Interaction between a turbulent flow and heat transfers in high temperature solar receiver

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Strong temperature variations can appear in a receptor of solar power plan which induce significant changes of the fluid properties. In order to prevent these phenomena and to understand the impact of thermal gradients, we perform numerical simulations on a turbulent channel flow with imposed wall temperatures and friction Reynolds numbers of 180 and 395

In a first time, in order to study the abilities and limits of the thermal RANS models using a commercial code, we realised theses simulations with Fluent. Results on mean velocity and temperature fields were compared to direct numerical simulation (DNS) of the literature data. For the isothermal case, we found a good agreement using the RNG k-ε model and Reynolds Stress model (RSM) with enhanced wall treatment. At the opposite, the non-isothermal cases, with weak and strong temperature gradients, showed that Fluent was unsuccessful - even using Large Eddy Simulation (LES) recently developed in the fluent software - to simulate the temperature effect on the fluid properties and the consecutive effect on the velocity. We noticed that higher is the gradient effect, higher is the error between Fluent results and literature data.

We deduced of this study that we must use more precise Computational Fluid Dynamics (CFD) software (which requires additional memory and CPU time). We considered the low Mach number equations and carry out Large Eddy Simulations using Trio_U software - developed by the CEA-Grenoble. These LES simulations were validated by comparisons with DNS data, for both the isothermal and non-isothermal cases. The first analysis of the temperature gradient effects showed a dissymmetry appears in the mean velocity and temperature profiles and a strong effect on the turbulent parts.

Perspectives of this work are a spectrum analysis, a spectrum study of the local entropy production and to take into account radiative heat transfers.