Success Story
COMET

XTribology
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Lab-2-Field development environment for service life prediction

Wear is a crucial factor for determining the service life of agricultural implements. Together with its project partners, AC²T is searching for the optimal material for the proverbial "use in the field". For this purpose, wear tests in the laboratory and computer simulations were combined in order to enable a service life prediction for real operating conditions. With this Lab-2-Field environment the development process for wear-resistant tools/components can be significantly accelerated. New materials and their behaviour in real operation can be quickly evaluated and optimised by coupling a laboratory test with a wear simulation.

Wear behaviour – service life

Wear of tillage machinery and food processing equipment is of tremendous economic importance for the entire agricultural sector. Due to harsh environmental conditions (e.g., sand, gravel in the soil), alternating structure and composition (e.g., moisture, acidity, silicate content), mechanical and corrosion-related requirements often vary significantly and impose high demands on machinery components. These requirements are further rising by ever-faster processing speeds and increasing automation.

To meet the growing demands on cost-efficiency and sustainability, new methods of wear protection are required. Earlier investigations showed the possibility of increasing fracture resistance in order to prevent total failure during operation. This resulted in guidelines for the use of highly wear-resistant materials for tillage machinery (e.g., carbide-rich steel).

The aim of this project is to design the base material via different processes of massive hardfacing even more wear-resistant. This wear-resistant hardfacing layer – in contrast to hard coating, which is largely used for metalworking tools – is used in special applications for protection against extensive wear. An example of this is the laser cladding of a hard material in powder form which is selectively melted at the specific region of the tillage implement which are exposed to particularly high wear attack.

Simulation – experiment – validation – the Lab-2-Field approach

Since testing in the field is not only time-consuming and cost-intensive, but also – notably in the case of agricultural applications – limited to a few weeks per year, a Lab-2-Field approach has been developed which can make extremely reliable predictions for the wear and service life expected in the field application (see Fig. 1).

Initially, the wear rate of selected materials was simulated in a simplified wear test under laboratory conditions (friction wheel test according to ASTM G65). The same experiment was replicated in parallel by means of numerical simula-

tion in a virtual environment. Through this combination of experiment and computer simulation, a number of mathematical wear models could be verified and the corresponding wear rates were calculated.

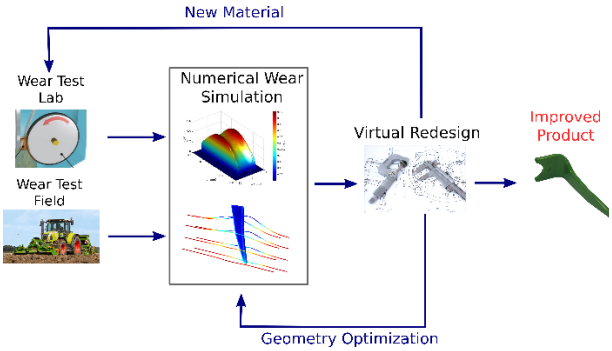

Fig. 1: Lab-2-Field diagram for service life prediction and optimisation

In a further simulation step, these wear models were applied to a real component – in particular the tine of a rotary cultivator. The major challenge was to map the mechanical stress exerted on the tine when plowing the soil as efficiently and in as realistic a manner as possible. For this purpose, a fluid-mechanical equivalent model for the soil was selected, i.e. the soil (clay or sand) was modelled as a so-called Bingham fluid. Bingham fluids are media such as ketchup or toothpaste, which begin to flow only after an initial mechanical stress – think of a ketchup bottle, which can be turned around without any leakage; only knocking on the bottle bottom makes the ketchup suddenly begin to flow.

With the help of the above-mentioned model, pressure distributions and velocity profiles could be determined for the real component and subsequently combined with the wear model verified on the test stand (see Fig. 2). Depending on the application or driving conditions, respectively, of the respective equipment this resulted in time-resolved wear intensities at the real component. In several computation steps successively material was removed from the interest in the last phase of the simulation and the wear progress was simulated. The calculated tine geometry matches very well with the measured geometry of a component used in the field.

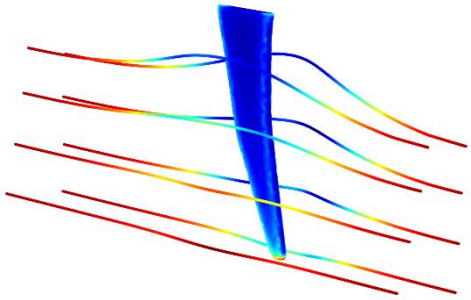

Fig. 2: Simulated pressure and velocity profile of the real component

Impact and results

With this Lab-2-Field development environment, wear components can be developed and optimised quickly and efficiently in the future. Both new wear-resistant surface layers can be quickly validated for their durability, as well as the geometrical design of the component itself.

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