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Normal and abnormal states investigation of molten salt experimental loop using CFD

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Research Centre Řež

- **Established 2002**
- **Part of the UJV Group**
- **Two reactors: LVR-15 and LR-0**

Figure 1: Nuclear research complex, Řež, Czech Republic.

Experimental Molten Salt Loop - MSL

Purpose:

- **Material research**
- **Components development**
- **Methods testing**

Data:

• **Dimension**	**2.5 x 1.0 m**
• **Volume**	**3.7 dm³**
• **Operating temp.**	**700 °C**
• **Salt used**	**FLiBe**

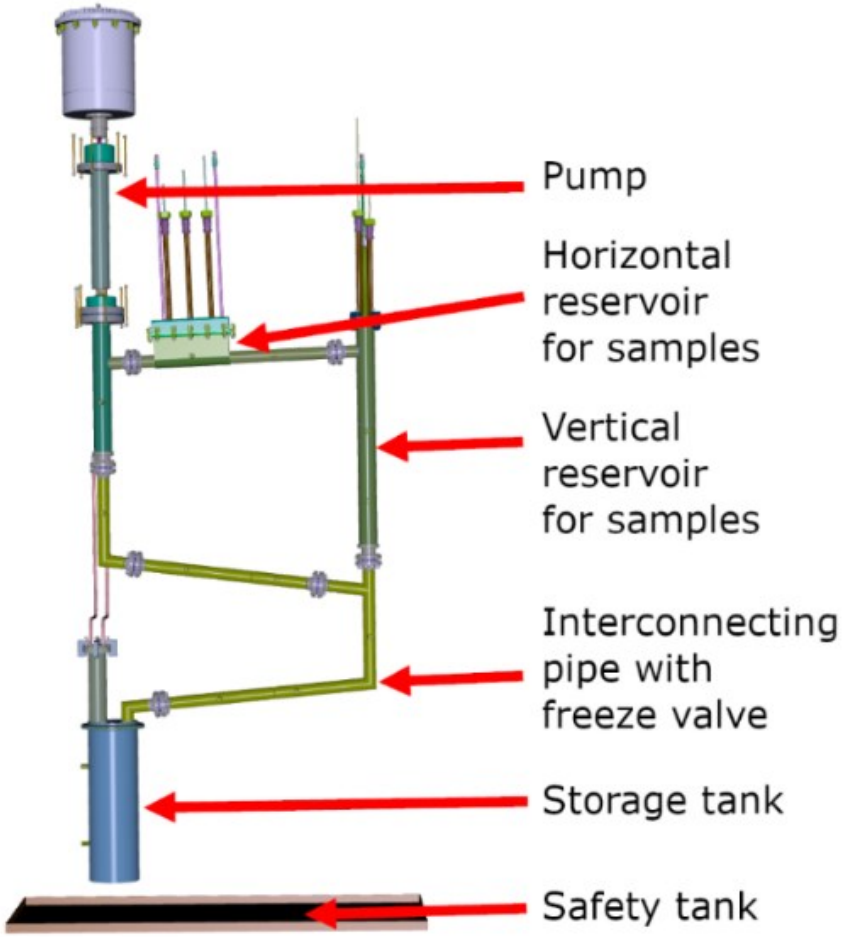


Figure 2: Diagram of experimental loop MSL.

Numerical model

Orthogonality:

- **0.311**

Skewness:

- **0.6997**

Aspect ratio:

- **30.9**

Cells:

- **352 884**

Faces:

- **1 965 754**

Nodes:

- **1 434 429**

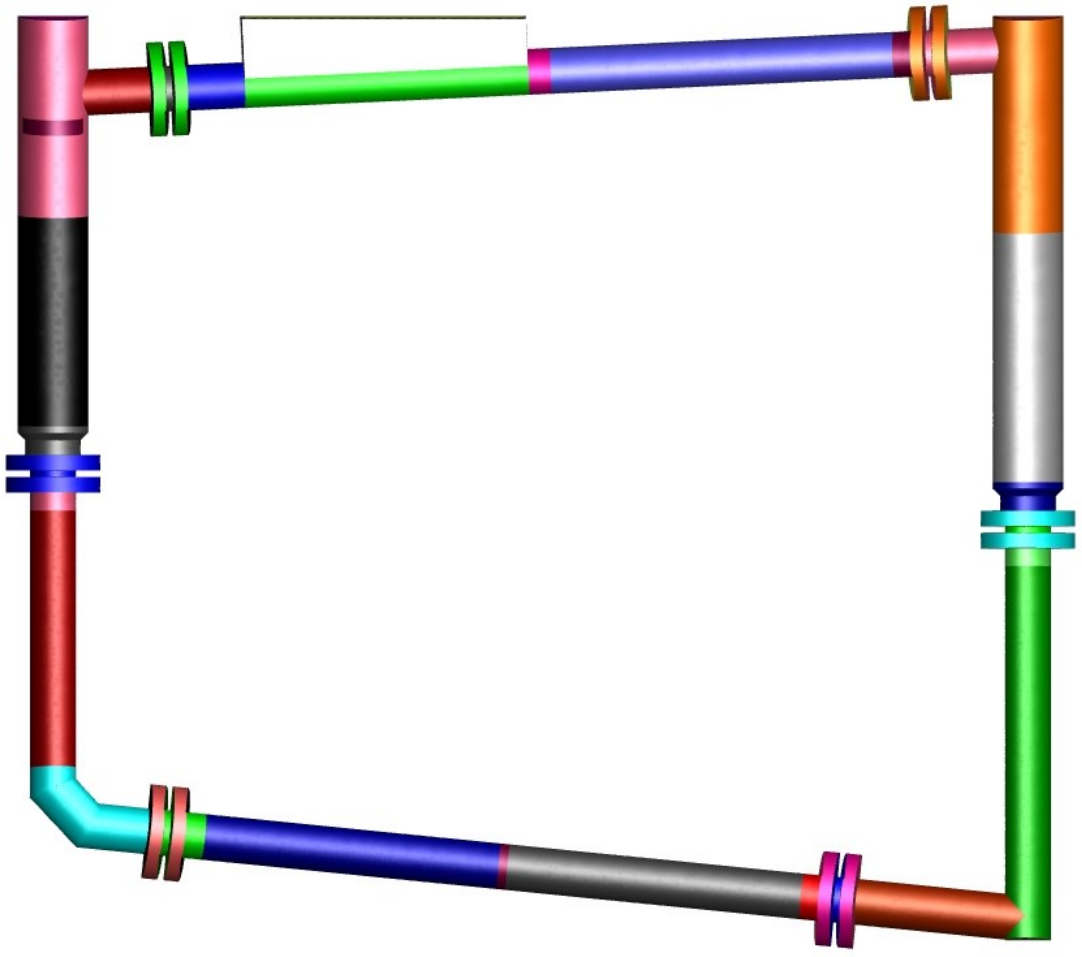


Figure 3: MSL loop numerical model in Ansys Fluent.

Mesh quality sensitivity analysis

			1x	2x	5x
Average Temperature	$\overline{T}$	°C	699,7	699,8	699,9
Maximum Temperature	T_{min}	°C	719,2	720,0	719,9
Minimum Temperature	T_{max}	°C	681,1	681,4	680,7
Enthalpy	h	J	5 729 500	5 714 243	5 719 703
Mass Flow Rate	$\dot{M}$	$g \cdot s^{-1}$	10,577	10,592	10,591

Table 1: C8 configuration results for different mesh densities.

Heat transfer coef. sensitivity analysis

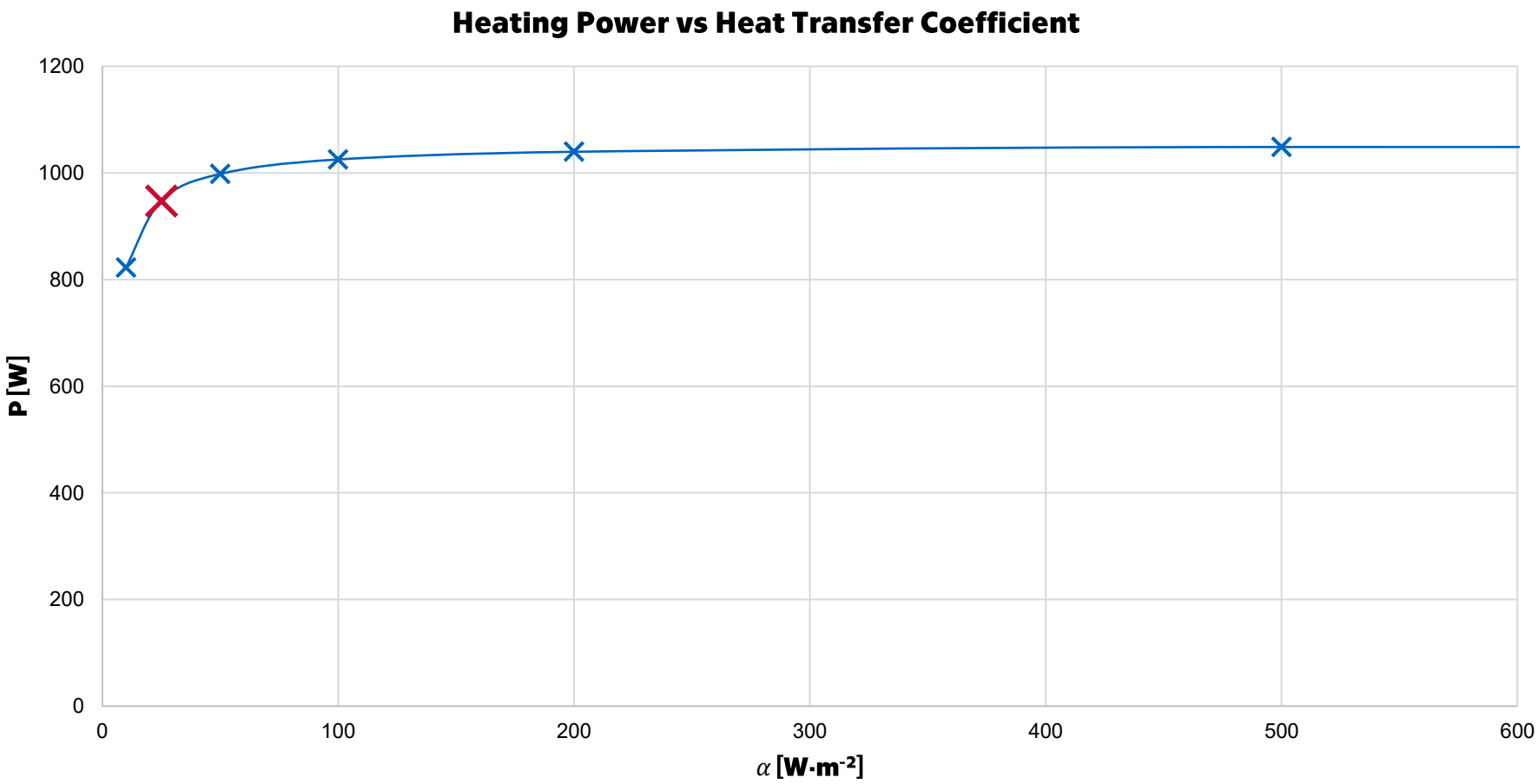


Figure 4: Heating power dependency on the heat transfer coefficient between insulation and air.

Natural convection

		C1	C2	C3	C4	C5	C6	C7	C8
$\overline{T}$	°C	700,0	700,1	699,9	699,9	700,1	700,3	699,9	699,7
T_{min}	°C	683,5	682,4	678,7	679,6	680,4	676,6	682,9	681,1
T_{max}	°C	711,8	713,2	714,6	716,4	718,3	722,9	723,3	719,2
$\dot{M}$	$g \cdot s^{-1}$	7,62	7,91	6,76	8,09	8,93	6,67	11,85	10,58

Table 2: Results for natural convection configurations C1-C8.

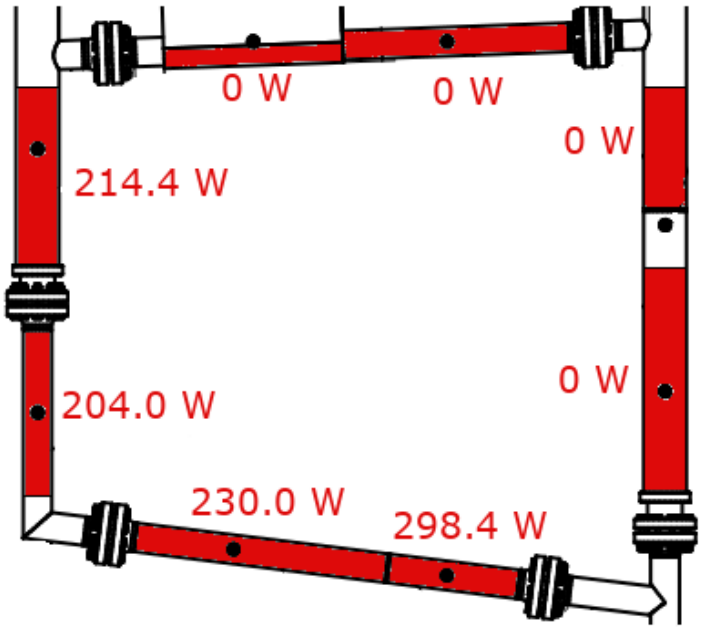


Figure 5: Heating power on the elements of the MSL loop in the C8 configuration.

Forced convection

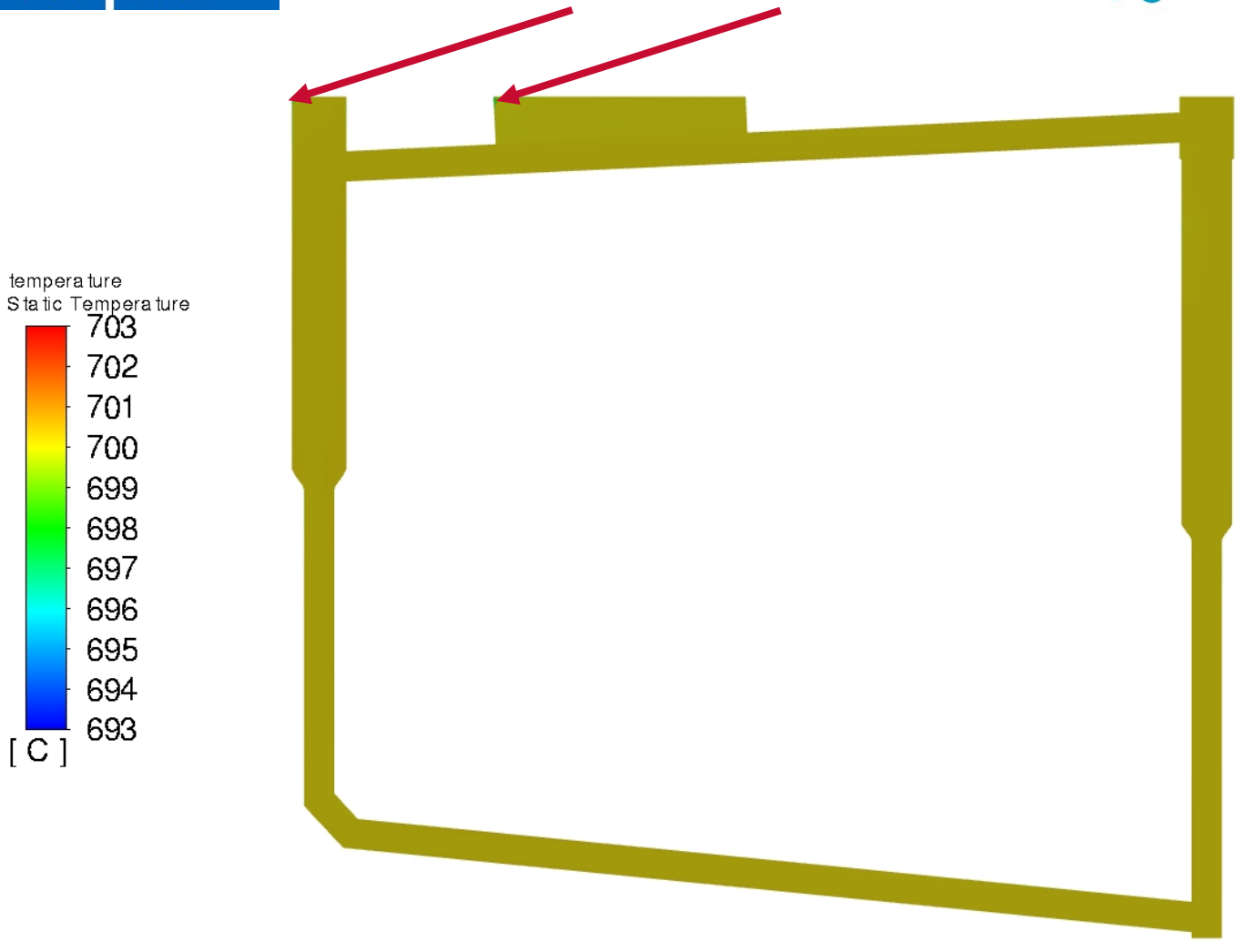


Figure 6: Temperature field in cross-sectional symmetry during forced convection.

Loop startup

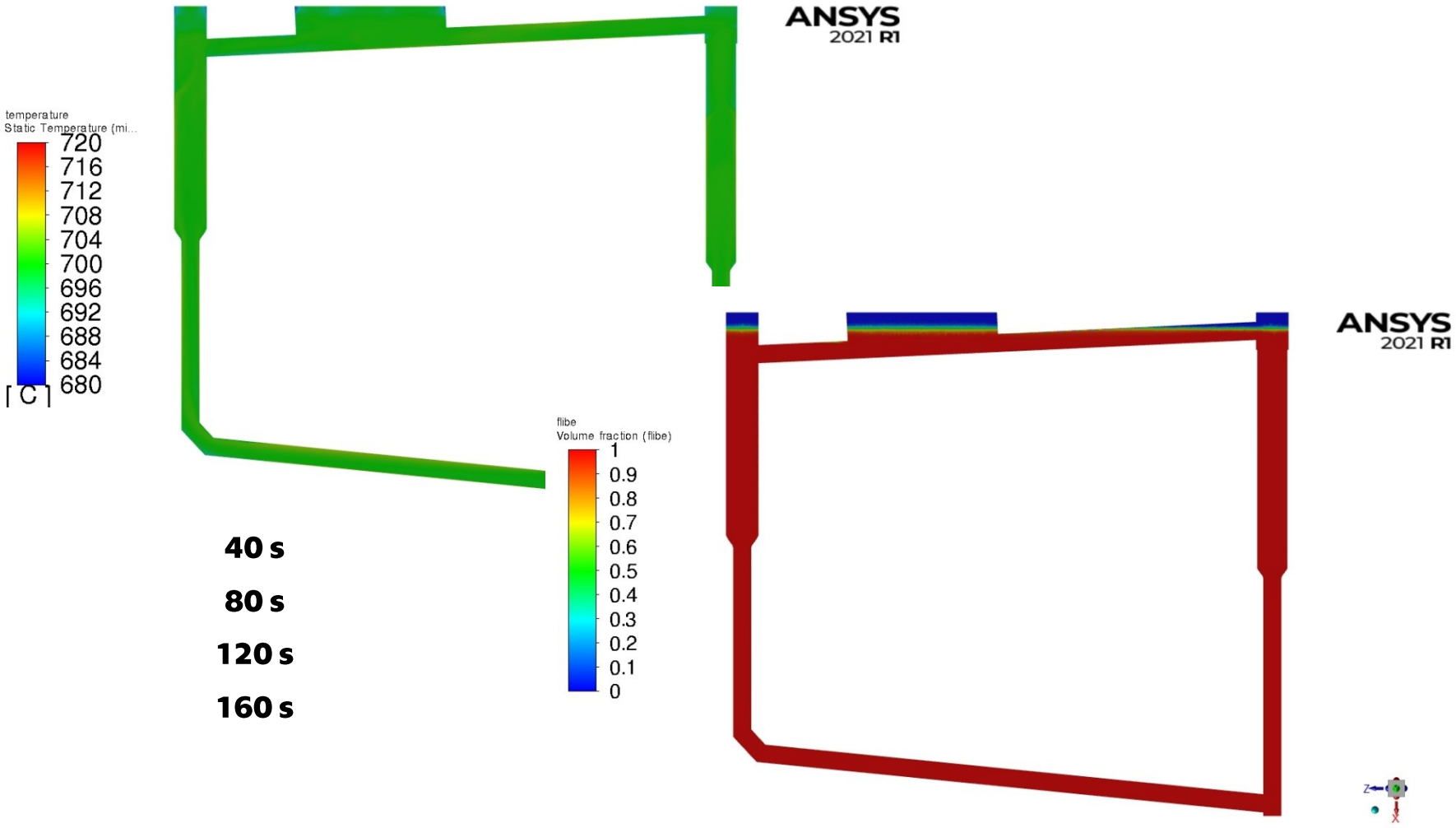
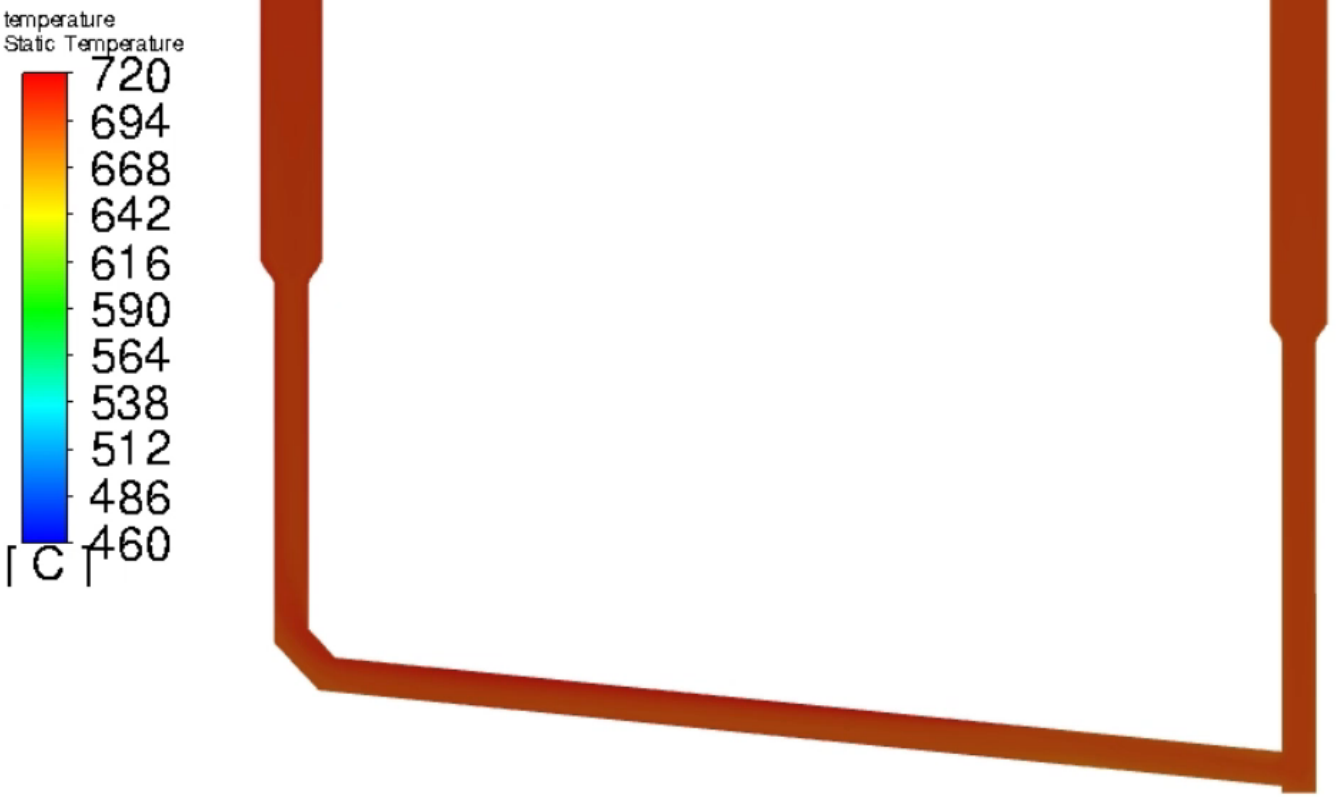


Figure 7: Temperature field in cross-sectional symmetry during loop startup.

Heating cutoff without draining



Animation 2: Temperature evolution after heating cutoff without draining.

Insulation failure

- Currently being investigated
- Might be heavily dependent on the insulation failure position
- In some cases, when the heating is still applied, there is a natural flow established.
    - What will be the stable state? Will it be above or below the melting/freezing temperature?

Conclusions

- **Numerical model:** The quality of the mesh is acceptable.
- **Heat transfer coefficient:** Changes heat losses for less than 15 %.
- **Natural convection:** Heating power distribution heavily influence MSL behavior.
- **Forced convection:** Heating power distribution has negligent influence on the MSL behavior.
- **Startup:** No overheating during the process.
- **Heating cutoff without draining:** There is less than 2 hours 17 minutes before salt freezing.

- **Insulation failure:** Need to be studied further.

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