Calibration of reference torque wrench by new reference torque standard machine at nim

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Abstract. The paper describes the calibration of three kinds of reference torque wrenches by the new reference torque standard machine at NIM, which was finished at the end of 2017. The new reference torque standard machine is designed to calibrate the reference torque wrench and torque transducer. The relative expanded uncertainty of this torque standard from 10N•m to 5000N•m is better than 5×10^{-4} (k=2).

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

1. Introduction
Recently, with the development of manufacturing industry, the requirement of bolt assembly quality become more and more strictly. So, we propose the new method of calibrate the torque wrench calibrate instrument in the promulgation of national verification regulation of torque wrenches calibrate instrument. The requirements of calibration of reference torque wrench become more and more. For this demand, we specially designed and built a reference torque standard machine. The new reference torque standard machine was completed by the end of 2017. The relative expanded uncertainty of this torque standard from 10N•m to 5000N•m is better than 5×10^{-4} (k=2)

2. The reference torque standard machine

2.1. The main structure of 5000N•m reference torque standard machine
5000N•m reference torque standard machine is a kind of reference torque standard machine. Use vertical structure. The machine consists mainly of the vertical reference structure and the anti torque arm supporting structure. The vertical reference structure consists of four parts. The bottom of the structure is the loading mechanism, which is composed of a loading motor and a large speed ratio reducer. On the top of the loading mechanism is the standard torque transducer. In this part we can change the transducer convenient. The third part of this machine is the support part. Here we use an air bearing as a support. The upper part is a fixed end, including the lifting mechanism and the adapter. The anti torque arm supporting structure is designed for calibration of reference torque wrench, which is located at the middle part of the machine. The mechanical structure is shown in fig.1.
1. Loading motor 2. large speed ratio reducer 3. Standard torque transducer 4. Face tooth adopter 5. Air bearing 6. Frame 7. Standard torque transducer 8. Lifting mechanism 9. Reference torque wrench 10. reaction mechanism

Fig.1. Standard torque equipment

2.2. The performance of new machine

The repeatability experiments were carried out in the range of 10N·m-5000N·m. Three torque transducers with nominal capacities of 100N·m 1kN·m 5kN·m was used in the tests. The measurements for each torque transducer were done in clockwise and anti-clockwise sirection. Each measurement sequence includes three preloading and three increasing measurements at initial mounting position of torque transducer, one preloadingand one increasing measurement at each of other two rotational positions of torque transducers. The repeatability is calculated by formula (1).

$$R = \frac{\sum_{j=1}^{n}(X_j - \bar{X})^2}{n-1} \times 100\%$$

(1)

Where, n is the number of the increasing series at 0° position, $X_j$ and $\bar{X}$ are the deflection and average value of deflections with increasing test torque at 0° position respectively. The results of repeatability test are shown in Fig.2. The results indicate the repeatability of 5kN·m reference torque standard machine is better than $5 \times 10^{-4}$.

Fig.2. The results of repeatability test in 100N·m, 1kN·m, 5kN·m segment
3. Calibration procedure of reference torque wrench
According with the DKD-3-7 and Verification regulation of standard torque wrench of china. the calibration procedure was shown in Fig 3.

![Fig. 3. Calibration procedure](image)

Each measurement sequence includes three preloading and two increasing measurements at initial mounting position and the average lever load point of reference torque wrench (0°), one preloading and one increasing measurement at each of other two rotational positions and the average lever load point of reference torque wrench (90° and 180°), one increasing measurement at the last rotational position and the min lever load point of reference torque wrench (180°). We can refer to the table 1 to get the length of lever.

| Torque $M$ (N·m) | Min $l$ (mm) | Ave $l$ (mm) |
|------------------|-------------|--------------|
| 50-150           | 300         | 500          |
| 400-1000         | 600         | 1000         |

4. The reference torque wrench to be calibrated
After we finished our machine. We calibrate three kinds of reference torque wrenches by this machine. Table 2 shows the reference torque wrenches. Here we introduce the calibrate experiment of three types of reference torque wrenches.

![Fig. 4. reference torque wrenches](image)

| Reference Torque wrench | Range of wrench               |
|-------------------------|-------------------------------|
| STW-100(NIM)            | 10N·m$^\sim$100N·m (0.1×10^{-3}) |
| STW-1000(NIM)           | 100N·m$^\sim$1000N·m (0.1×10^{-3}) |
| DMTS-1000(GTM)          | 100N·m$^\sim$1000N·m (0.1×10^{-3}) |
| BNJ-1000(304)           | 100N·m$^\sim$1000N·m (0.1×10^{-3}) |

5. Calibration experiment and calibration results
Fig 5 shows the experiment picture of calibration of reference torque wrench. The process of experiment is strictly in accordance with the steps shown in Figure 3.

5.1. Calibration experiment of reference torque wrench
5.2. Calibration results

Fig 6 shows the Calibration results. The main parameters include indication error, repeatability, reproduction at average lever, reproduction at different load point.

The experiment results show the reference torque wrench have good performance. The main parameters are less than 0.1%. It can be used for calibration of torque wrench calibration instruments. The new standard machine loading stability, high accuracy.

6. Conclusions

In order to eliminate the influence of lateral force when calibrating the reference torque wrench, the new reference torque standard machine adopts the air bearing with low friction to reduce the friction to minimum, so the new machine has high performance. Suitable for calibrate the reference torque wrench. and also, can be used for calibration of torque transducer. The three kinds of reference torque wrenches mentioned in paper also have good performance.

7. Acknowledgments

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