XXI IMEKO World Congress "Measurement in Research and Industry"
August 30 – September 4, 2015, Prague, Czech Republic

DESIGN OF 20 kN·m TORQUE STANDARD MACHINE AT NIM

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Abstract – A 20 kN•m torque standard machine has been designed and developed at National Institute of Metrology (NIM) since 2012. The torque standard machine adopts the lever-deadweight type, the air bearing with low friction is adopted to support the arm lever at the fulcrum, the invar alloy with the low expansion coefficient is used as the material of the arm lever, the weight suspension part and weight loading system are specially designed to ensure the force generated by the weights is applied accurately and reliably. 20 kN•m torque standard machine is capable of realizing the torque from 100 N•m to 24 kN•m both in clockwise and anti-clockwise direction. This paper introduces the mechanical structures and the electrical control system of the machine.

Keywords: Torque standard machine, air bearing, arm lever, weight loading system.

1. INTRODUCTION

Torque measurement is widely used in automobile, aerospace, shipping and wind power industry. In recent year with the development of the wind power and shipbuilding, there is a growing demand for the large torque measurement. The establishment of large torque standard machine may provide reliable technical support for various industries. As the national metrology institute, NIM is responsible for establishing and maintaining national torque standards, ensuring accuracy and consistency of torque dissemination and providing calibration services for customers in various sectors of industry. In the past years 5 sets of torque standard machine have been established at NIM, including 50 N•m, 1 kN•m, 5 kN•m torque standard machines with the knife-edge support and 1N•m, 100 N•m torque standard machine with the air bearing support, these torque standard machines are capable of realizing the torque in the range of 1 mN•m-5 kN•m. In order to meet the requirement of large torque measurements, a 20 kN•m torque standard machine has been developed at NIM since 2012, the range of the torque machine is from 100 N•m to 24 kN•m. The machine will be accomplished in the end of 2016.

2. THE MECHANICAL STRUCTURE OF 20 kN·m TORQUE STANDARD MACHINE

20 kN•m torque standard machine adopts the lever-deadweight type. The machine consists mainly of air bearing, arm lever part, weight suspension part, weights loading system, transducer couplings, counter bearing part and pedestal part. The mechanical structure of 20 kN•m torque machine is shown in Fig.1.

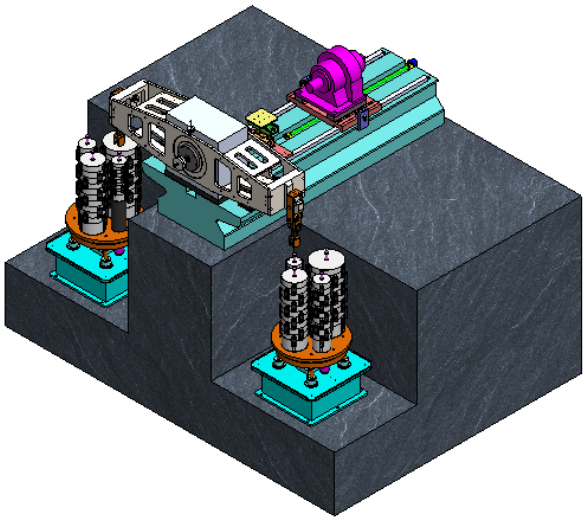

Fig.1 Mechanical construction of 20 kN•m torque machine

2.1 Air bearing

The H-type air bearing is adopted as the arm lever support to minimize the friction at the fulcrum. The work pressure range of compressed air supplied to the air bearing is 4-6 bar. The mist separator with membrane air dryer and fine filters are used to eliminate the dust and moisture from the compressed air. The radial load capacity is 60 kN, the axial load capacity is 15 kN, the horizontal bending moment capacity is 3400 Nm. The residual friction of air bearing is 60 μN•m.

For the air bearing used as the arm lever support at the fulcrum in the large deadweight torque standard machine, the loading capacities for the radial, axial and horizontal bending moment are important technical parameters, It directly affects whether the air bearing can work properly. In order to verify the carrying capacity of the air bearing, a set of test device is designed and made which may apply the radial load, axial load, horizontal bending moment to the air bearing and check the work status of the air bearing. The schematic diagram of the test device is shown in Fig.2 (a,b,c), among them, a is for the radial load capacity test, b is for the axial load capacity, c is for the horizontal bending moment capacity test.

a b c

Fig.2 Test device for the radial load capacity, axial load capacity and horizontal bending moment capacity test

2.2 Arm lever part

The arm lever system adopts the multi-components frame structure. The nominal length of the arm lever is 1600 mm. The invar alloy with the low thermal expansion coefficient is used as the materials of the arm lever in order to reduce the uncertainty caused by length change of arm lever due to the temperature variation. The weight loss holes are designed to reduce the weight of arm lever. The mass center of arm lever may be adjusted by regulating the counterweights in arm lever. The laser displacement sensor is used to measure the position of arm lever, and the arm lever is adjusted to the initial horizontal position by controlling the counter bearing drive. Overload protection part is used to control the swing amplitude of the arm lever and to ensure the arm lever in the normal work status.

The weight suspension assembly is designed to keep the force applied by weights vertically downward and be free from the parasitic force. The force generated by the weights is applied on the arm lever by a side knife-edge suspension component which has good reliability and stability, the manufacturing materials of side knife and edge adopts special powder metallurgy high-speed steel AH10, quenching hardness is HRC67~69. The side knife and edge are processed by mirror grinding technology. The structure of the arm lever is shown in Fig.3.

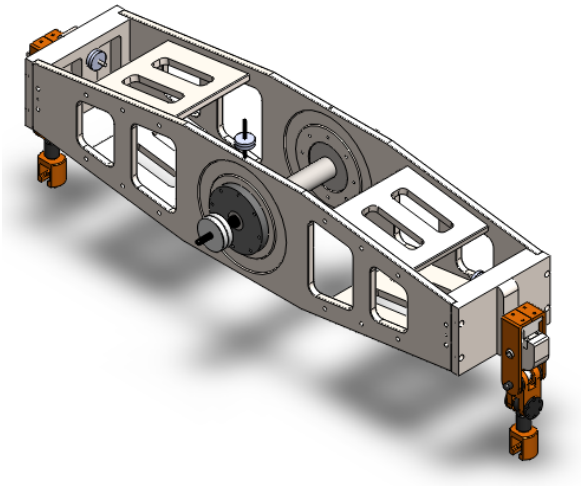

Fig.3 Structure of arm lever part

2.3 Weight loading system

The machine has two sets of weights which are at two sides of arm lever and may generate clockwise and anticlockwise torque separately, each set of weights consists of five groups weights, the composition of weight series is as follows:

(1) 62.5N×12 ×2
(2) 125N×12×2
(3) 312.5N×12×2
(4) 625N×12×2
(5) 1250N×12 ×2

The groups of weights are placed on the turntable. The weights of each group are connected in series by 3 external hooks with tapered guide positioning pins. The weights can be loaded by weight loading lifter. The different groups of weights may be selected by rotating the turntable. Automatic turntable reversing accuracy does not exceed ± 0.05mm. Each group of weights at left side and right side may generate torque separately or combined to generate the torque in the different range. Fig.4 shows the Configuration of the weights loading system

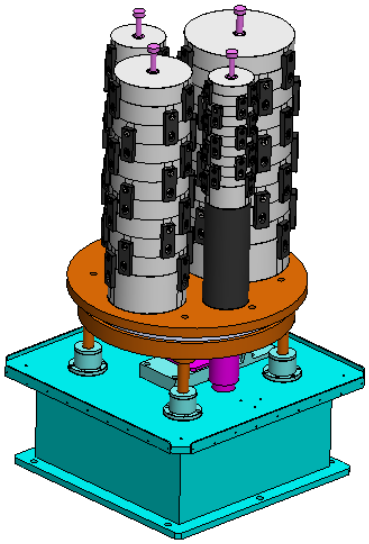

Fig.4 Configuration of the weights loading system

2.4 Connection part of torque transducer

The drive shaft of torque machine adopts keyless round shaft, which connects with torque transducer by the flexible couplings and hydraulic clamps. Using a pair of flexible couplings can compensate effectively twist angle, axial and radial offset caused by the weights of torque transducer and couplings.

3. ELECTRIC CONTROL SYSTEM

The industry control computer is used as the controller to realize the centralized control and management of the machine. Programmable controller (PLC) is adopted to control the motions of the execution components, the work statuses of the components are real-time displayed on the screen of computer. The position of the arm lever is measured by the laser displacement sensors and adjusted accurately by controlling the counter bearing drive, so that the arm lever may be kept in the initial horizontal position after torque applied. The measuring amplifier which is used to measure

the output of the torque transducer is communicated with the computer via the serial interface. By designing the complex program, the machine realizes the full automatic control. The block diagram of electrical control is shown in Fig.5.

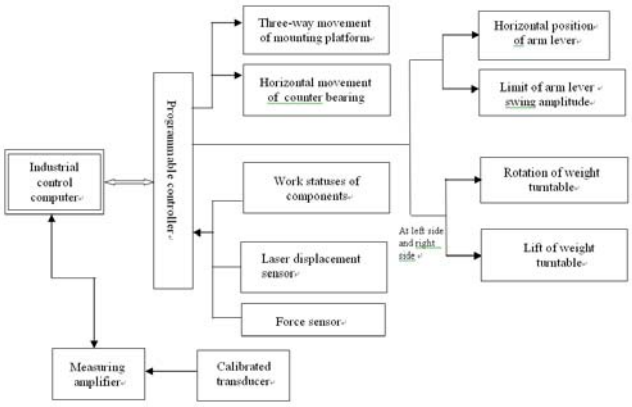

Fig.5 The block diagram of electrical control

4. CONCLUSION AND FURTHER WORK

20 kN•m torque standard machine has been developed at NIM since 2012. The design of mechanical construction and electrical control system have been finished, the mechanical components have been put into manufacture. 20 kN•m torque machine has the following main features: The air bearing with low friction is adopted to minimize the friction at the fulcrum; the invar alloy with low thermal expansion coefficient is used to reduce the uncertainty caused by the arm lever length change due to temperature variation; the weight loading system which includes five groups of weights may realize no weights exchanges while calibrating different range of transducers, therefore avoid reverse process during loading. The torque machine is capable of generating clockwise and anticlockwise torque in range of 100 N•m-24 kN•m. The project of establishment of 20 kN•m torque standard machine will be finished in 2016.

ACKNOWLEDGMENTS

The project of "The research and development of 20 kNm torque standard machine" is supported by the Ministry of Science and Technology, China, the project No.:2012YQ090208.

REFERENCES

[1] D. Röske, "Investigation of the influence of disturbing components on the torque measurement", 16th IMEKO TC3 conf., pp. 280-285, Taejon, Korea, 1998.

[1] Zhang Zhimin, Zhang Yue and etc., "The development of 100 Nm torque standard machine at NIM", XIX IMEKO World Congress, Lisbon, Portugal, 2009