nm to 4kNm. And we can operate the equipment by computer or by hand. machineWith the worm and worm gear we can turn the transducer instead of move the wrench handle. Therefore we can get more stability measurement.

Here we calibrate the reference torque wrench by 4kNm standard torque equipment as Fig. 3 shows. With this equipment we can easily adjust the stress position.

Fig. 3. 4kNm standard torque machine

As fig 4 shows, we put a TB2 transducer between the reference torque wrench and standard torque transducer.

Fig. 4. 4kNm standard torque machine with TB2 torque transducer

Get the three sets of data at the same time. This is shown in Fig 5. First set of data is the data of reference torque wrench. The second set of data is the data of TB2. The third set of data is the data of 4kNm standard torque machine.

Fig. 5. Instrument display

3.2. Second experiment

We also built a deadweight experimental device especially for reference torque wrench calibration. With this device we can adjust the stress point of reference torque wrench by change the position of screw mechanism.

Fig. 6 shows a reference torque wrench was fixed on the device.

Fig. 6. by deadweight standard machine

3.3. Third experiment

In 2010 we had established a multifunction torque standard machine as fig 7 shows. 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）

Fig. 7. 30kNm standard torque machine

Here we use the third function, as the fig 8 shows. The reference torque wrench was fixed on the machine by a reaction force plate. The torque load will be added on the reference torque wrench when the torque transducer rotation.

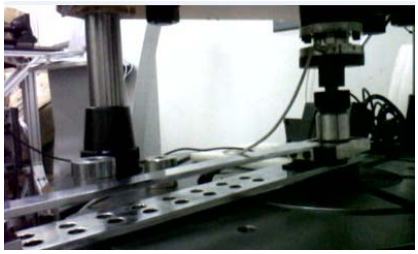

Fig. 8. Reference torque wrench fixed on 30kNm standard torque machine

4. CALIBRATION PROCEDURE AND RESULTS

Here we shose two reference torque wrenchs to do the calibration. First is STW-200Nm, the second is CNJ-300Nm.

4.1. Calibration condition and procedure

According with the DKD-3-7 and Verification regulation of standard torque wrench of china. the calibration procedure was shown in the Fig 9.

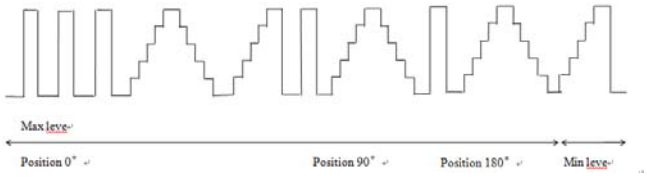

Fig. 9. Calibration procedure

4.2. Results of STW-200

Fig. 10 to fig 12 shows the calibration results of STW-200 by three standard torque machines.

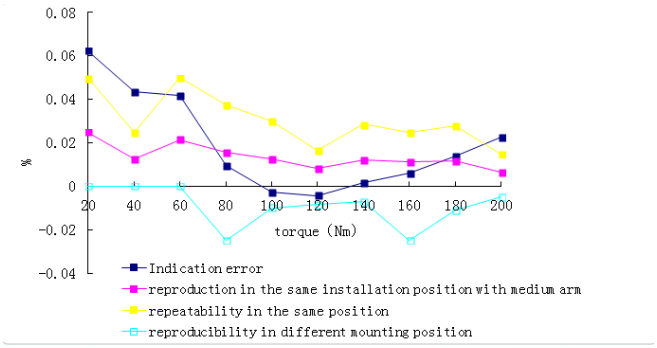

Fig. 10. Calibration results of STW-200 by 4kNm machine

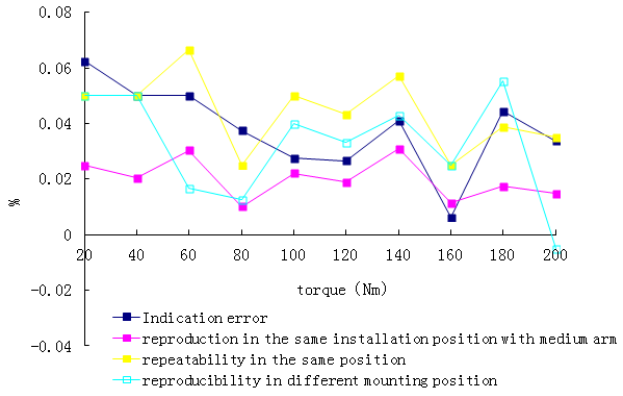

Fig. 11. Calibration results of STW-200 by 1000Nm machine

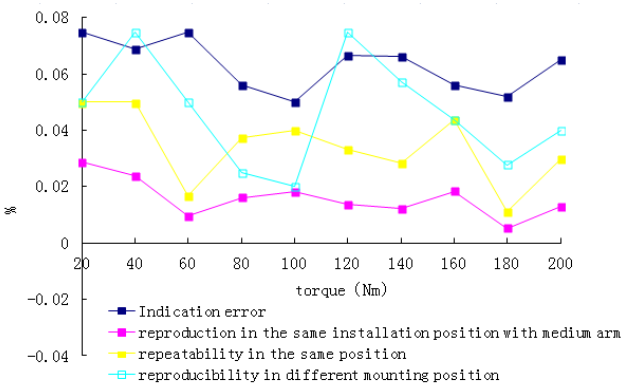

Fig. 12. Calibration results of STW-200 by 30kNm machine

4.3. Results of CNJ-300

Fig. 13 to fig 15shows the calibration results of STW-300 by three standard torque machines.

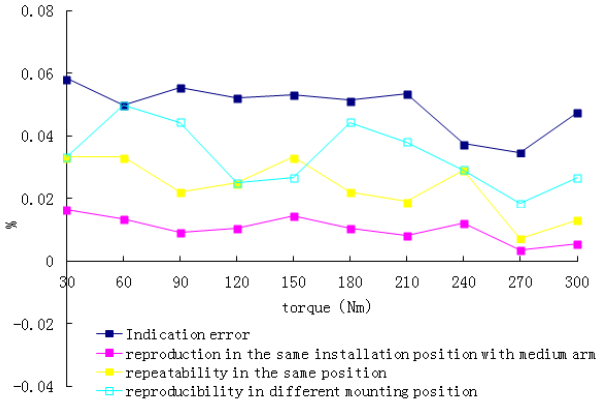

Fig. 13. Calibration results of CNJ-300 by 4kNm machine

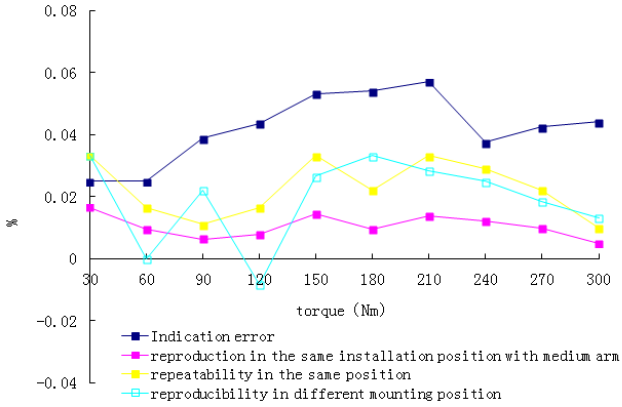

Fig. 14. Calibration results of CNJ-300 by 1000Nm machine

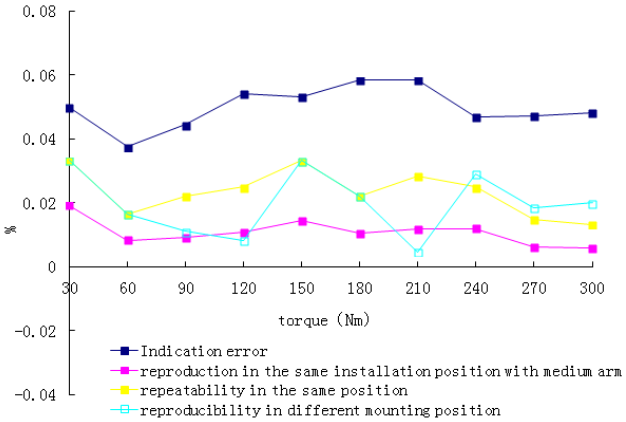

Fig. 15. Calibration results of CNJ-300 by 1000Nm machine

5. RELATIVE UNCERTAINTIES OF THE CALIBRATION RESULTS

The sources of uncertainty are list in the table 4. The main sources are u(b'), u(b), u(bl) ,and u(Ms) .
The distribution and function also list in the table 4.

Table 4 Standard uncertainty subscale

Sources of uncertainty	Distribution function	Relative standard uncertainty
Zero errorZ_r	Rectangular distribution	$u_0 = \frac{\left(\frac{Zr}{2}\right)}{\sqrt{3}}$
u(b') Span in the same installation position*b'*	Normal distribution	$u_{b'} = \frac{b'}{\sqrt{2}}$
u(b) Span in various Mounting positions b	Normal distribution	$u_b = \frac{b}{\sqrt{n}}$
u(b_l) Span at various lever arm bl	U Distribution	$u_{b_l} = \frac{\left(\frac{b_l}{2}\right)}{\sqrt{2}}$
u(r) resolution r	Rectangular distribution	$u_r = \frac{\left(\frac{r}{2}\right)}{\sqrt{3}} \cdot \frac{100}{\overline{X}}$
u(h) Hysteresis h	Rectangular distribution	$u_h = \frac{\left(\frac{h}{2}\right)}{\sqrt{3}}$

u(M_s) uncertainty of standard machine	Evenly distributed	$u_{M_s} = \frac{\delta_{M_s}}{\sqrt{3}}$

6. CONCLUSIONS

We can calibrate the reference torque wrench by the 4kNm standard torque equipment, 1000Nm deadweight standard machine and 30kNm standard torque machine. There are different effect between several methods.

The status of reference torque wrench and its actual use in a consistent state, when we calibrate the reference torque wrench by 4kNm standard machine. Therefore we recommend using this method. But now need to further improve the accuracy of 4kNm torque standard equipment in order to be more suitable for the calibration of the reference torque wrench. In the future we will build another torque standard machine for calibration of reference torque wrench. This machine will use an air bearing to support the standard torque transducer to reducing the influence of lateral forces.

REFERENCES

[1] Verification regulation of calibration instrument for torque wrenches of china.

.[2] Meng feng, Tanggefei, Zhangzhimin,4kNm Torque standard equipment. Proceedings of Asia-Pacific symposium on measurement of mass force torque and density (APMF2007) October 24-26, 2007, Sydney, Australia

[3] Meng Feng, Zhang Yue, Zhang Zhimin and Li Tao, "A new multifunction torque standard machine at nim", XX IMEKO World Congress Metrology for Green Growth September 9-14,2012, Bussan, Republic of Korea.

[4] Meng feng, Zhangzhimin, COMPARISON BETWEEN A REFERENCE TORQUE STANDARD MACHINE AND A DEADWEIGHT TORQUE STANDARD MACHINE TO BE USED IN TORQUE CALIBRATION, (APMF2013) ,November ,20-22, 2013, [C]. Taibei, China, APMP2013 ,

[5] Guideline DKD-R-3-7 static calibration by indicating torque wrenches