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Thermal and Fluid Dynamics Studies Applied to Steel Industry

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INTRODUCTION

The energy pay back is one of the most interesting field especially in the steel industry where this contribution is strictly connected to steams and emissions inside and outside the plant. Perhaps, this application is sometimes disturbed by a strong variation of emissions.

PCM: Phase Changing Material

Material used in correspondence with its phase transition in order to use the change in its properties.

Concerning energy recovery, elements consisting of PCM are used due to the capacity to absorb latent heat during the melting process and to release it during the solidification phase.

Typical PCM:

Aluminium (Al)
Lead (Pb)
Tin (Sn)
Bismuth (Bi)
Cadmium (Cd)

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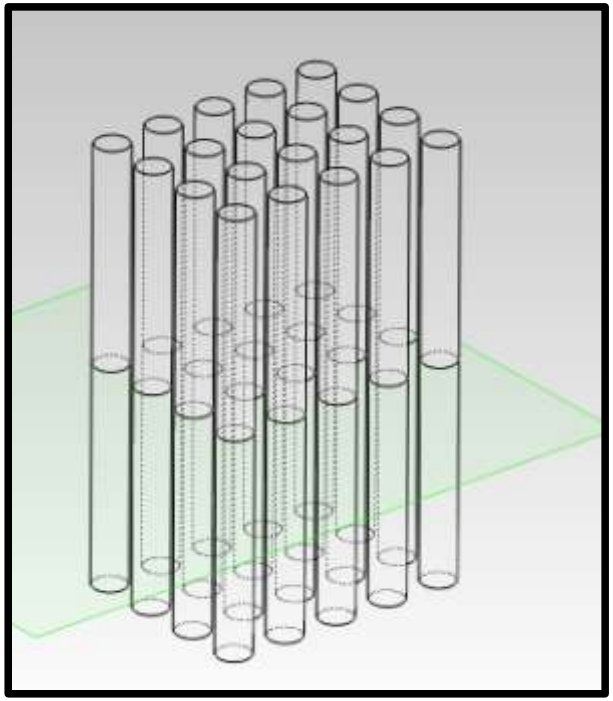
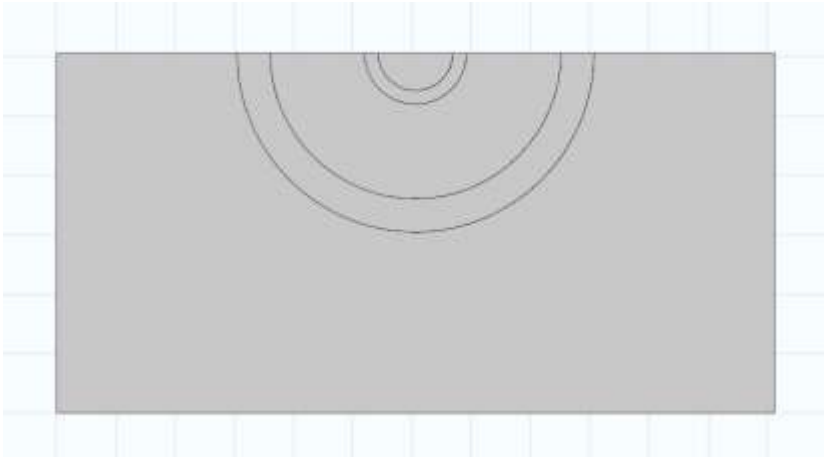
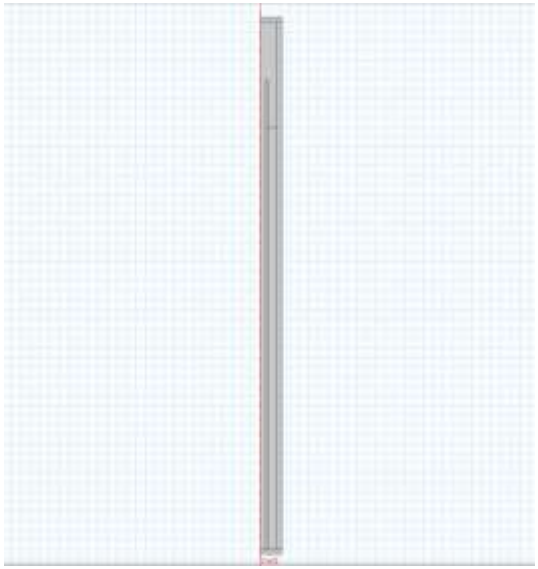
PCM

We will consider tubular elements consisting in an external steel casing filled with aluminum.

these elements are collected into groups brought into contact with the stream of fumes from which we intend to operate the energy recovery

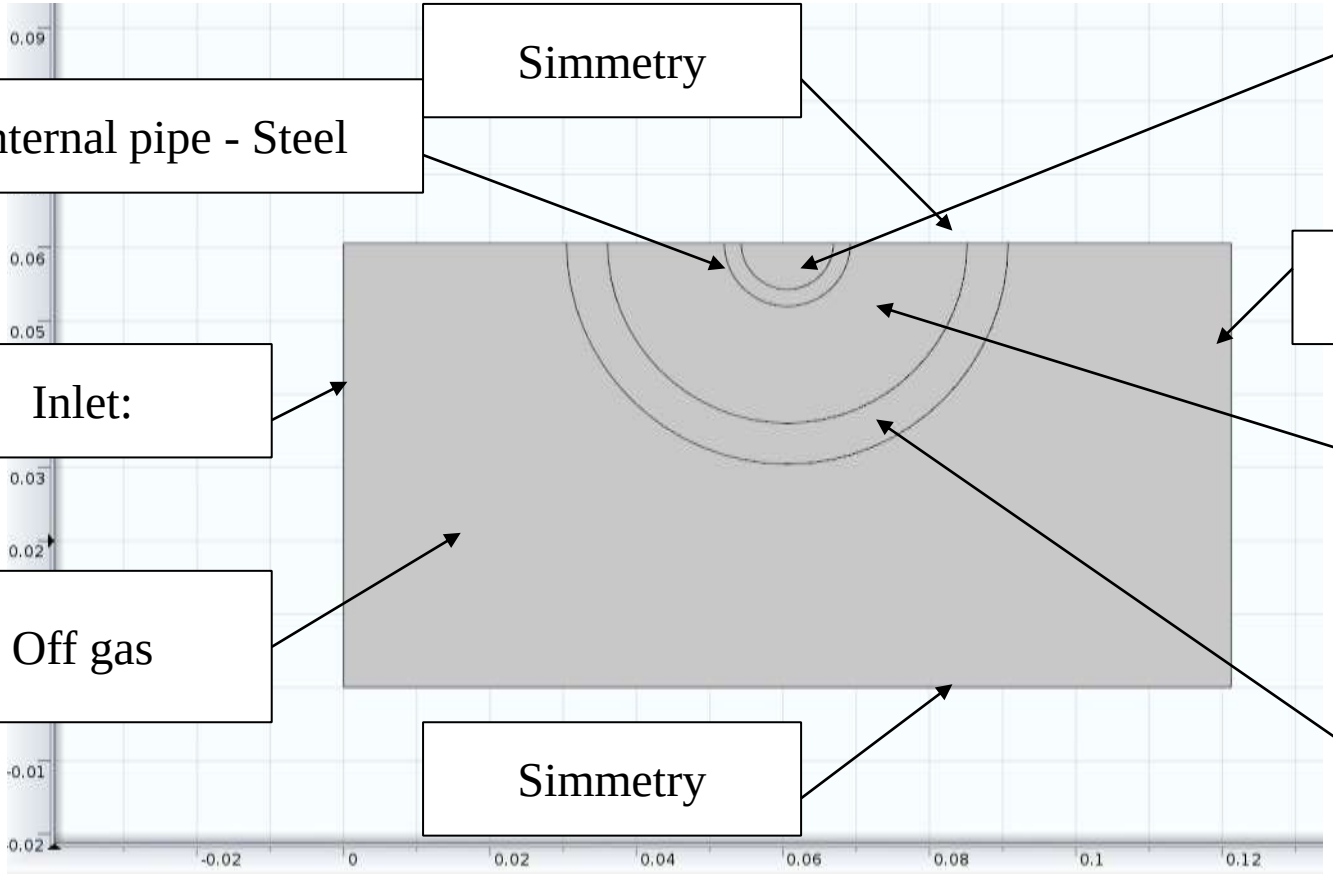






In order to determine the temperature fields within the system and consequently the position of the interface of solidification and the values of heat exchange we will use the non-isothermal flow physics interface.

MODEL – A



Simmetry

Internal pipe - Steel

Inlet:

Off gas

Simmetry

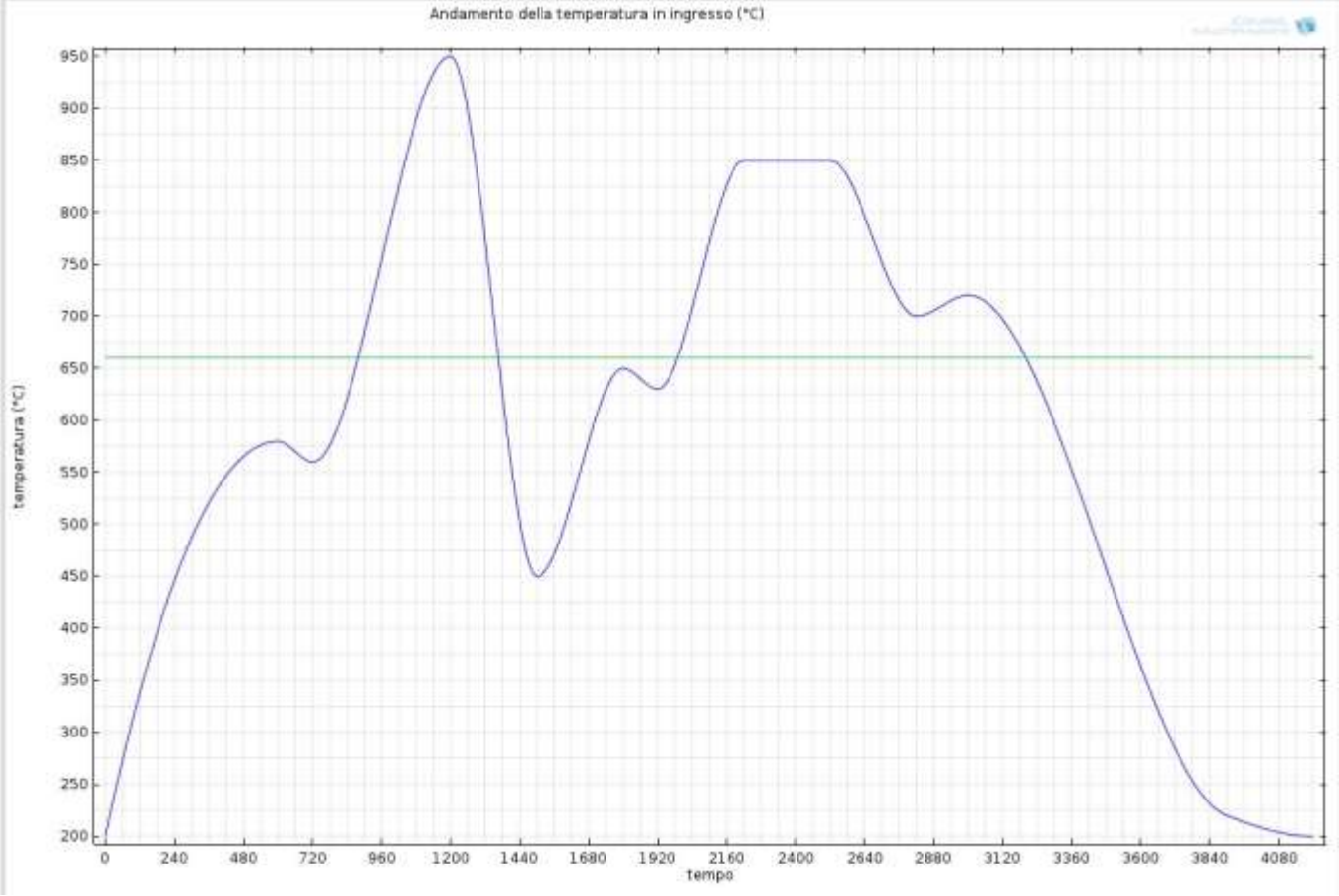
Nitrogen

Outlet

Aluminum

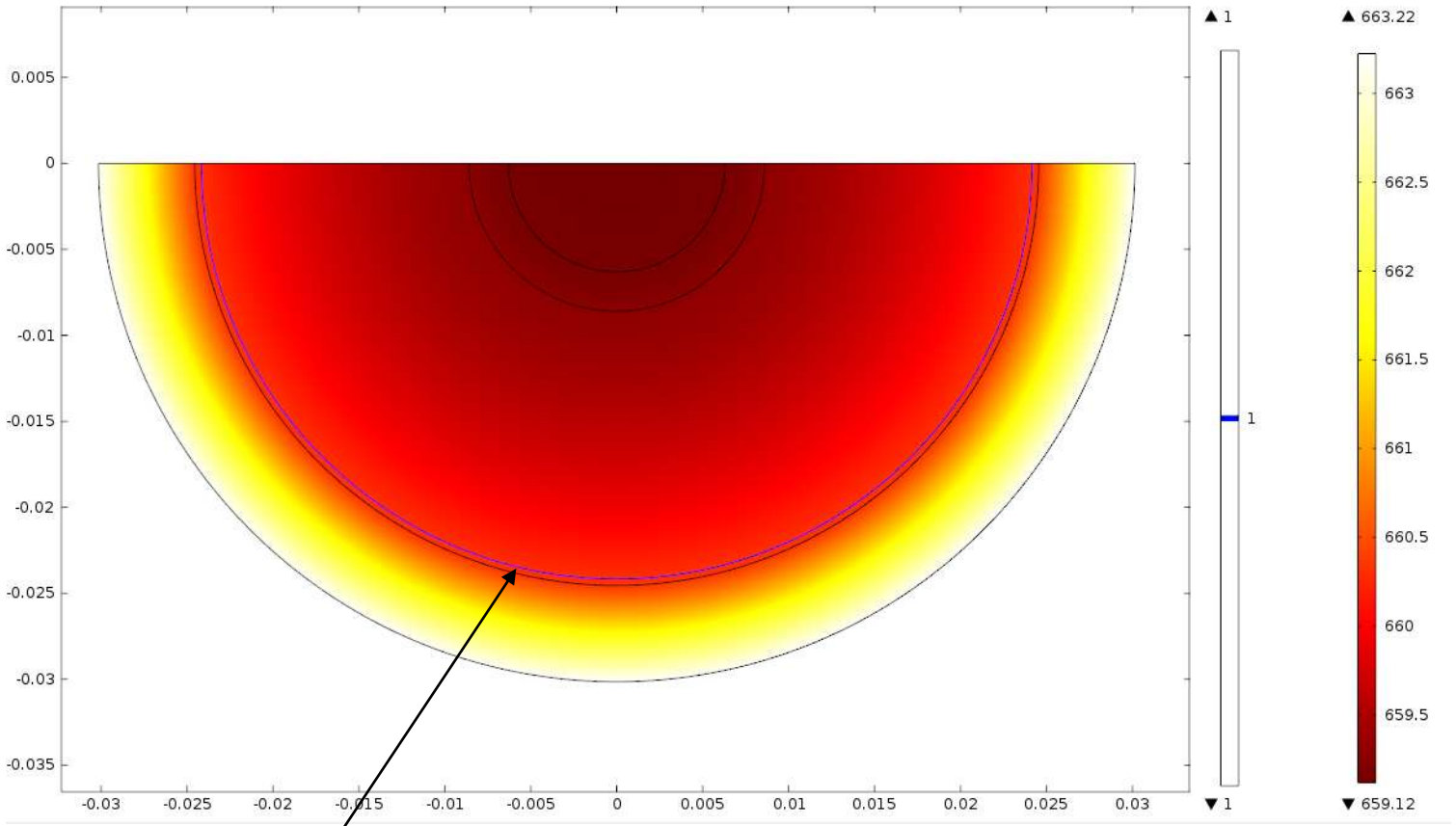
External pipe - Steel

MODEL – A



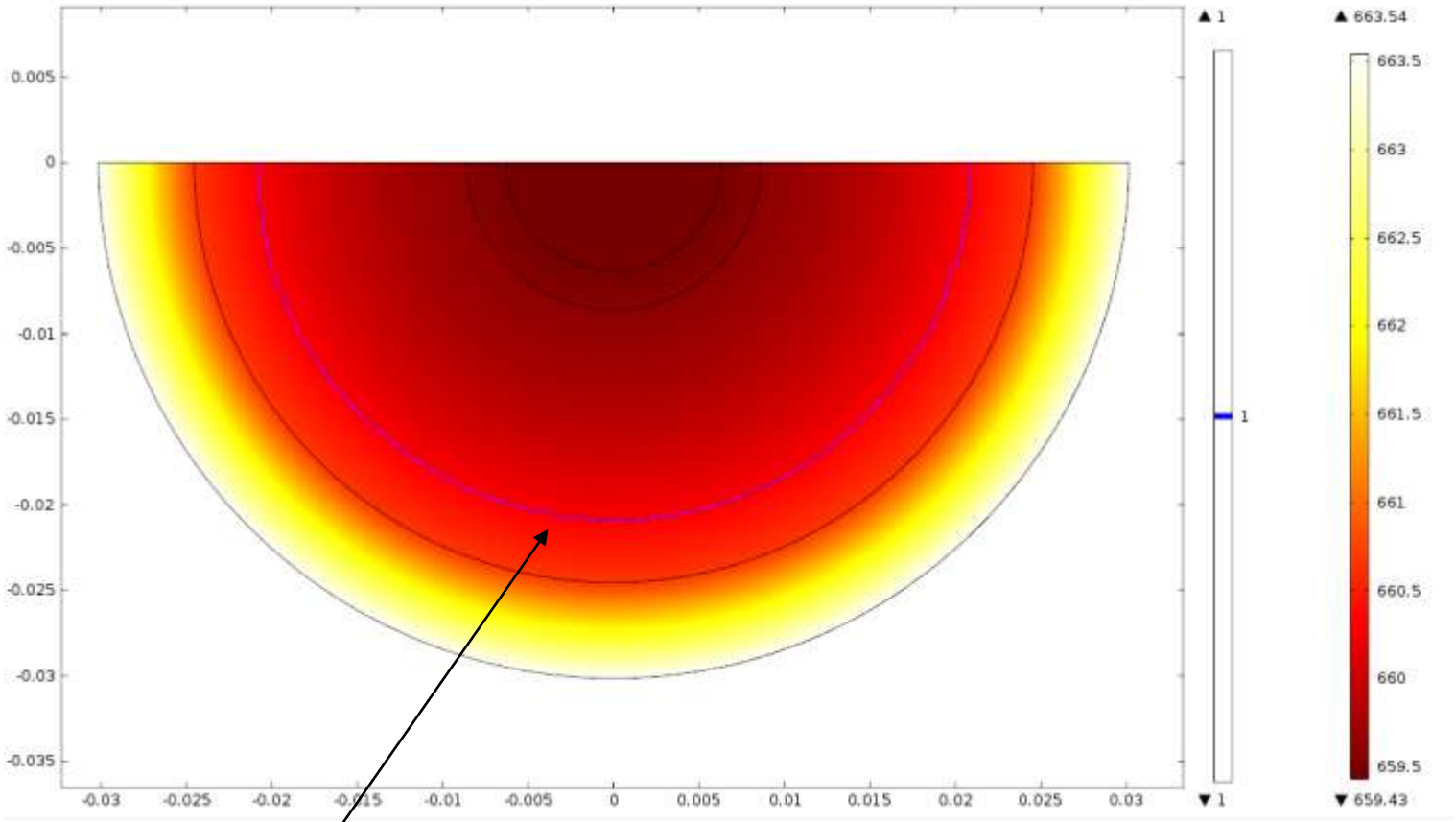
Temperature profile as a function of time imposed to off-gas input

MODEL – A



Melting front

MODEL – A



Melting front

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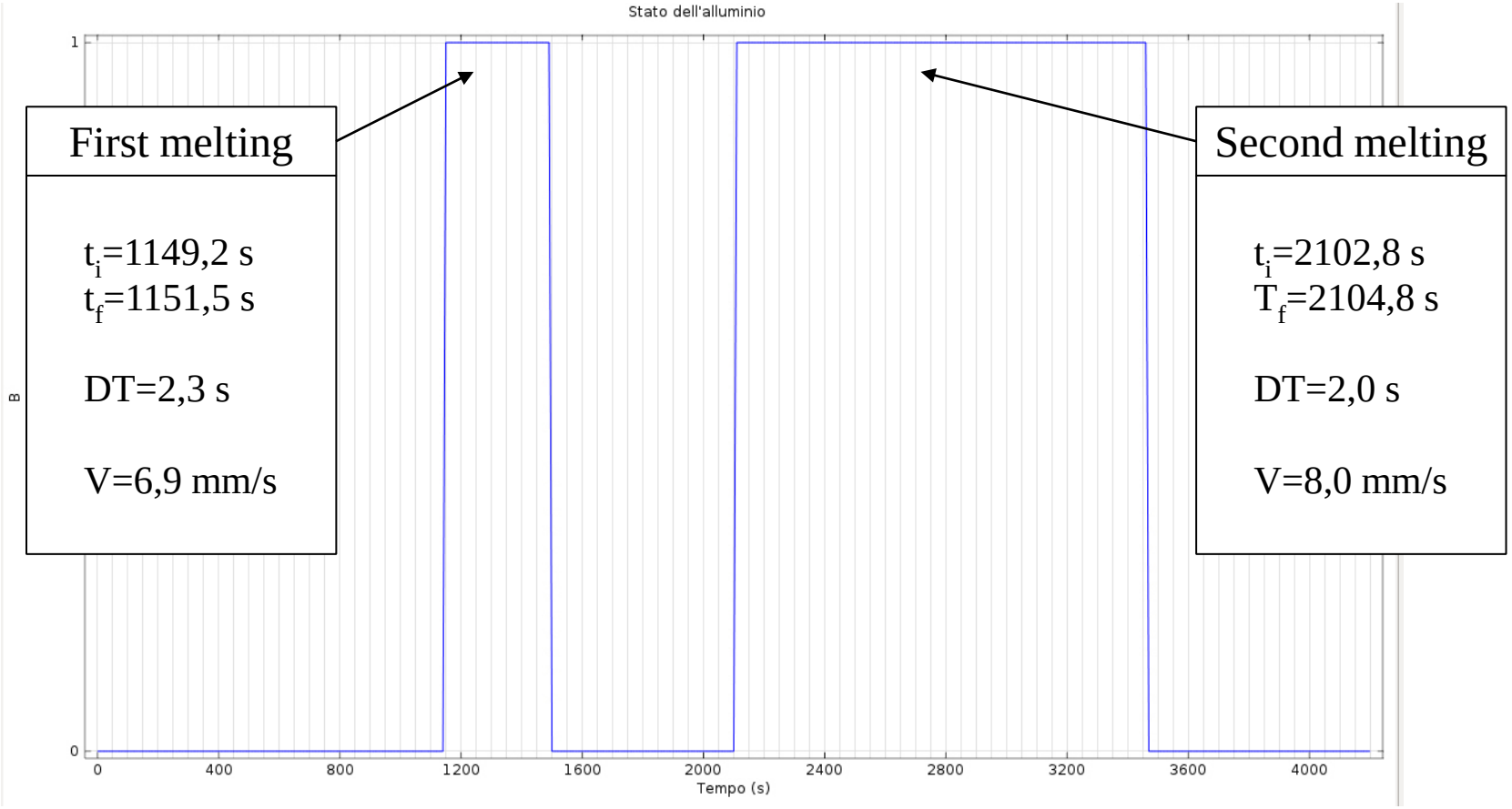
MODEL – A



First melting

t_i=1149,2 s
t_f=1151,5 s

DT=2,3 s

V=6,9 mm/s

Second melting

t_i=2102,8 s
T_f=2104,8 s

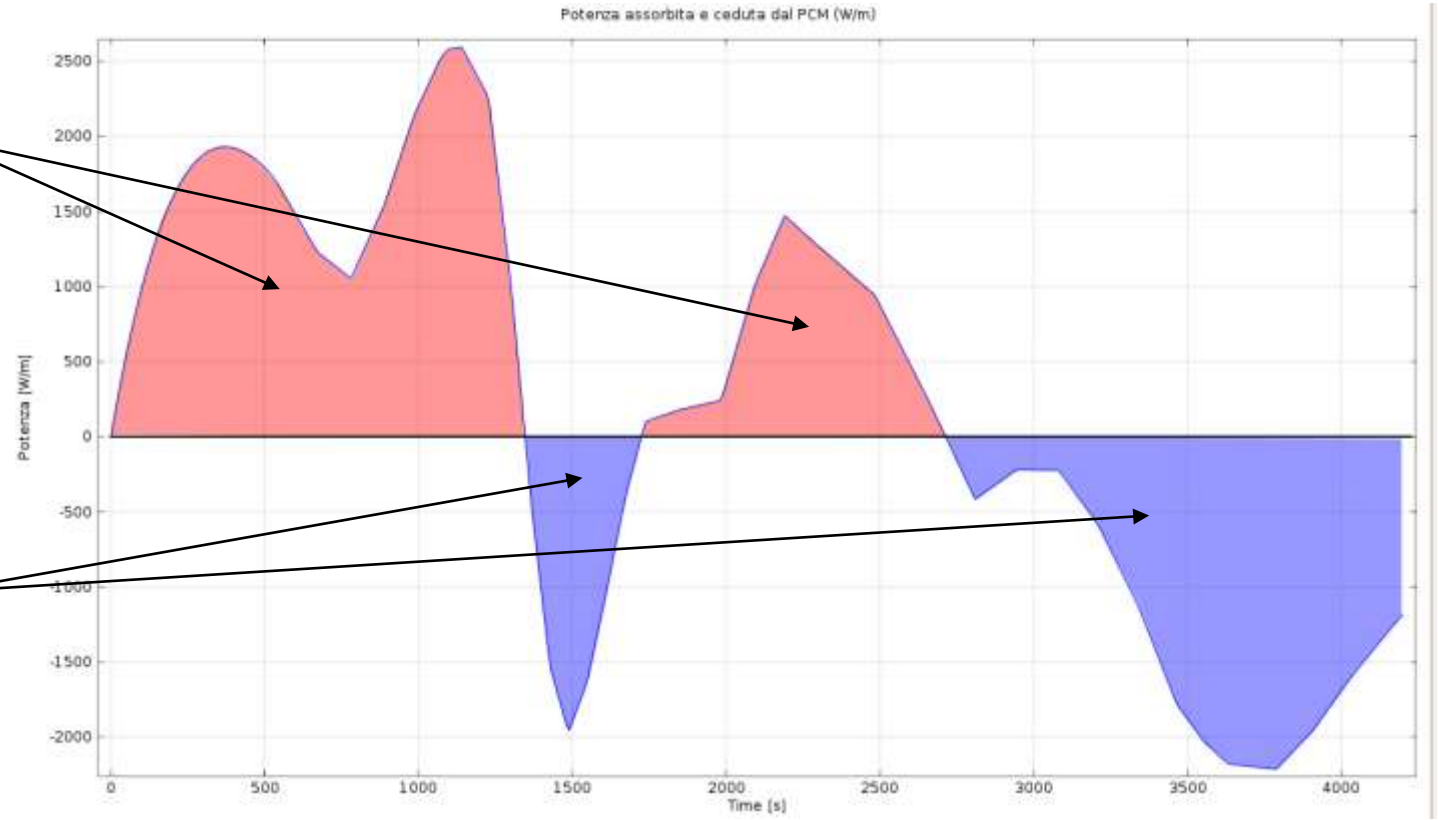
DT=2,0 s

V=8,0 mm/s

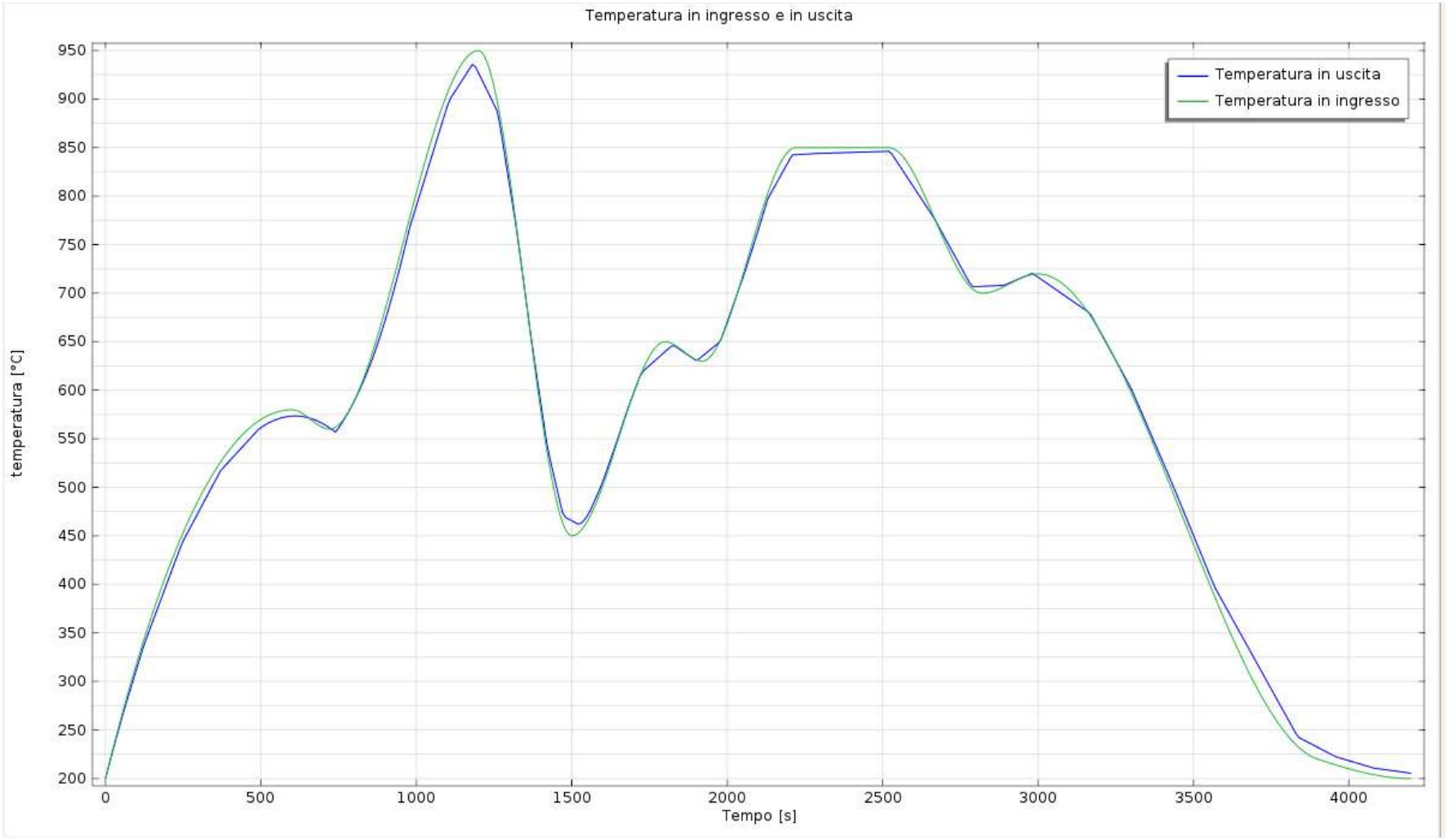
MODEL – A

Heat absorbed by PCM

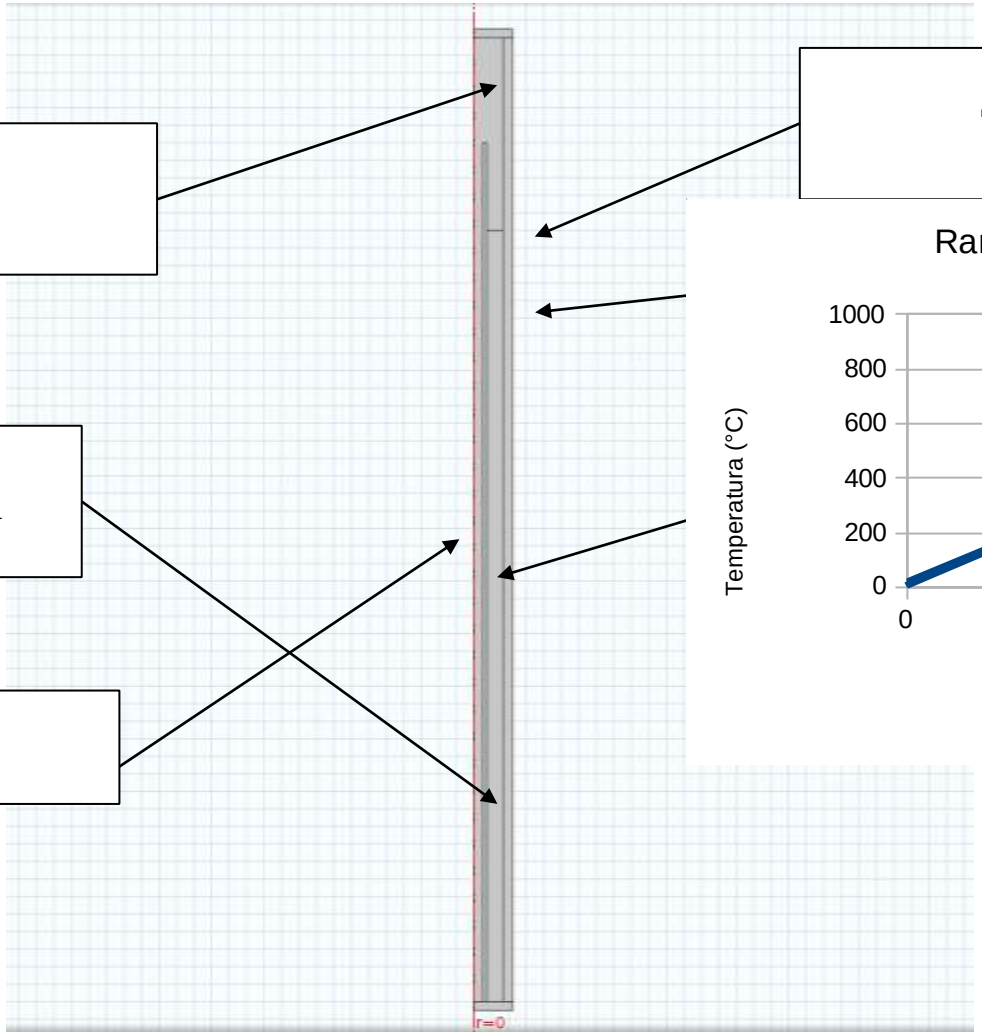
Heat released by PCM



MODEL – A


Temperatura in ingresso e in uscita
Temperatura in uscita
Temperatura in ingresso
temperatura [°C]
Tempo [s]
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
0
500
1000
1500
2000
2500
3000
3500
4000

MODEL – B

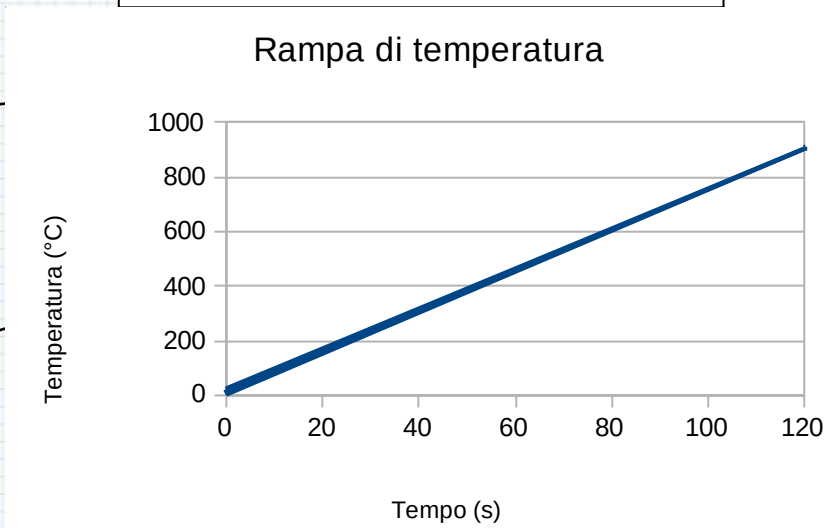


Nitrogen

Internal pipe - Stell

Simmetry Axis

Temperature



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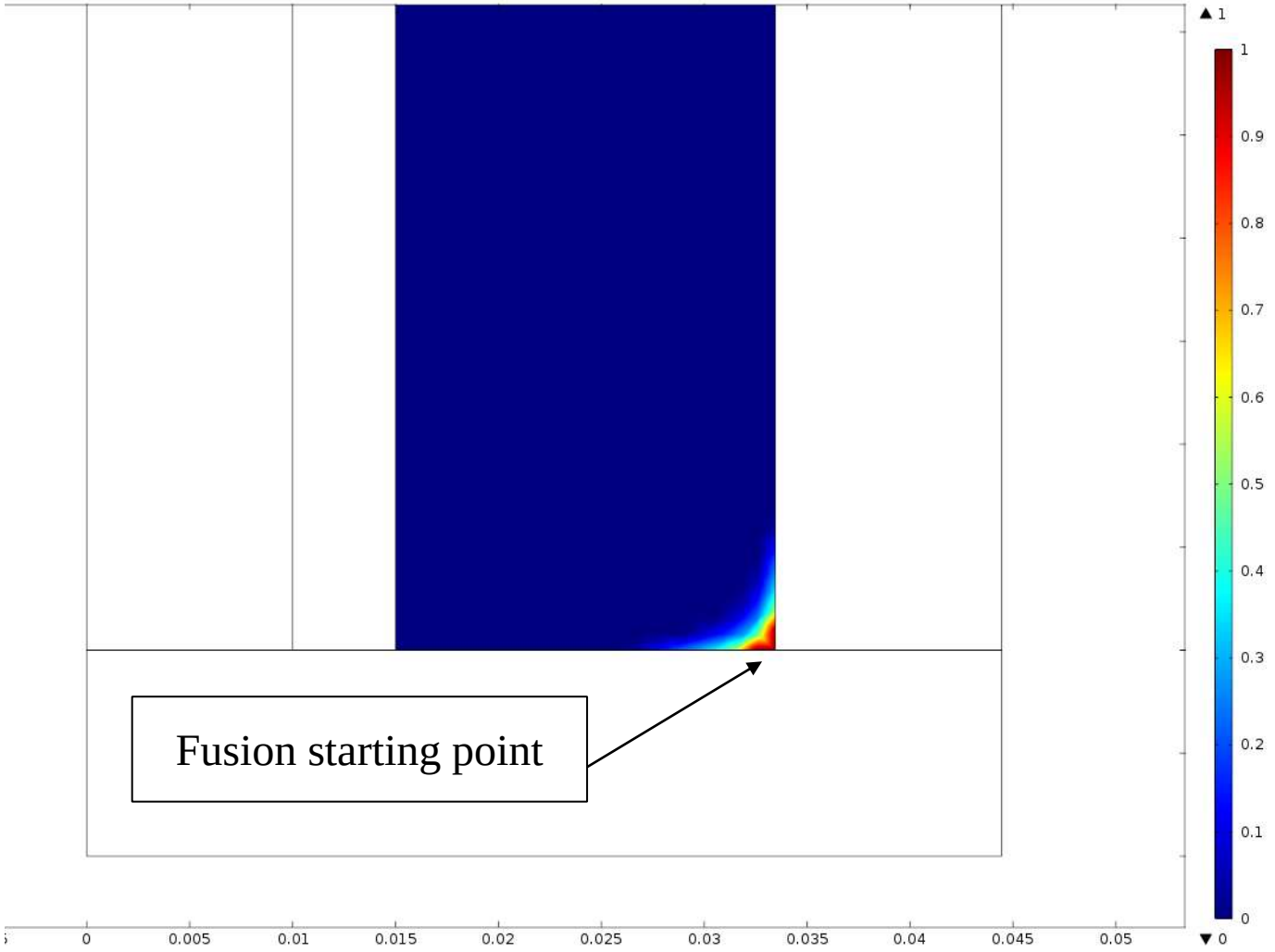
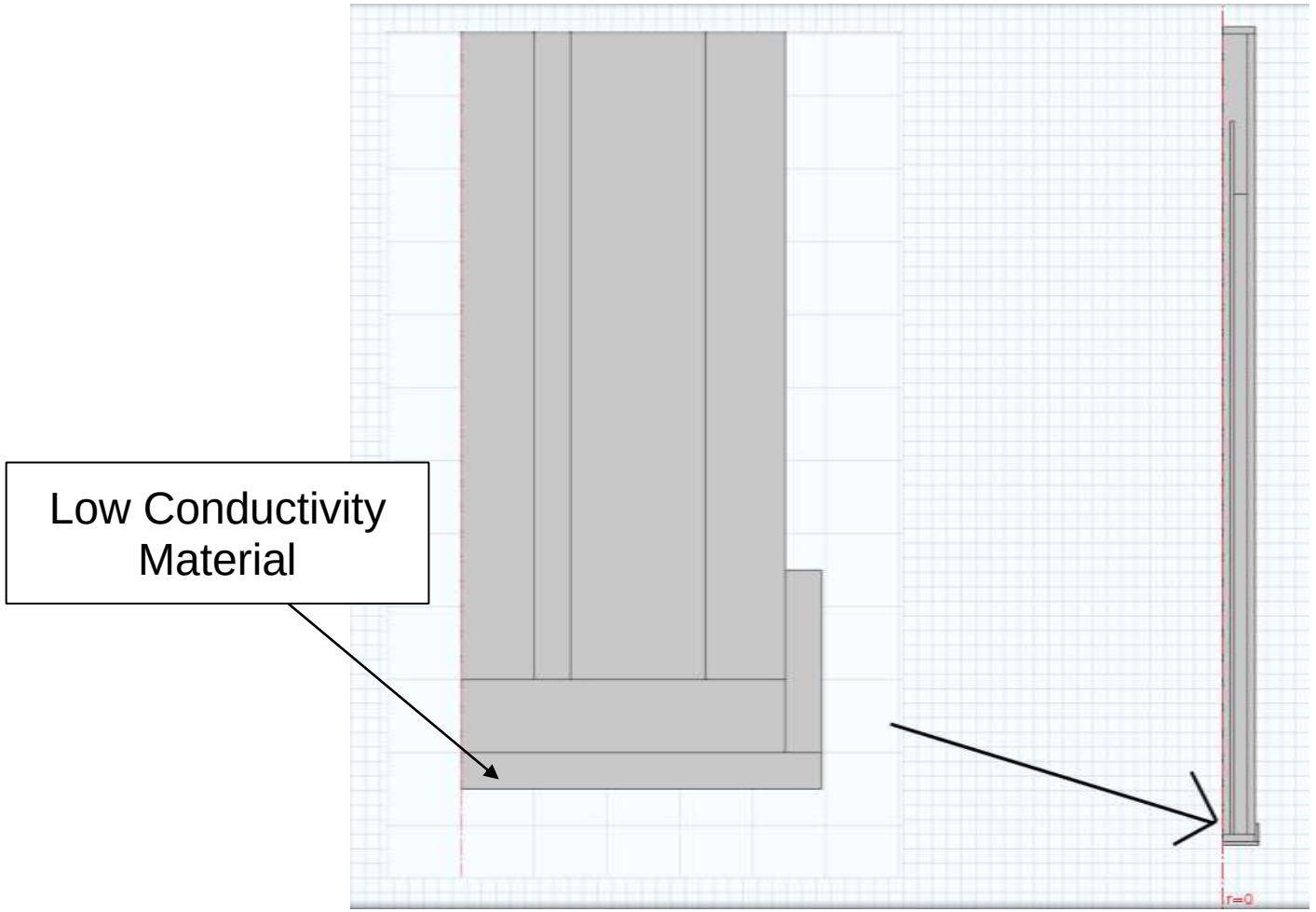
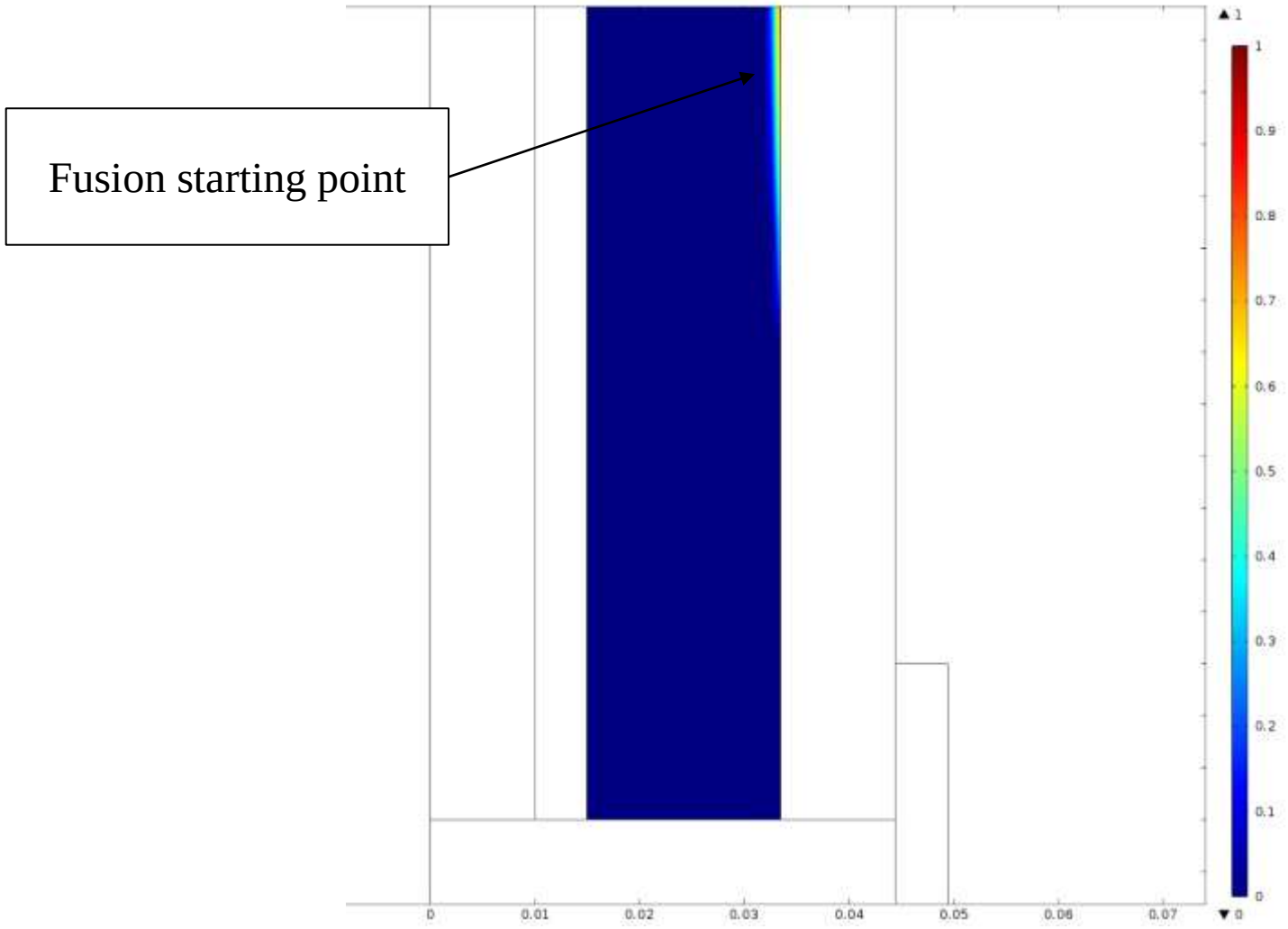
MODEL – B



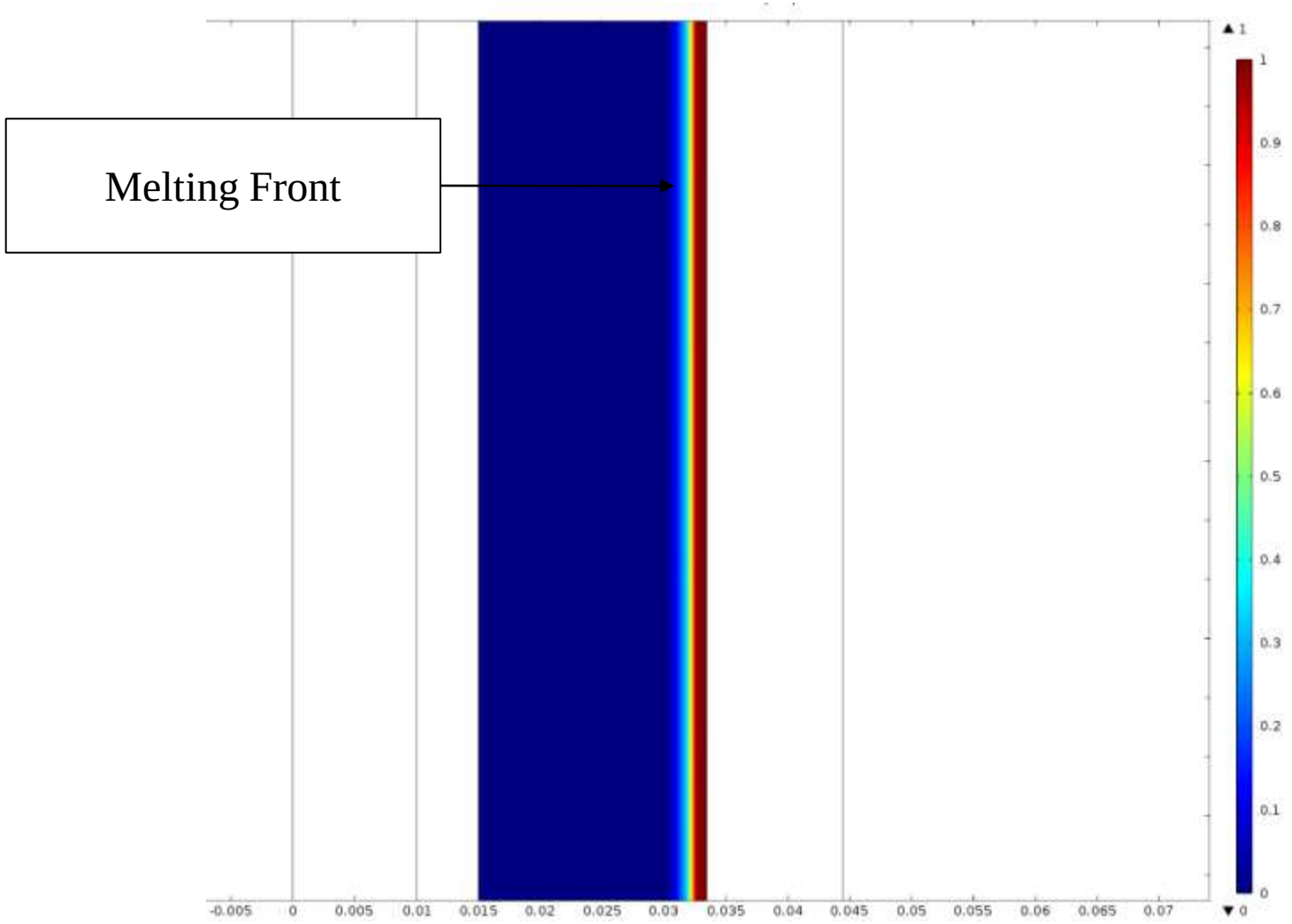
MODEL – B



MODEL – B

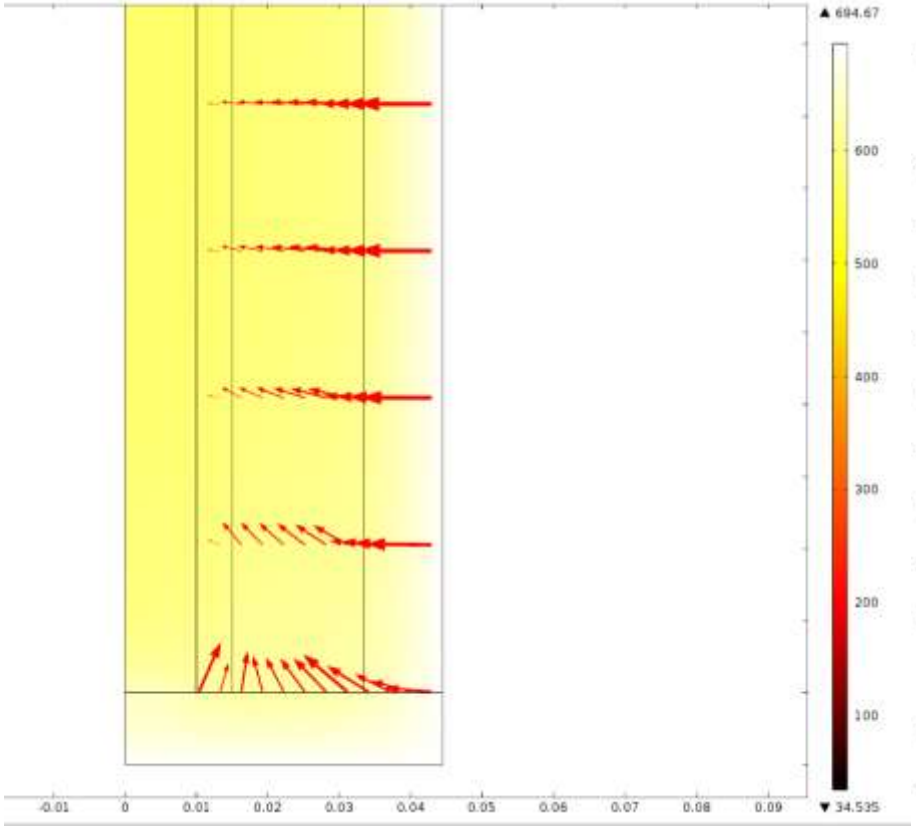

Fusion starting point
▲ 1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
▼ 0
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07

MODEL – B

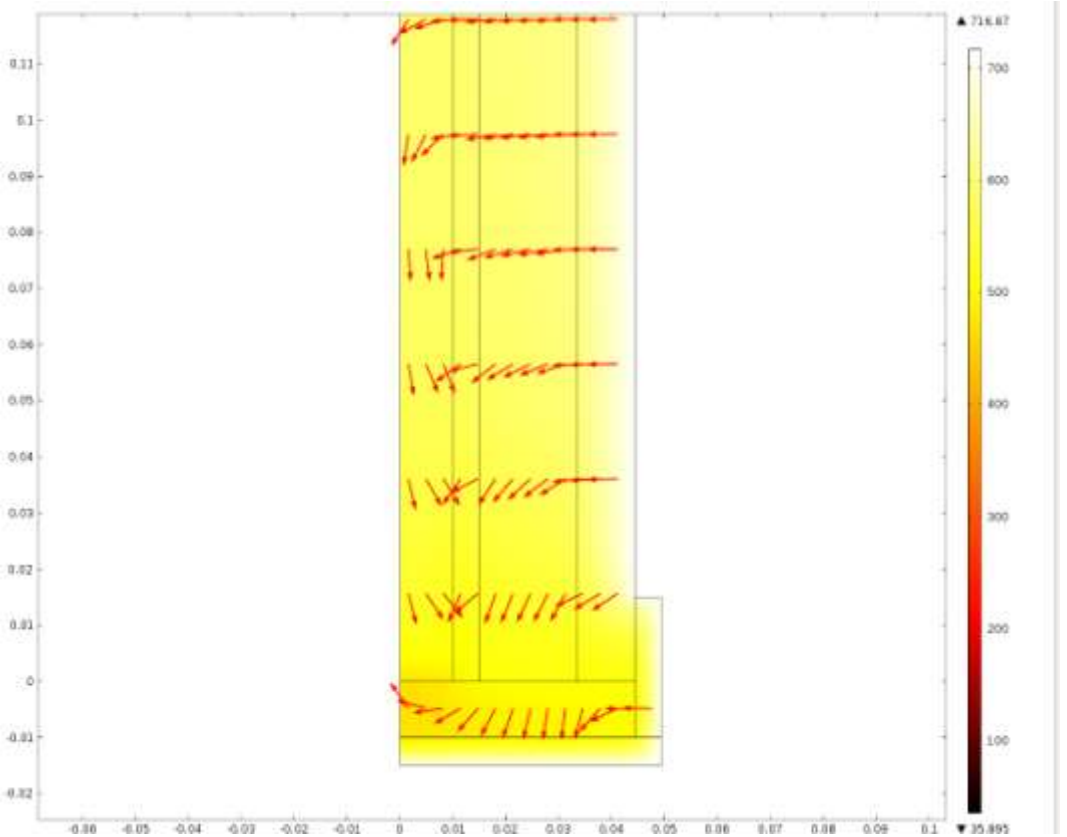

Melting Front
▲ 1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
▼ 0
-0.005
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
0.04
0.045
0.05
0.055
0.06
0.065
0.07

MODEL – B

Visualization of the temperature field and the heat flux



Unprotected bottom



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CONCLUSION

Using the multiphysics simulation allowed the evaluation of the various aspects related to the use of PCM and the relationships between them, it was then possible to determine the geometry of the PCM themselves and to assess their effectiveness in stabilizing the gas temperature.