Shadows as a measure of quality

Fully automated inspection of precision parts

The automotive industry sets high standards on the parts production of its suppliers. A 100-percent quality inspection is thus often essential. To ensure the exact concentricity of the tip of hardened pins for use in motor vehicles, a company from the German state of Thuringia has been using an automated testing system since the start of the year. A sensor solution from ipf electronic plays a decisive role in this system.

The name speaks for itself: Präzisionsdrehteile Barchfeld GmbH (Barchfeld Precision Turned Parts) produces only high-precision turned parts. Going into greater detail, Michael Grobe, managing director of the mid-sized company based in Barchfeld-Immelborn (Wartburg county, Thuringia), says: "We are a turning shop that uses automatic production, whereby the batch sizes range from small quantities to large series. The operating range begins with a workpiece diameter of 2mm and extends to 42mm. We process only machinable materials, i.e., metals, both for system suppliers from the automotive industry as well as for the sensor, measuring and control technology sector, to name our most important customers."

Tight tolerances for exact concentricity

Working on behalf of a system supplier, Präzisionsdrehteile Barchfeld produces, among other things, metal pins for use in motor vehicles. "The tips of these 3-mm-diameter pins must demonstrate exact concentricity of maximum 0.06mm after hardening and grinding. To ensure a high production quality, a comprehensive inspection of all finished parts is therefore unavoidable. For this reason, we commissioned an engineering office to develop a solution for the fully automatic concentricity inspection of the pin tips," explains Grobe.

High-precision solution for fully automatic system wanted

This was a job for the firm Konstruktion & Musterbau Wohlgemuth, as the engineering office from Markkleeberg near Leipzig specializes in the development and production of special machines for various branches of industry as well as for suppliers for the areas of electronics, food and automotive. Uwe Wohlgemuth, junior manager of the company: "For the development of the testing system for Präzisionsdrehteile Barchfeld, we needed a sensor solution that could be integrated without problem in a fully automatic system, that needed to be fast with respect to short cycle times and, of course, had to be able to perform the demanding testing tasks with high precision. Contact with ipf electronic helped us here a great deal, as they provided us with competent advice and the answer that basically only a line sensor would come into question for our development."

Object edge in focus

The line sensors from ipf electronic are suitable above all for precise positioning of parts or for the exact determination of object dimensions. With respect to a high level of versatility, the sensors are offered as scanning systems (retro-reflective line sensors) and transmitter-receiver systems (laser line sensors), whereby the latter are also available as forked versions. One such forked system, the PG400140 line sensor to be precise, was recommended by ipf electronic for the automatic testing system of the Wohlgemuth engineering office.

Receivers with special features

Why, among other things, will become clear once one learns about the structure and function of the line sensors. The receiver consists of a CCD line detector that is made up of tightly arranged receiving elements, or pixels. The line-shaped, homogeneous laser light beam on the transmitter side is projected on this line detector. If an object is located in the light beam of the sensor system, the line detector of the receiver depicts the shadow of the object on the individual pixels of the CCD row. Because the spacing between the pixels on the respective CCD row is known, it is possible, for example, to determine the size of the generated shadow area and, thus, determine, e.g., the diameter of a measured object.

Intelligent software for configuration

The line sensors are configured using special software. Displayed in this Windows interface is, among other things, an exposure curve of the CCD row in which the brightness information of each individual pixel of the row is reflected. The user can thereby directly see whether and where areas of the CCD line detector are shaded by an object. This so-called video signal can be evaluated in a number of different operational modes, such as "Left-Edge," "Right-Edge," "Center" and "Width," depending on the measurement task. For this purpose, the evaluation mode is defined via the configuration software and transferred to the line sensor. Once configured, the sensor systems function with no connection to a PC in stand-alone mode.

Automated infeed into the testing system

The PG400140 line sensor integrated in the testing system for Präzisionsdrehteile Barchfeld features a 6 x 1mm wide red light laser line as transmitting element, while the active sensor surface consists of a CCD line detector with 512 pixels. The resolution of the sensor system is typically 2µm. Uwe Wohlgemuth explains how the system functions: "The pins are first fed from a storage bin to a spiral conveyor, which guides the parts, now oriented lengthwise, to a linear conveyor belt with a parts buffer. Because the parts are not yet properly oriented for a test of the pin tips in this part of the system, after the buffer they are aligned in a turning station and are then transported directly to the testing station."

"Center" evaluation mode plus Min-Max mode

In this station, each pin is rotated one and a half times in order to obtain conclusive test results. The concentricity of the pin tip is checked on the basis of the deflection of the pin, whereby the test is performed with the "Center" evaluation mode. With this operational mode, the center position of a shadow produced by a component (here, pin tip) is determined in the measurement system. In addition to this, the "Min-Max" evaluation mode is used to determine the absolute movement of the center of the component within the line system over a measurement cycle. In concrete terms, this means: If, during a rotary movement, the pin tip exhibits a so-called radial run-out caused by bending, the position of the component center also changes during this rotary movement.

Individual inspection of each test item

This change in position is observed, whereby the sensor system saves the respective extreme values in both deflection directions (min and max). The difference constantly determined from these values corresponds to the radial run-out of the currently tested component and is converted to an analog signal for evaluation. This signal is transmitted to the PLC of the automated testing system and is processed there in order to separate NOK from OK parts.

So that the previous min/max values are not used for the concentricity evaluation of each new pin that is tested, the limit values are to be reset for each test item. This is performed via an external input on the system to which 24V is briefly applied after a new pin is fed into the testing station.

Integrated "signal amplification"

As already mentioned, the PG400140 sensor system used in the automated testing system has a measuring range width of 6mm. The measurement width is twice as large as the component diameter and is much larger than the expected radial run-out of the pin tips. The advantage: It is not necessary for the system to be exactly positioned in order to ensure that the pin tips protrude into the light beam. The disadvantage: Only small analog signals resulting from the run-out are available to the PLC for evaluation. The system addresses this problem with an integrated "zoom function", which, at the analog output, converts small changes in the component position to large signal deflections.

Comprehensive and high-speed quality control

"The actual test process for each pin takes just tenths of a second," explains Uwe Wohlgemuth. Taking into account the mechanical components for the insertion and removal of the pins near the testing station, cycle times of 2.5 seconds per test item are achieved.

A result that thoroughly convinced Michael Grobe from Präzisionsdrehteile Barchfeld: "We have been using the system since February 2015 and have since then been able to realize gapless quality control, whereby we test approximately 1,400 hardened pins per hour."

Image captions:

ipf_electronic_Wohlgemuth_01:

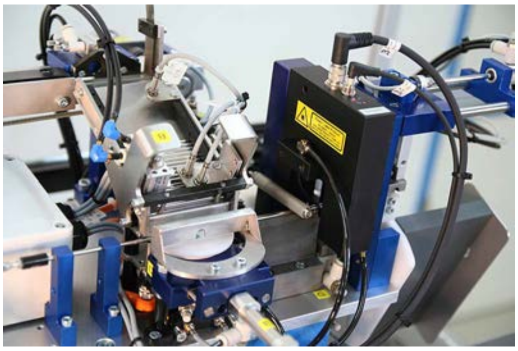
ipf_electronic_Wohlgemuth_02:

The system developed by the Wohlgemuth engineering office automatically tests the exact concentricity of the tip of pins for use in motor vehicles.

ipf_electronic_Wohlgemuth_03:

The pins are first passed from a storage bin to a spiral conveyor, which guides the parts, now oriented lengthwise, to a linear conveyor belt with a parts buffer.

ipf_electronic_Wohlgemuth_04:



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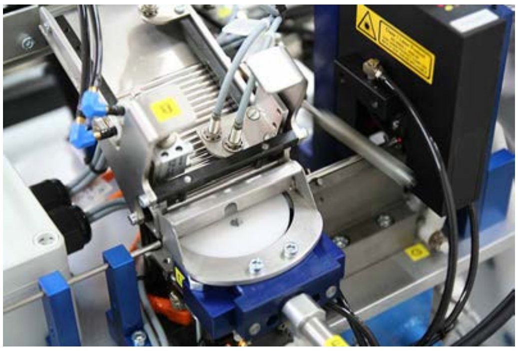

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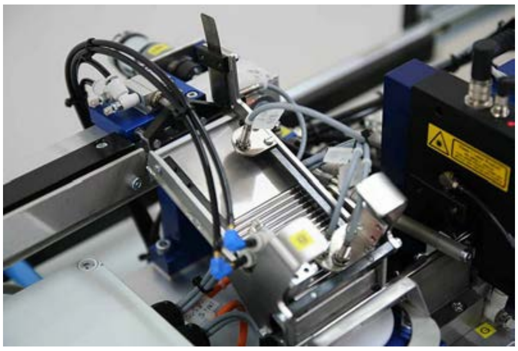
In front of the line sensor (right), the pins are correctly aligned for the test after the buffer in a turning station.



ipf_electronic_Wohlgemuth_07:

The concentricity of the pin tip is checked on the basis of the deflection of the pin, whereby the test is performed with the "Center" evaluation mode. In addition to this, the "Min-Max" evaluation mode is used to determine the absolute movement of the center of the component within the line system over a measurement cycle.

ipf_electronic_Wohlgemuth_08:

The difference constantly determined from the respective extreme values in both deflection directions corresponds to the radial run-out of the currently tested component and is converted to an analog signal for evaluation. This signal is transmitted to the PLC of the automated testing system and is processed there in order to separate NOK from OK parts after the testing station.