Numerical study on the heat transfer characteristics of oscillating flow in Cryogenic regenerators

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Abstract

In this project, the flow and heat transfer characteristics have been studied for an **oscillating flow regenerator**. An oscillating flow regenerator is a device (heat exchanger) which intermittently stores heat and then gives it back in the same periodic cycle. This can be seen extensively in the Stirling cycle, where the pressure variation can be modelled using a sinusoidal function.

The devices used today operate at frequencies ranging from 10 Hz to 120 Hz, but the analytical modelling of regenerators are very limited in literature. The important parameters we are interested in, is the study of drag coefficient for a steady flow simulation, which is dependent on the Reynolds number and the porosity of the wire packing. The Reynolds number for such mediums has been calculated using order of magnitude analysis. Further, Nusselt number and temperature profile has to be studied for a fully developed flow through the regenerator.

For this project, I have used OpenFoam to simulate the flow and heat Transfer. The *buoyantPimpleFoam* solver has been used to study the transient profile of the velocity and temperature, while the density changes with temperature have been neglected. The simulation is carried on for a cryogenic fluid, Liquid helium. The flow is assumed to be laminar for the experiment and *swak4Foam* has been used to set the user-defined functions at the inlet (for inlet velocity) and at the outlet (for outlet pressure).

The purpose of this endeavor is to study the several of Nusselt numbers at higher frequencies and also the trade-off between heat transfer and frictional losses as we increase the porosity of the medium.

Domain

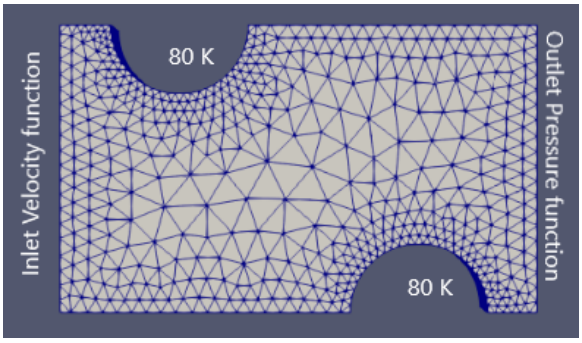

Fig 1 *– Unit block*

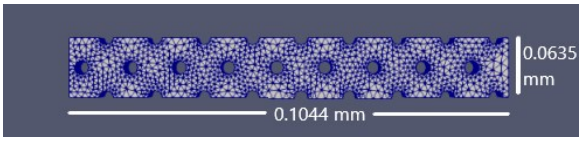

Fig 2 *– 9 such unit blocks*

The entire geometry has a dimension of 0.1044 mm × 0.0635 mm. For better results, the number of cells consider are 6214. Other meshes have also been taken into account, with the number of cells as 3407 and 1725 cells. Fluid enters with a user-defined function determining the velocity, which is sinusoidal with the simulation *runtime().* Critical Reynolds number for the above porosity is around 107.

Reference – Cryogenic journal 2018 – pages 99-107
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