Example: Inertia Mixing of Liquids

Elmer Basic Course

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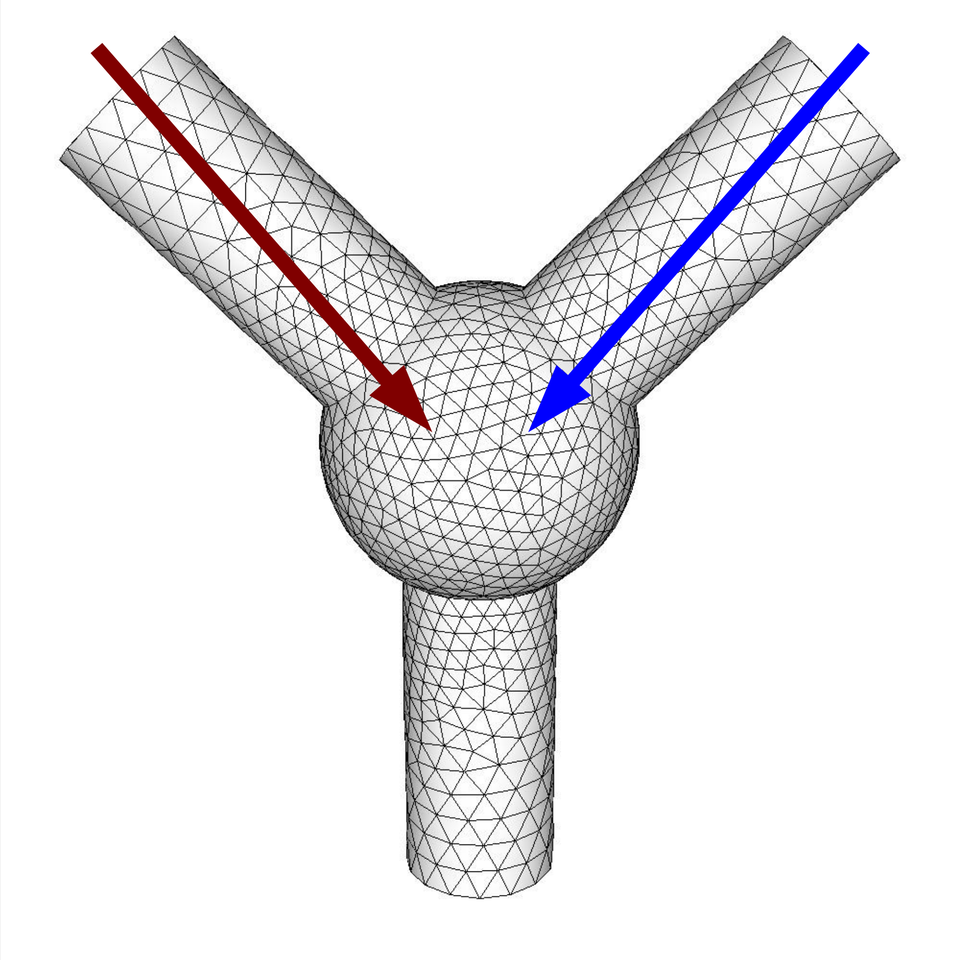
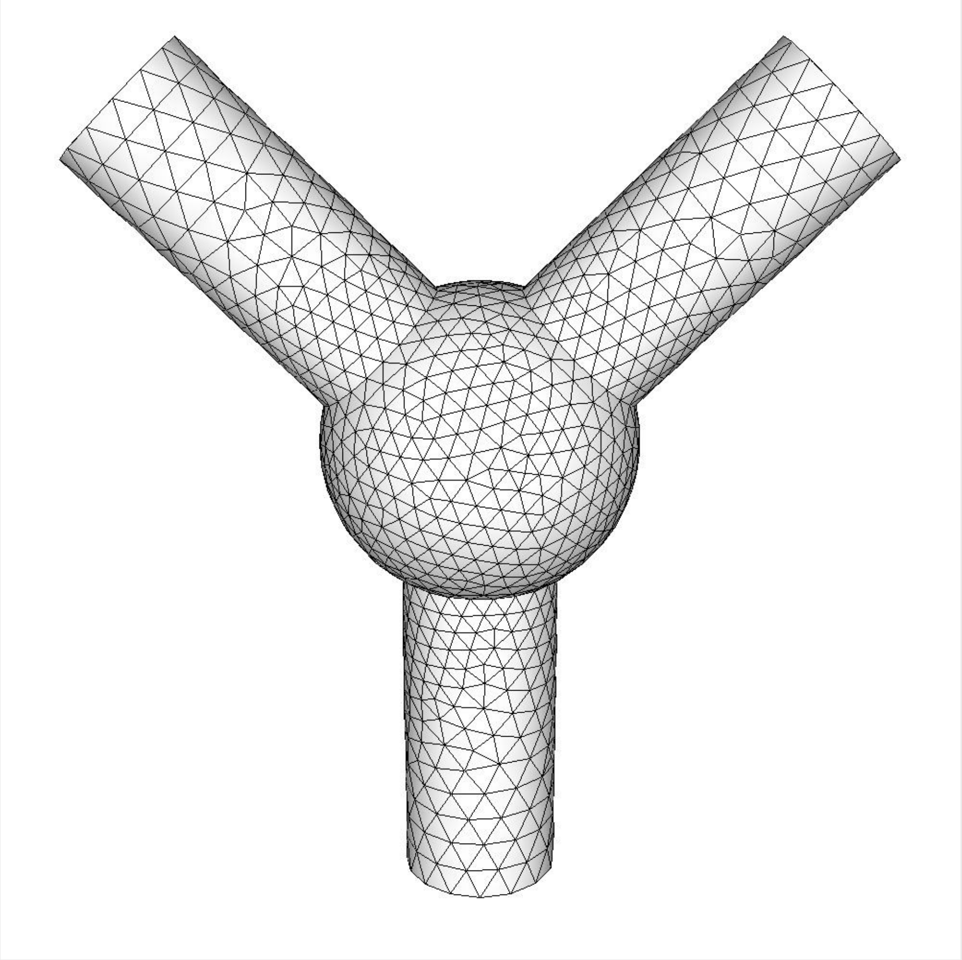
Problem Outline



- **Geometry:**
  - Sphere of radius 2 cm
  - 3 pipes of diameter 2 cm and 4 cm lenght
- **Mixing of different temperature:**
  - Inflow “hot”: v=10 cm/s, T=90 °C
  - Inflow “cold”: v=20 cm/s, T=20 °C
  - Walls: no-slip and T=20 °C
- **Material parameters:**
  - ρ= 1000 kg m^{-3}
  - μ= 1 kg m^{-1} s^{-1}
  - c=1000 J kg^{-1} K^{-1}
  - κ=0.1 W m^{-1} K^{-1}
- **Steady state solution**

Mesh Generation

- **Mesh has been created in commercial pre-processor Gambit**
  - Outputformat: Fidap-Neutral
  - CAD-format: IGES, STEP
- **Create mesh from Fidap-Neutral:**
  - Using ElmerGrid (pre-view):
    ```
    ElmerGrid 7 3 mixer.FDNEUT
    -order 0.1 0.01 1.0
    ```
  - ElmerSolver mesh:
    ```
    ElmerGrid 7 2 mixer.FDNEUT
    -order 0.1 0.01 1.0
    ```



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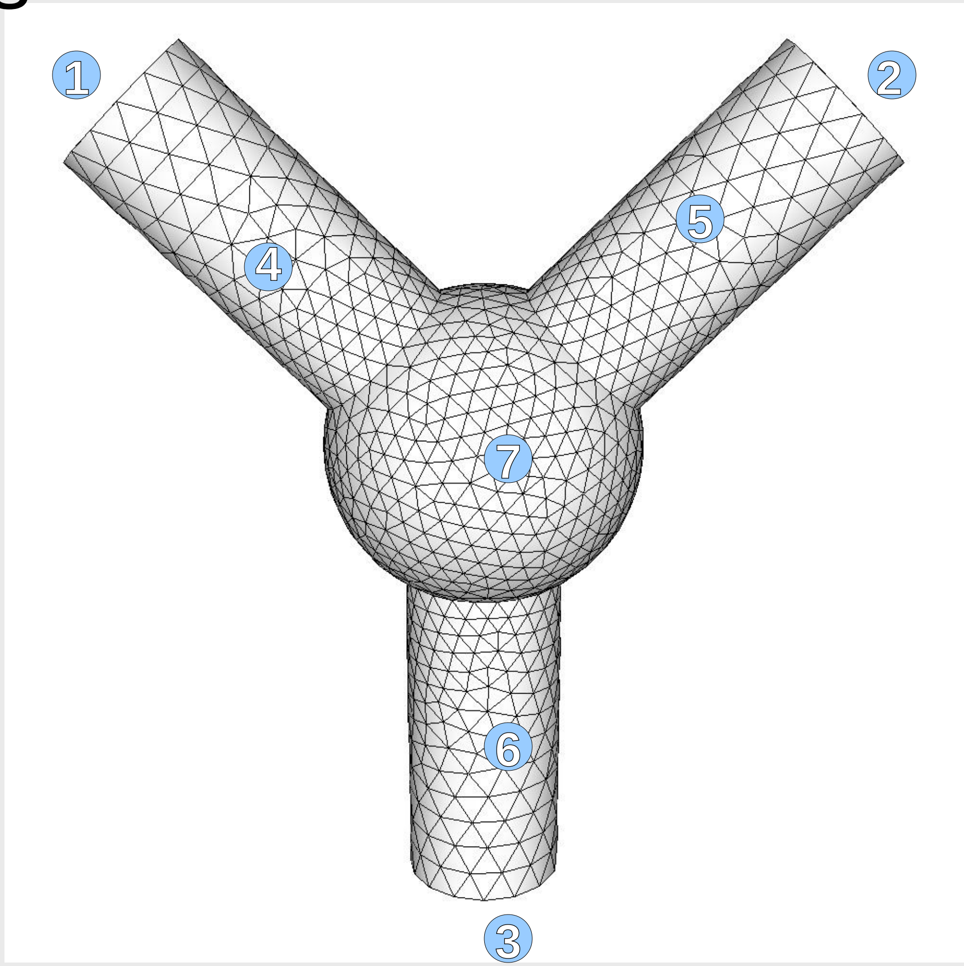
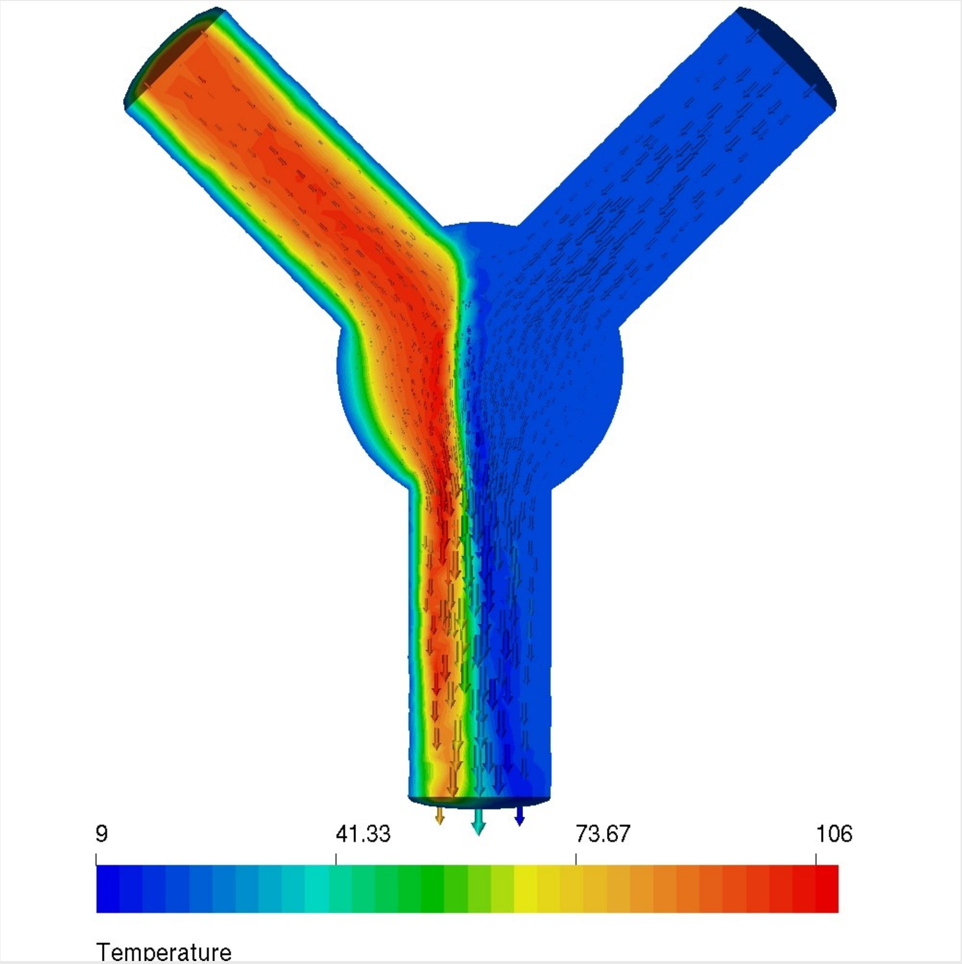
Boundary Conditions

- **Initial Condition**
  `Velocity 1/2/3 = 0.0`
  `Temperature = 50.0`
- **Inflow “hot”:**
  `Temperature = 90.0`
  `Normal-Tangential Velocity = True`
  `Velocity 1 = -0.1`
- **Inflow “cold”:**
  `Temperature = 20.0`
  `Normal-Tangential Velocity = True`
  `Velocity 1 = -0.2`
- **Outflow:**
  `Normal-Tangential Velocity = True`
  `Velocity 2/3 = 0.0`
- **Sidewalls:**
  `Target Boundaries(4)= 4 5 6 7`
  `Velocity 1/2/3 = 0`
  `Temperature = 20.0`



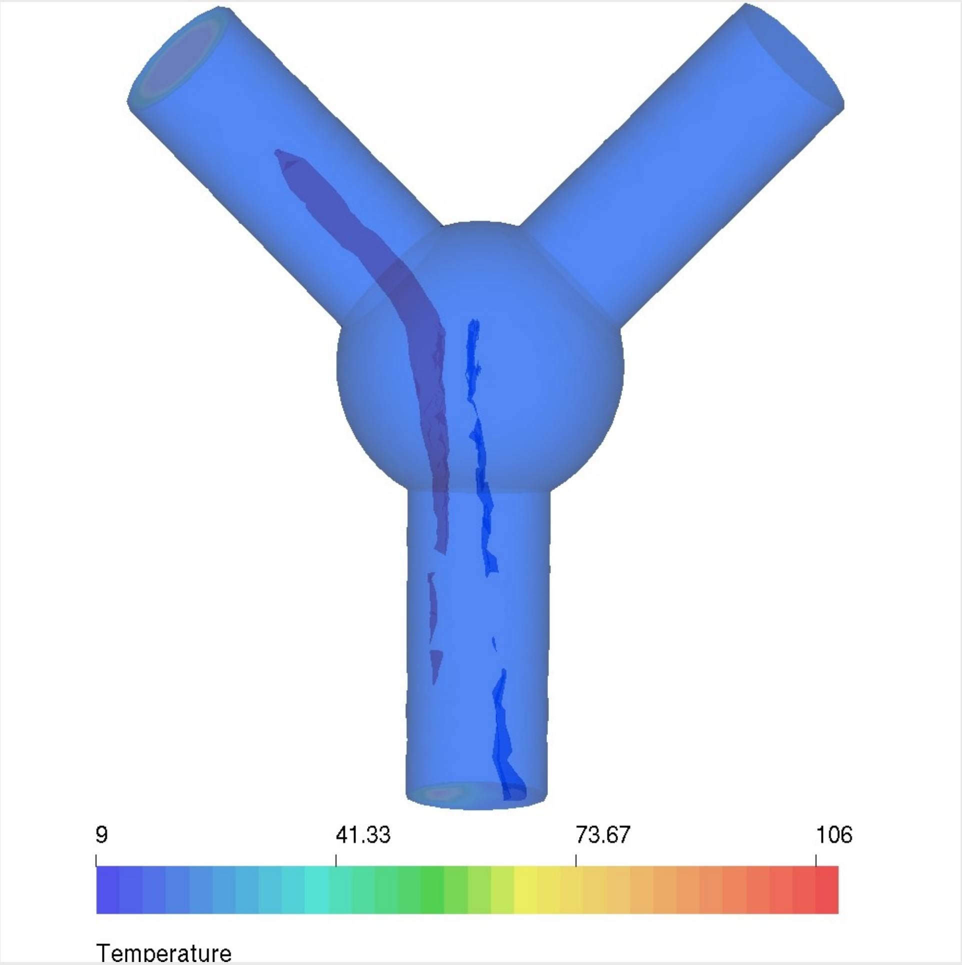
Result

- **Not really mixing!**



Result

- **Not really mixing!**
- **Why is Temperature < 20 and > 90?**
  - Numerical issue?!
  - Or is it thermodynamics?!
- **Try with …**
  - A finer mesh
  - Adiabatic walls



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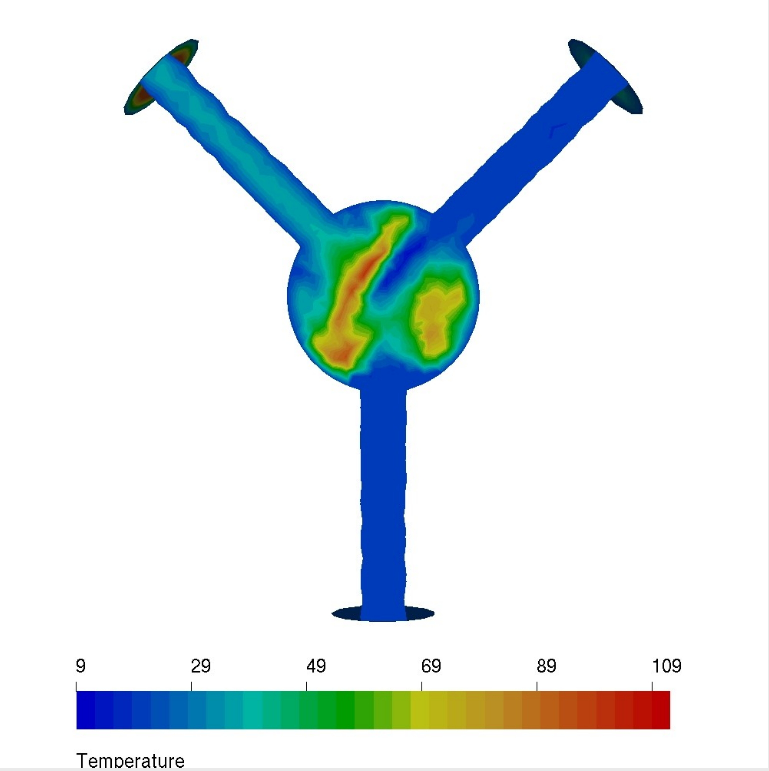
Exercises

- **Interchange the boundaries 2 and 3 and decrease the viscosity** μ= 0.01 kg m^{-1} s^{-1}
  - Better mixing because of geometry and lower viscosity (try with old viscosity)



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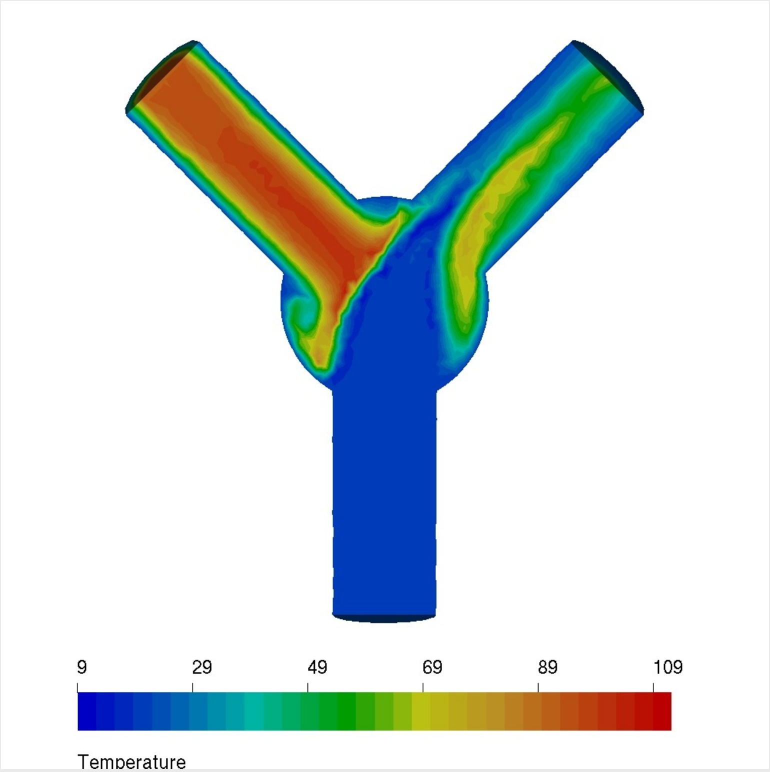

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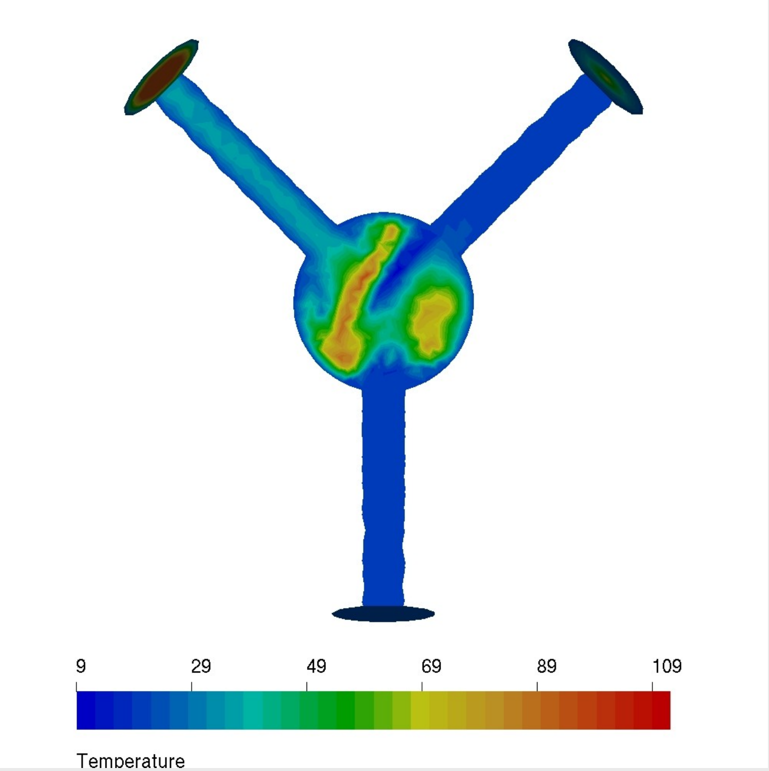

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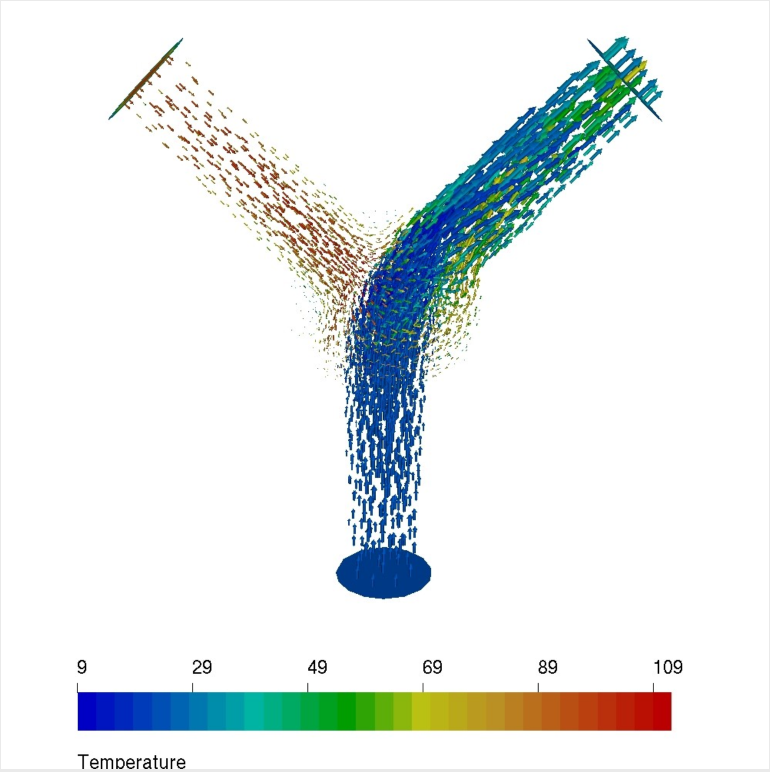

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- **Do a time dependent run with the previous settings:**
  - **What would be a good size for the time-step?**
  - **When will the steady state be recovered?**

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Timestep Intervals = 50
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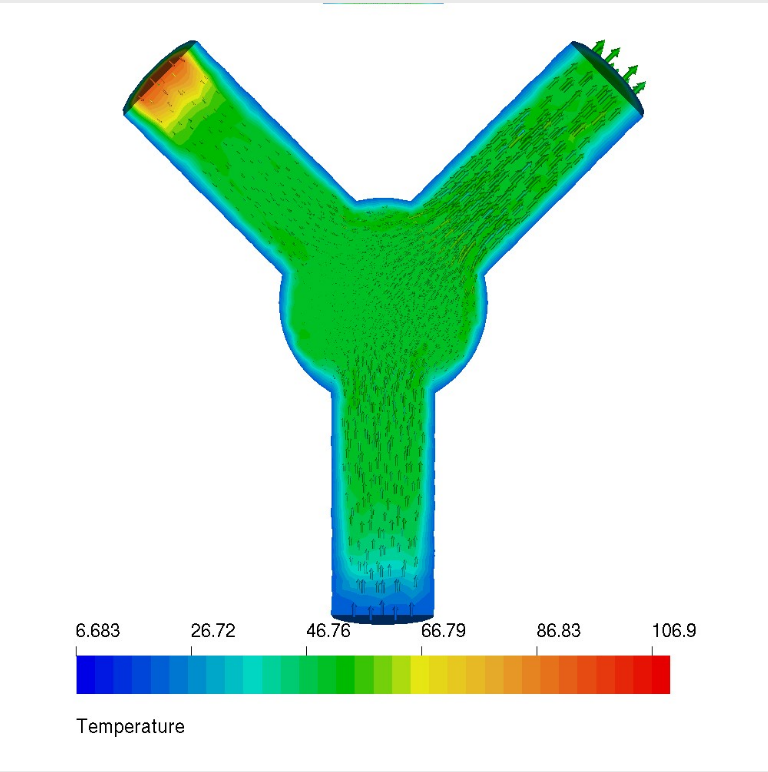

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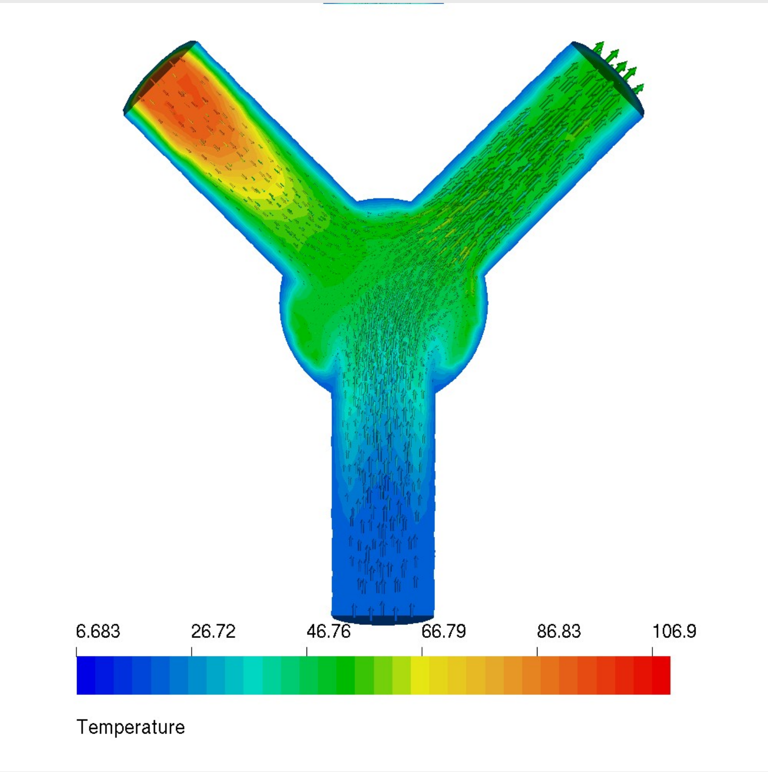

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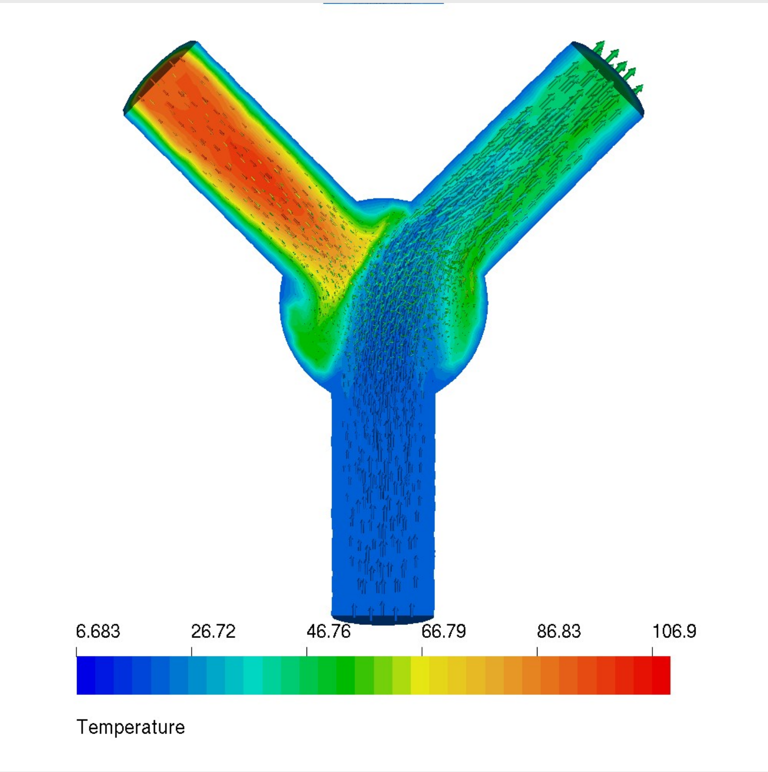

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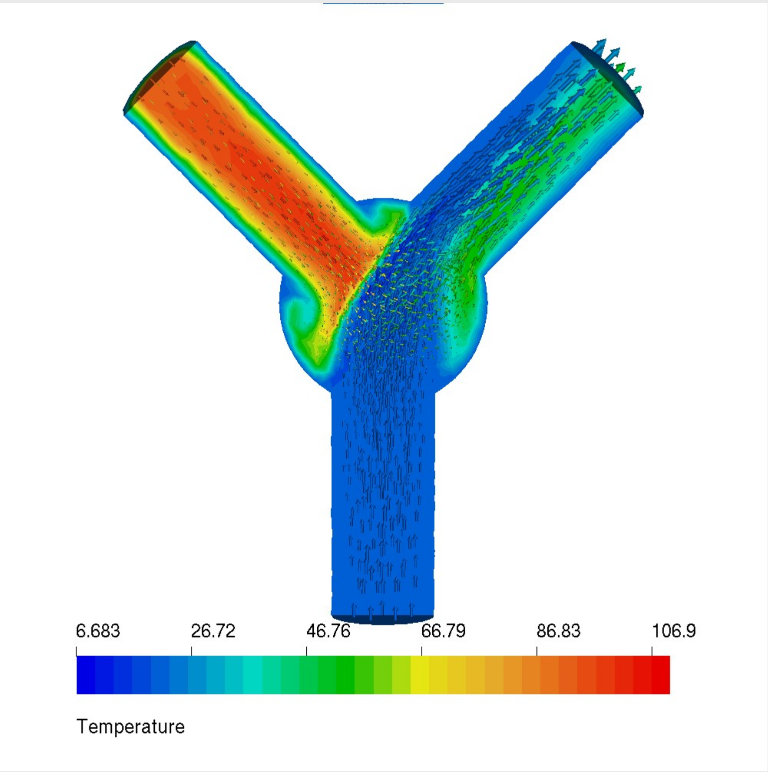

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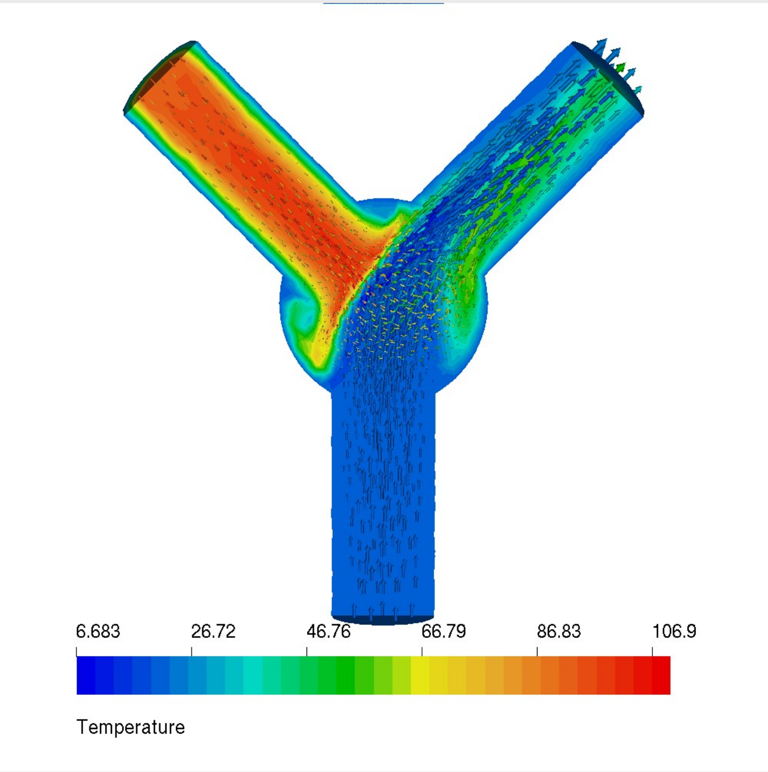

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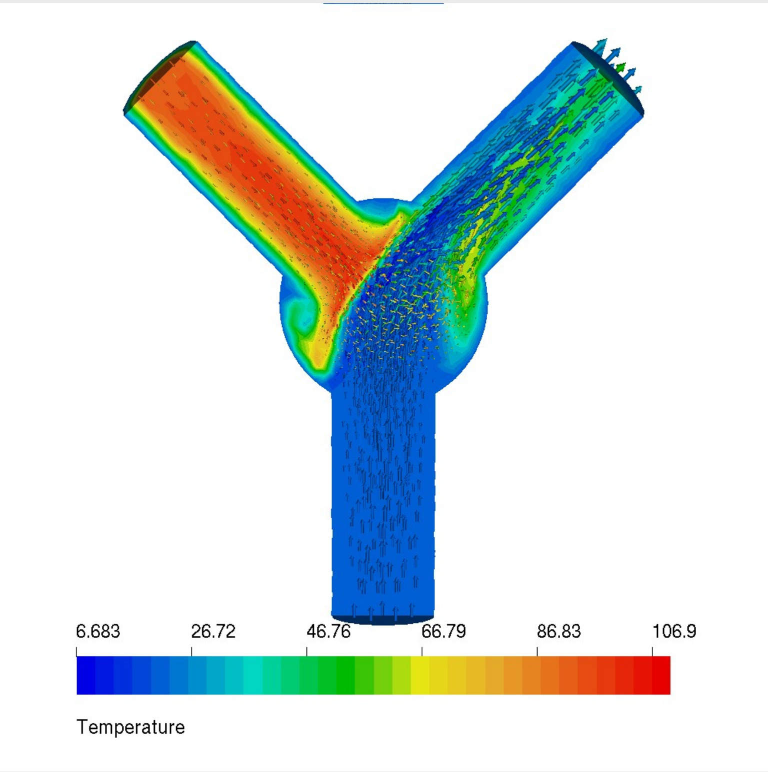

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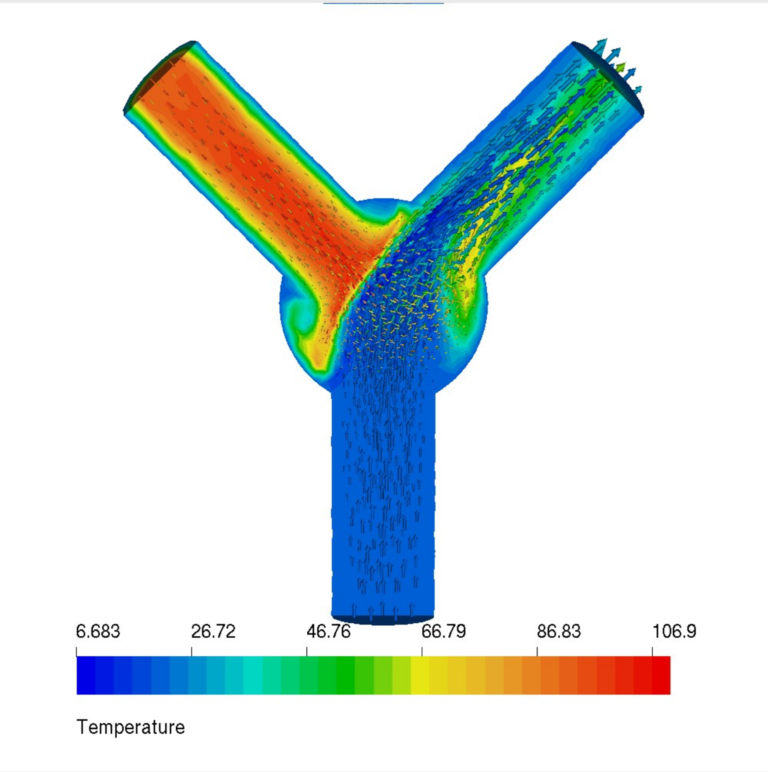

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