SmartWEAR

Control, prevention and prediction of wear phenomena in multistage forming processes

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Duration	October 2021 – March 2023
Department	Tribology
Funded by	Bundesministerium für Wirtschaft und Klimaschutz | AiF | ZIM

Abstract

Wear significantly determines the resulting product quality and therefore the service life of the tool used. Monitoring the development of wear and planning proactive maintenance interventions is therefore of particular importance. The main focus of this project is on the wear caused by copper processing, as this material is being used more and more frequently in the context of the electrification of road traffic.

Project description

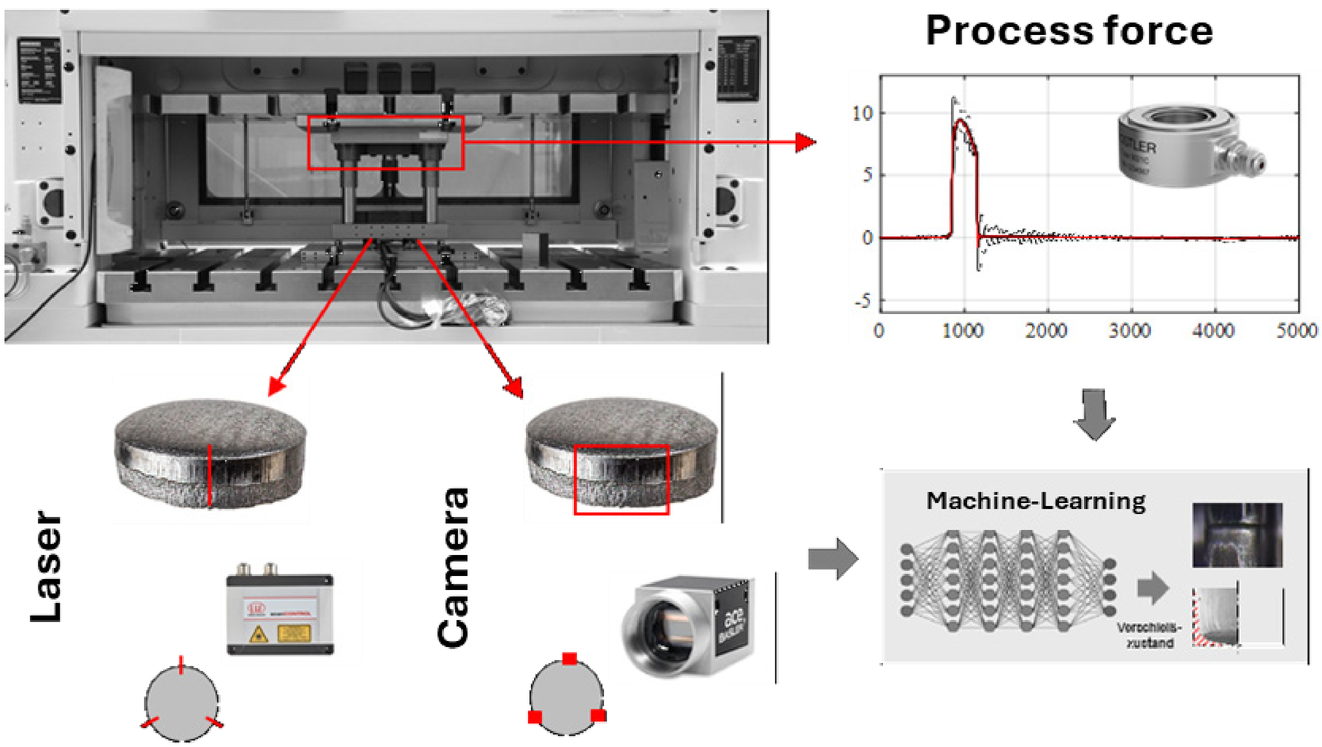
In order to explore the possibilities for such continuous wear measurement, PtU is cooperating with national and international research partners in the present research project. For this purpose, continuous wear tests are carried out at PtU together with Filzek TRIBOTech on an FVW on the institute's own high-speed press and various process variables are recorded. The tool used is manufactured and provided by the Turkish production company HATKO Elektronics. The Turkish Hatcettepe Universitesi is responsible for the numerical investigation of the cutting behavior.

The process data collected in the endurance tests will be used at PtU to train machine learning algorithms (Figure [1]). These models will later be able to predict the current wear condition in the process on the basis of current data from production. The training of the algorithms takes place hand in hand with regular application of the algorithms to further tests and possible correction.

At the end of the project, the developed models will be applied to an actual production process at HATKO ELECTRONICS and their effectiveness will be verified.

Results

As part of the project, a modular real-time process monitoring and evaluation system based on envelope curves and other extractable features was implemented in the industrial tool. For validation, several wear test series were carried out with punches in different wear states. Characteristic force curves were recorded for the punches identified as quality-critical by the



[1] Process parameters in blanking

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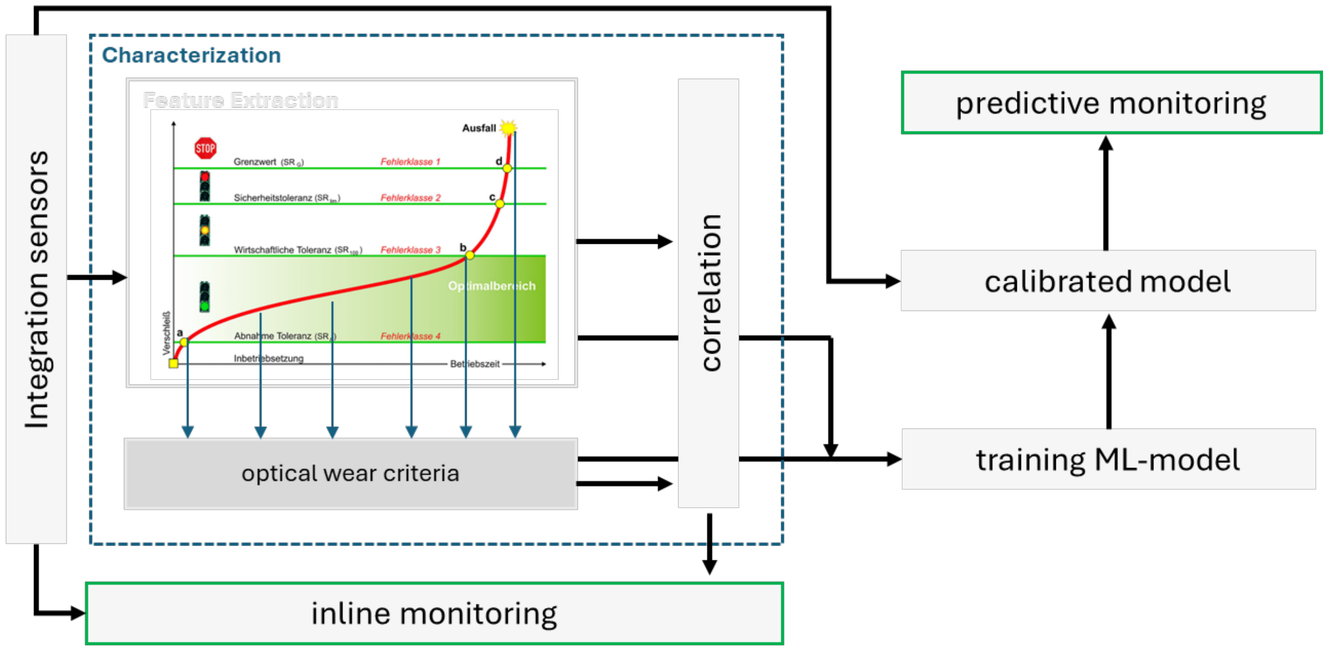


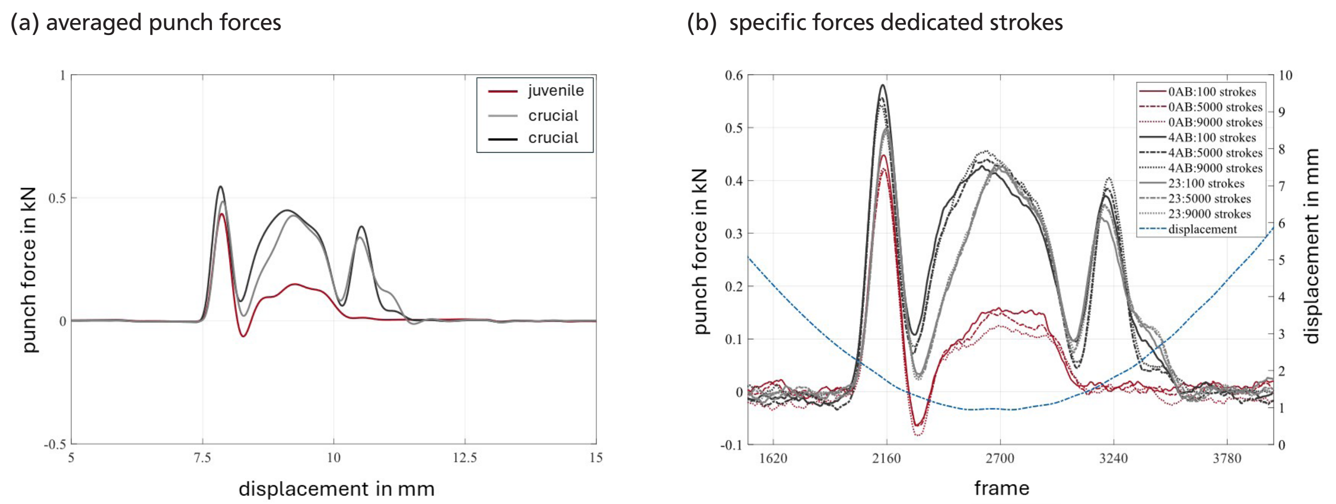
[2] Applied monitoring strategy

industrial partner and used to feed back recommendations for action into a real-time monitoring system. Figure [2] visualizes the strategy derived for this purpose.

The industrial test tool is a multi-stage progressive die (PD). In addition to simple hole punching, an external contour cut and embossing operations take place in several stages. A strip of sheet metal is fed into the tool from the coil, and the contour cuts are arranged in the PD itself in such a way that two identical components are produced per punching. This means that the strip is split, which ends at the end of the module with a two-lane strip guide and finally an open cutting process. This finally separates the two components from the belt. Due to the production of two components per stroke, two of the cutting punches identified as critical to quality are also engaged per stroke. These are floatingly mounted in the guide plate of the tool module. The integrated force measuring ring is positioned so that it is in contact with both punches. The recorded force signal thus represents the course of both cutting punches. Using the previously implemented measuring chain, endurance tests were carried out and evaluated for six punches with a stroke of 30k. The monitoring criteria were derived from this.

Figure [3] shows an evaluation of the tests carried out for the punches under consideration. The classified wear groups, which were classified as representative by the partner HATKO Electronics, are shown. Both the averaged stroke curves, which describe the general characteristics of the respective wear condition, and selected individual strokes after several thousand strokes are shown.

Although a blanking phase and a pronounced blanking impact



[3] Process forces of various wear classes

can also be seen here with unused punches, which decreases sharply with punches that are already worn, the push-through phase and the retraction phase differ significantly. Particularly with increasing wear, the push-through phase tends to be bell-shaped (gray lines). There is no retraction phase in the classic sense. Although the worn punches have a very pronounced third phase, which is suitable as a quality criterion for inline monitoring, a compressive force is recorded rather than a tensile force despite the retraction stroke. One possible explanation for this is the multi-stage tool structure and the shunts that develop due to punch wear.

As discrete quality criteria for process monitoring, the position and height of the cutting impact, the maximum penetration force at the UT and the position and height of the “retraction phase” are therefore implemented in the monitoring system for the case under consideration. The values can be discretized in real time and evaluated using a simple traffic light system. If the maximum permissible cutting force is exceeded, this is initially only indicated by an orange traffic light. The findings have shown that this is only an early indicator, but does not yet trigger any need for action. If, however, the push-through or retraction force exceeds a defined threshold value, the traffic light shows a red light and thus signals insufficient product quality or rejects. As the industrial reference tool had to be repeatedly adjusted during the project, the threshold values were implemented in such a way that the position and level can be shifted by simple operator intervention. This proved to be a very practical solution for everyday industrial use.

The motoring system is an effective instrument that can adapt dynamically to changes in the production environment and enables robust process monitoring. The necessary interventions are limited to the integration of a force sensor into the main force flow. Due to the very small dimensions of the piezo force measuring rings used, this is possible without any problems in a large number of industrial applications. A measurement methodology has been developed that makes it possible to significantly reduce the reject rate compared to the previous reactive and maintenance-controlled random sample monitoring and increase internal efficiency.

Acknowledgement
This Project is supported by the Federal Ministry for Economic Affairs and Climate Action (BMWK) on the basis of a decision by the German Bundestag.
Through the cooperation of international funding agencies (IraSME), collaboration with national and international partners was made possible. We would like to thank our project partners.

Funded by

GEFÖRDERT VOM Bundesministerium für Bildung und Forschung

AiF Forschungsnetzwerk Mittelstand

ZIM Zentrales Innovationsprogramm Mittelstand

Project Partners

FILZEK TRIBO tech

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