Replacing Destructive Measurement of HPD

Hardening of steel is a common process to increase life time especially of strongly loaded contact areas of critical parts, like many kinds of bearings, rails or railway wheels. The hardness penetration depth (HPD) is crucial for the quality control. State-of-the-art are destructive tests where samples need to be cut in pieces for optical- and Vickers-tests. Laser Ultrasound (LUS) is an exciting alternative to state-of-the-art methods as it is a non-destructive and even non-contact technology, which allows to analyze samples still hot from the thermal treatment.

The most common hardening process is a heat treatment followed by quenching, which changes the microstructure at the surface of the steel down to a certain depth. It is of great interest for the quality control of the manufactured part to know this HPD. The state-of-the-art procedure to determine HPD is destructive, i.e. cutting the part to get access to the cross section, grinding and polishing the surface and then doing either an optical microstructure analysis or a classical hardness determination according to Vickers or Brinell. The result is HPD at one position of the cut cross section – only!

For many cases this destructive procedure can be replaced by LUS!

In principle, LUS is similar to commonly known ultrasonic techniques with piezo transducers. But it is fully contactless, broadband and delivers stable signals in industrial environment. Both, excitation and detection, are conducted by lasers. The advantages are obvious: a distance of several centimetres is possible, which allows for automation but also enables measurement on still hot samples. Thus this technique is very appropriate for the determination of the HPD: every single measurement gives an HPD value which enables a fast process for a complete volume!

Fig. 1 shows an etched micrograph image of a crankshaft (top) in comparison to a LUS result (bottom), which shows a very clear transition from the hardened area to the untreated material.

Fig. 1 Comparison of a stitched and etched micrograph of an inductively hardened crankshaft (top) and the respective laser ultrasound result (bottom).