PROZESS SIGNATUREN
TRANSREGIONALER SONDERFORSCHUNGSBEREICH 136

University of Bremen · RWTH AACHEN UNIVERSITY · Oklahoma State University

Research Site
Bremer Institut für angewandte Strahltechnik

bias – Bremer Institut für angewandte Strahltechnik

Processes with thermo-chemical impact

Subproject F07 –Prof. Dr.-Ing. Frank Vollertsen

Objective and approach

In subproject F07, process signature components (PSK) with thermo-chemical and thermal impacts are developed in order to predict the functional properties of a component on their basis. For this, the correlations between thermo-chemical load and resulting material modifications are investigated. Also, correlations between the multiple thermal load and the resulting hardness-depth curve are investigated. Subsequently, fatigue specimens with different boundary zone properties will be produced and tested for their fatigue behavior. This knowledge is then used to identify and further develop relevant PSK that allow the specific adjustment of functional properties.

Current state of knowledge (May 2021) – chemical

The roughness can be successively reduced by multiple cyclic loading. The PSK depends on the thermal load T_L and the number N of cycles.

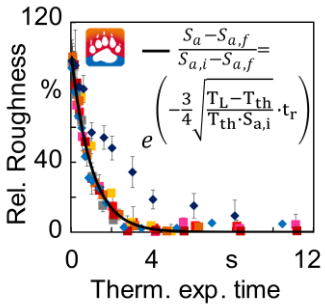

Fig.1 :PSK of the surface roughness

Current state of knowledge (May 2021) – thermal

Due to a multiple thermal load, the hardness shows an exponential and converging relation to the integral transformation time in the boundary area.

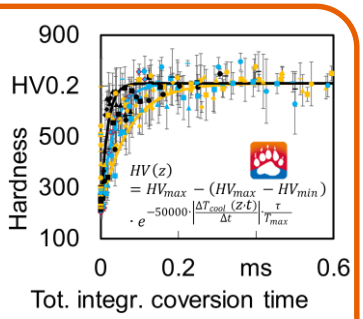

Fig .2 :PSK of the hardness-depth curve

Conclusion and further procedure

Thermal load and exposure time were identified as material loads for the LCM process. The material load for laser hardening could be linked back to the temperature load. Thus, PSKs could be defined for the arithmetic roughness and for the hardness-depth curves. In order to enable a function-oriented manufacturing for processes and process chains based on process signatures with thermo-chemical impact, the influence of the microstructure on the roughness change is considered as a further component of the PSK for the LCM process.

Publications

[1] Borchers, F.; Clausen, B.; Eckert, S.; Ehle, L.; Epp, J.; Harst, S.; Hettig, M.; Klink, A.; Kohls, E.; Meyer, H.; Meurer, M.; Rommes, B.; Schneider, S.; Strunk, R.: Comparison of Different Manufacturing Processes of AISI 4140 Steel with Regard to Surface Modification and Its Influ-encing Depth. Metals 10 (2020), 895. 10.3390/met10070895

[2] Eckert, S., Vollertsen, F.: Mechanisms and processing limits of surface finish using laser-thermochemical polishing. Manufacturing Technology 67 (2018), 201-204. 10.1016/j.cirp.2018.04.098

[3] Eckert, S.: Multi Cycle Process Signature of Laser Induced Thermochemical Polishing. Journal of Manufacturing and Materials Processing 3 (2019), 90. 10.3390/jmmp3040090

[4] Eckert, S.; Vollertsen, F.; Rommes, B.; Klink, A.; Schupp, A.; Zander, D.: Understanding the Influence of Chemical and Thermal Loads on the Productivity for Processing 42CrMo4 Steel and Titanium via LCM, 9th CIRP Conference on High Performance Cutting (HPC 2020) (akzep-tiertes Manuskript, Konferenz durch Covid 19 auf 2021 verschoben)

[5] Frerichs, F.; Lübben, T.; Lu, Y.; Radel, T.: Process Signature for Laser Hardening. Metals 11(3) (2021), 10.3390/met11030465

[6] Lu, Y.; Meyer, H.; Radel, T.: Multi cycle phase transformation during laser hardening of AISI 4140. Proc. of the 11th CIRP Conference on Photonic Technologies (LANE 2020), eds.: M. Schmidt, F. Vollertsen, E. Govekar. Procedia CIRP 94, Elsevier B.V. Amsterdam (2020), 919-923 (online). 10.1016/j.procir.2020.09.073

[7] Zhao, T.; Eckert, S.; Vollertsen, F.: Recast Zone and Unmelted Zone of the White Layer In-duced by Microsecond Pulsed Laser Surface Processing of 42CrMo4 Alloy steel, Lasers in Engineering 41, Old City Publishing (2018). 349-358.