Innovative Testing Concept of Cylinder Heads

The increasing demands for improving the specific power output of modern power-trains and for reducing the component weight via lightweight design, require detailed expertise about the damage mechanisms occurring under real service loading conditions. Taking into account requirements for accelerated, cost-effective component testing and damage analysis, IABG developed a new test stand for thermo mechanical fatigue testing of cylinder heads. Thereby, both the test and development process of cylinder heads may be accelerated significantly. The implementation of an in-situ crack detection system enables the investigation of crack initiation and propagation as well as a 24/7 service of the test stand.
Numerous failures of cylinder heads originate from cracks in the combustion chamber’s pent roof – induced by thermo mechanical fatigue. Critical areas are often valve reinforcing ribs, or spark plug/injector nozzle caps.

Under full-loading conditions, the pent roof is subject to high thermal input. In the formentioned critical areas this causes thermal expansion – which is simultaneously restricted by surrounding zones that are cooler and often more inflexible geometrically. Depending on the load conditions, the resulting compression stresses in these key areas may lead to local plastic deformation. Once the thermal input is then reduced, as a result of load reduction or even engine braking, where the injected fuel volume is removed and “cold air” ingested, strong tensile stresses can occur in these zones. This can lead once again to plastic deformation. As a result of the fact that compression stresses – i.e. negative stresses – occur at high temperatures and tensile stresses under low-temperature conditions. This kind of thermo mechanical loading is often referred to as “out-of-phase loading”.

High tensile stresses occurring in cool-down phases are often the main reasons of crack initiation and propagation in the above-mentioned areas, as a result of thermo mechanical fatigue. Some of these cracks may have the potential to extend as far as the coolant channels.