FOSSEE, IIT Bombay
OpenFOAM Research Migration Project
April 21, 2022

Numerical Simulation of a food Sterilization Process involving Natural Convection Heating.

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Synopsis

In this research migration project, the Natural Convection heating-based sterilization process of canned liquid food was numerically studied, and the transient temperature and velocity profiles were generated. The temperature profiles were used to determine the time taken by the **Slowest Heating Zone (SHZ)** of the can to reach the sterilization temperature ($T_s = 100°C$), while the velocity profiles were used to track the motion of the SHZ inside the can.

The can is $0.107\,m$ tall and has a radius of $0.0419\,m$. It is heated from the cylindrical and bottom surfaces by condensing high pressure steam at a temperature, $T_c = 121°C$. Since the geometry (cylindrical can) and the external conditions (heat sources) are **axisymmetric**, the problem can be solved in two dimensions.

Water was used as the simulation fluid because it is the major constituent of many liquid foods. Its viscosity varies with temperature, and the variation was modelled using a polynomial equation ($\mu = aT + bT^2 + cT^3$). Similarly, the density variation was modelled using the **Boussinesq's approximation**. All other thermo-physical properties of water were assumed to be constant. For simulating the turbulence, the $k - \omega$ SST model was chosen over others owing to its reliability in both free stream and near wall regions.

The simulation was performed on **OpenFOAM v2012** and the data was post-processed on **ParaView 5.9.0**. The transient **buoyantBoussinesqPimpleFoam** solver was used for the simulation owing to its ability to accurately simulate buoyancy-driven turbulent natural convection flows. The results obtained by Ghani et. al.[1] using the commercial CFD code **PHOENICS** were used as a reference to assess the accuracy of the current simulation.

References

[1] AG Abdul Ghani, MM Farid, XD Chen, and P Richards. Numerical simulation of natural convection heating of canned food by computational fluid dynamics. *Journal of Food Engineering*, 41(1):55–64, 1999.