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New reference force transducer for compressive forces based on the radially symmetric shear-beam principle

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Summary:

Shear beam type force sensors are very common in the world of experimental mechanics, testing machines and in advanced production lines. High stiffness, high output signal and good robustness are the proven advantages of this technology. The principle has been increasingly used for reference sensors in the last years. A new sensor design shows an even higher accuracy for compressive forces.

Keywords: Force transducer, force reference standards, force calibration, radial symmetric force trassnducer

Introduction

Radial symmetric shear type sensors are available with capacities from 1.25 kN to 5 MN. A spring body of such a sensor is shown in figure 1. The force is introduced in a central thread in the middle of the transducer, the outer flange allows the connection to the components below of the sensor.

Strain gauges are placed on the bars in a way so that they measure the strain under 45 degrees to the sensor axis. Those strains are shear strains- this is also the reason for the naming of the sensors. [1]

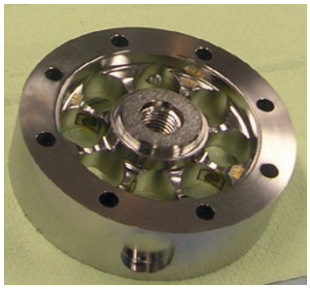

Fig.1: A spring body of a radially symmetric shear-force transducer. The strain gauges are glued on the bars in a way that there is always one strain gauge picking up the negative strain and another one picking up the positive strain. The Wheatstone bridge circuit compensates the temperature influence on every single bar so that the sensor has an excellent behavior under temperature gradients.

The sensors are available with and without a load base, shown in figure 2. As the mounting of the sensor to its load base is of high importance for the many of the sensor characteristics, in the world of reference force transducers all sensors are coming along with a mounted load base.

Fig.2: Radial symmetric shear types without (left) and with (right) load base: Picture: HBM

Radial symmetric shear type load cells are available with Chrome – Nickel strain gauges which offer a higher sensitivity [2] and a design with a constant strain field. Because of both facts the output signal is 4 mV/V and more at full load. This is twice the value of other mechanical principles for reference force transducers.

The hysteresis is the limiting point with the shear type load cells. The reason is given by the mechanical characteristic of the bolting between sensor and load base. In case of tensile forces, the stresses between the load base and the sensors decreasing at this point so that

very little movements are possible. Those movements lead to changes in the stress state of the sensor and therefore finally to differences between increasing and decreasing loads [1]- monolithic sensors have a clear advantage with tis characteristic.

The hysteresis effect is not of importance for compressive forces as those loads increase the stresses between sensor and load base. Therefore, the new design is for compressive forces only.

New design for compressive force (Type designation: C15)

Hysteresis effects

A higher torque is applied to the bolts that connect the load cell to the base. (Fig. 3). Therefore, the contact of both parts is better than with tension/compression force transducers with a similar design. This makes the connection more stable and optimized the hysteresis characteristics of the transducer.

Repeatability

The load bases for radial shear types for experimental tasks are massive- for highest stiffness and easy mounting. The disadvantage is that those load bases introduce bending moments in the sensor so that the repeatability in different mounting positions is not on the level of a high-end sensor. A new load base has been designed in order to provide a good stiffness in the direction of the load, but less stiffness for bending moments. (Figure 3)

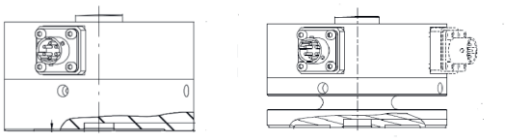

Fig.3: Load base for experimental tasks (left) and for reference tasks (right).

Results are shown in figure 4. Depending on the load base mounted the uncertainty of the sensor changing as well. With the new design it is possible to achieve a repeatability in different mounting position of less than 0.01 %.

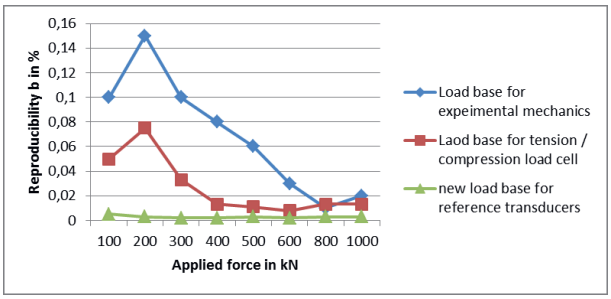

Fig 4: Comparison of the same sensor but with different load bases. The new load base shows by fat best results.

1. Conclusion

Radial shear type load cells fulfil class 00 according the ISO376 standard for compressive forces. By optimizing the stiffness of the load base, the results are on reference level in a measurement range from 10 % to 100 %. The advantages of high output and general robust design stay also with this new sensor.

References

[1] Thomas Kleckers, “Radial Shear Beams used as high precision transfer transducers”, IMEKO 2010 TC3, TC5 and TC22 Conferences Metrology in Modern Context, November 22-25, 2010, Pattaya, Chonburi, Thailand

[2] Karl Hoffmann, “Eine Einführung in die Technik des Messens mit Dehnungsmessstreifen” Hottinger Bladwin Messtechnik GmbH, Darmstadt, 1987; Page 62