MULTI-MATERIAL HEAT TRANSFER ANALYSIS OF AN ENGINE CYLINDER HEAD

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ABSTRACT

Significant effort is being spent to improve the power performance and fuel economy of IC Engines. As the loading capability of IC engines increases, the thermal and mechanical load increase rapidly. Another aspect is that the amount of CO_2 emissions per energy unit is relatively high from fossil fuels. Obviously, this is not desirable from the global climate perspective and has to be reduced.

One efficient way of reducing these emissions would be to replace fossil fuels with other fuels, such as biofuels. Another way is to find ways to increase the efficiency of the current internal combustion (IC) engines, leading to less CO_2 emission for each unit volume of fuel. One of the most important fields related to this objective is heat transfer analysis. From the heat transfer perspective it is of interest to reduce the heat losses in the engine in an attempt to achieve higher mechanical work output. CFD simulation is already an established approach in engine development especially in the component design phase.

The present study describes a novel approach of using multi-material heat transfer analysis for the prediction of temperature distribution in the solid structure of a research IC engine. This is an alternative method to the conventional fluid-solid (CFD-FE) coupling which is usually used for temperature distribution in solid structure and stress analysis. This proposed approach represents the simulation of the heat transfer within the cylinder head structure and its parts by considering the solid and fluid parts of the engine as a multi-domain. Heat exchange is determined depending on the engine operating conditions by considering the complete engine cycle on the gas side. This includes induction, compression and the expansion stroke. With this method the three domains approach is reduced to only two CFD domains where the finite element (FE) tool is no longer required. The CFD tool AVL FIRE is used instead and the simulation workflow is also simplified. A nucleate boiling effect is considered on the water side. A comparison between the conventional CFD-FE coupling method, multi-material CFD simulation and measurement is discussed at the end of the study.