NUMERICAL MODELLING OF TRAPPED AIR IN ENGINE JACKET COOLING SYSTEMS

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ABSTRACT

This presentation will detail an empirically validated CFD model for predicting the behaviour of trapped air in an engine's jacket cooling system at cold start following liquid filling.

The 3D model utilises an implicit unsteady, Volume of Fluid (VoF) solver to model the time dependant behaviour of phase interfaces in a simplified cooling channel geometry. The geometry is based on those commonly found to trap air in engine cylinder heads. Model outputs are validated both qualitatively and quantitatively against Particle Image Velocimetry (PIV) and High Speed Imaging (HSI) data, acquired in an identical rig geometry.

The presentation will provide a brief background to the subject of cooling system gases, including their sources, types and implications. The commercial need for the numerical model will then be presented and its subsequent build stages. These will include model setup, applied solvers and outputs.

The empirical modelling approach will also be summarised, reviewing how the geometry was manufactured, the boundary conditions defined and fluid circuit setup to generate them. The PIV and HSI data acquisition methods will be briefly reviewed and examples of result data presented.

The audience will then be taken through the stages of model validation. Initially, model outputs were verified through qualitative, visual comparisons between empirical and numerical results. Once a good visual match was achieved, a quantified assessment was carried out. For this, digital image processing in Matlab was performed, graphically comparing trapped air pocket size over the unsteady air entrainment process.

The validity of solver outputs will be discussed and their applicability to engine cooling system design. Model limitations are highlighted alongside alternative solvers which, in further work, could be investigated to improve model accuracy in certain flow conditions.

The presentation will provide the audience with a commercially adopted approach for modelling unsteady multiphase flows, advanced methods of model validation and the limitations of current multiphase solvers.

This talk will be given in the UK HPC Infrastructure track organized by the NAFEMS HPC Working Group.

SUGGESTED THEMES

Engine Cooling Systems, Fill Entrapped Air, Multiphase Modelling, CFD Model Validation, Particle Image Velocimetry, High Speed Imaging.