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Fast Optical Measurement of the Roughness and Waviness of Mechanical Components for Electric Power Steering Systems to Improve Efficiency and Quietness

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A new measuring method will be presented that optically measures the roughness and waviness of mechanical components for electric power steering systems. It will be shown that the optical roughness parameter *Aq* is directly related with the friction property of the worm and therefore responsible for the power efficiency of the worm gear. With the same evaluation method, the residual waviness can also be measured, which often causes noises. The measuring system can be calibrated with standards according to ISO 17025.

The angle-resolved roughness and form measurement according to VDA 2009 can capture the properties of the entire illuminated surface with spot light by evaluating the behavior of scattered light reflected from the surface. Depending on the structure and roughness of the surface, the roughness measurement results in different intensity distributions which are statistically evaluated. The roughness value *Aq* is the variance of the distribution and corresponds to the profile angle parameter *Rdq*.

Also, this measurement method can get local slope of the surface from the center of gravity of the scattered light distribution, that is *M* value. If the sensor or the surface is moved and the *M* value is measured at equidistant intervals, the sensor records a slope profile from the surface that mathematically corresponds to the derivation of the shape profile. If the measured *M* values are added up, the shape profile can be calculated from this.

Figure 1 shows the measurement setup of the scattered light system, which determines the roughness of the worm flank using a deflection mirror. The mirror is mounted on a rotatably mounted mirror head, so that both flank sides of the worm can be measured in one clamping. With the aid of CNC-controlled linear axes, it is possible to capture the entire surface of the worm. The comparison with the test results shows a very good correlation of the *Aq* value with the coefficients of friction. Figure 2 shows the coefficients of friction of the different final machining processes of the contact surface of the worm as a function of the *Aq* values. The correlation coefficient R^2 is 0.8. When correlating the parameters with the efficacy results of the test bench, no or only a weak correlation could be established for the investigated parameters of ISO 4287 such as *Ra* and *Rz*. This shows that these parameters do not contain lateral information as well as the limits of the probe system whose uncertainty increases with increasing surface smoothness.

In addition, an example of measuring the profile of the ball race of the steering rack by the scattered light measurement method will be shown. By using a scattered light sensor, it is possible to detect higher-order waviness that are difficult with a stylus-type measuring instrument.

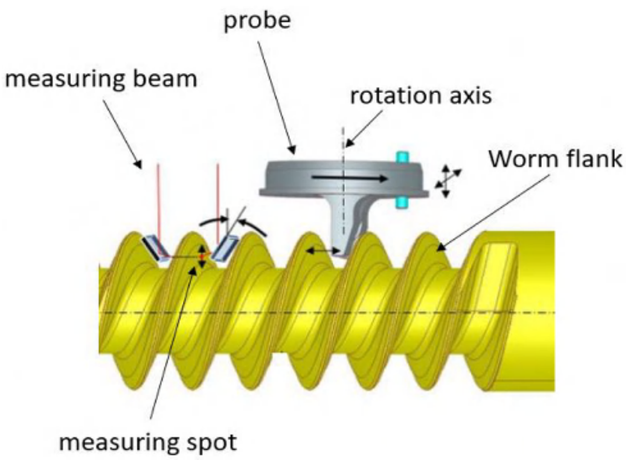

Fig.1 Schematic structure of the scattered light system for worm measurements

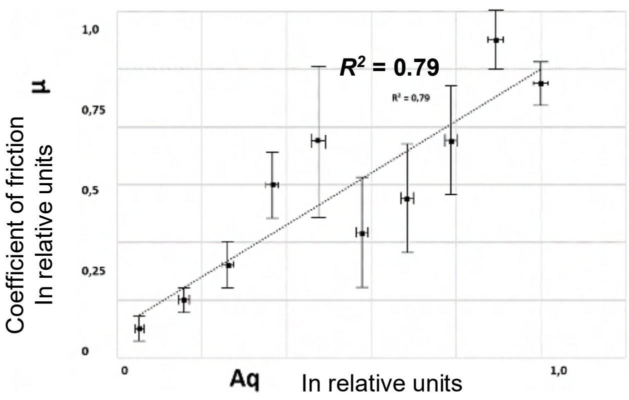

Fig.2 Correlation of the friction coefficient with the *Aq* value of the worm flank

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