PROZESS SIGNATUREN
TRANSREGIONALER SONDERFORSCHUNGSBEREICH 136

Universität Bremen · RWTH AACHEN UNIVERSITY · OKLAHOMA STATE UNIVERSITY

Research Center
Bremen Institute for Metrology, Automation and Quality Science (BIMAQ)

BIMAQ

Areal Optical Measurement of Mechanical Material Loads

C06/Speckle Photography – Prof. Andreas Fischer

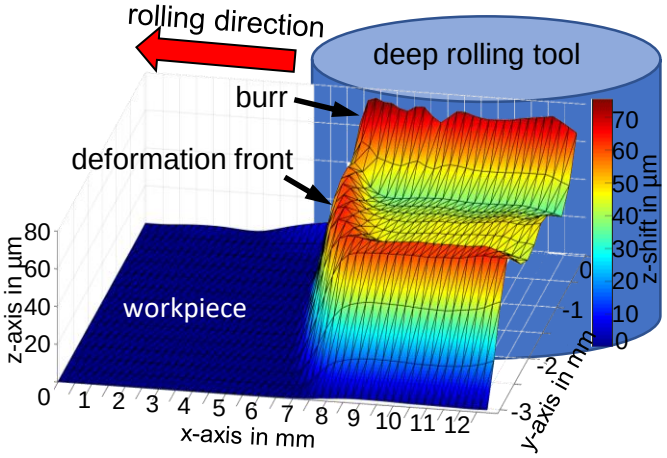
Objective and Approach

The determination of material loads in the form of component deformations and strains is essential for the development of process signatures. Therefore, the aim of subproject C06 is to investigate deformation-based loads and modifications of workpieces in different manufacturing processes. For the measurements, the method of digital speckle photography, which was successfully introduced in the first phase, will be used and extended with respect to a three-dimensional displacement evaluation.

Current State of Knowledge (May 2021)

Digital speckle photography (DSP) offers the possibility for contactless measurement of displacements and strains. Thereby, DSP is based on the correlation of image captures before and during strain. By using a high-speed camera and ultra-short pulse exposure, highly dynamic deformations and strains in various manufacturing processes can be measured with a resolution of less than 20 nm.
Specially adapted evaluation algorithms, which analyze the decorrelation of the speckle patterns under load, meanwhile enable the metrological detection of displacements in the out-of-plane direction of the camera and thus, for the first time, the determination of three-dimensional deformation fields.

Out-of-Plane Displacement



Speckle photography while deep rolling

Conclusion and Further Procedure

With the aid of temporally resolved 3D deformation information and new measurement setups and evaluation algorithms specially adapted to the manufacturing environment, complete mechanical load measurements can be carried out even under difficult conditions such as the use of cooling lubricant. Observations beyond the point of loading additionally allow the measurement of modifications, which will be used to establish and investigate process signature components for single and multiple stressed systems. In addition to the validation of algorithms for the calculation of individual load fields, the simulations of complex process signature components can thus also be verified.

Publications

[1] Tausendfreund, A.; Stöbener, D.; Fischer, A.: *In-process workpiece deformation measurements under the rough environments of manufacturing technology.*
Procedia CIRP 87:409-414, 2020.

[2] Tausendfreund, A.; Stöbener, D.; Fischer, A.: *Induction of highly dynamic shock waves in machining processes with multiple loads and short tool impacts*.
Applied Sciences 9(11):2293 (13 pp.), 2019.

[3] Tausendfreund, A.; Borchers, F.; Kohls, E.; Kuschel, S.; Stöbener, D.; Heinzel, C.; Fischer, A.: *Investigations on material loads during grinding by speckle photography*.
Journal of Manufacturing and Materials Processing 2 (71):1-12, 2018. (selected article as cover story)