Surface and shape measurement solution integrated in laser machine for the characterization of round parts

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Abstract

The downsizing of many applications such as semiconductors, medical devices or mobile phones demands the micro-manufacturing of a wide range of industrial products to be more precise, faster, cheaper, and smarter than its predecessors. Like every manufacturing process, the micro-manufacturing techniques also require metrology to control critical dimensions or surface functionalities. Thus, the measurement of geometric features at the micro-scale or even nano-scale range on macro-size components becomes a challenge for the micro-manufacturing processes.

This article presents a solution for the in-process measurement of micro-geometries on round parts such as dynamic seals, grinding shafts or even the wear analysis of metal cutting tools. It presents the adaptation and continuation of the already-presented research work, the so-called "Accuracy evaluation of optical 3D profiler integrated on a machine tool adapted for laser-based processing " presented by Dr Kortaberria at euspen's 19th congress where the integration of the system architecture was already depicted.

Here, the integration of a high-positioning accuracy (± 5 arc-sec) rotary axis into a laser machining machine is presented. The integration process has evolved considering the position and orientation of the rotary axis in the machine tool kinematics. For this purpose, the research presents an extrinsic calibration method to characterise the effect of the rotary axis misalignment within the measurement reconstruction process, using consecutive kinematic transformations. Thus, the 3D surface of the rotary part is reconstructed by deploying rigid known transformation and best-fitting strategies that minimize the effects of implicit geometric errors coming from either the machine tool, the integrated rotary axis or even the relative positioning between both systems characterized through the referencing methodology. Fusing all these aspects directly affects the accuracy of the 3D reconstruction process which is enhanced by smart data processing strategies. The evaluation of such a reconstruction method has been assessed by calibrated workpieces with micron-level uncertainty values. Preliminary results confirm that the implementation of the above-mentioned systems (machine, measuring head, rotary axis, 3D reconstruction) is close to being validated. Further research work is being performed to optimize the accuracy of the solution.