Effective Thermal Conductivity of Trapped Fluids

Abstract

Study of trapped fluids has some important applications in Oil&Gas industry. In the subsea Oil domain, the thermal analysis of Wellhead and Manifolds is performed to study the temperature behavior after the main oil valve is closed/opened. The main purpose is to study hydrate formations. These components have a lot of annular spaces which contain trapped fluids mainly sea-water. Therefore, thermal behavior of these trapped fluids is of importance. The trapped fluids generate natural convection currents called as Benard cells, which assist the transfer of heat. It is computationally too expensive to simulate this convective heat transfer by performing Computational Fluid Dynamics, therefore a simpler and computationally less costly method can be used.

In general, when there is no convection, the fluid will behave as a solid with the fluid's conductivity. But with convection, there is additional heat transfer. In order to account for this additional convective heat transfer, the fluid is treated like a solid but is assumed to conduct heat with a higher conductivity called as 'Effective Thermal Conductivity'. This parameter depends on various parameters such as Prandtl Number, Grashof Number, Geometrical Dimensions, and Orientation to name a few. The relations of relating these parameters with the effective thermal conductivity are mainly empirical in nature.

In the final presentation, I wish to present these relationships and explain their practical importance while performing Thermal Finite Element Simulation. The idea of doing iterative simulations in order to achieve convergence in the temperature dependent terms in Thermal Conductivity will be explained in depth. Also the errors in this method and the limitations of this method will be described. A few comments would be mentioned about the advantage in computational time that this method gives versus performing actual Computational Fluid Dynamics.

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