UNIVERSIDADE FEDERAL DE MINAS GERAIS

OpenFOAM Thermal-hydraulic Model of the Most Powerful Fuel Assembly from the SMART Small Modular Reactor

C. G. Oliveira[1], A. J. S. Piña [2], I. K. Umezu[1], B. V. Melo[1], A. L. Costa[1], C. A. M. Silva[1] e D. M. Godino[2]

[1]Universidade Federal de Minas Gerais - Departamento de Engenharia Nuclear - Escola de Engenharia, Brazil.
[2]CIMEC - Centro de Investigacion de Métodos Computacionales, UNL/CONICET, Santa Fe, Argentina.

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INTRODUCTION

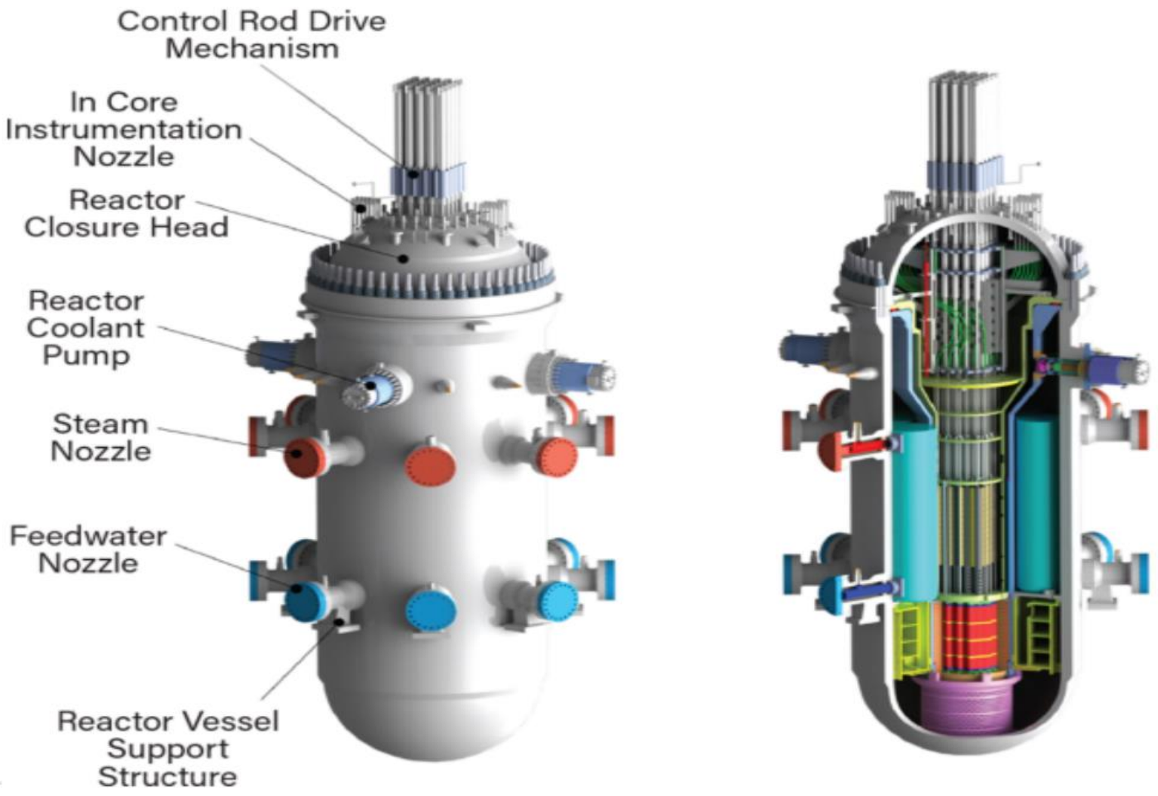
- SMART Nuclear Reactor
- Objectives
- Present Model
- Next steps

SMART NUCLEAR REACTOR

- Small Modular Reactor (SMR
- Nominal Power = $330\ MW_{Th}$
- Nuclear Fuel UO_2
- Light water as both coolant

and reflector

- Cladding made of Zircaloy-4
- Similar to PWR



OBJECTIVES

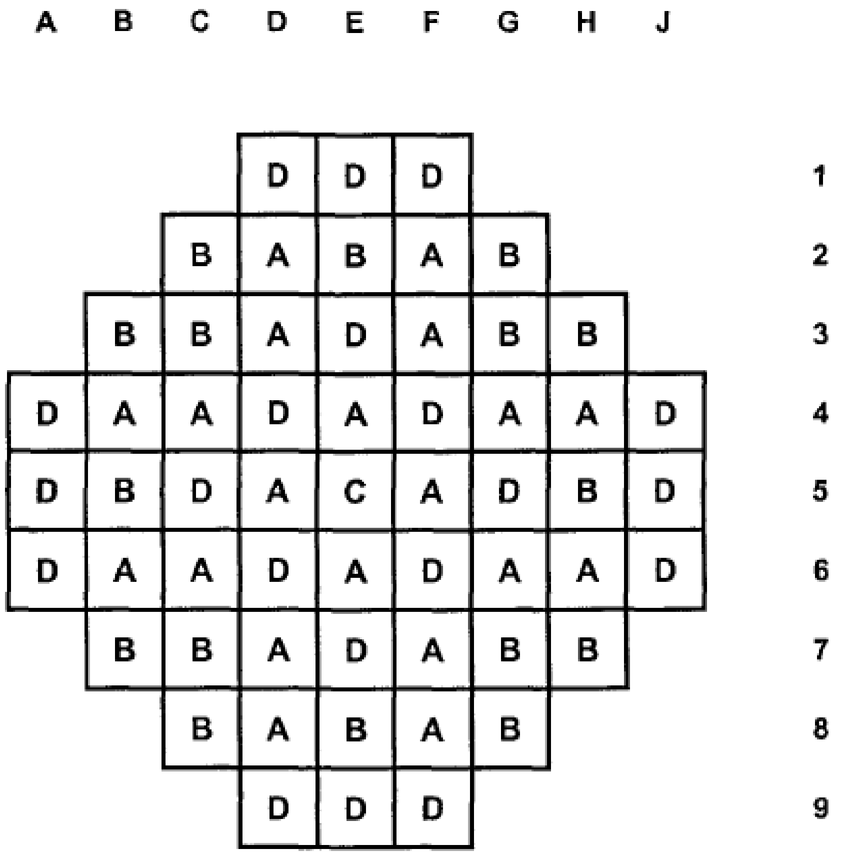
- Project purpose

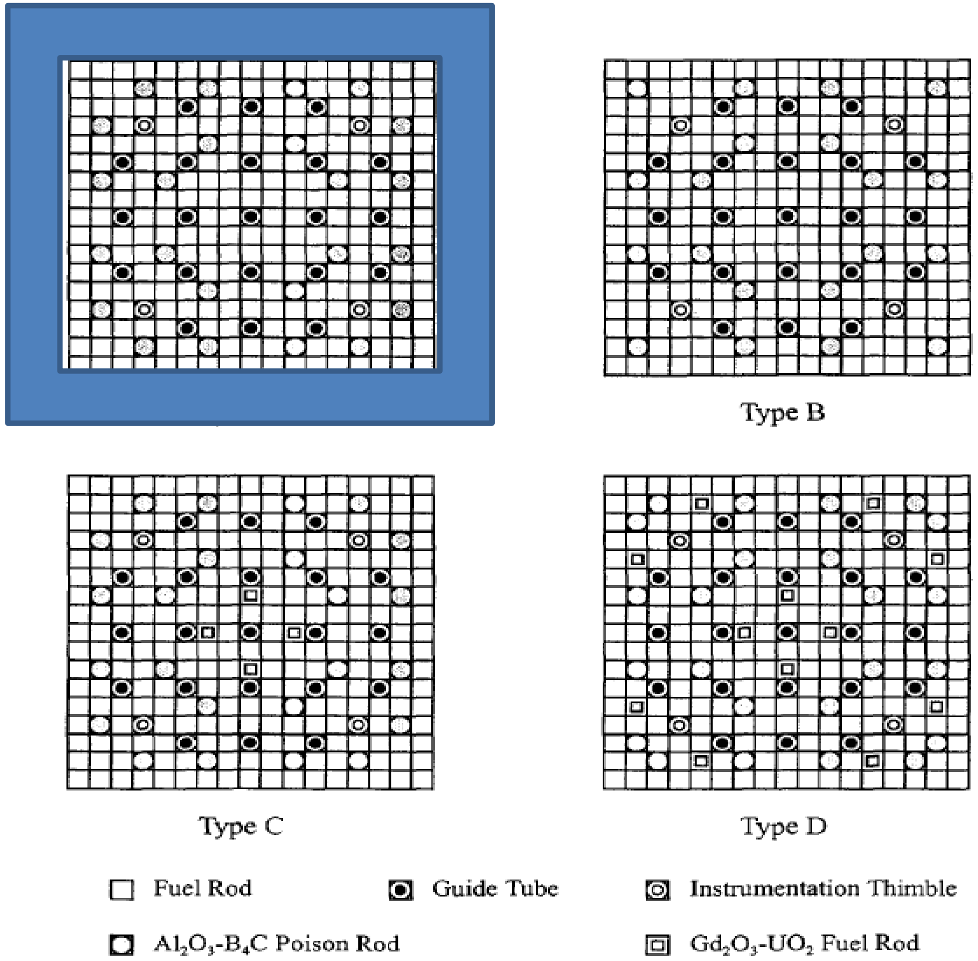
Build a thermal model for the most power (Critical region) of SMART Nuclear Reactor.

- Purpose of the presentation

Present the thermal model constrution process as well the first results.

REACTOR CORE AND ASSEMBLY





KAERI, 1998. Nuclear Characteristics Analysis Report for System-integrated Modular Advanced ReacTor

METHODS

OPENFOAM

- Solver solution for differential equations by the Finite Volume Method (FVM)
- Can be used for solve consevation equations for the fluid transport (Energy, mass and momentum)

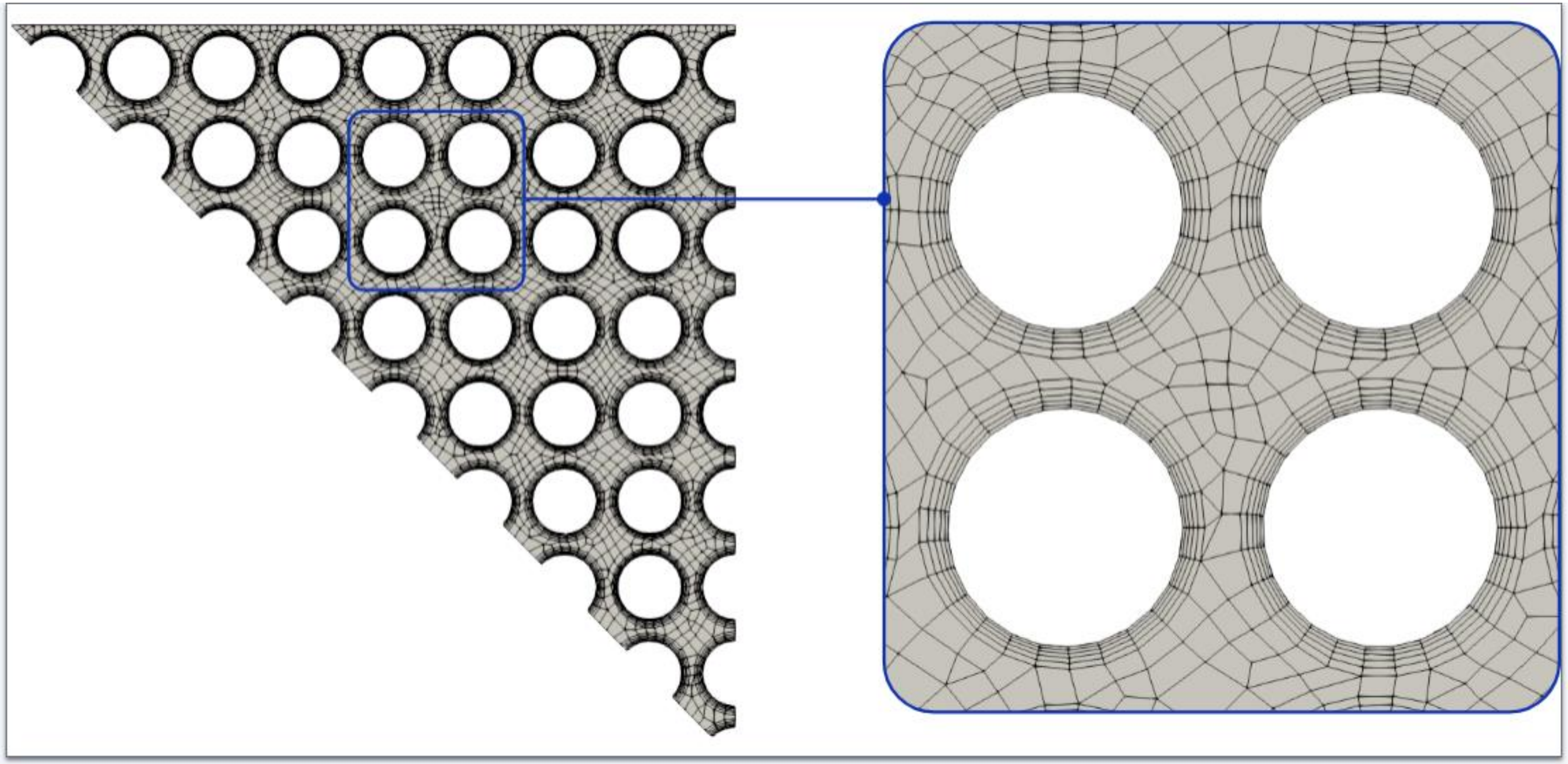
Main input parameters:

(1) Mesh (Domain discretization)

(2) Boundary Condition: Pressure, temperature, flow velocity ...

(3) Control parameters: Number of interations and decomposition of the process

MESH



For the first results only the fluid regions was simulated at steady state.

MAIN OPERATIONAL ASPECTS

The simulations were performed using both constant and sinusoidal power distribution.

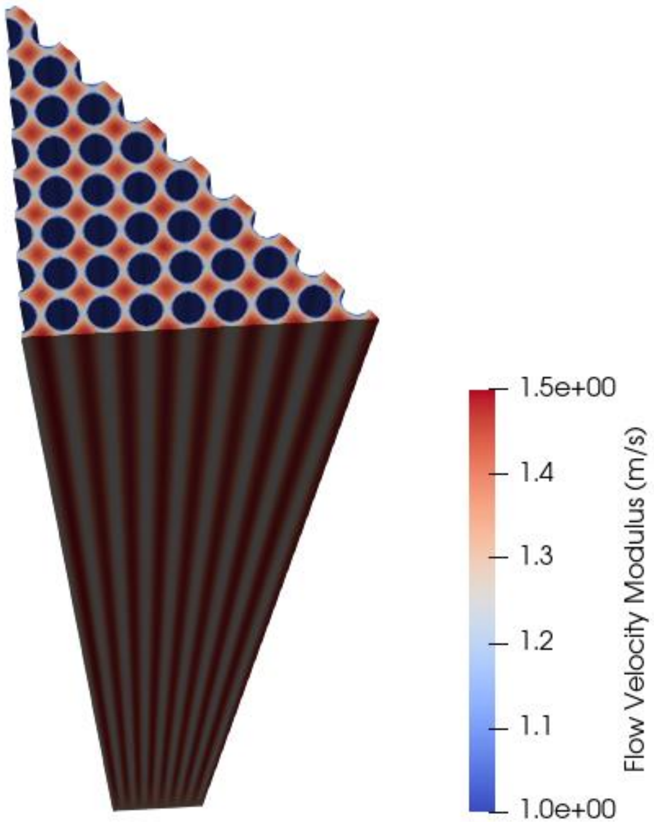
Table I. Main operational parameters used during the simulations.

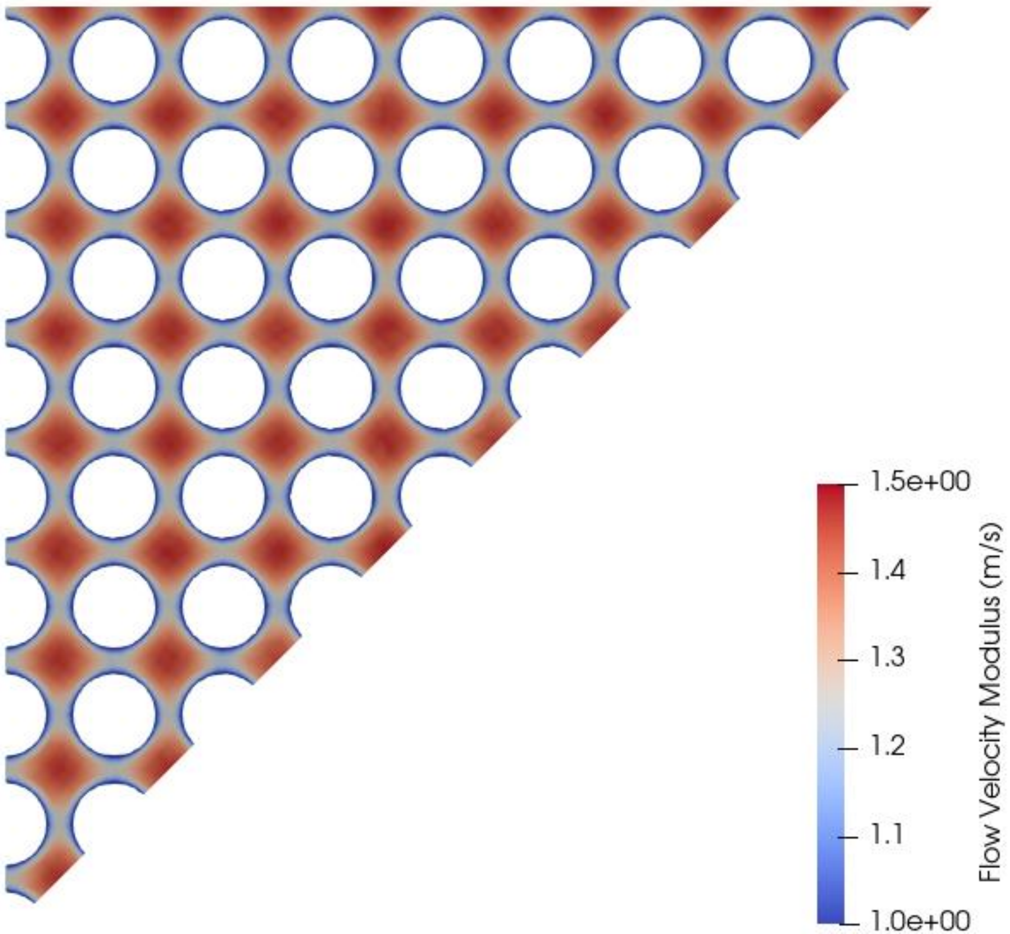
Parameter	Value	Units
Inlet Pressure	15	$[MPa]$
Inlet Temperature	543.15	$[K]$
Inlet Coolant velocity	1.294	$[m/s]$
Fuel Assembly Height	2166	$[mm]$
Rods Diameter	9.5	$[mm]$

KAERI, 1998. Nuclear Characteristics Analysis Report for System-integrated Modular Advanced ReacTor.

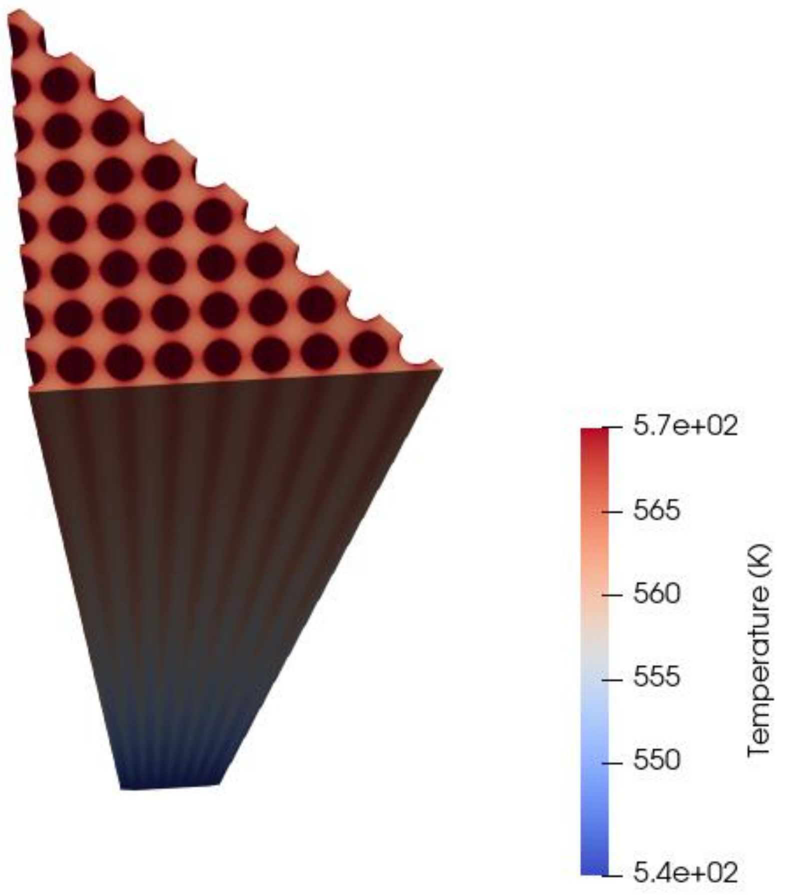
RESULTS USING CONSTANT POWER

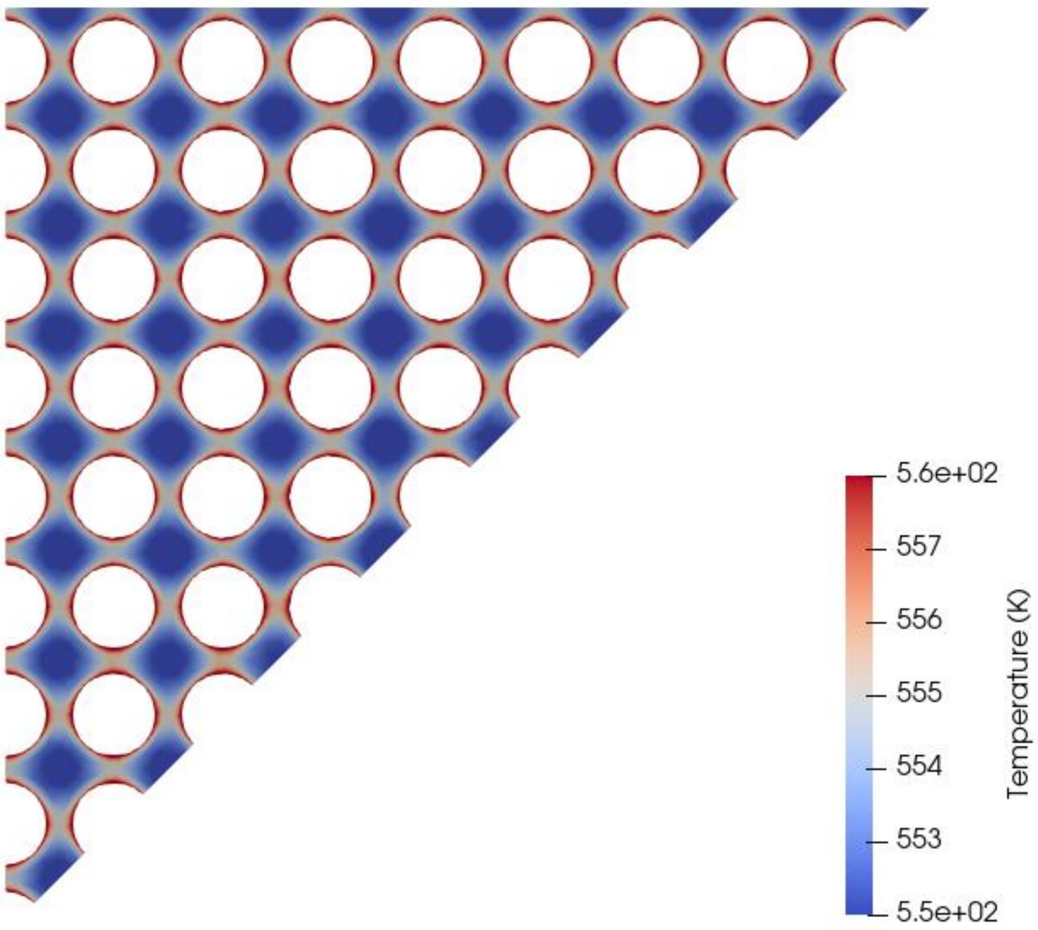
COOLANT VELOCITY PROFILE AT CONSTANT POWER DISTRIBUTION



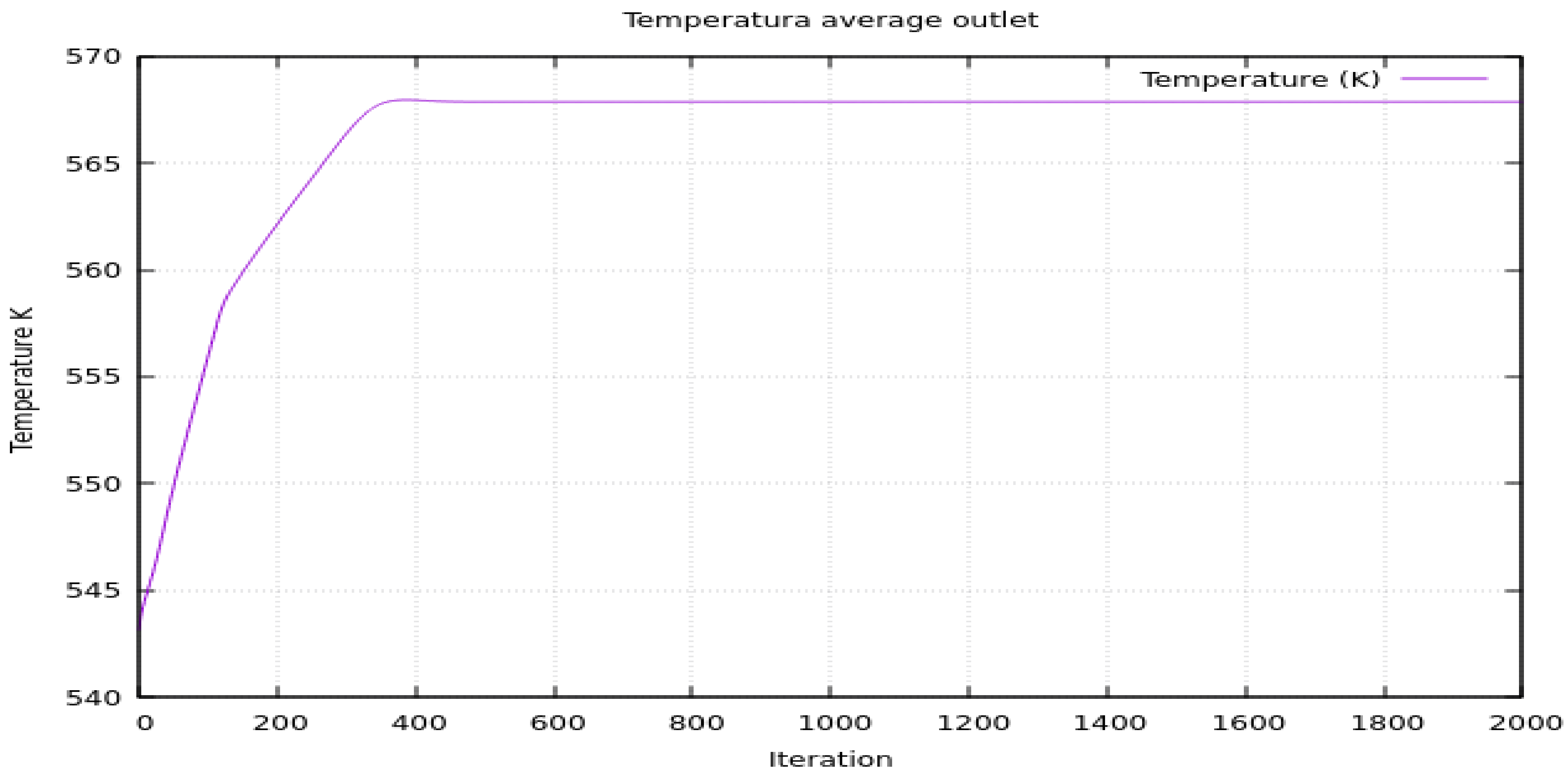


COOLANT TEMPERATURE AT CONSTANT POWER DISTRIBUTION



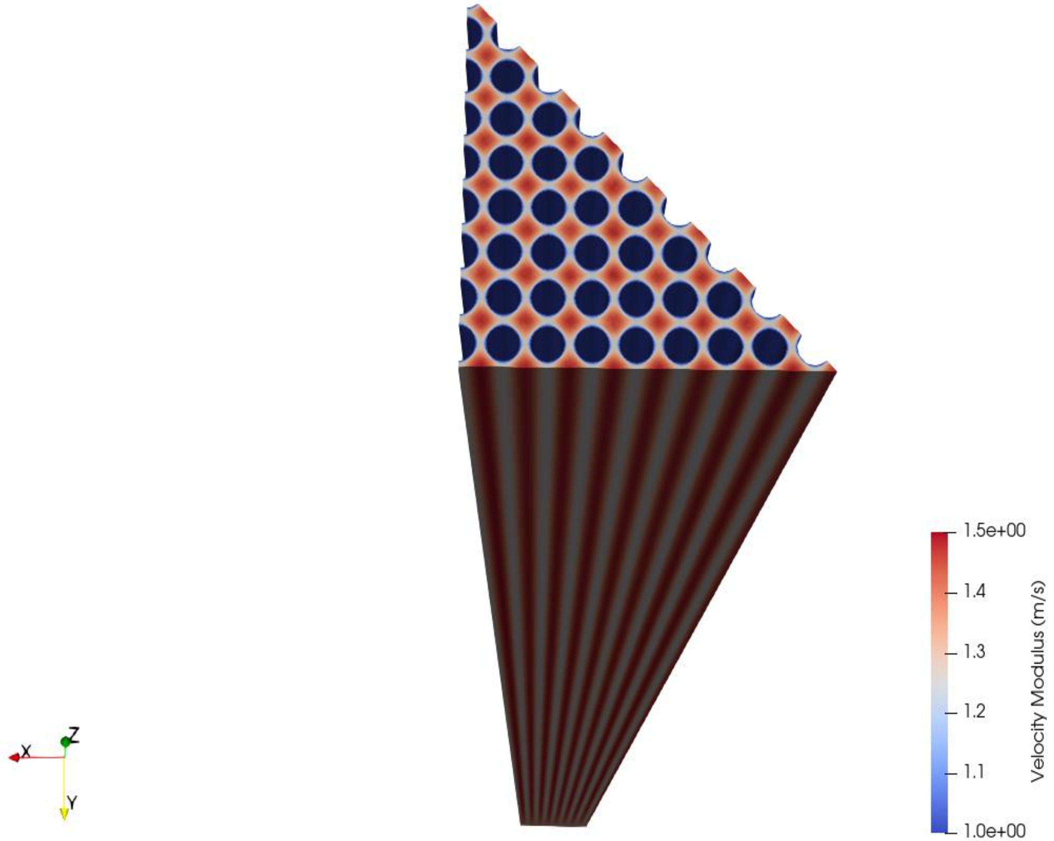


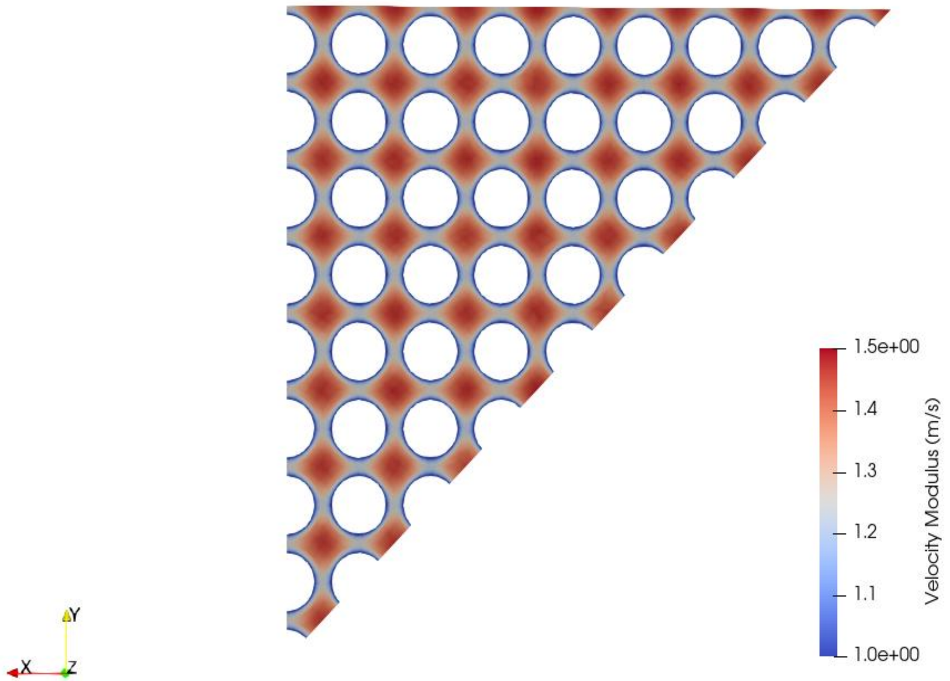
AVERAGE OUTLET TEMPERATURE



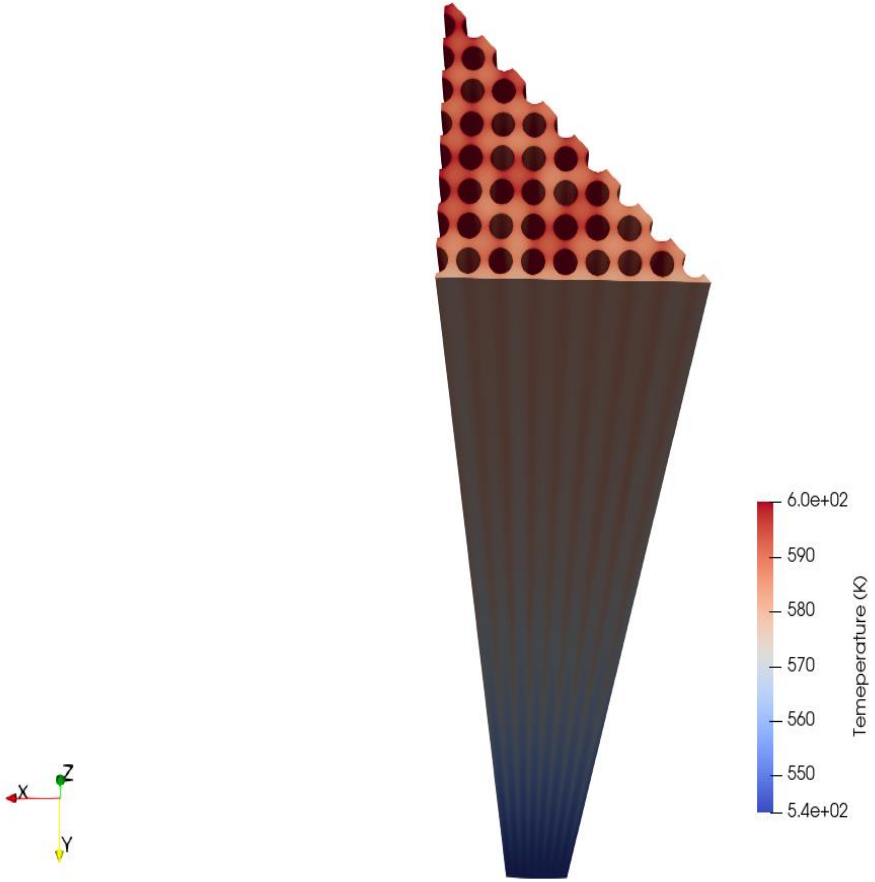
RESULTS WITH SINUSOIDAL POWER DISTRIBUTION

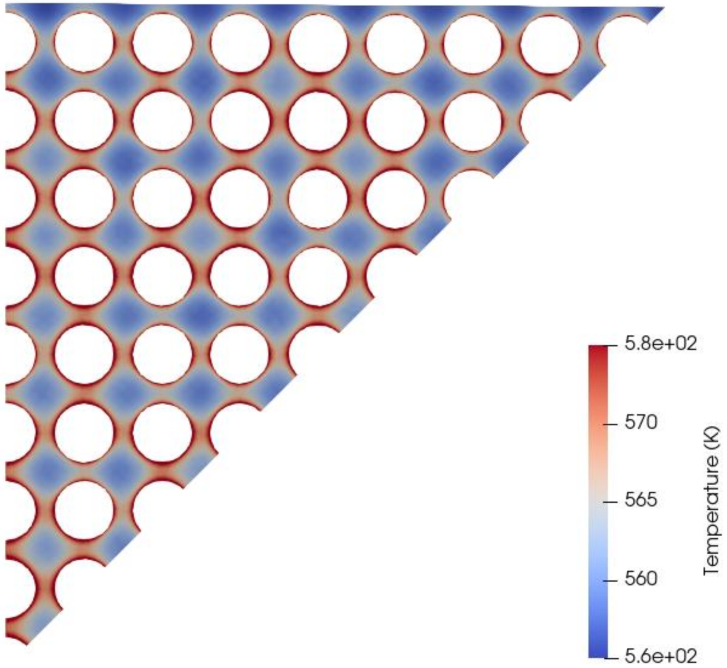
COOLANT VELOCITY MODULUS USING SINUSOIDAL POWER DISTRIBUTION

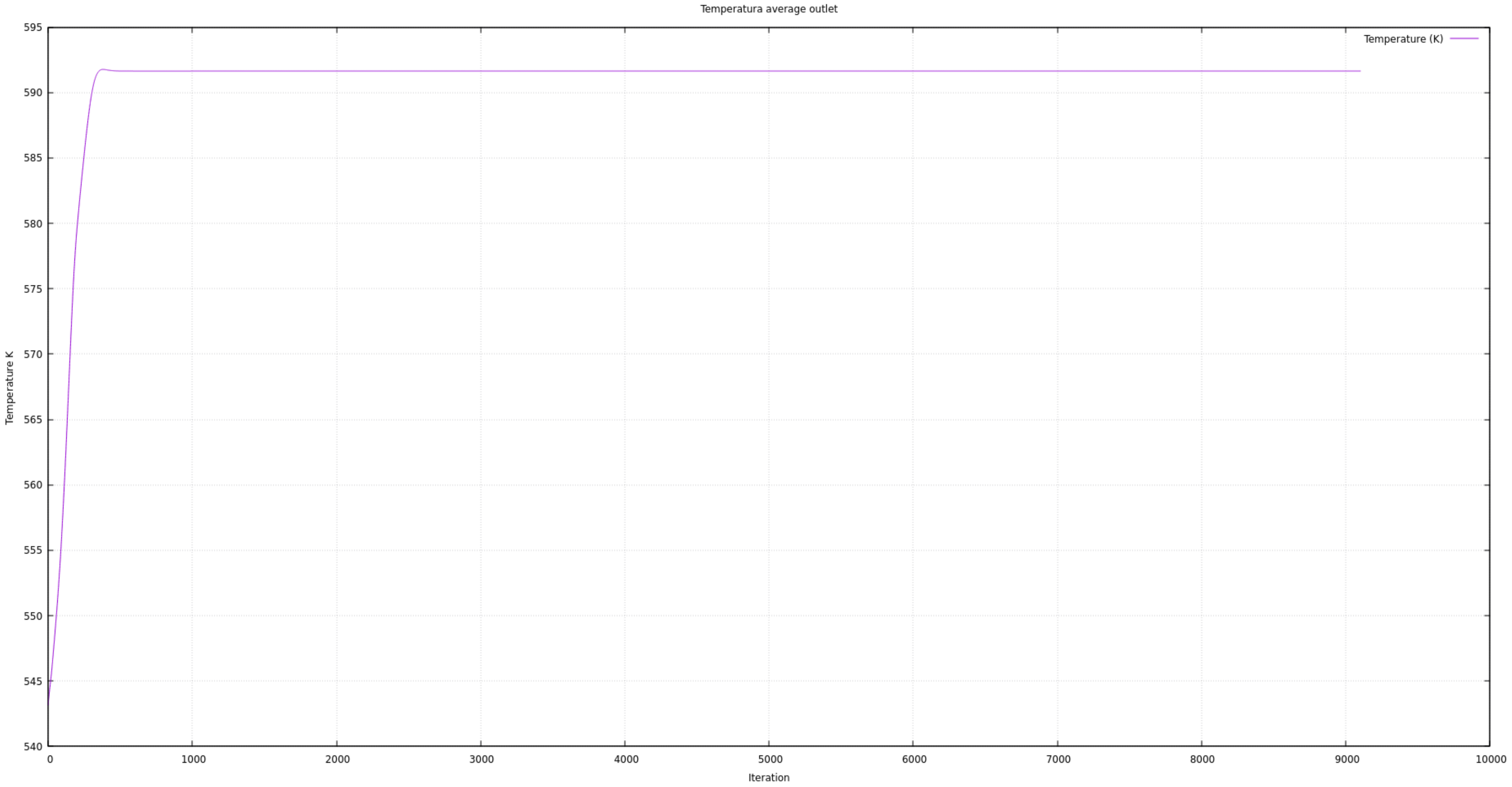




COOLANT TEMPERATURE USING SINUSOIDAL POWER DISTRIBUTION







Temperatura average outlet
Temperature (K)
Temperature K
Iteration
595
590
585
580
575
570
565
560
555
550
545
540
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000

CONCLUSION

At both cases the profile of the physical proporties presents a compatible patter with the expected for the power distribution imposed as initial condition. The coolant temperature presents high values at the points closed to the rods na gradative decrease with the distance. The maximum flow velocity was found at point near to the middle of the thermal hydraulic channel.

NEXT STEPS

- Construct the solid regions for the new mesh
- Impose the real SMART power distribution
- Impose the adjacent fuel assemblies as boundary condition
- Use the thermal model to make previsions of physical changes in the reactor project

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