Surface measurement on the shop floor

Measurement of the surface roughness, waviness and form of highly functional surfaces using scattered light technology

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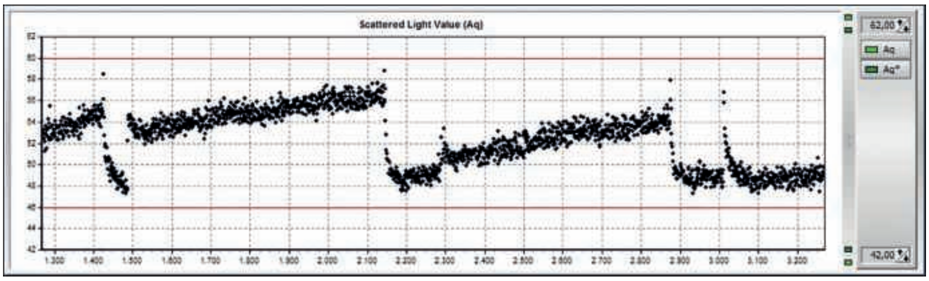
More and more branches of industry depend on the measurement and characterisation of functional surfaces. Especially in the automotive sector, functional requirements for technical surfaces are increasing constantly, and this necessitates a change of view in process control and quality assurance regarding the measurement of roughness, roundness and waviness. This change of view is expressed in the fact that measurement equipment is more often in demand and is being shifted directly into shop floor environments, with high frequency testing, or even up to 100 percent testing, is demanded instead of spot checks in inspection rooms. Apart from quality control, the data obtained can be used to optimise machining processes, resulting in higher efficiencies and significant cost reduction. The following examples briefly illustrate these enhancements and the advantages gained from scattered light technology.



Process monitoring of the roughness value (Aq), showing the dressing cycles. X-axis: number of parts, Y-axis: roughness Aq

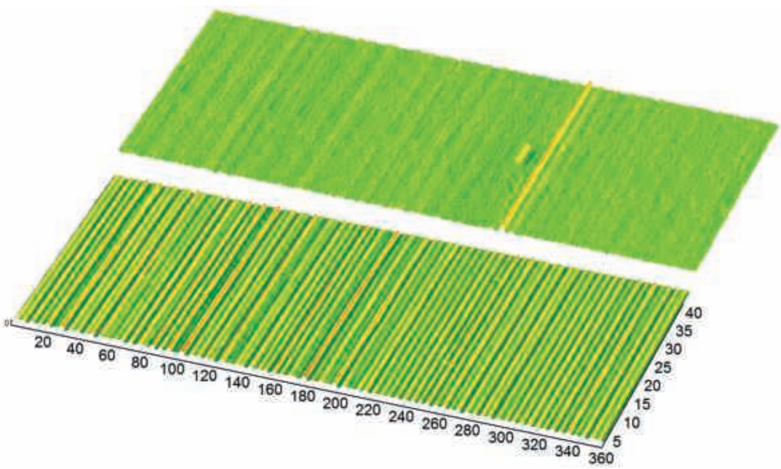
Preventing noise emissions on gear shaft running surfaces

Despite the ongoing developments in e-mobility, gear shafts and balance shafts remain important components in the automotive industry. In the development and production of transmissions high efficiency, durability and minimum noise emissions are targeted in the interaction of the rotating components. A typical reason for noise emissions in transmissions is chatter marks. These are periodic form deviations in the sub-micrometre and nanometre range. Chatter marks are mostly transferred during the grinding process due to the influence of production machines. Machine influences are not predictable and occur irregularly, for example through the vibration of grinding wheels.

One specific example of critical precision surfaces that can cause noise emissions from the surrounding installed transmission components due to chatter marks is the running surfaces of gear shafts and the running surfaces of needle bearings on which gear shafts are mounted for friction optimisation.

At present, inspection for chatter marks is often performed in separate testing rooms on precise tactile roundness measuring machines. In the best case, one single measurement takes several minutes. Because of the slow measuring times, sampling inspection is the common standard for quality assurance. Due to increasing production rates the frequency of tactile measurements is significantly lower than the total amount of industrially-produced parts. However, as already mentioned, the wear of machine tools is not predictable. This unpredictability is the main problem with tactile measurement methods, and it means that sampling inspection is inadequate to relate measured data directly to the production process. Therefore, the produced gear shafts and needle bearings need to be measured directly on the shop floor. The scattered light technology offered by the German company OptoSurf is ideal for this challenging task.

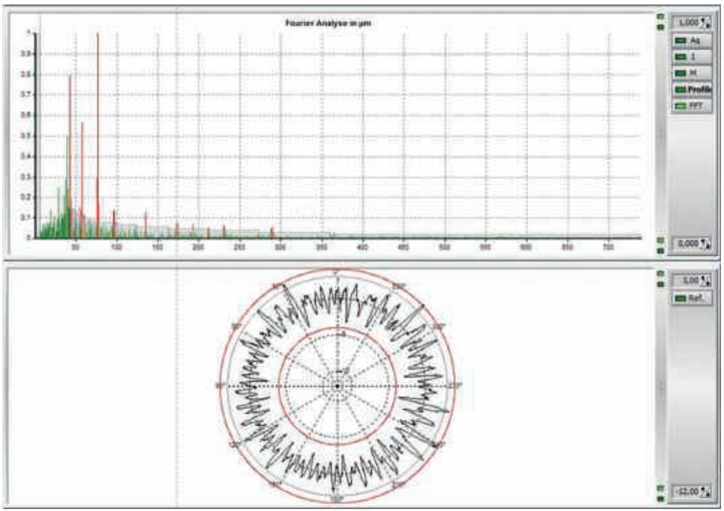
Using scattered light technology, it is possible to measure roughness, roundness and waviness simultaneously on whole running surfaces on gear shafts and balance shafts for quality assurance, in the rough shop floor environment. The data gathered can also be analysed according to various criteria. Scattered light sensors work by the simultaneous detection of microstructure angles and macrostructure from the centre of gravity of the distribution curve. The method works by illuminating the surface with a light spot (Ø 0.9 mm). The light reflected and scattered by the microstructure is then emitted by a photosensitive diode array. Thanks to high measurement speeds, the measurement



Gear shaft bearing seat 3D profile map. Top: OK surface. Bottom: seat with chatter marks, amplitude 0.05 µm

process only takes a few seconds. Even ambient vibrations induced by harsh production environments do not affect the measurement results. The sensor's maximum scanning frequency is up to 2,000 measurements per second, with a measuring accuracy of a few nm and achievable Cg values > 1.33 even for small tolerances.

Scattered light sensors can also be used for process control. Grinding processes and tool wear can be monitored with this technology. The main sign of a worn grinding wheel, for example, is a decreasing roughness value (Aq) on the measured running surfaces. In the worst case, this value can decrease until grinding burns occur. The correlation helps to maximise machine run time while not dressing machine tools too late. This way it is possible to save production costs and to produce larger quantities with one grinding wheel.



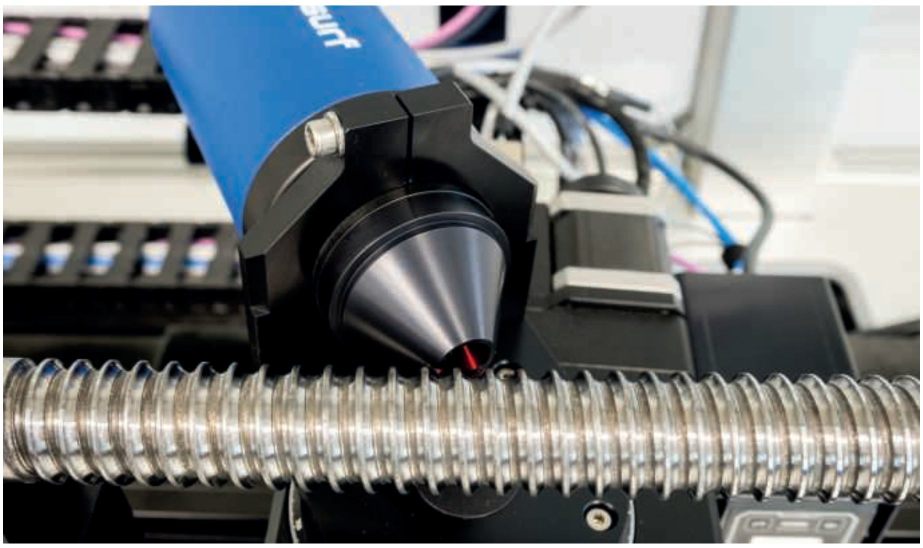
Gear shaft seat. Roundness measurement with FFT analysis and RONt = 2.4 µm

The ball screw – not only smooth-running but also quiet

Nowadays Electric Power Steering (EPS) systems are an indispensable component in modern cars. The benefits are obvious: These systems are significantly less complex, offer more driving comfort due to smoother steering, and use less energy compared to hydraulic systems. One kind of EPS, especially suitable for heavy cars like SUVs, is ball screws. This type of system translates a rotary movement precisely into a linear movement. It works using a rotating spindle and a nut which is mounted on rollers.

Scattered light technology is ideal for the measurement of complex forms like spindles and nut ball races. The measurement of running surfaces on the "Gothic arch" of the spindle races is especially important, due to their high functional relevance for noise emission and wear characteristics of the ball screw. An uneven finishing process can lead to local differences in roughness. These differences are a typical reason for possible noises in the steering process, and for premature wear of the balls. Using limit value settings for roughness values (Aq) in the software, it is possible to identify NOK parts with scattered light sensors directly after the finishing process, even in the harsh conditions of the production environment.

In a further step the spindle is measured with a smaller light spot (30 µm) for waviness on the spindles bearing tracks. The method used is a FFT (Fast Fourier Transformation). This operation selects the measured profile in sinusoidal waves and looks for waves with prominent amplitudes. This frequency components are displayed in the software assigned to their order and amplitude levels up to the 500th order. If the waviness is at an unfavourable ratio to the spindle circumference and the ball diameter, noise may be generated by vibrations occurring in the steering system which are audible in the car's interior. The form deviation measured using scattered light technology is comparable to the result obtained with precise tactile measurement machines. A significant difference is that with scattered light it is possible to measure both flanks of the spindle separately and to assign anomalies directly to the steering direction. By comparison, a coordinate measuring machine, for example, generates mixed results due to the fact that the tactile ball rests on both flanks simultaneously. For the FFT it is also possible to create individual limit value settings. This is important because not every frequency component and amplitude level have a negative influence on the functionality. Even if there is some waviness on the surface, the part may be OK provided the waviness is in tolerance.



Automated measurement of roughness, form and waviness of the races of a ball screw

These examples are brief illustrations of the fact that with the right measurement system it is possible to gain a lot of information about surfaces, and consequently about production processes. Using fast, robust scattered light measurement technology, up to 100 percent of all parts can be tested and machines can be used more efficiently.

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