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Process signatures – a new approach for the description of surface layer property changes caused by manufacturing processes

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Abstract

The generation of well-defined geometrical properties in machining processes is state of the art in industry. This is not true for chemical and physical material properties of the workpiece surface layer – neither in industry nor in research, c.f. CIRP Keynote paper on surface integrity in 2011. However, these properties are of major importance regarding the functional performance of the part. The reason is that even today a fundamental understanding of the basic mechanisms leading to material alterations in machining processes is still missing.

Only recently the Deutsche Forschungsgemeinschaft decided to fund the new collaborative research center “Process signatures” (CRC 136) aiming exactly at this knowledge gap. The CRC is a collaborative research effort of the University of Bremen, RWTH Aachen University, both Germany and a sub-project at Oklahoma State University, USA.

All machining processes generate a specific load characterized by the time-dependent stress-strain state, temperature field and spatially varying chemical potential. In order to reduce the complexity of the problem it is sought to characterize these fields by energetic parameters and their gradients. This working hypothesis is based on the fact that all machining processes are energy transformation processes. The work within the CRC 136 will mainly focus on identifying the quantitative dependence of state variable changes (material modifications) on the load state of the workpiece material during different manufacturing processes. Processes to be analyzed were chosen on the basis of their predominant influences on the workpiece surface layer ranging from mechanical, thermal, chemical to thermo-mechanical and thermo-chemical influences.

By means of Process signatures it will be possible to describe manufacturing processes in a unified way for the first time. The long-term objective of the research work is to solve the so-called inverse problem of manufacturing technology: Based on previously defined chemical and physical material properties of the workpiece surface layer, it shall be possible to generate the desired surface properties based on a scientifically selected choice of manufacturing processes, the corresponding parameters, and the subsequent application of machining processes on the basis of Process signatures.