



LASER-BASED FORCE SENSOR

Task

High-precision force sensors play an important role in many areas of production and quality assurance. Kistler Instrumente AG is the world market leader in the field of piezoelectric sensors for the measurement of pressure, force, torque and acceleration. In piezoelectric sensors, the stress generated by deformation of a crystal is analyzed, allowing highly accurate relative measurements. A direct absolute measurement of the force is, however, not possible owing to the principles involved. In close cooperation with Kistler, Fraunhofer ILT investigated a laser-based method for high-precision force measurement, which also enables absolute measurements. The force acting on the laser crystal is determined by a frequency measurement of this laser.

Method

A flexible laboratory setup was developed to investigate the different influencing factors on the measurement and to identify suitable components. For this purpose, ILT developed the optical design of the laser, the pump and analysis optics, the selection of suitable components and FEM analyzes to determine the resulting stresses in the crystal. In addition, the potential of the process was analyzed in extensive laboratory investigations. The studies focused on essential questions for potential product implementation, such as accuracy, reproducibility and long-term stability.

Results

Key influencing factors were identified, and absolute adjustments of 0.5 ‰ and reproducibility of 0.1 ‰ could be achieved by adapting the structure. Even over a larger temperature range up to 70 °C, the deviations were below 3 ‰.

Finally, two demonstrators were constructed to further investigate the potential of the technology on Kistler's premises. The demonstrators were built on the basis of commercially available components with a flexible and high-precision mounting method in a customized housing and have dimensions of 150 x 45 x 30 mm³.

Applications

With this technology, high-precision measurements of absolute forces can be made for use in calibration and reference measuring systems.

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2 Demonstrators of a laser-based force sensor.