UNIVERSITY OF EXETER

Knowledge Transfer Partnerships

Ginsters of Cornwall real honest food

Investigation of cooling process using CFD

Outline

- The aim of the project
- CFD Approach
  - Estimation of the current set up
  - Mathematical Models
  - CFD approach: validation of solvers
- Summary

Aim and motivation

- Investigation of cooling process in spirals using CFD

- Motivation:
  - Reduction in energy consumption
  - Increasing productivity
  - Product exportation possibility
  - Improving spirals environment

Estimation

- Current facts on spiral (ambient)

  Flow rate $\approx 10\ m/s$

  Volume of air injected $6\ m^3/s$

  Total volume $6\ \times 5400\ (90\ \text{minutes}\ ) = 32400\ m^3$

  $\approx 3.6\ m^3/s$ for each pasty

- Pasty cooling requirement

  Total surface of a unit product $\approx 0.03\ m^2$

  Required air volume for cooling $\approx 0.3\ m^3\ /s$

we could cool 12 units!!!

Mathematical models

- Navier-Stokes equations for flow

$$\frac{\partial\rho}{dt} + \rho(\nabla \cdot \boldsymbol{u}) = 0$$

$$\frac{\partial(\rho\boldsymbol{u})}{dt} + \nabla \cdot (\rho\boldsymbol{u} \times \boldsymbol{u}) = \boldsymbol{\nabla}P + \nabla\tau + \rho\boldsymbol{g}$$

- Transport equation for heat transfer

$$\frac{\partial T}{\partial t} + \boldsymbol{u} \cdot \nabla T = \alpha\Delta T$$

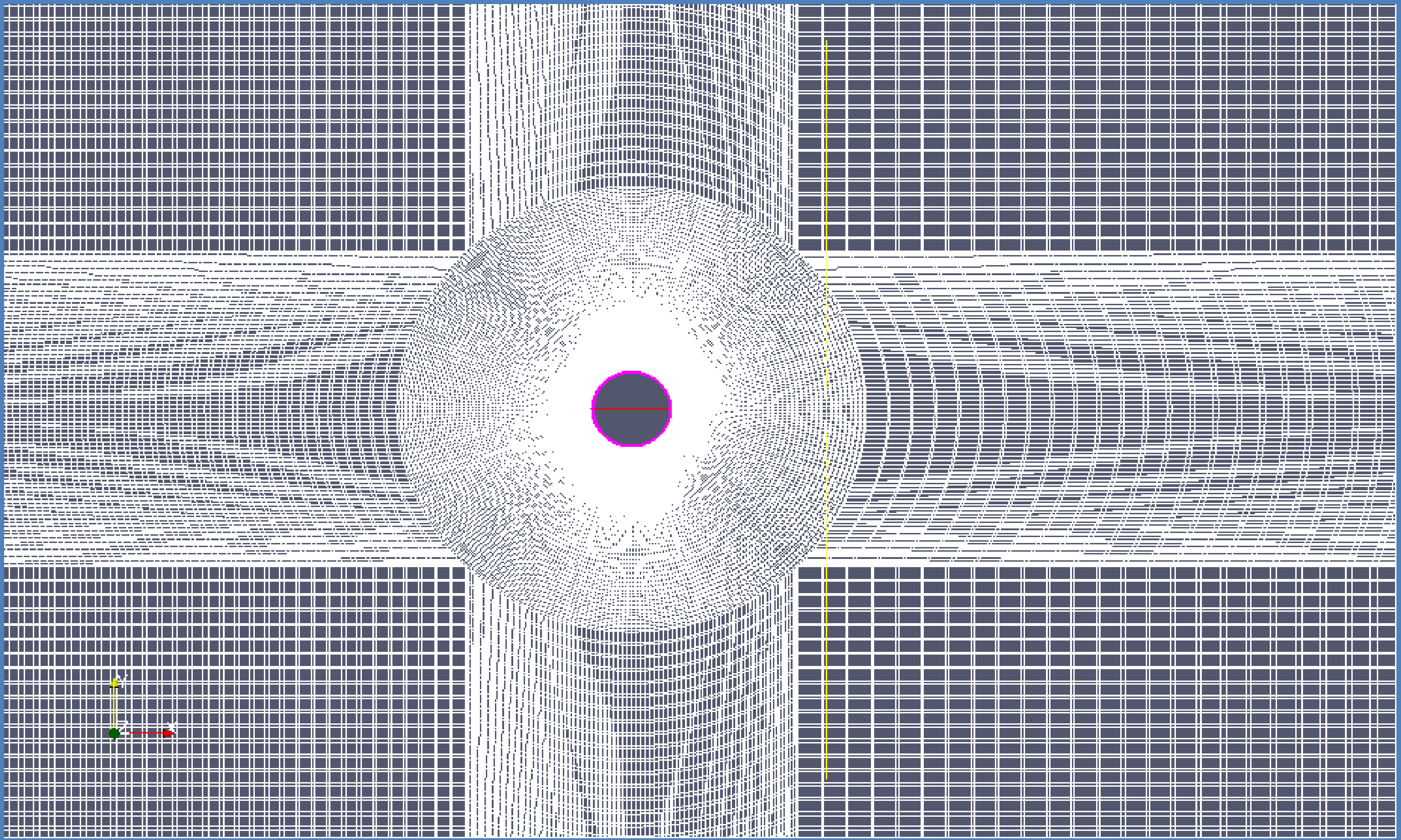
CFD approach

- Why CFD?
  - Computer based experiments
  - Low cost and applicable to most of the cases
  - Credibility of CFD solution?
- Mesh generation (pre-processing): Discretization of the domain into small sub-volumes (cells)
- Approximation of Mathematical models: Finite difference, finite volume or finite elements
- Post processing: Analysing and interpreting data
- OpenFoam converts the equations into algebraic equation: $A\,V = B$

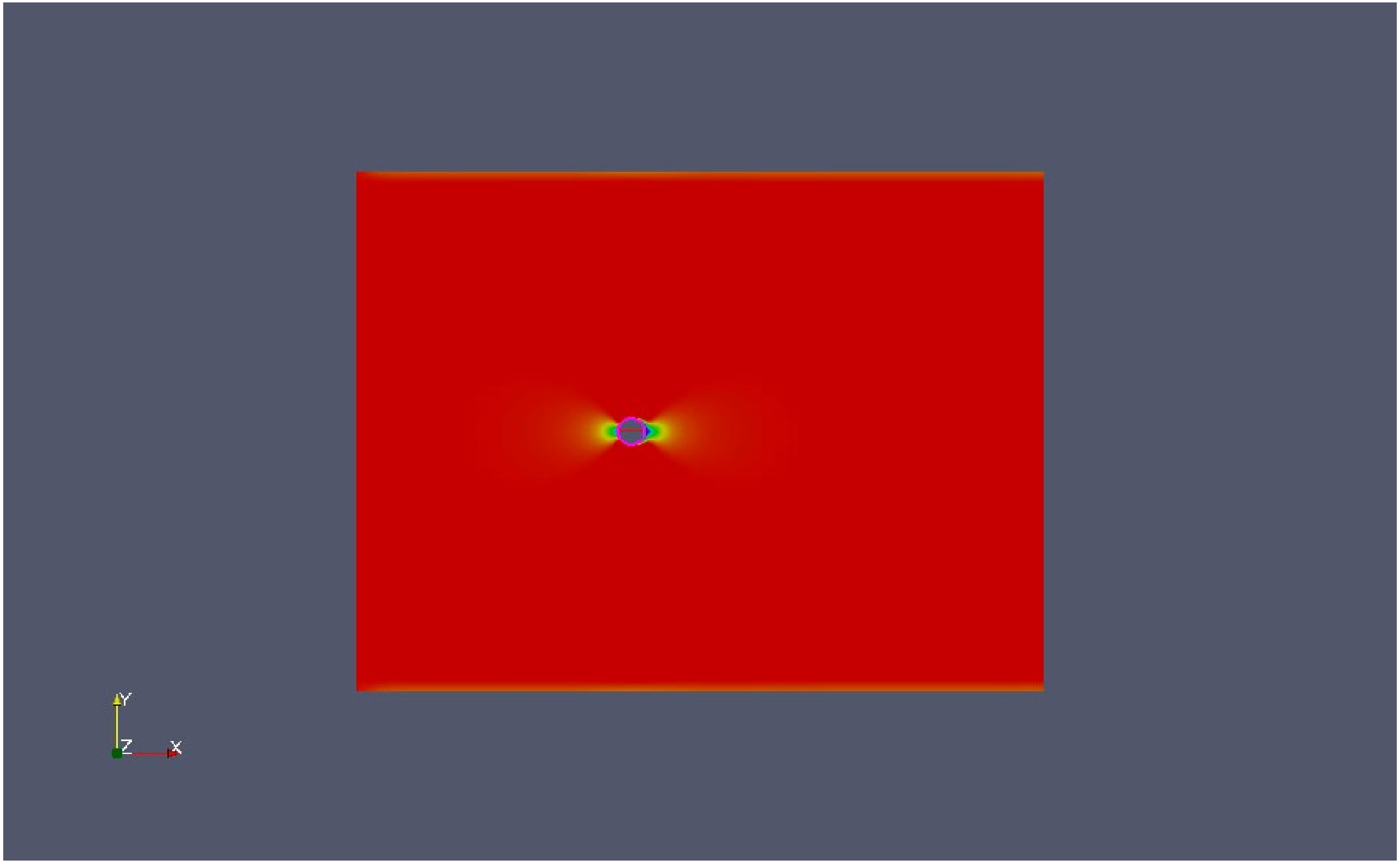
Validation of OpenFoam

- Hydrodynamic Solver

  Incompressible flow around cylinder



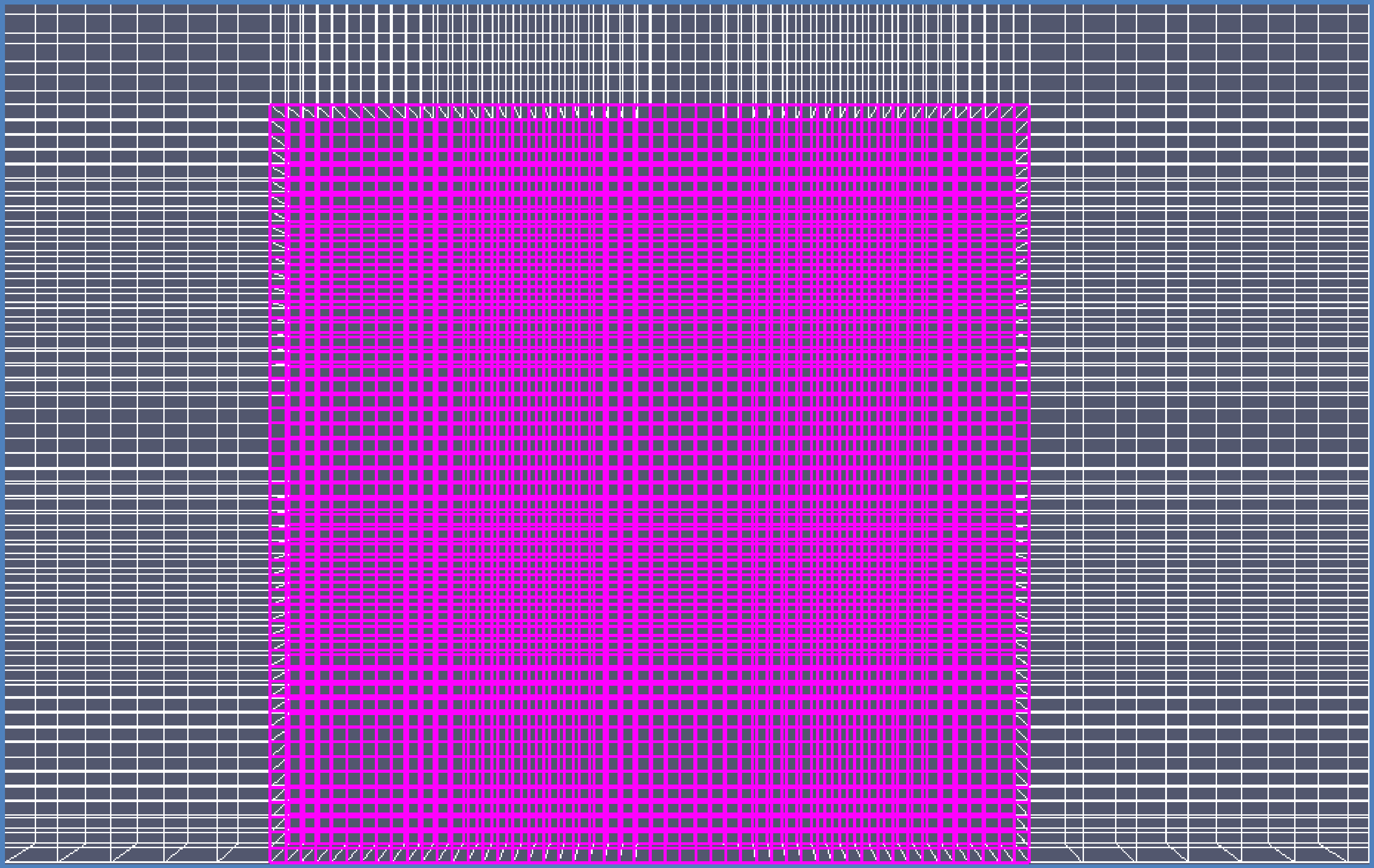
Validation of OpenFoam



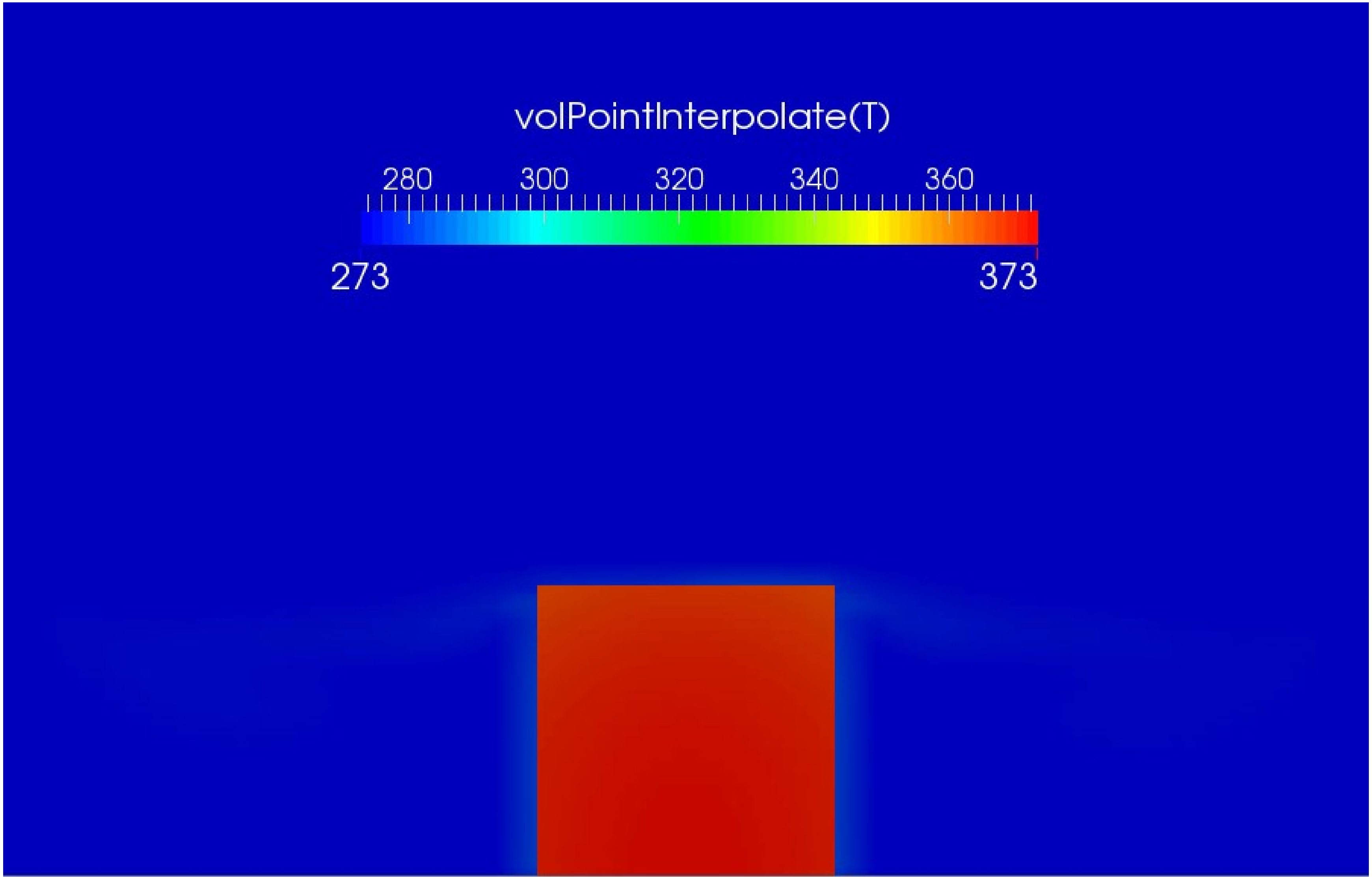
Validation of OpenFoam

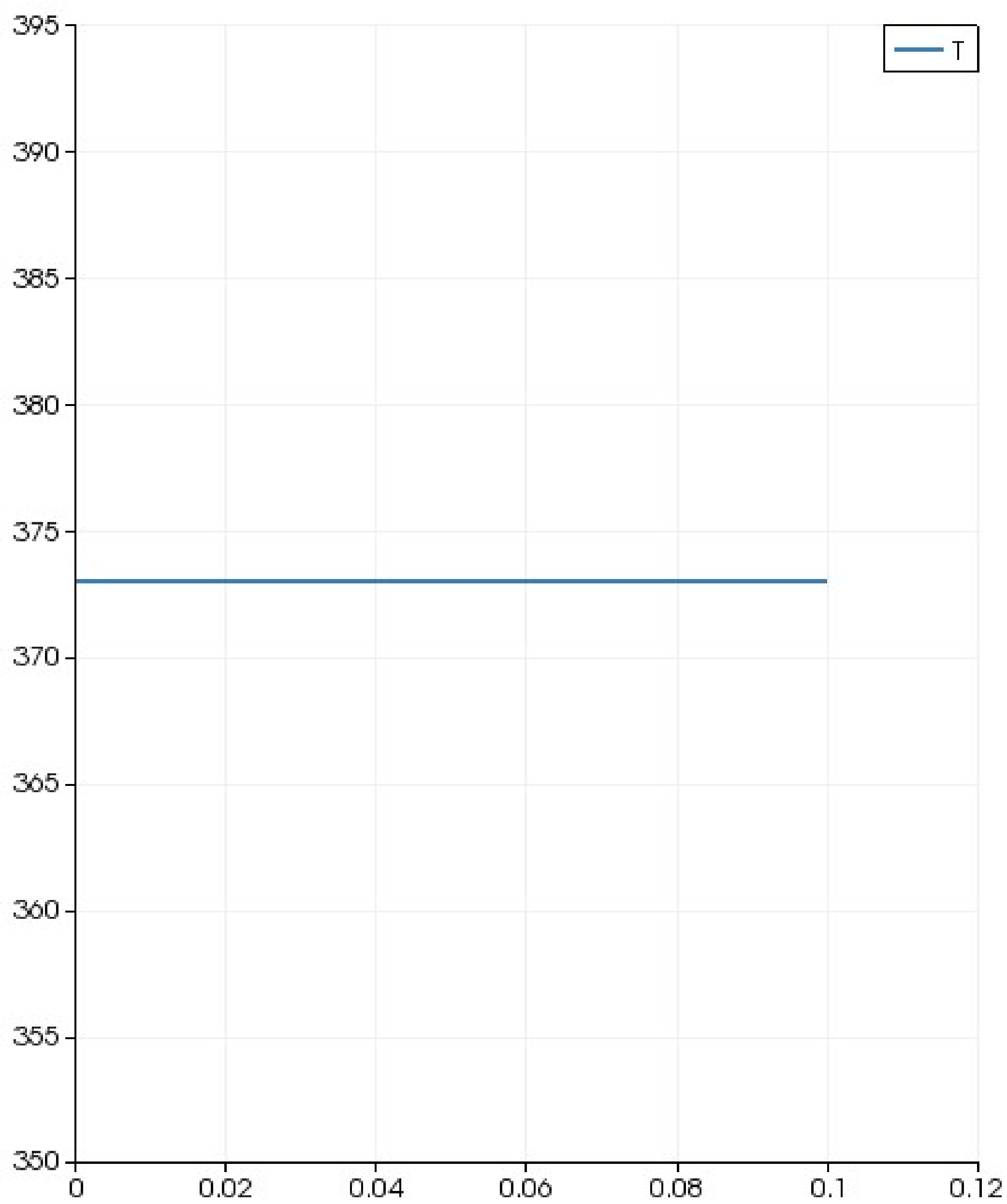
- Heat Transfer Solver

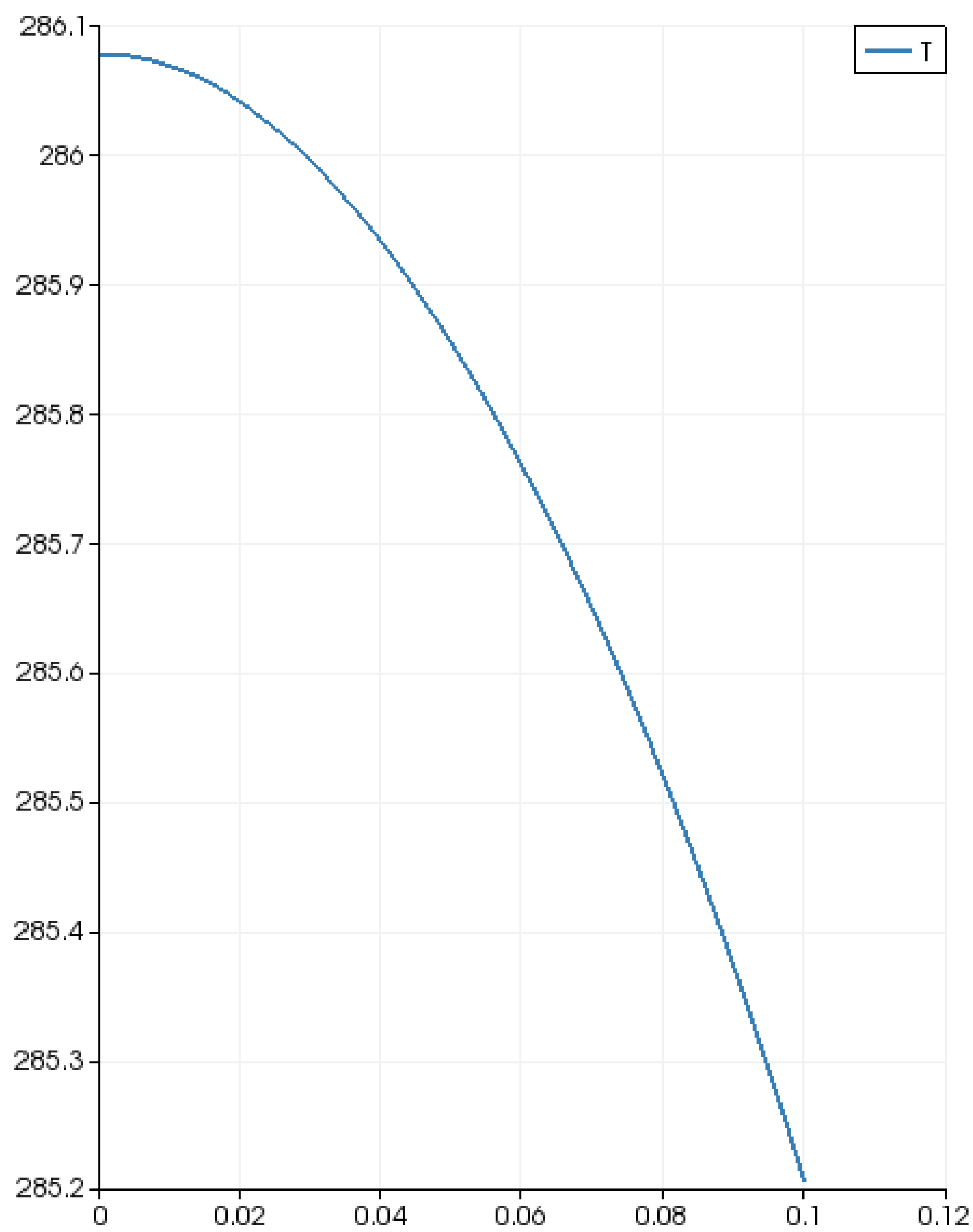
  Cooling rectangle metal



Animation







Temperature distribution profile in solid box from the bottom to the top at t=0 s

Temperature distribution profile in solid from the bottom to the top at t=4.7 S

Summary

- Solvers reproduce flow behaviour and show heat extracting from a solid
- Investigation of the coupled hydrodynamics-Thermal solvers
- Applying it to pasty (model)