DEVELOPMENT OF THE 1 kN·m STATIC TORQUE STANDARD MACHINE AT UME

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Abstract: *In the last decade, the increase in the need for the accuracy of the torque metrology created an obligation to produce a new torque standard machine for precise measurement of torque. This paper summarizes the torque standard machine designed and manufactured at UME with the range from 2 Nm up to 1 kNm. In this machine torque is realized by a lever-mass system. Nominal force arm length of the lever is 0.5 m and constant. In each side of the lever, there are 6 different weight sets; and each set is containing 13 individual mass-stacks. For minimizing the torque loss at fulcrum an aerostatic bearing is used, and the change in the lever position due to the dead weights loading is corrected.*

Keywords: *Torque Standard, Torque Measurement, Dead Weight*

1. INTRODUCTION

Due to the increased demand to the traceable calibrations of torque measuring devices in industrial applications as well as in institutions, UME (National Metrology Institute of Turkey) has decided to establish a laboratory under the heading of Force Measurements Laboratory. Calibration range was chosen to be from 0.1 Nm up to 25 kNm. In order to be able to cover this range we decided to design three torque standard machines; one set-up for lower range between 0.1 Nm and 20 Nm, the second one with range from 2 Nm to 1 kNm and the third machine to have a range from 2 kNm up to 25 kNm [1,2,3]. Torque standard machine with a rated capacity of 1 kN·m was decided to be initially designed and manufactured by means of UME.

This report summarizes relevant details of the first torque standard machine with a rated capacity of 1 kNm designed and manufactured in UME.

2. MAIN COMPONENTS OF THE MACHINE

The machine realizes the torque by a lever-mass system and the measurement axis is horizontal. The force is generated on a two-arm lever either for right-hand or left-hand torques by masses under the effect of local gravitational acceleration. The schematic view of the machine is given in Figure 1.

The main components are basically explained below;

2.1. Main Frame

The main frame of the machine is a body of a universal lathe. All the parts and auxiliaries are mounted on that body by bolted arrangements. Bolted connections principally give possibility to align any axis in the machine.

2.2. Air Bearing As Fulcrum

In order to be able minimize torque loss at fulcrum, an aerostatic bearing unit is used. Operational air pressure of the bearing is about 500 kPa. Axial and radial run out of the bearing is less than 2 μm and its frictional moment is expected to be less than 20 μNm and it will be investigated further.

2.3. Lever

The lever is composed of two symmetric force arm length in order to apply a right-hand and left-hand torque. Total length of the lever is 1100 mm, and nominal force arm length is 500 mm. A 3D coordinate machine (CMM), which is traceable to national standards of length, was used for the measurement of initial force arm lengths under the environmental temperature of 20 °C. Results of initial force arm lengths are 500.0580 mm for left hand torques and 500.0615 mm for right hand torques. The uncertainty of measurement is better then ±1 μm.

Lever was initially made of austenitic steel in order to be able to investigate effect of change in temperature in the laboratory within a band of 0.2 K/hour. After that it will be replaced by new ones made of Invar alloy.
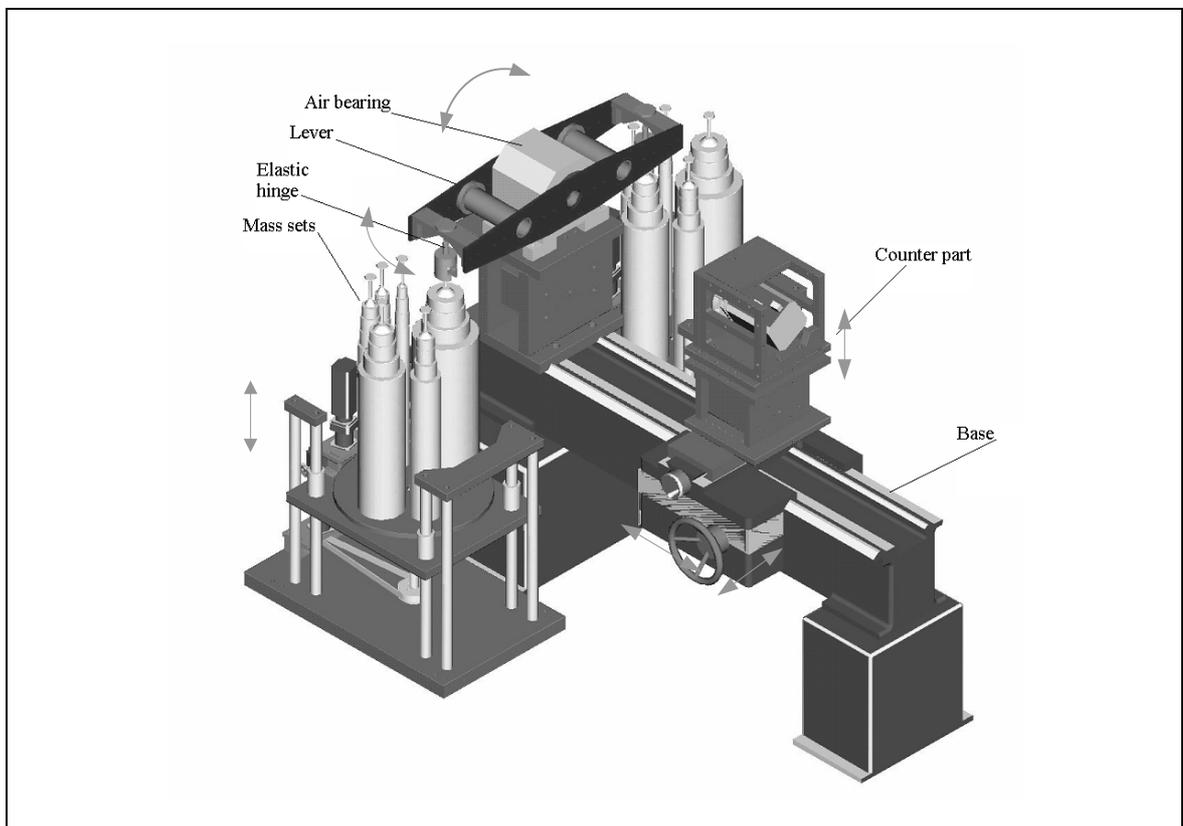

Figure 1. Schematic view of the 1 kN m Torque Standard Machine

2.4. Suspension Mechanism of Weights

At each end of the lever, a strain controlled elastic hinge is used instead of metal bands [4]. By using this elastic hinges, fastening problem of metal band is overcome [5]. Bending moment occurred due to applied load is measured by elastic hinges and signal taken from elastic hinges are also used for the position of lever.

2.5. Weight Sets and Tray

Force is generated by disk shaped stainless steel mass stacks (deadweight), which are positioned at each side of the lever for right and left hand torque values. There are 6 different weight sets at each side of the lever. Each mass set is chain type

and consists of 13 masses. Details of each set are given in the table 1. All the weights are traceable to the national mass standards and relative uncertainty is better then 3 ppm. For the first five sets of weights, it is possible to generate torque values with the steps of % 2, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110 of the capacity. For the last set of weight, torque values can be generated with the steps of % 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130.

Table 1: Weight sets of the torque standard machine

1. Set for 1000 Nm:	40N x 1,	60 N x 1,	100 N x 1,	200 N x 10
2. Set for 500 Nm:	20 N x 1,	30 N x 1,	50 N x 1,	100 N x 10
3. Set for 200 Nm:	8 N x 1,	12 N x 1,	30 N x 1,	50 N x 10,
4. Set for 100 Nm:	4 N x 1,	6 N x 1,	10 N x 1,	20 N x 10
5. Set for 50 Nm:	2 N x 1,	3 N x 1,	5 N x 1,	10 N x 10
6. Set for 20 Nm:				2 N X 13

2.6. Parts for Counter Torque Application

As counter torque application part of the machine, a servomotor and a harmonic drive (as a gear box) was used. By the use of it, it will be possible to control horizontal position of the lever within ± 2".

2.7. Parts for Transducer Coupling

Coupling arrangement for installation of torque transducer to the machine has a large influence on the uncertainty of the calibration [6]. Torque transducers having a variety of size and shape can be installed on the torque standard machine by using different type of couplings. It is possible to mount a torque transducer to the machine with the radius of 500 and length of 1000 mm

2.8. Operational System

There is an IBM compatible computer and a user interface software which is also developed by the staff of UME. The software allows the operator to select all the relevant variables such as transducer capacity, direction of rotation, amplifier options, load steps, etc, and then calibration sequence can be prepared and stored on the HDD. The software has option to make either fully automated calibration or a manual operation of the machine. But, in any case the operational system keeps the safety conditions of both the machine and the transducer by a suitable PLC unit and certain switches.

3. CONCLUSION

As a beginning step of torque metrology in TURKEY, this torque standard machine was developed for dissemination of torque standards from 2 Nm to 1000 Nm. Expected relative uncertainty of the machine is better than 1×10^{-4}. Mechanical productions were completed and the machine was assembled and erected in the laboratory. Now the functional tests are being performed. After that, relevant studies will be completed in order to be able to evaluate the best measurement capability of the machine.

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