

Towards construction of Dual Fluid Reactor: CFD modeling of mini-demonstrator



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- **Dual fluid reactor**
 - DFR Team
 - Description of Reactor.
 - Development sequence and research goals.
- **Mini-Demonstrator**
 - Design Sequence of the mini demonstrator.
 - Cycle Design.
 - Cycle Description and running conditions mechanism.
- **Mini-Demonstrator Core Design**
 - Early Idea of mini-Demonstrator Core.
 - Core size reduction analysis
 - Water-based preliminary results of CFD analysis.
- **Summary and further work**



The DFR team consists of several amazing minds

Götz Ruprecht

Daniel Weissbach

**Jakub
Sierchuła**

Xiang Wang

Ewelina Kucal

**Konrad
Czerski**

Rafael Macian-Juan

Michał Komorowic

Hisham Elgendy

Armin Huke

Mariusz P. Dabrowski

Tomasz Hanusek

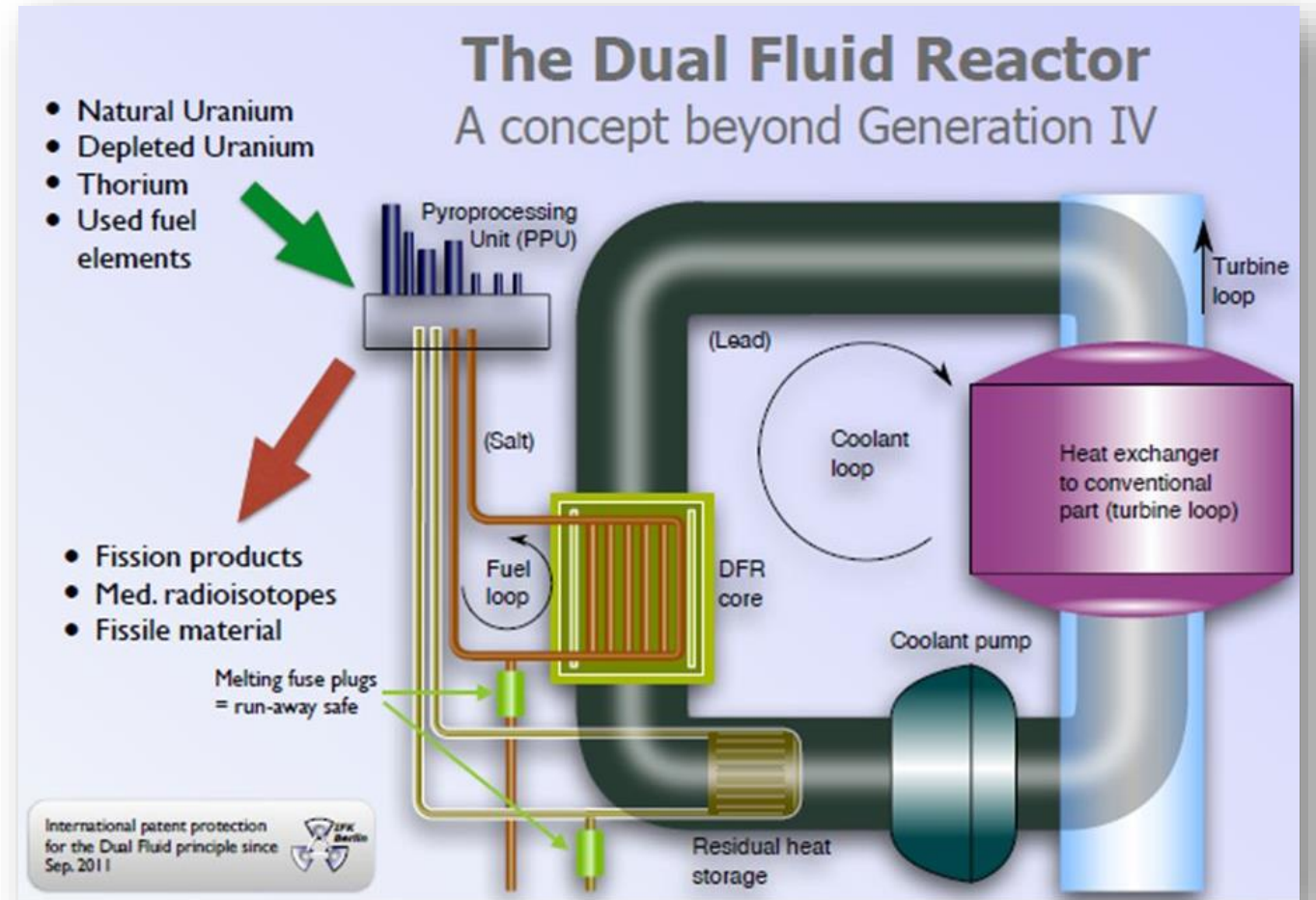
Mateusz Nowak



A- Description of reactor mechanism

Fuel: Uranium- Chromium Eutectic loop.

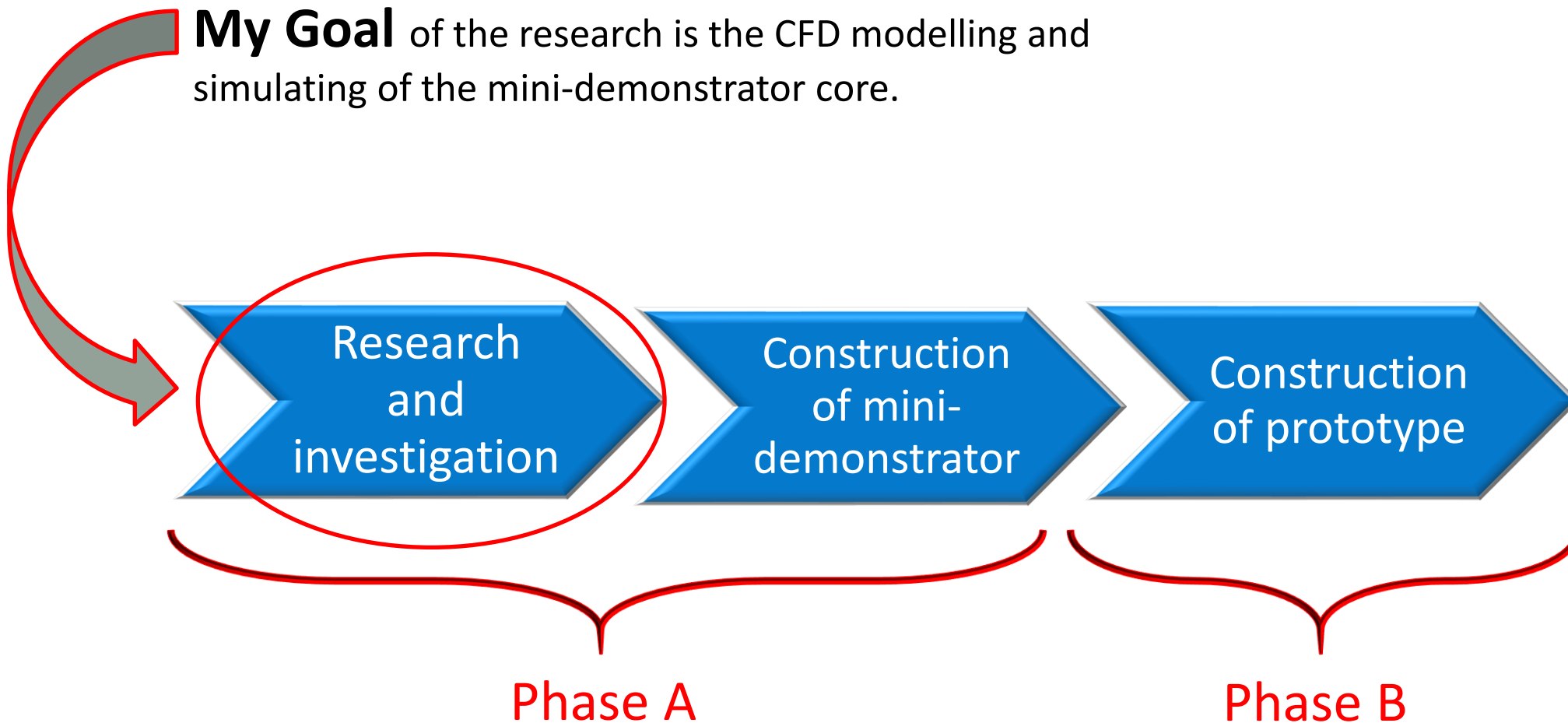
Coolant: Molten Lead loop.





B- Development sequence and research goal

My Goal of the research is the CFD modelling and simulating of the mini-demonstrator core.





A- Design Sequence of the mini demonstrator

- Design the mini-demonstrator loops cycles.
- Design the core.
- Choosing the right code/software for CFD analysis.
- Analyze the designed core and improving the core design if necessary.



We are
here!



A- Cycle Design

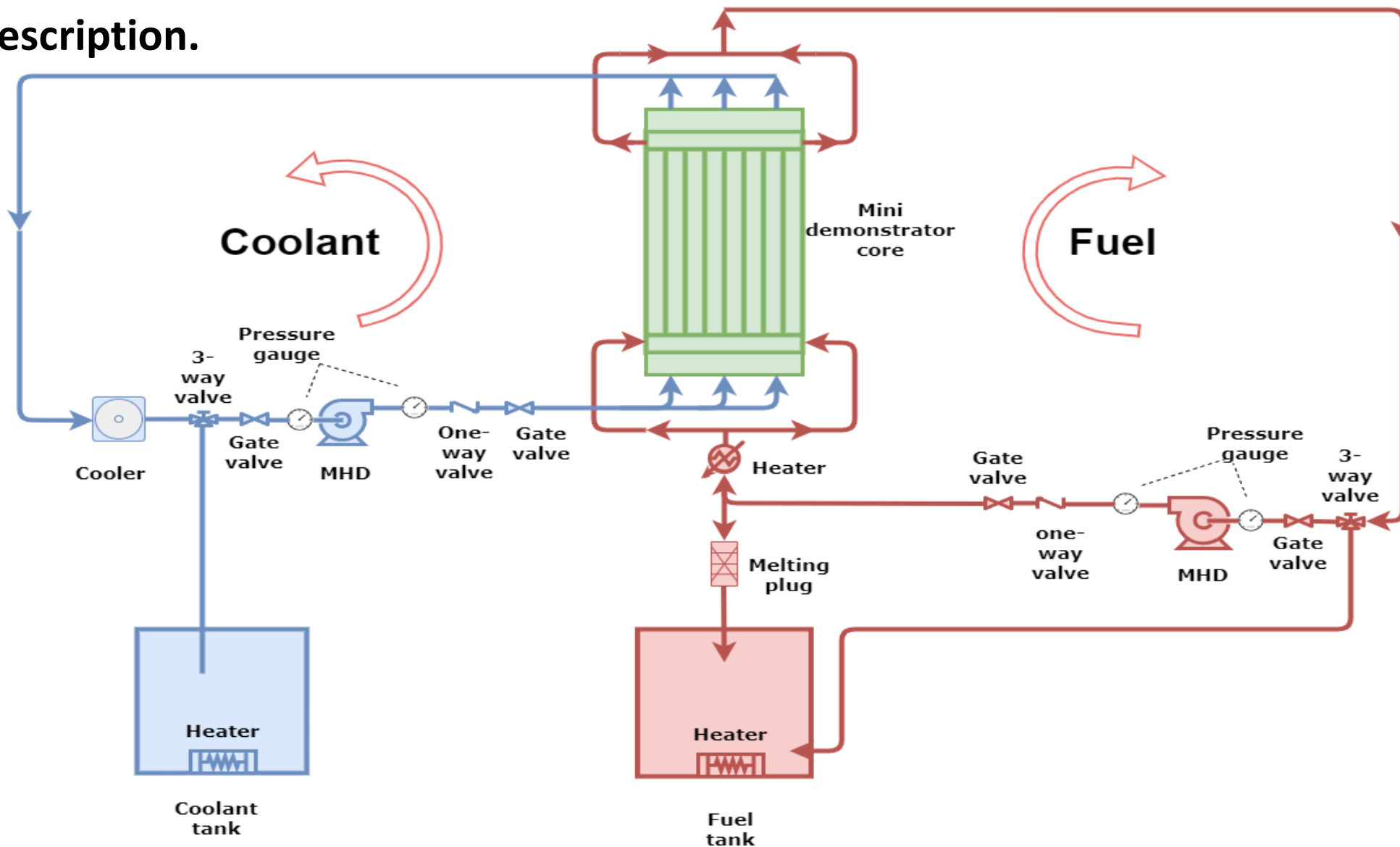
The cycle design has two stage:

(In scope)



- **General Design:** contains the schematic diagram, and describes the idea of the design and the operation mechanism.
- **Workshop Design:** contains the details of the installation including elevation levels, dimensions, sizes, ...,etc.

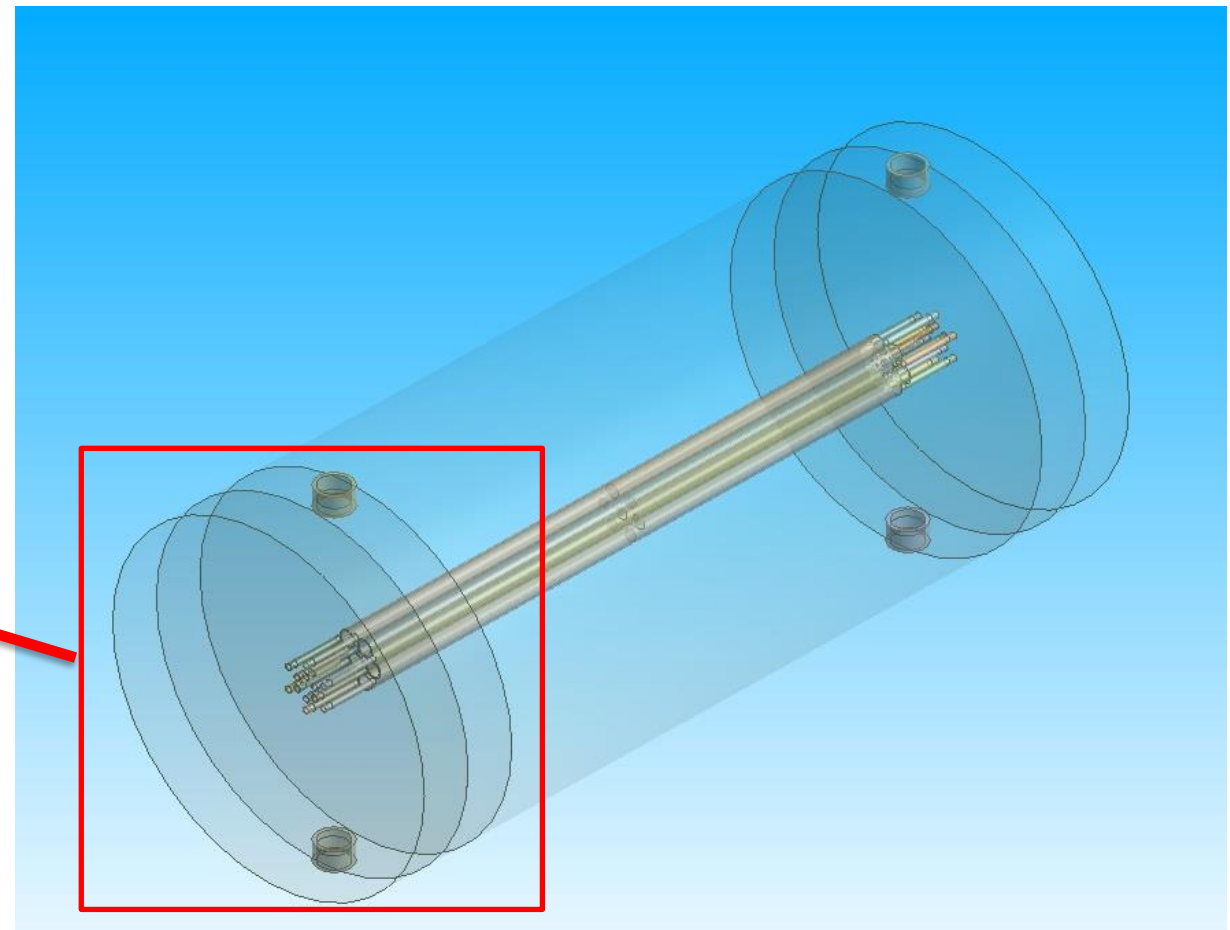
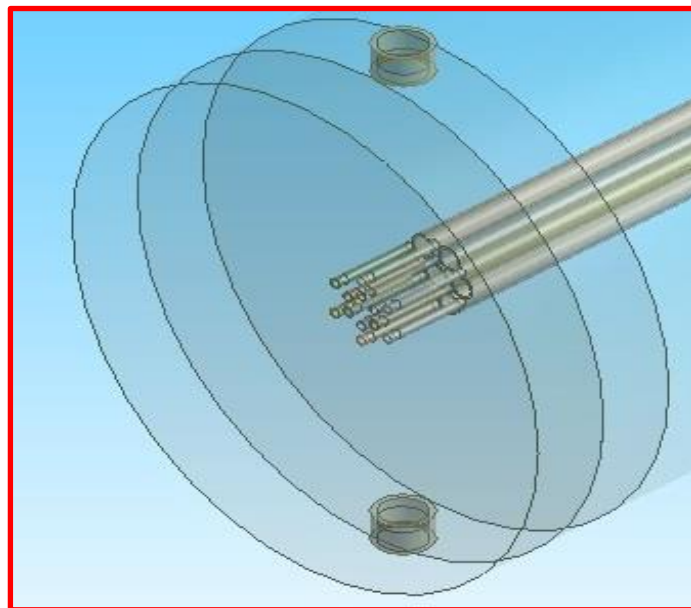
B- Cycle Description.



A- Early idea of the MD core

Number of fuel pipes **7 pipes**

Number of coolant pipes **12*2 pipes**

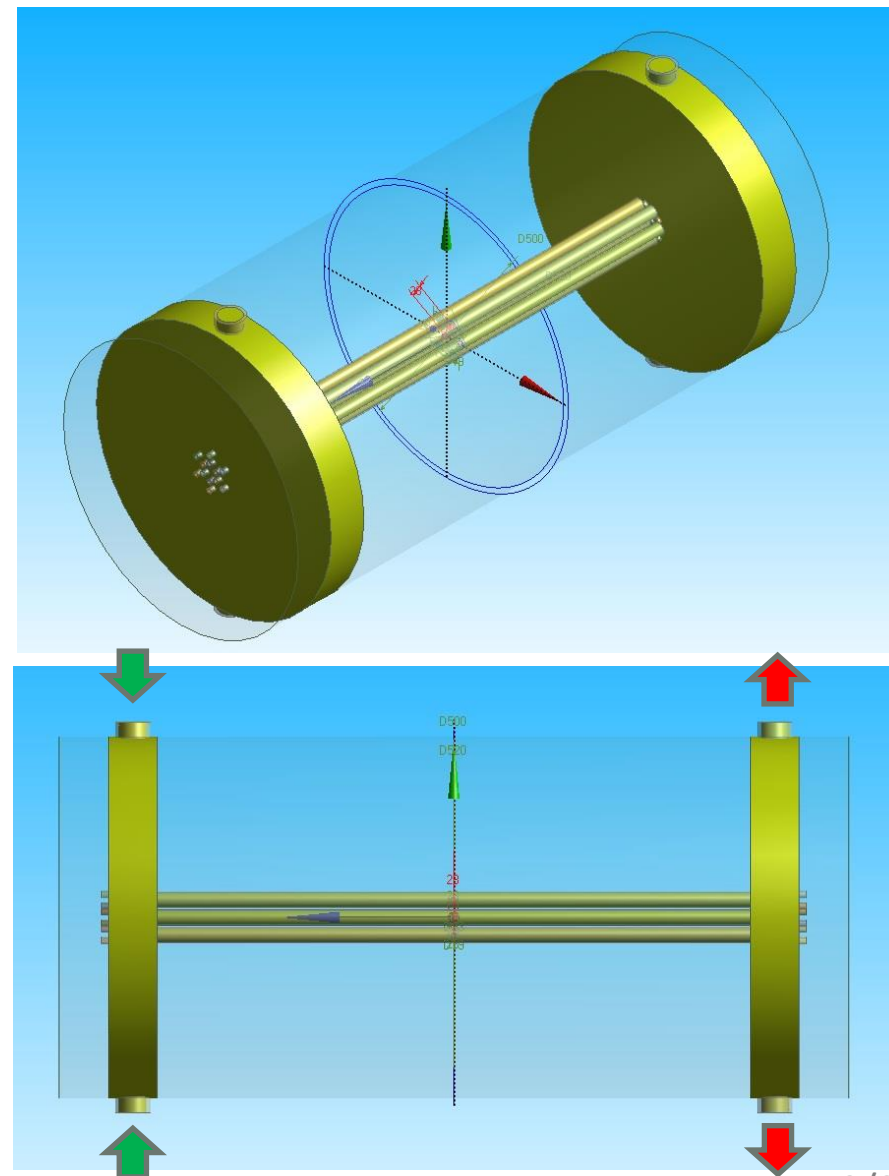


Early mini-Demonstrator Core idea



The figures show:

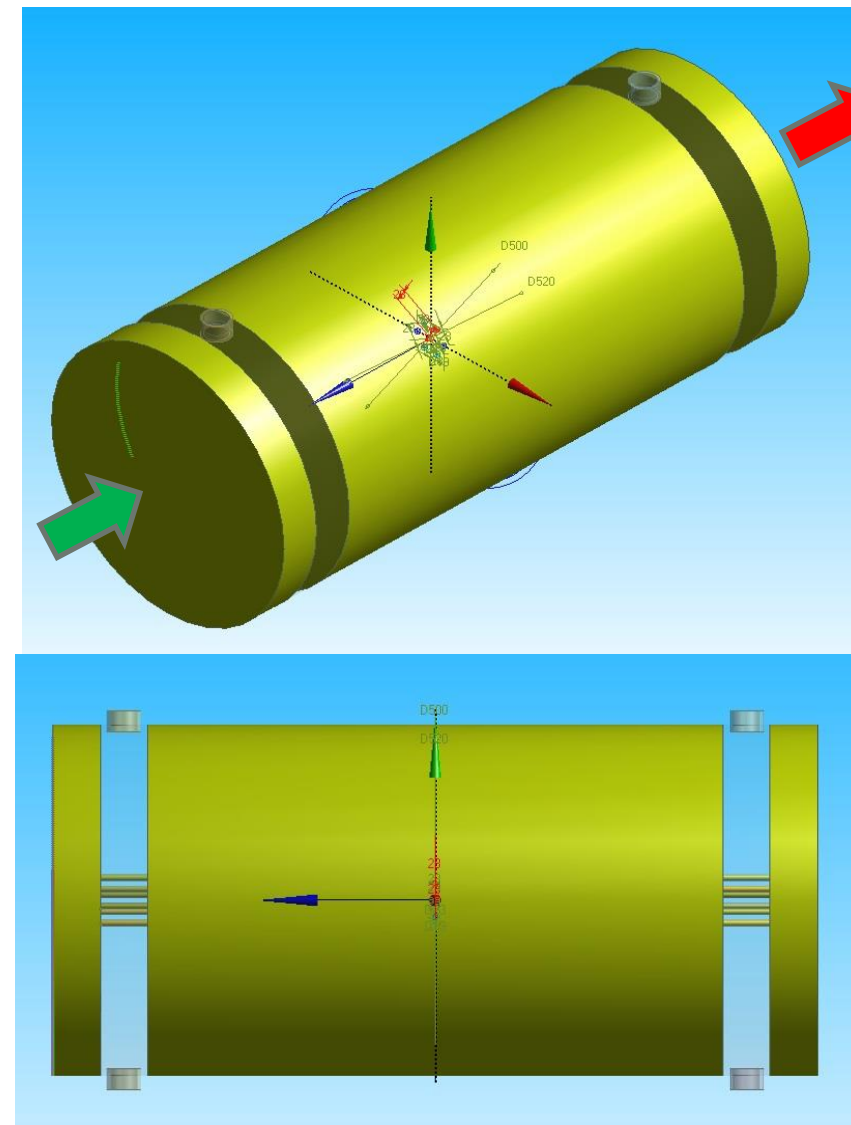
- Fuel entrance (**two** inlets perpendicular to the core flow direction).
- Fuel pipes (7 pipes).
- and Fuel exit (**two** outlets).





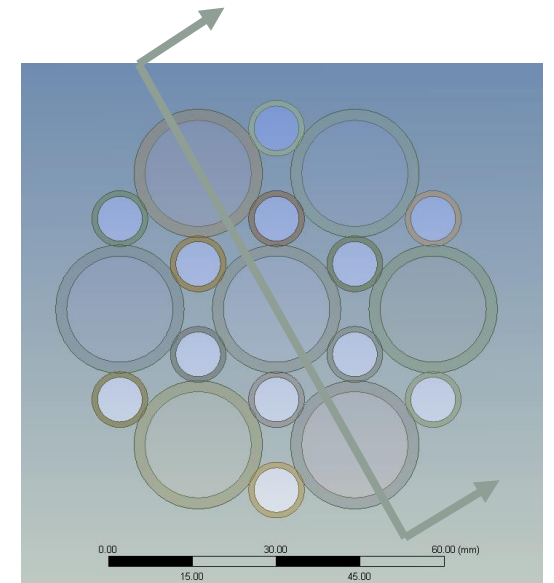
The figure shows:

- Coolant entrance **one** inlet parallel to the core flow direction.
- Coolant pipes (12 pipes).
- and Coolant exit (**one** outlet).



Effect of Mini-demonstrator (MD) core diameter reduction and number of tubes on the Y-velocity and temperature profile at the OUTLET.

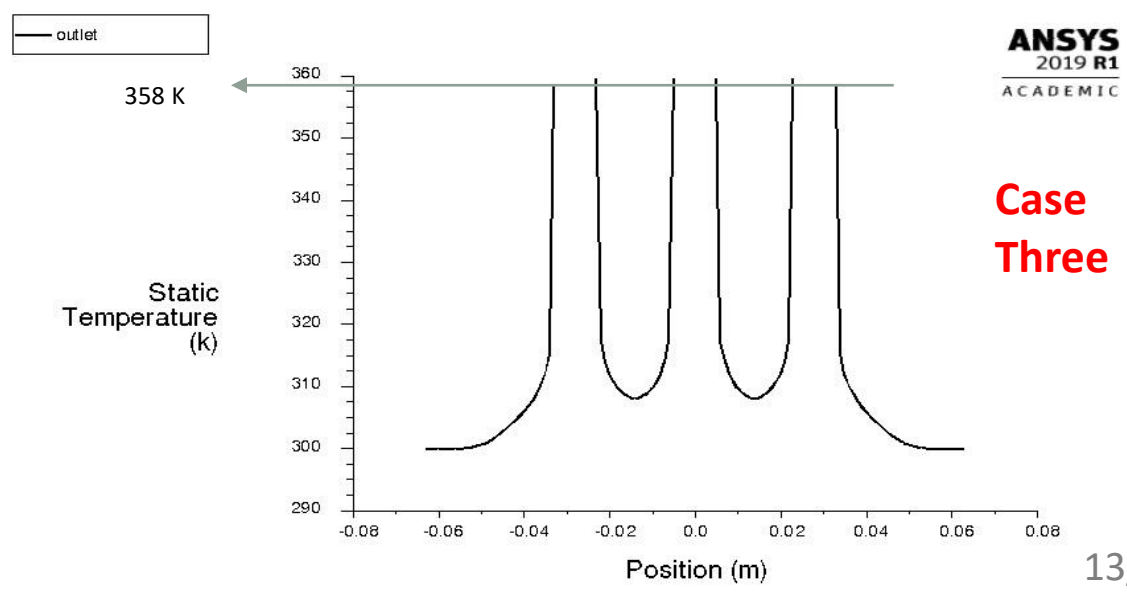
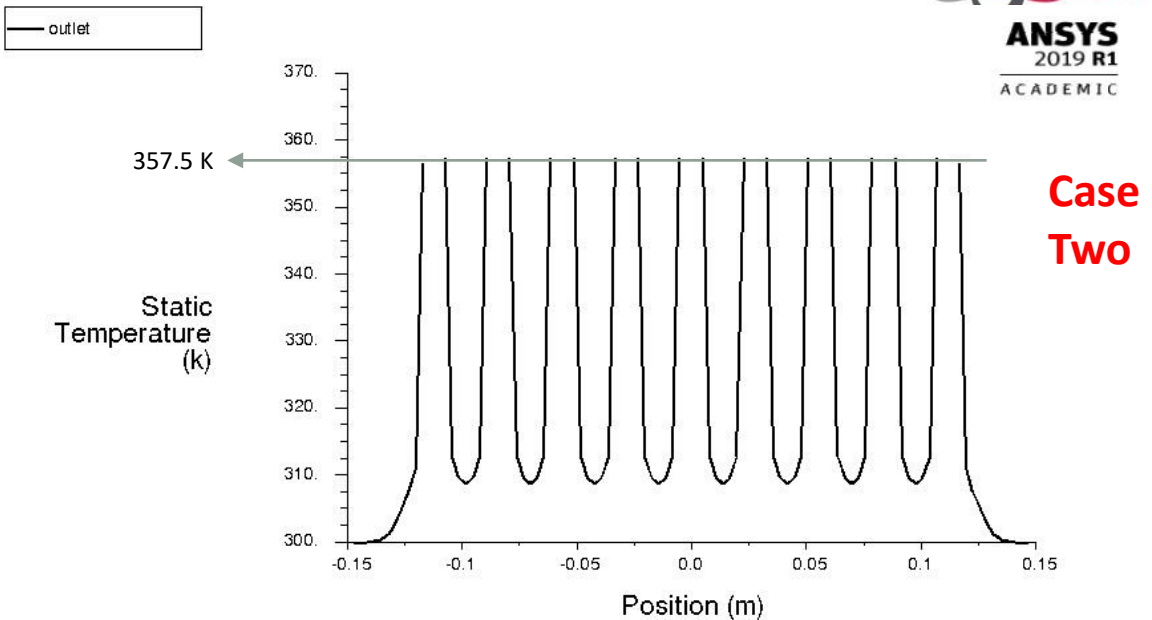
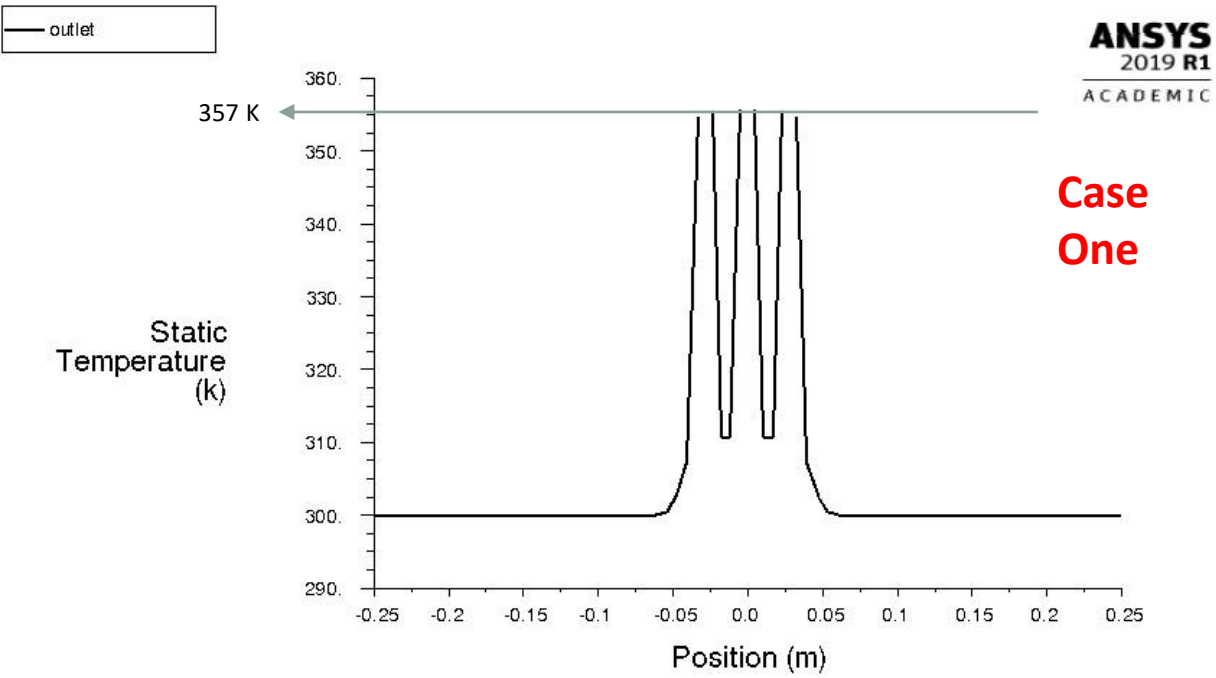
- To assure more accurate simulation of the actual DFR, a reduction of the MD core diameter was introduced to the design.
- As for the scope of the test, 3D simulation doesn't differ significantly to the faster 2D one.
- Using **Ansys Workbench Design modular**, tests on 2D models were conducted to estimate the changes in temperature and velocity profiles in different diameters and different number of pipes taking the water/Al based as dummy.
- Tested Cases:
 - **Case One:** 50 cm (original diameter) / 3 pipes (Cord section).
 - **Case Two:** 30 cm / 9 pipes.
 - **Case Three:** 16 cm / 3 pipes.





Mini-Demonstrator Core Design (5)

Temperature Profile in the Three cases

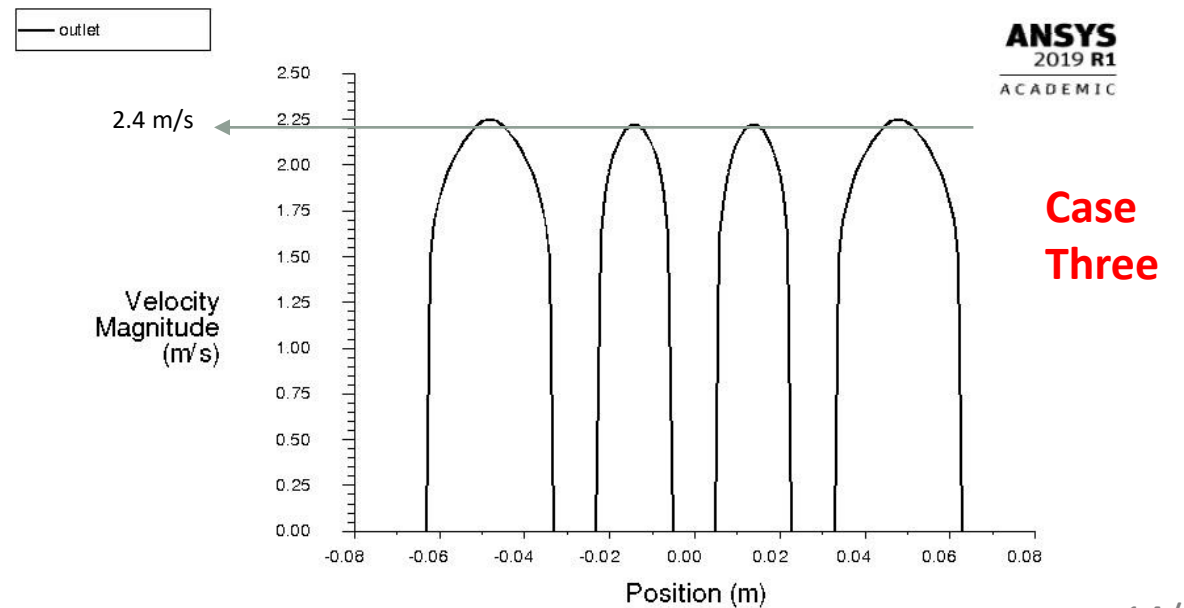
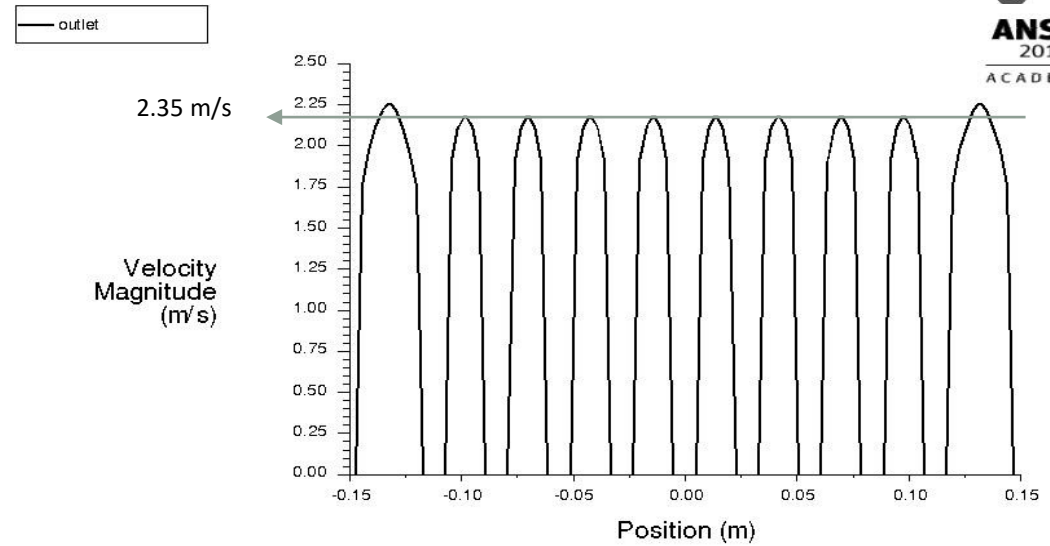
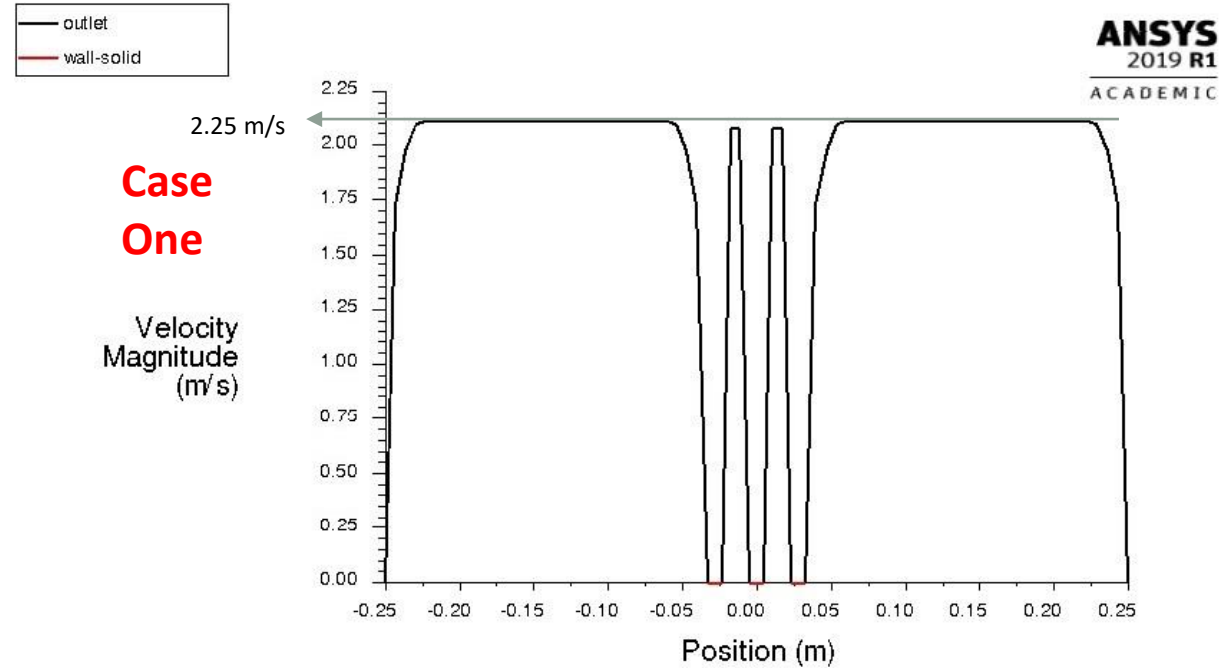


Three cases showed insignificant differences in temperature values.



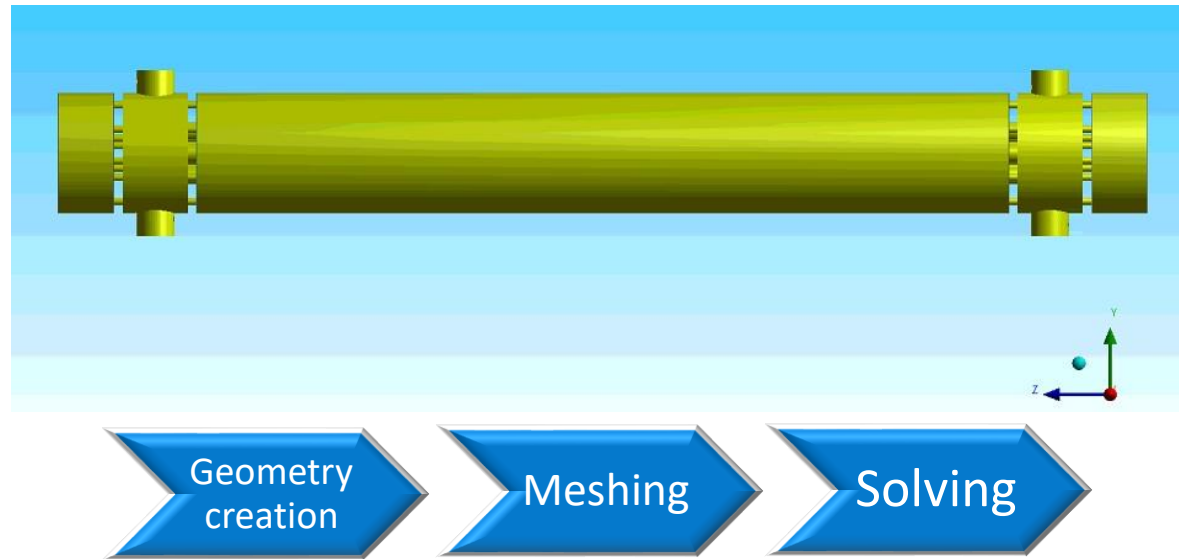
Mini-Demonstrator Core Design (6)

Velocity Profile in the Three cases



Three cases showed insignificant differences in velocity values.

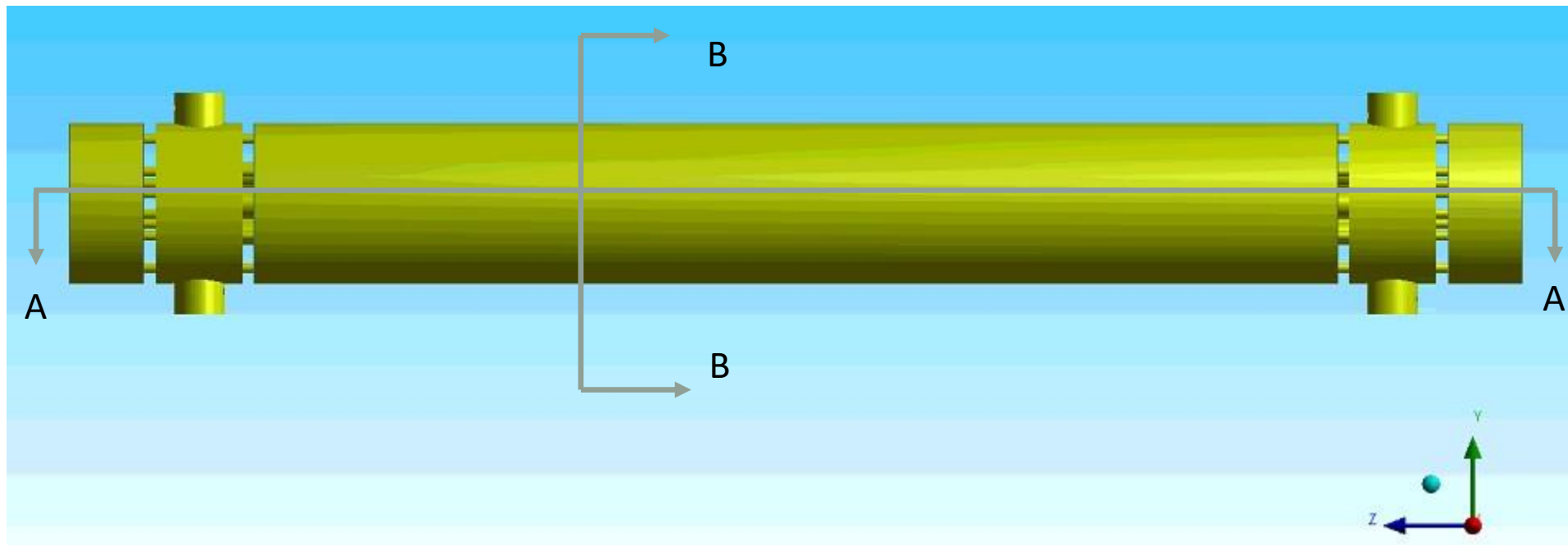
Ansys sequence of solution



To ensure that no problems took place in the first stages, a dummy Boundary Conditions, Material properties (Water/Al) were inserted to the system to observe any problems in geometry and evaluate the mesh accuracy.



Latest Design of the MD core

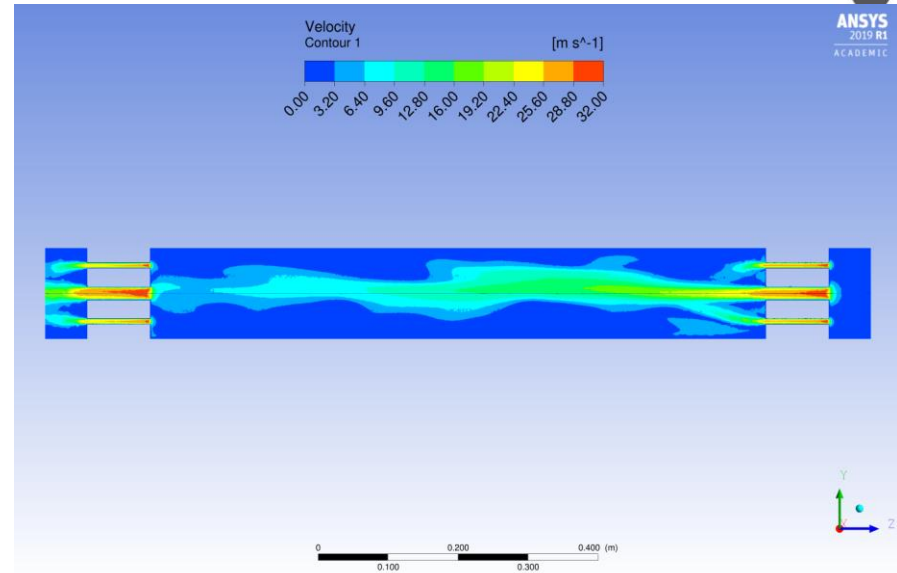


The figure shows the two sections used for showing the analysis

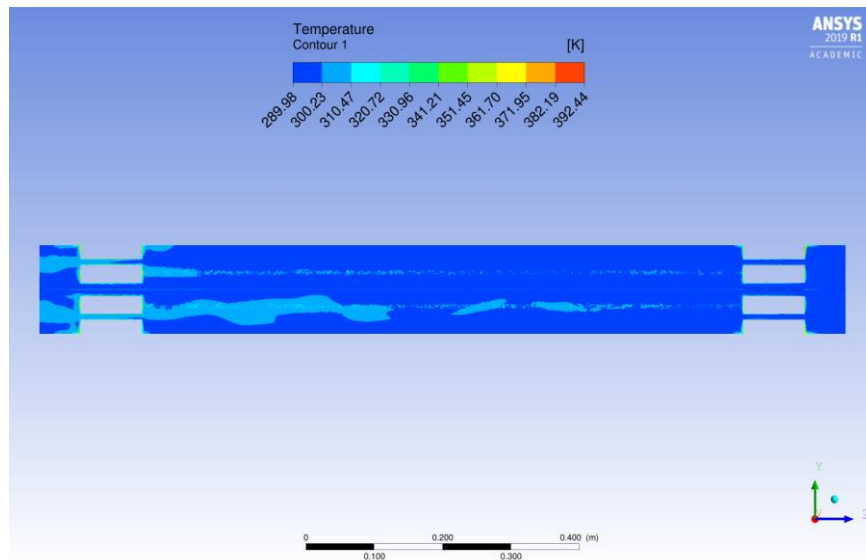


Mini-Demonstrator Core Design (9)

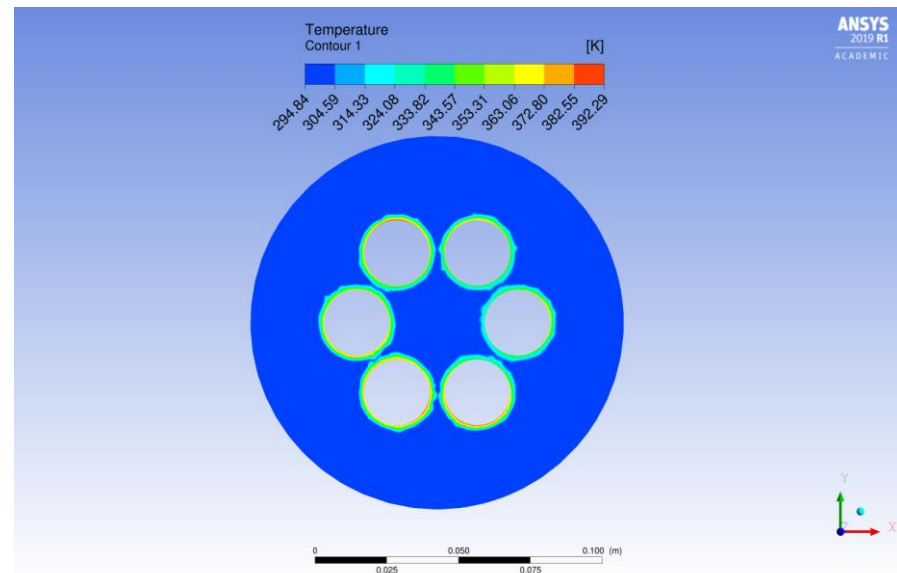
Coolant **Temperature** and **velocity** Profiles of the water based model



Section A-A



Section A-A

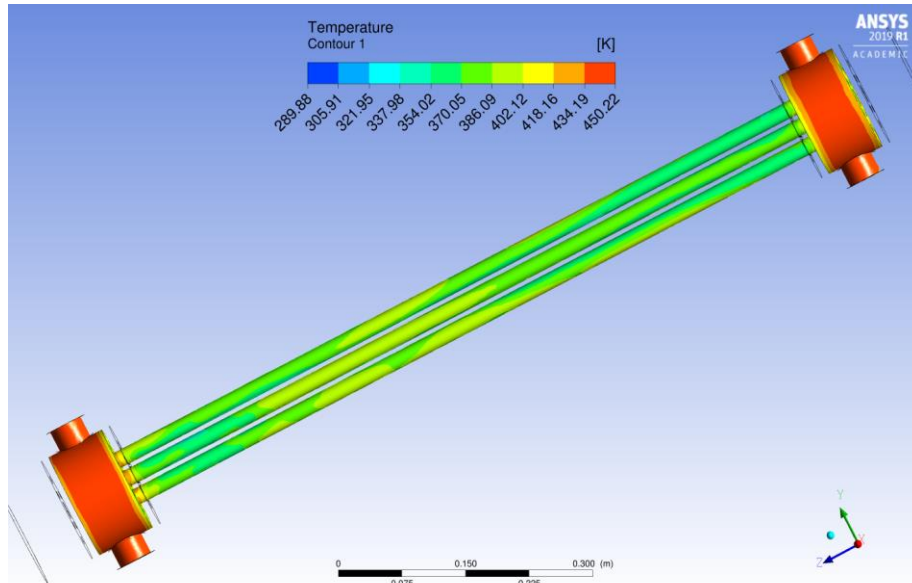


Section B-B

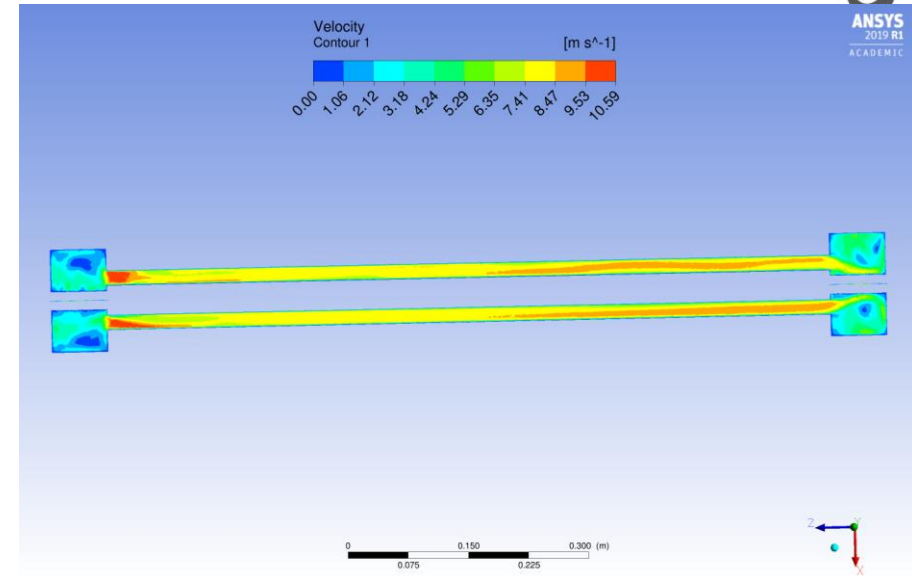


Mini-Demonstrator Core Design (10)

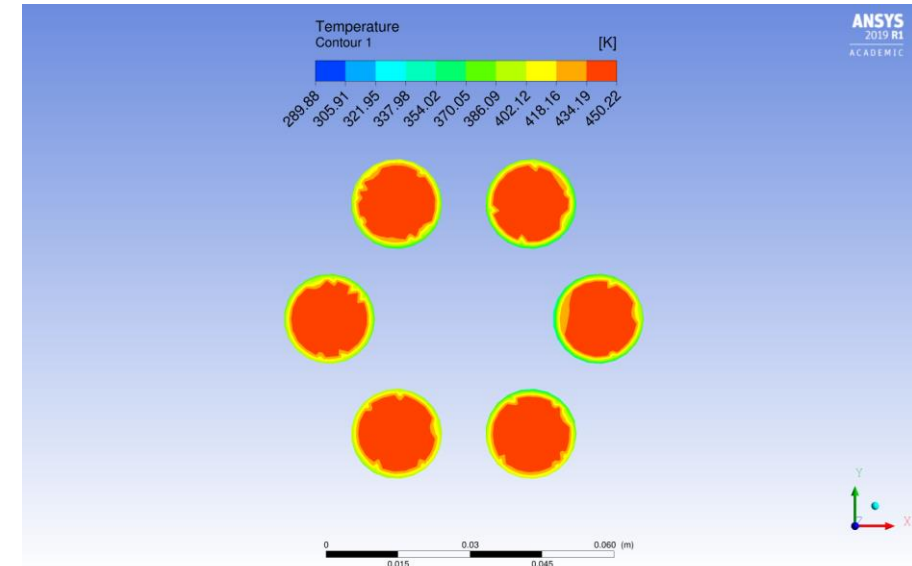
Fuel **Temperature** and **velocity** Profiles of the water based model



Inc. Iso



Section A-A



Section B-B

Summary

- The mini-demonstrator loops have been designed taking into considerations storage, start-up, shut-down and emergency shut-down due to overheating.
- The Core of the mini-demonstrator has been designed and then improved several times to achieve as similar geometrical design as possible to the actual DFR.
- Testing the model through ANSYS fluent solver using a dummy water/Alu sample to ensure the consistency of the geometry and flows, and estimate the mesh quality/ results accuracy ratio.

Further work

- Mesh improvement to achieve even more accurate result.
- Along with the model improvement, a Cooperation with colleagues who work with Pumps and material properties to supply the solver by neat boundary conditions to get the most reliable results. (currently happening)
- For the purpose of validation of solvers, a visit to "KTH Royal Institute of Technology" is planned.