

## A NEW CALIBRATION DEVICE FOR SILK SCREEN TENSION METER

*Hu Xiaoyin, Yu Yueling, YuPeiying, and KangZhangy*

Shanghai Institute of Measurement And Testing Technology(SIMT), Shanghai, China,  
Large Force Building 205, ZhangHeng Road 1500

**Abstract:**In this paper, a calibration device for silk screen tension meter is designed. The device has a measurement range from 5 to 100N/cm. It can achieve simultaneous loading in x and y directions by servo motors. For loading accuracy, two high precision force sensors are utilized in the closed-loop control system for each direction. To verify the device, it is utilized to calibrate a commercial available silk screen tension meter. The results from the device are compared with that from the Swiss Federal Office of Metrology. It demonstrates that the max error is 0.5 %.

**Keywords:** silk screen tension meter; calibration device; force; Din 16611-1990

### 1. INTRODUCTION

Silk screen tension meter (see Fig. 1) is widely applied in textile, electronics, silk screen printing industry to measure tension magnitude, a key factor that affects the quality of products [1-3]. In China, there is no calibration device dedicated to the calibration of tension meter so far. There are few possibilities for calibration on the market especially not in China. With its really big market for silk products, there is an economic reason to make these developments.

In this paper, a new calibration device for the silk screen tension meter is proposed. For the absence of corresponding standard in China, the device is designed according to German standard DIN 16611-1990 [4]. The performance of the device is verified through experiments. The results demonstrate that the device satisfies the requirements of DIN 16611-1990.



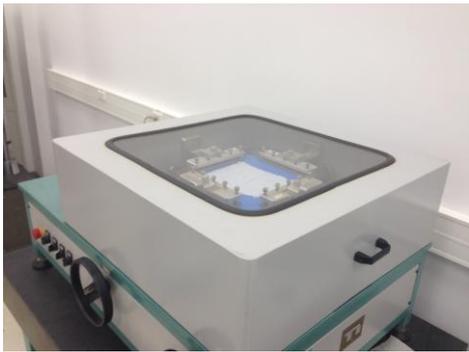
Fig. 1 Silk screen tension meter

### 2. STRUCTURE AND WORKING PRINCIPLE OF THE DEVICE

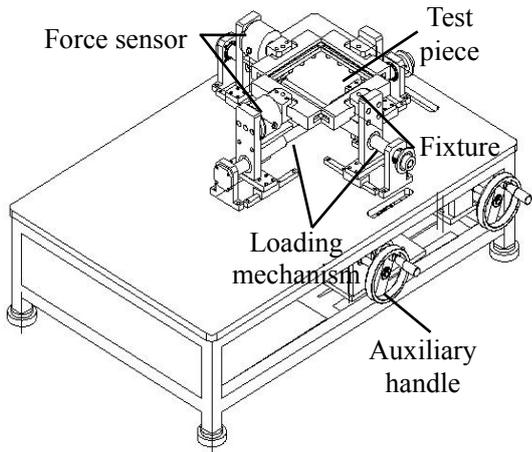
The schematic diagram and the picture of the calibration device is depicted in Fig. 2. It is composed of fixture, loading mechanism, force sensor, test piece and auxiliary handle. The test piece is fixed on four fixtures, two in x direction and the other two in y direction as shown in Fig.3. The test piece is made by polyester mesh fabric according to DIN 16611-1990. Fixtures in one direction are installed on a screw rod, which has opposite direction threads at both ends. The screw rod is mounted between two fixed ends, one end of which is connected with a servo motor. To control the force magnitude, a high precision force sensor is placed between the fixture and fixed end as illustrated in Fig. 4. The performance of sensor is listed as in Table. 1.

The working principle of the device is described as follows. The device can achieve simultaneous loading of x and y direction, depicted in Fig. 5. Due to the same principle of two directions, illustration is just for the sole one. When actuated by the servo motor, the screw rod

rotates and the fixtures move. For the reverse directions of thread on the rod, the fixtures move simultaneously toward reverse x directions (see Fig. 4). The distance  $L$  enlarges and the test piece is loaded. The force loading is controlled by a closed-loop system. As the test piece is stretched by fixtures, the force loading is measured by the force sensor. The signal is transmitted to the control system and computer. Through the control system and software based on Labview, the force magnitude can be adjusted to the set value.



(a) Picture of the device



(b) Structure of the device

Fig. 2 The designed calibration device

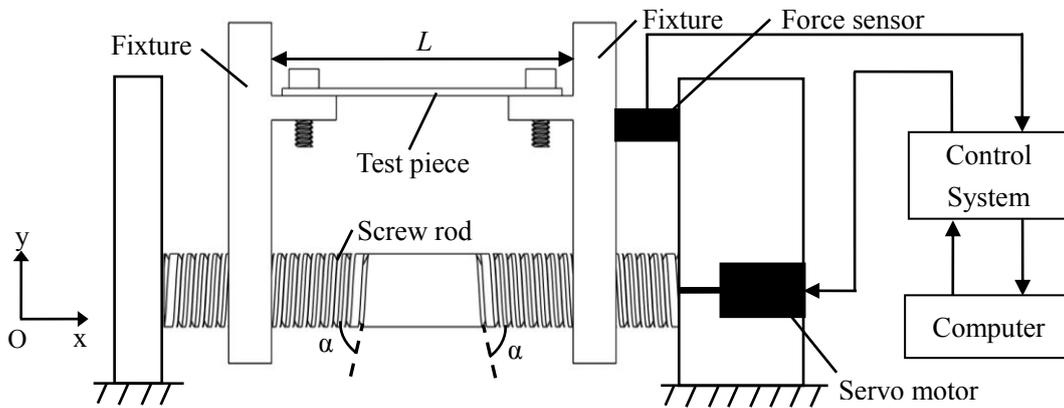


Fig.4 Loading system

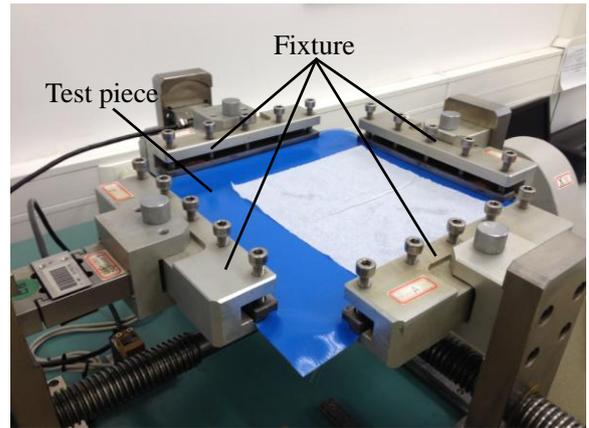


Fig.3 Picture of the fixture with test piece

Table. 1 The performance of the force sensor

Model	Rated capacity	Precision	Nonlinearity
S40-2kN	(0.1-2)kN	$\pm 0.05\%$	Within $\pm 1\%$

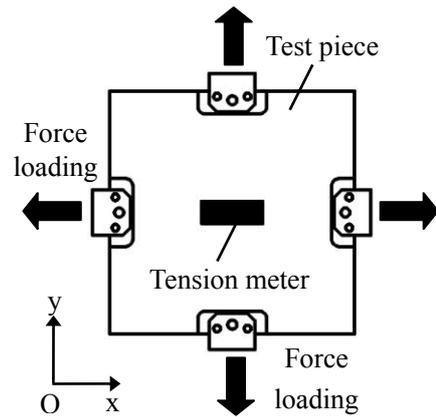


Fig. 5 Loading in x and y directions

To prove the performance of the loading system, a experiment is carried out. The test piece is loaded simultaneously in x and y direction for a same value. The pre-set values of force are 7N, 10N, 20N, 30N, 40N and 50N. The force loading maintains for 60 seconds at each value. The results are shown in Fig. 6. It can be concluded that the system can realize the same force loading in two directions and maintain for a while. The max error between set values and real loading is 0.1 %.

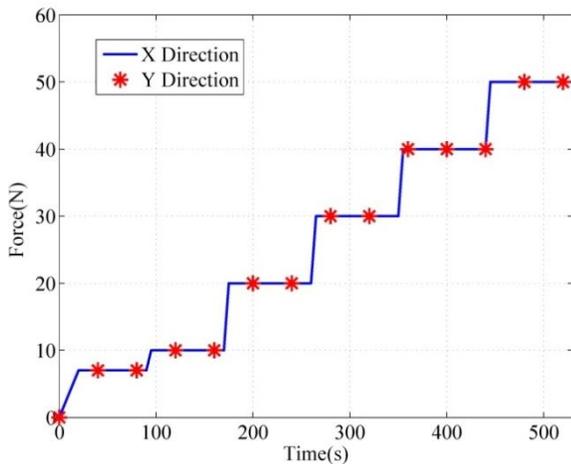


Fig. 6 Force loading in x and y direction

### 3. DEVICE VERIFICATION

Calibration of the designed device includes two steps: test of force sensors and uncertainty calculation.

Two force sensors are tested according to Chinese Verification regulation JJG455-2000 and JJG 391-2009 [5-6] by force standard machine whose precision is 0.01 %. Results show that the force sensors has the precision of 0.1 %.

The source of uncertainty includes: force sensor, resolution and precision of control system, environment temperature variation, unlevelness and repeatability.

Table. 3 Summary of standard uncertainty

Origins of uncertainty	Value
precision of force sensor	0.01 %
resolution of control system	0.15 %
precision of control system	0.15 %
environment temperature variation	0.05 %
unlevelness	0.06 %
repeatability	0.08 %

With the combination of test results of force sensors and calculation of uncertainty as listed in Table 3, the designed device has the precision of 1 %.

To verify the measurement precision of the designed calibration device, a commercial available silk screen tension meter (TETKOMAT-N50, see Fig.1) is applied, as shown in Fig. 7. The performace of the tension meter is shown in Table. 2. It is calibrated by the SFOM(Swiss Federal Office of Metrology) according to Din 16611 before purchase. Our calibration results from the designed device are compared with that of SFOM.



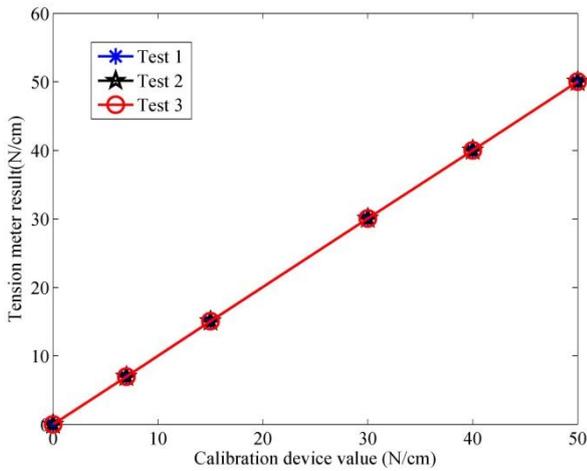
Fig. 7 Tension meter calibration using designed calibration device

Table. 2 The performance of the tension meter

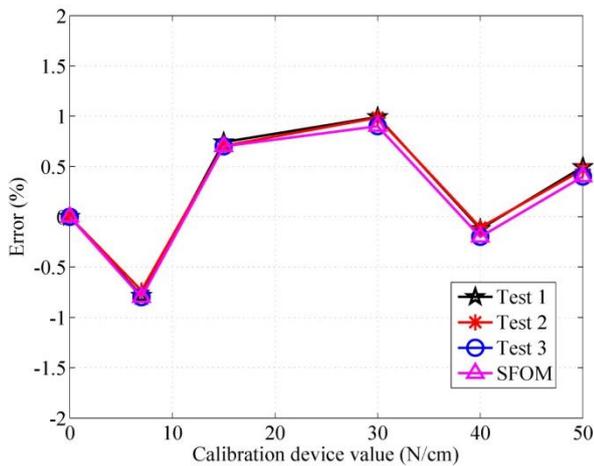
Model	Measurement Range	Weight	Precision
TETEKOMAT-N50	(7-50)N/cm	500g	±5 %FS

Before the test, the tension meter is set to zero. The tension meter is placed on a smooth marble, and it has a read on the dial. Through adjust the dial, the value of the pre-tension can be clean. As illustrated in Fig. 5, then, the tension meter is placed at the center of the test piece. The loading procedure is divided into five steps: 7, 15, 30, 40, 50N/cm. For each step, when the readings on computer monitor and tension meter keep stable, measured results are recorded. Moreover, to get reliable measurement results, the whole test procedure is carried out for three times. The results for the tests are plotted in Fig. 8(a) which prove the good repeatability of the calibration device. Fig. 8(b) is the error analysis of the calibration results. It demonstrates that the

results from the designed calibration device agree well with that from SFOM. Take the SFOM data as the benchmark, the max error of the designed device is 0.5 %.



(a) Comparison of tension meter and calibration device



(b) Error analysis of test results

Fig. 8 Results of the test

#### 4. CONCLUSION

In this paper, a calibration device for silk screen tension meter is designed and its performance is verified. The structure and working principle of the device are described in detail firstly. Then, the loading precision of the device is tested experimentally. Results show that the max error between set values and real loading is 0.1 %. Finally, the measurement precision of the device is verified by calibrating a silk screen tension meter. The calibration data is compared with that from SFOM. The results show that the max error of designed device is 0.5 %. To fill in the

corresponding blanks of standards in China, based on the development of calibration device proposed in this paper, the standards in China about the calibration of silk screen tension meter is under writing by SIMT and several other Chinese institutes.

#### 5. REFERENCES

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