CADFEM Consulting

Thermo-Mechanical Analysis of a Cylinder Head

ANSYS CFD and FEM Analysis of a Marine Engine's Cylinder Head Considering Fluid Structure Interaction

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Task

Modern engine development needs to combine economical aspects with high technological standards. Aiming for consistent life durability, while achieving a more efficient design, weight reduction directly increases the economical efficiency in engine development. Durability analyses based on static and cyclic stresses considering the combustion cycle and its thermo-mechanical influence on the durability as well as static loads resulting from press fittings or pretension are performed to ensure the endurance strength of the engine.

Finite Element Analyses determine reliable thermo-mechanical stresses due to the compression process of the air-fuel mixture, combustion, exhaust outlet and the air fuel mixture inlet. Here the analysis considers the engine's cooling process in combination with the combustion cycle as well as the thermal interaction between fluid and structure within the cylinder head.

Fig. 1: MAN medium speed four-stroke engine; mainly used in cruise vessels, ferries and large multi-purpose freighters.

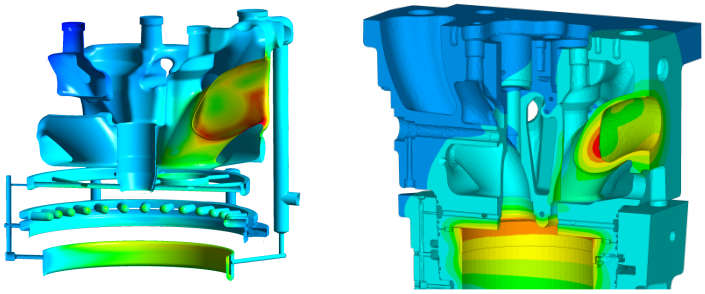

Fig. 2: CFD result of the temperature distribution of the cooling fluid (left) and temperature distribution within the structure after mapping from CFD to FEM (right).

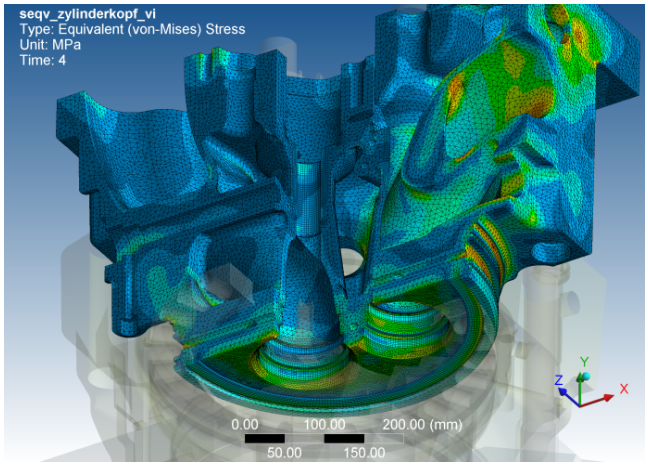

Fig. 3: Equivalent (von Mises) stress distribution in the cylinder head while complete combustion takes place within the combustion chamber.

Solution

A CFD analysis by ANSYS CFX covering the cooling and combustion process determines the thermal behavior within the engine and provides the basis used for a subsequent stress analysis. This mechanical analysis implies several load cases describing the combustion cycle as well as temperature dependent material properties and nonlinear contacts in a comprehensive finite element model (3,200,000 nodes and 60 nonlinear contact regions). Thermo-mechanical stresses within critical regions of the engine are determined for a subsequent durability analysis in a non-linear ANSYS FE simulation. Further results focus on the contact behavior and the deformation of specific parts and the entire model. The complex analysis of the engine behavior provides information about the contact pressure and possible gaps occurring within the combustion cycle. This information is used to rule out undesired effects on the thermo-mechanical behavior of the engine and its several parts already in the design phase.

Figures by Courtesy of MAN Diesel SE