

## PRESS RELEASE

Aachen, August 1<sup>st</sup>, 2023

### Accurate Prognosis of the Tool Wear Development: Greybox Model as a Combination of Process Data And Domain Knowledge

#### Start of the Sub-Project "GreyWearHT" In DFG-SPP 2402: Development of a Greybox Model for Wear Prediction of PVD-coated Carbide Tools in High-Performance Turning of Steels.

Laboratory for Machine Tools and  
Production Engineering (WZL) of  
RWTH Aachen University

Alexa Wietheger  
Head of Press and Public Relations

Campus-Boulevard 30  
52074 Aachen  
GERMANY

Phone: +49 241 80-24955  
Fax: +49 241 80-22293  
a.wietheger@wzl.rwth-aachen.de  
www.wzl.rwth-aachen.de

The enhancement of tool life is pivotal in increasing productivity during machining processes. The utilization of Physical Vapour Deposition (PVD)-coated cutting tools has emerged as the prevailing practice, presenting a promising solution for economically achieving High-Performance Cutting (HPC) of heat-treated steels such as 42CrMo4 and C45. The augmentation of tool life necessitates the judicious design of tool microgeometry, coating properties, and cutting process. However, the wear process of coated tools is a system of complex interconnected physical phenomena, posing significant challenges in the development of cost-effective cutting tools and processes. The continuous degradation of coatings and cutting materials during machining leads to non-stationary thermomechanical stresses on PVD-coated cutting tools. Previous attempts to predict wear on coated tools through deterministic wear models (white-box models) based on established knowledge have proven to be insufficiently accurate, as these models assume stationary thermomechanical loads and fail to account for the transition from linear to progressive wear. On the other hand, data-driven black-box models have demonstrated the capability to capture complex correlations effectively; however, they lack a fundamental understanding of the underlying physics and their robustness under varying boundary conditions remains uncertain. Thus, a precise prognosis of tool life and the knowledge-based qualification of coated cutting tools for demanding machining processes remain impossible.

To address this existing knowledge gap, a practical investigation will be undertaken within the collaborative research project "GreyWearHT: Development of a Greybox Model for Wear Prediction of PVD-coated Carbide Tools in High-Performance Turning of Steels," conducted at the Laboratory for Machine Tools and Production Engineering WZL in cooperation with the Surface Engineering Institute IOT in the coming three years.

The primary objective of this research project is to develop a greybox model capable to predict the tool wear development and the remaining life of PVD-coated carbide tools in high-performance turning of steels accurately. This entails the combination of analytical white-box models to determine non-stationary thermomechanical stresses in the cutting process and data-driven black-box models. Particular emphasis is placed on investigating the impact of temperature-dependent coating properties on wear progression.

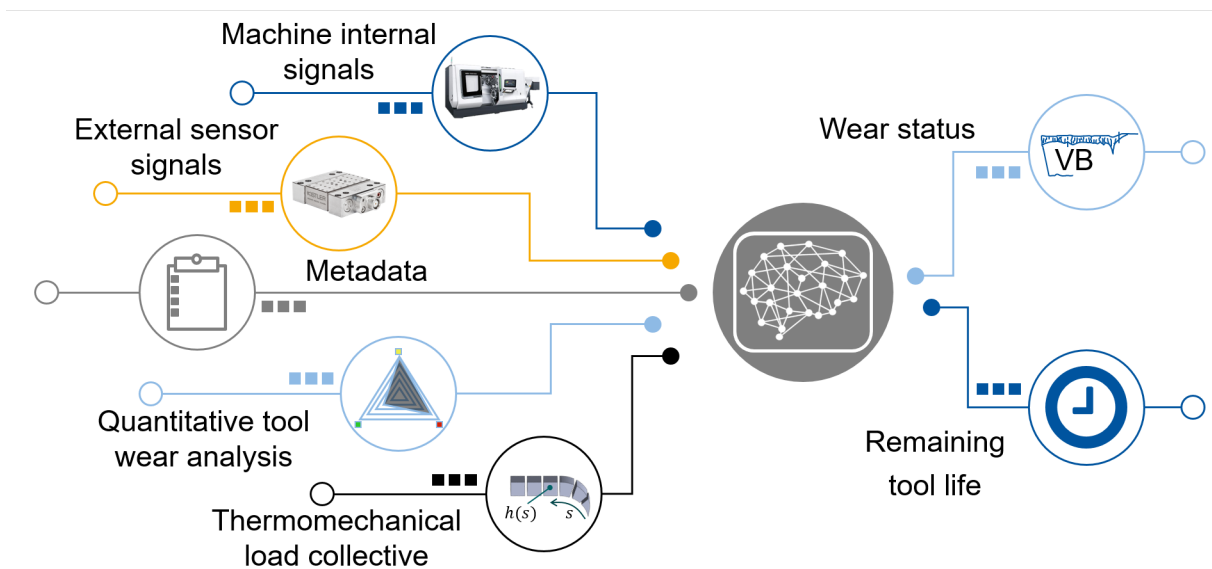
## PRESS RELEASE

Aachen, August 1<sup>st</sup>, 2023

The research scope entails the deposition and characterization of TiAlCrSiN and TiAlCrSiON coatings with varying thicknesses on indexable inserts. Subsequent dry rough turning of heat-treated steels C45 and 42CrMo4 is performed using the coated tools. The focus here is on in-situ measurement of process state variables, particularly in the transition zone from linear to progressive tool wear. The acquired experimental data form the basis for a comprehensive quantitative tool wear analysis. Simultaneously, targeted analogous cutting tests will be conducted to establish a precise whitebox model, enabling accurate determination of thermomechanical tool loads at different process settings. Finally, a greybox model will be developed as a combination of the established black-box and white-box models to facilitate a reliable prognosis of tool wear progression.

### Foundation:

This Project is supported by German Research Foundation (DFG) – BE 2542/160-1



© WZL: Structure of Greybox Model

## **PRESS RELEASE**

**Aachen, August 1<sup>st</sup>, 2023**

### **Contact**

Zongshuo Li, M.Sc.

+49 241 80-20522

[z.li@wzl.rwth-aachen.de](mailto:z.li@wzl.rwth-aachen.de)

### **Laboratory for Machine Tools and Production Engineering (WZL)**

The Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University enhances the innovative strength and competitiveness of the industry with trend-setting basic research, applied research and the associated consulting and implementation projects in the field of production technology. In the research fields of manufacturing technology, machine tools, production engineering, gear technology as well as production metrology and quality management, practical solutions for rationalizing production are developed with industrial partners from a broad range of branches.