Development of a Portable Intelligent Electric On-site Wrench Calibration Device

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Abstract. In large assembly workshop, such as automobile assembly workshop, the number of the wrenches is large. Some wrenches that used in fields are scattered. It is not convenient to send all such wrenches to laboratory for calibration at the same time, so it is necessary to develop a torque wrench calibration device which is suitable for on-site calibration. An intelligent indicator with MCU was developed, which can display and record the torque value, which is convenient for operators to record the data without paper and can check the data later. The intelligent indicator can also calculate the error at the same time, which improves the work efficiency by replacing manual calculation. A DS2401 chip was hidden in the transducer. It is cheap and has an unique sequence code, which is easy to identified by MCU. The MCU seeks the codes already stored in the indicator and matches linear correction coefficient to the transducer. It is first to use DS2401 chip to realize plug and play, which can avoid the measurement error even device damage caused forgetting switch the channel. The device also has an chargeable motor, which can save time and labor especially when mechanical gap exists and load a large torque value. The main characters of the device are auto-identifying transducer, powerful data handling similar to a compute and chargeable motor. All of these guarantee the device being intelligent and efficiency for the on-site wrench calibration.

Keywords: Intelligent; Portable; Wrench; Calibration device; On-site.

1. Introduction
Thread connection is the most widely used mechanical connection in engineering. In order to prevent the gap or displacement of the connections, the thread connection needs preload force. Torque wrench can feedback tightening torque in real time, and can apply more accurate tightening torque, widely used in engineering applications. The wrench can be divided into manual, pneumatic, electric and hydraulic type according to its power supply. From the display point of view, it can be divided into pointer and digital display. From the implementation effect, it can be divided into set-value warming and overload failure type. In order to ensure the reliability of the connection and ensure the accuracy of the torque value of the wrench, it is necessary to check the wrench regularly[1]. In the field such as car assembly workshop, the usage of torque wrench is very large, or some occasions such as weapons and equipment serving in open field, the distribution of working wrenches is relatively scattered. It is not convenient to send all those wrench to the laboratory for calibration. Therefore, it is necessary to carry out an on-site calibration. Generally, for the convenience of carrying, the computer is not concluded in the on-site calibration devices. The operator needs to record the number of the wrench and the calibration results of each wrench, and mark the unqualified wrench. The workload without computer is large and time consuming. The ranges for the wrench covers from a few N.m to a thousand N.m. If the operator forgets
to change the channel, it is easy to cause calibration data error, transducer overload, or even wrench
damage. Many on-site calibration equipment, data need to be manually recorded, so the work efficiency
is not high. Many on-site calibration equipment load torque manually, which are both strength
consuming and time consuming. Above all, it is necessary to develop a more intelligent and portable
on-site calibration device and provide a technical guarantee for improving the measurement accuracy of
the wrench.

2. Introduction of the On-site Wrench Calibration Device
The whole portable intelligent electric on-site torque wrench calibration device consists of torque
loading system, intelligent transducer and intelligent indicator, as shown in Figure 1. The combination
of automatic and manual loading improves work efficiency and saves efforts of operator. Intelligent
transducer adopts low cost DALLAS2401 semiconductor chip, which reduces production cost and can
realize automatic recognition function. The indicator with touch screen can realize the functions of
automatic peak collection, storage, calculation and query, which can replace the computer completely.

![Figure 1. Diagrammatic sketch for system compositio.](image)

3. Intelligent Transducer
Producers of data acquisition modules and transducers such as NI[2] and HBM have TEDS smart
transducers. TEDS is an intelligent transducer based on a IEEE 1451.4[3-6] standard that contains some
general information such as manufacturer, model and serial number. TEDS with IEEE 1451.4 standard
also contains the transducer-specific data sheet information typically including power requirements,
electrical output range, measurement range as well as calibration data. By this way, the transducer
information is written to the table, and then the information is read out by special software, so that the
transducer can realize instant plug and instant use. TEDS transducers have their own protocols and
matching indicators. The cost of purchasing or converting the existing transducers into TEDS smart
transducers is high. In this article, a DS2401 chip[7] is used to realize the function of TEDS smart
transducer. The DS 2401 semiconductor chip is engraved a 64 bit registration code (8 bit family code, 48
bit sequence code and 8 bit CRC check code),when it is produced in the factory. The 64 bit registration
code guarantees the chip can to be exclusive and the chip can be identified by its registration code. The
low cost TSOC surface mount package, easy to be installed in the sensor plug. The schematic diagram is
shown in Figure 2. The voltage analog signal of the transducer Wheatstone bridge is converted into the
digital signal through the CS5530 A/D converter. The MCU in the indicator will receive the digital
signal converted by CS5530 A/D and also read the 64 bit registration code at the same time. The MCU
controls the clock circuit, reset circuit, power circuit, serial communication module and storage module.
4. Intelligent Indicator

The intelligent Indicator contains two main functions. One is to identify the 64 bit registration code of the transducer automatically, then to apply the information such as calibration data to the transducer which has the registration code in accordance with the one which saved in the indicator when the transducer calibrated. The working process of the indicator in detail is explained as follows. Firstly, read the registration code. When the MCU in the indicator is powered on, the MCU will read the registration code at preset interval, and is stored in the register. The MCU will compare the registration code read at the current time interval and at the next time interval. If the registration code is same the MCU will discard the new one, if not, the MCU will store the new registration code in register. Secondly, build the relationship between the registration code and the parameters of the transducer. When the transducer that is not calibrated connected with the indicator. The MCU in the indicator will store the unique registration code of the transducer and its information such as linear correction coefficient, production date, number, range, unit and decimal point position in register after the transducer calibrated. By this way the relationship between the unique registration code of the transducer and its calibration information are built. If the transducer that has been calibrated is used again, the MCU reads its registration code and searches the registration codes saved in its register. Once finding the same one, the MCU will match the calibration information to the transducer. Finally, the MCU converts the output voltage of the transducer bridge into a digital signal through the amplifier circuit, the filter circuit and the A/D conversion circuit, and outputs the digital signal value. According to the calibration data the MCU calculates the torque value and display the measurement data on the touch screen.

The other main function of the intelligent indicator is calculation and data storage. Most indicators can only display the torque value and can not store the measurement data or calculate the error. The workload of on-site calibration is large, the operator calibrates the transducer at the same time records the data. All these work will done manually. The efficiency of the work is low and it is easy to make mistake. The intelligent indicator has the ability to record all the calibration data in a digital form as well as the number of each wrench. After recording, it will calculate the average value and the relative error of the indication value and the repeatability according to the calibration regulation. All those results are saved in the indicator and the operator can check the data and issue the certificates according to the calculation results. According to the type of the wrench, there are two recording methods. For the ordinary wrench, the operator will record the measurement data by clicking "save" button on the indicator after the torque is stable. For the clicking wrench, the torque of the wrench will unload while it reaches the pre-set value. To record clicking wrench, the indicator will record the value automatically. The schematic diagram are shown in Fig.3, which explains the process of the judgment and the recording.

The threshold value 1 represents the judgment condition on which the indicator will enter the peak mode, and the threshold value 2 represents the judgment condition for peak recording. When the torque value exceeds the threshold value 1, the indicator will automatically changes from tracking mode to peak mode. When the D-value of the peak value and the current torque value is greater than the threshold value of 2, the indicator will automatically collect the peak value into the table and then enter tracking mode. The setting of threshold 1 and 2 is calculated according to the range of intelligent transducer. In
the indicator, the threshold 1 is 5% of the full range of the transducer, and the threshold 2 is 2/3 of the full range value. The indicator corresponds the number of the wrench to the measurement data and error results, then save all the results in the register. The calculation results of total 500 wrenches can be stored in the indicator.

![Flowchart](image)

**Figure 3.** Schematic diagram for auto-recording.

At the query interface, the operator can see through all the calibration results or entering the number of the wrench, the operator can seek the calibration information of the wrench in all the results. Moreover, all the calculation results are stored in CSV format, the operator can download the data in flash disk, and the data can be opened with Excel software on the computer. This function is convenient for the operator to record the calibration data without record by paper and pen. All the calculation results can be copied out in the future according to the need and can be used in issuing the certificate.

### 5. Electric Torque Loading Device

Since the on-site device need to easy carry, a foldable type is designed so that it is suitable for movement. The support arm of the device can fold, which is circled in the Fig.4. The standard torque transducer can directly insert into the connection hole and can be fixed and removed without any tools. The range of the device is from 2N.m to 1000N.m, according to the transducers. The intelligent indicator is connected to the device by an elastic part, which is convenient to adjust the angle as shown in Fig.4. Taking into account of the power supply problem on site, most of the device load torque by manual. In fact, to eliminate the mechanical gap and load large range torque are both time and labor consuming. In this device, a rechargeable powder is used to realize the electric loading, which can improve the work efficiency. At the same time hand-wheel is remained, when the range of wrenches below 500N.m are calibrated.
6. Test Results
The ranges of the wrench for calibration are 5N.m and 1000 N.m. The calibration results are shown in Table 1 and Table 2. The results show that the relative error for the device can reach 0.2%, which can calibrate all the working wrench.

7. Conclusion
A new kind of on-site intelligent wrench calibration device is introduced, which consists of intelligent transducer, powerful indicator and electric loading system with rechargeable power. Using DS2401 chip with unique registration code to realize plug and play, which can avoid manual operating error. The intelligent indicator has the function such as calculating error, auto-recording calibration data which is for preset value wrench, storing 500 wrenches calibration information for issuing certificates later. Electric loading system helps operator load torque quickly, which save time and labor.

### Table 1. The calibration results for 1000N.m wrench.

| calibration point(N.m) | Test results of 1000N.m wrench | relative error (%) | repeatability (%) |
|------------------------|-------------------------------|-------------------|-------------------|
|                        | 1 | 2 | 3 | aver |                       |                   |
| 0.0                    | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 200.0                  | 200.32 | 200.34 | 200.29 | 200.32 | 0.16 | 0.02 |
| 400.0                  | 400.61 | 400.61 | 400.67 | 400.63 | 0.16 | 0.01 |
| 600.0                  | 600.87 | 600.93 | 600.87 | 600.89 | 0.15 | 0.01 |
| 800.0                  | 801.21 | 801.27 | 801.22 | 801.23 | 0.15 | 0.01 |
| 1000.0                 | 1001.26 | 1001.44 | 1001.40 | 1001.37 | 0.14 | 0.02 |

### Table 2. The calibration results for 5N.m wrench.

| calibration point(N.m) | Test results of 5N.m wrench | relative error | repeatability (%) |
|------------------------|----------------------------|----------------|-------------------|
|                        | 1 | 2 | 3 | aver |                       |                   |
| 0.0                    | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.0000                 | 1.0025 | 1.0026 | 1.0023 | 1.0025 | 0.25 | 0.3 |
| 2.0000                 | 2.0046 | 2.0045 | 2.0048 | 2.0046 | 0.23 | 0.1 |
| 3.0000                 | 3.0066 | 3.0074 | 3.0072 | 3.0071 | 0.24 | 0.3 |
| 4.0000                 | 4.0095 | 4.0097 | 4.0092 | 4.0095 | 0.23 | 0.1 |
| 5.0000                 | 5.0120 | 5.0118 | 5.0116 | 5.0118 | 0.24 | 0.08 |

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