Heat Generation from H_2/D_2 Pressurization of Nanoparticles: Simulation of the Experiments on COMSOL Multiphysics

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1. Introduction

The main issue for the development of a Low Energy Nuclear Reaction (LENR) power unit is related to determining the power and energy output of the reaction. Our team is currently working on a *gas loaded nanoparticle-type cluster power unit* [1] which pressurizes various nanoparticle alloys with either deuterium or hydrogen. The principal elements in the various nanoparticle alloys are Nickel, Palladium and Zirconium, with each alloy containing different percentages of elements. The research is currently focused on determining excess energy output which can be attributed to LENR reactions [2]. The complexity of the heat transfer arises from various interactions between the reactor, piping, insulation and natural convection.

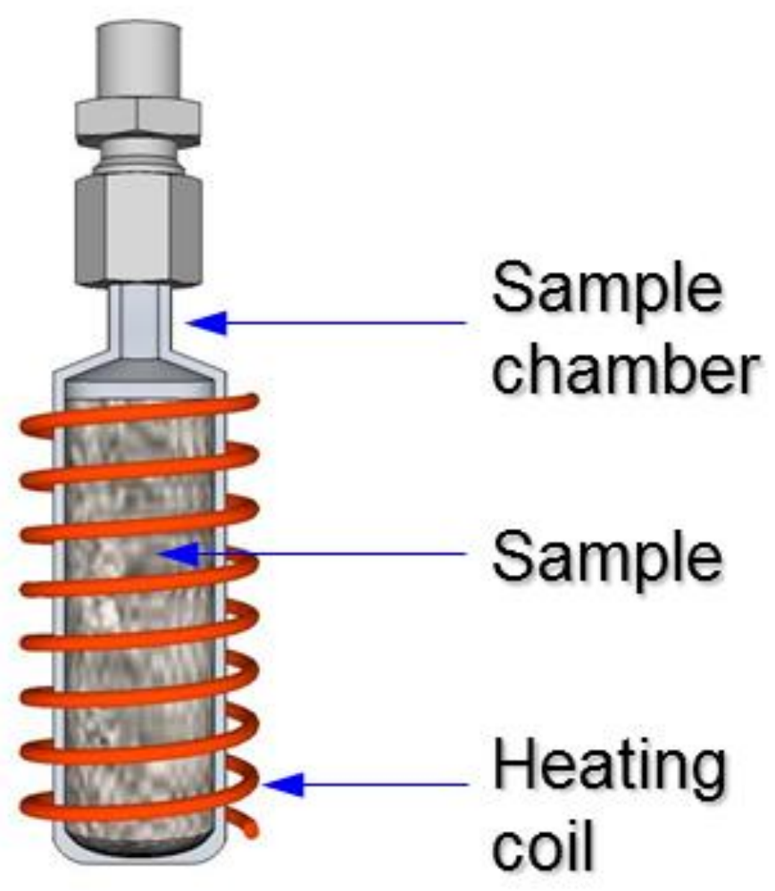

Figure 1. Schematic of one of our reaction chamber.

A Comsol Multiphysics model of the whole apparatus (Figure 2) has been created in order to simulate the pressurizations and understand the heat transfer.

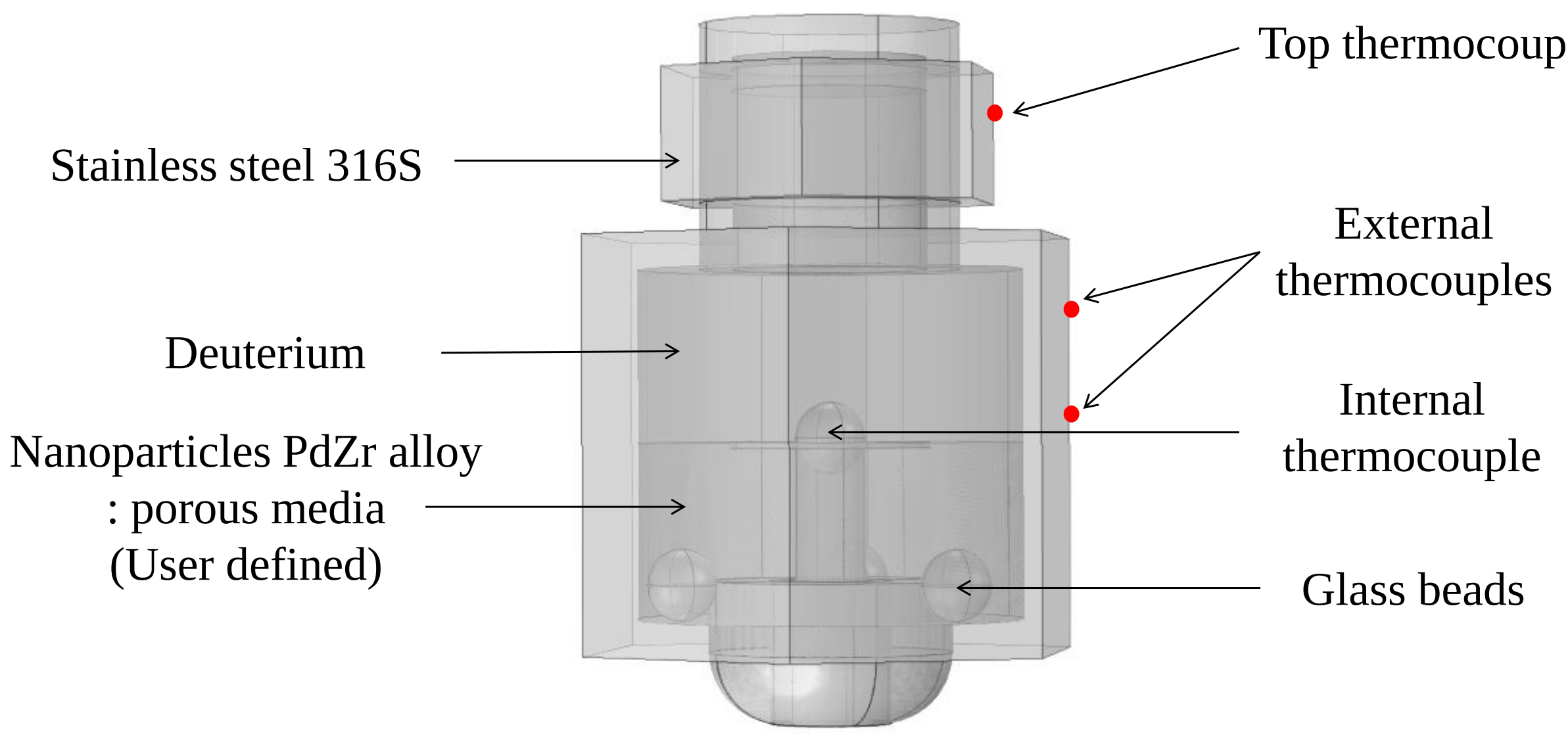

Figure 2. Geometrical model of the internal thermocouple chamber.

3. Computational methods

a. Approach

Using the thermal measurements from on a non-reactive chamber during a cooling process, we calibrated our model so that its thermal aspects reflect the ones of our experimental set up. We had to match three thermocouple measurements,

Final correspondence : < 3.3% in quadratic error on a 10000s basis for the three locations

b. Working model

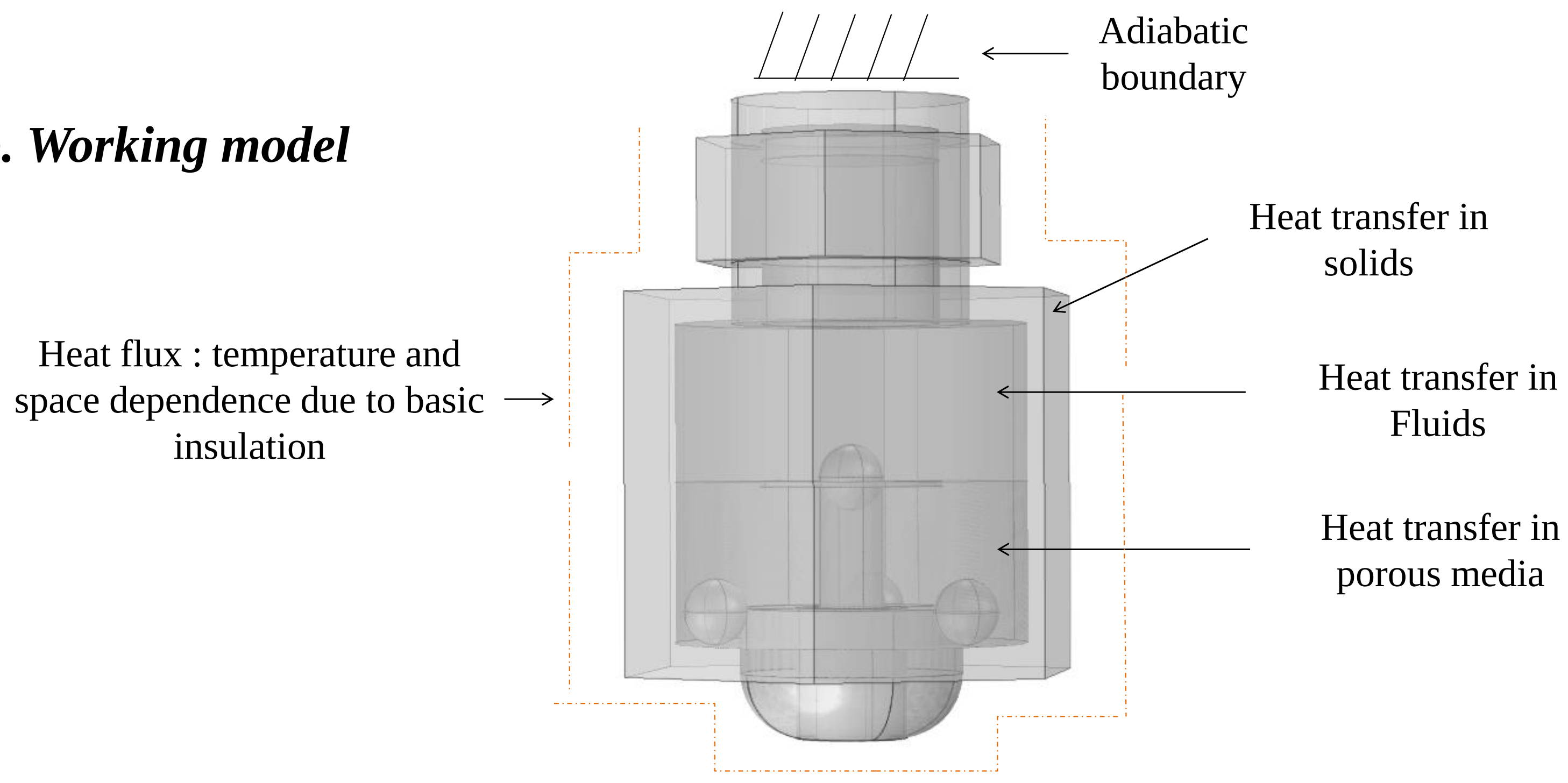

Figure 3. Physical model of the internal thermocouple chamber.

c. Difficulties encountered

- Meshing : The 3D geometry does not accept any meshing in the interior corners for coupling Heat transfer physics and Free and porous media flow. While looking for a solution, we have neglected the Free and porous media module. It stays consistent because, in this case, the fluid dynamics is far less influential on the temperature field and the energy transfer than the heat transfer phenomena.
- Calibration : Finding the profile of the exterior heat flux was difficult.

d. Reproduction of the pressurizations

In order to reproduce the pressurizations, the following variables are considered parameters : the location of the heat source, the conductivity of the nanoparticles and the time dependent profiles of the heat production. All these parameters influence simultaneously the thermal profiles. To simplify the parametric studies, some assumptions have been and made in the model.

4. Results

a. Calibration

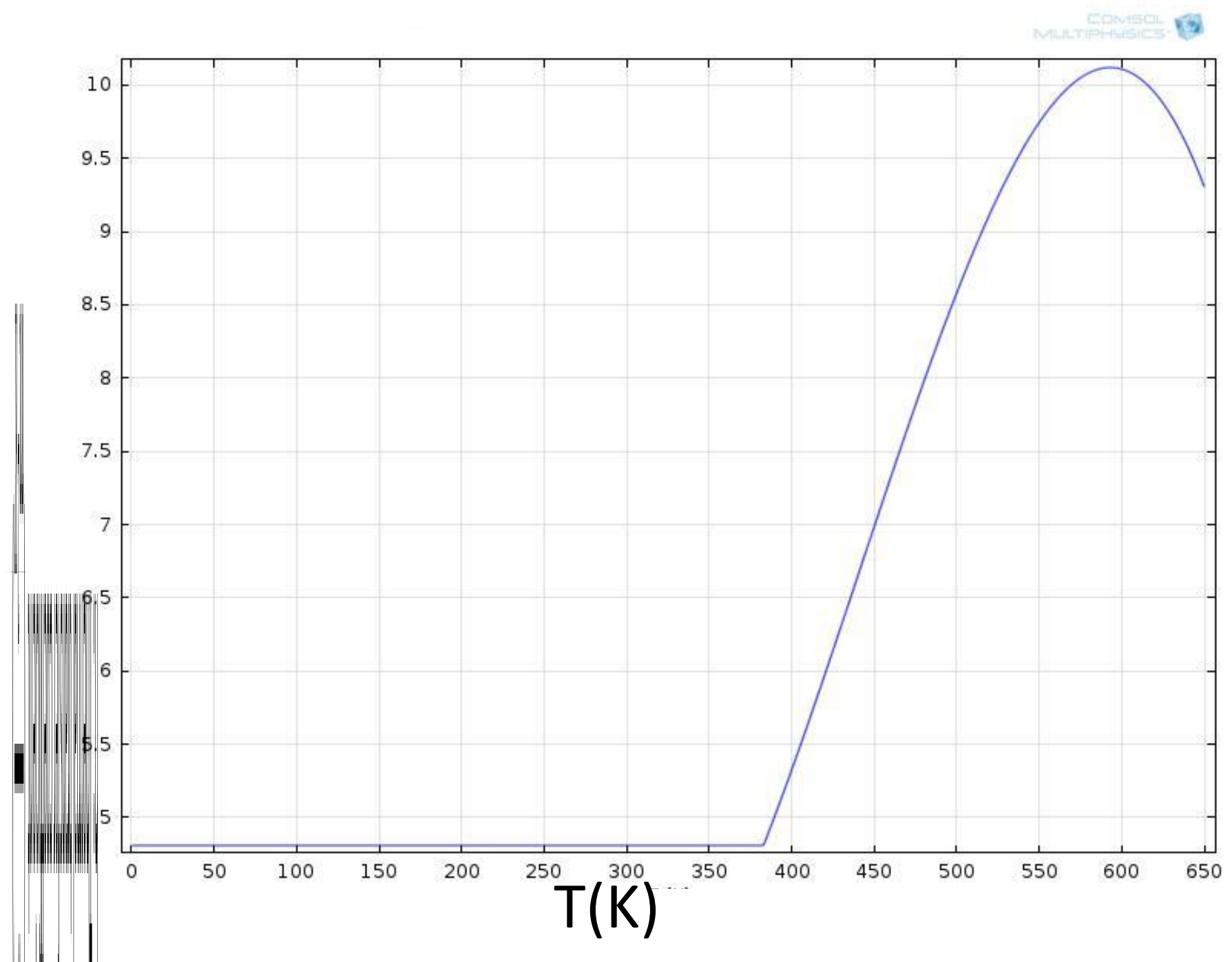

Figure 4. Profile of the exterior thermal transfer coefficient.

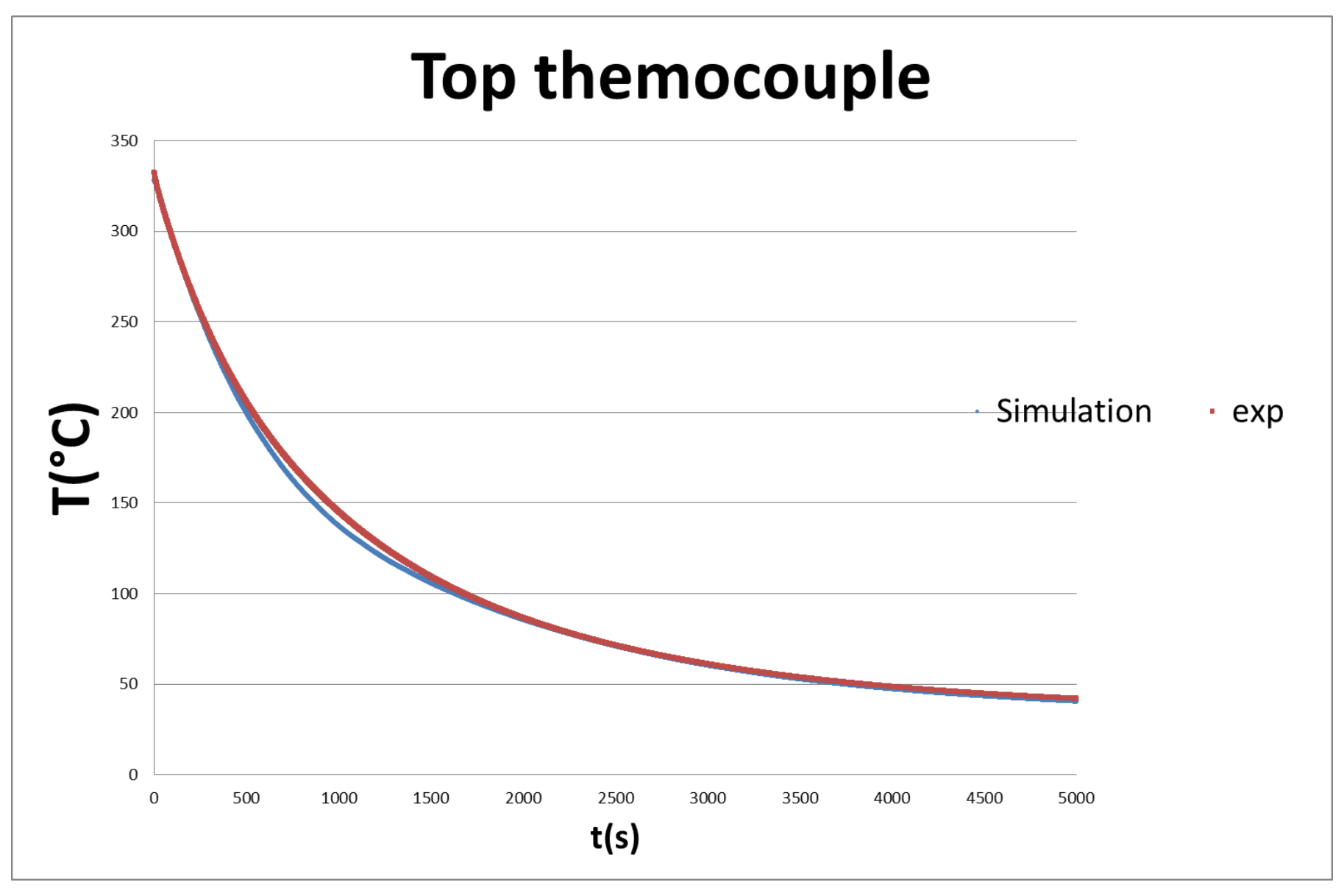

Figure 5. Example of correspondence between the simulation and a reference experiment for the calibration on a unique thermocouple.

b. Pressurization

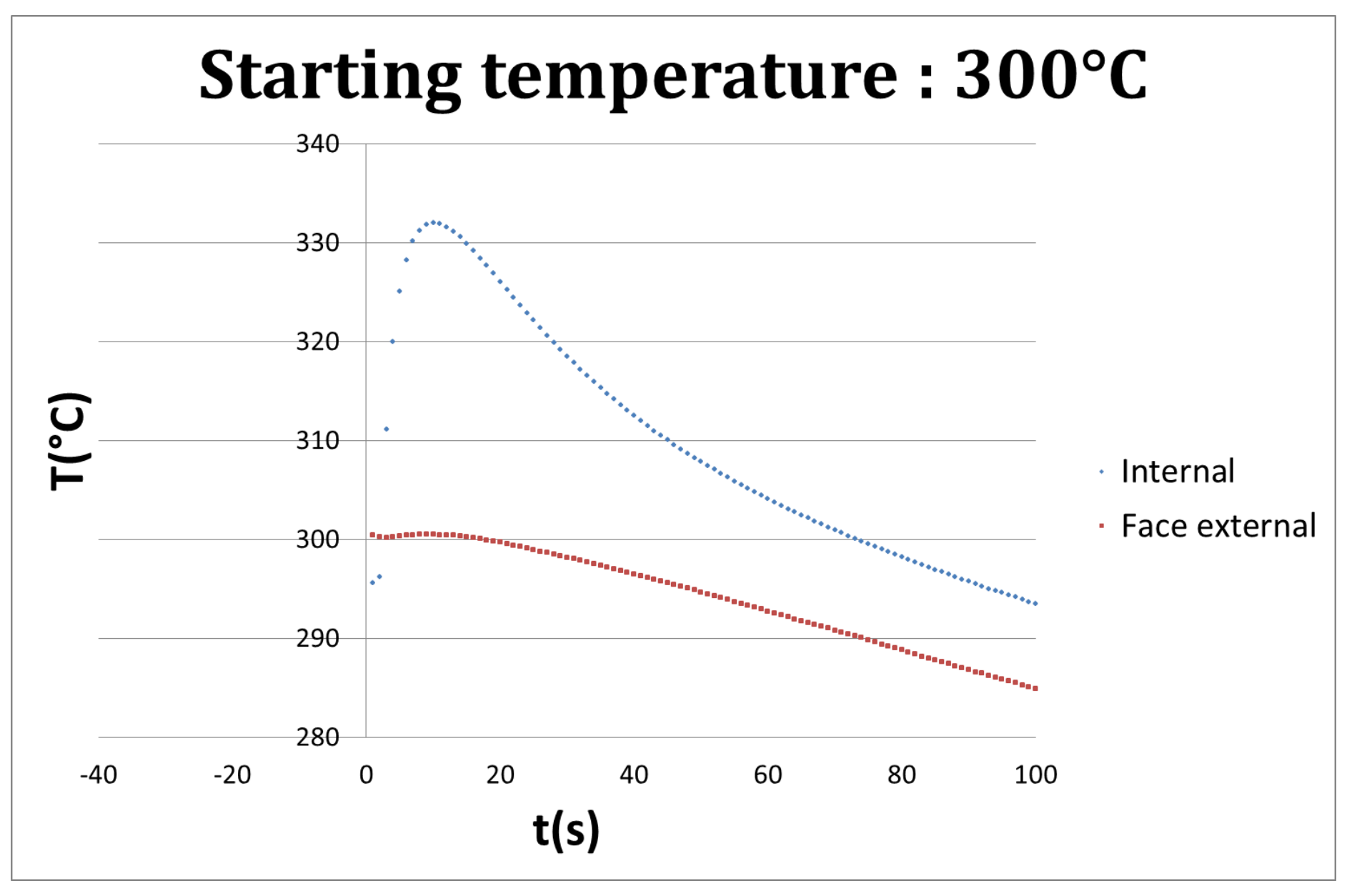

Figure 6. Example of experimental profile needed to be approach.

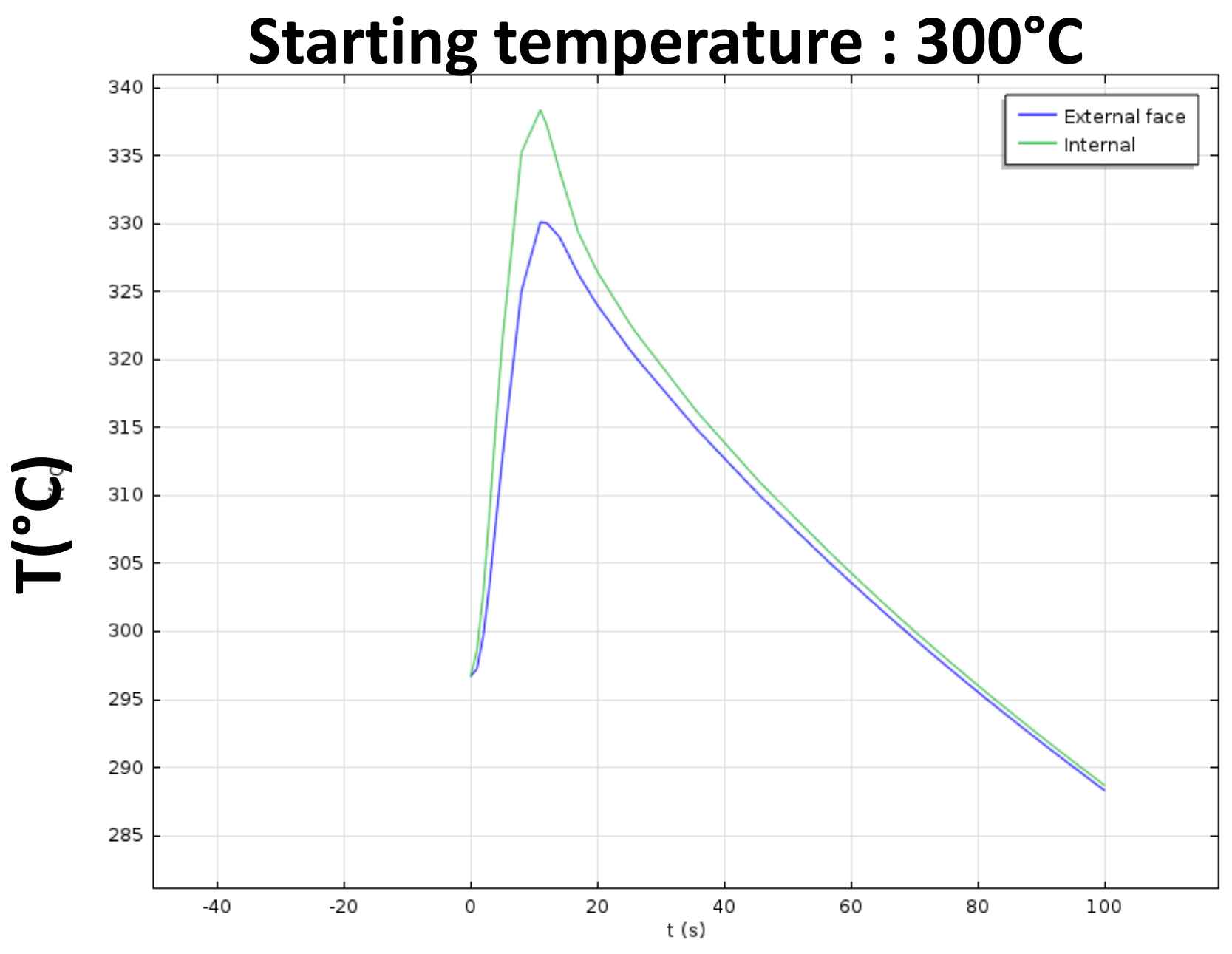

Figure 7. Result with uniform power source and a nanoparticle conductivity of 50W/(mK).

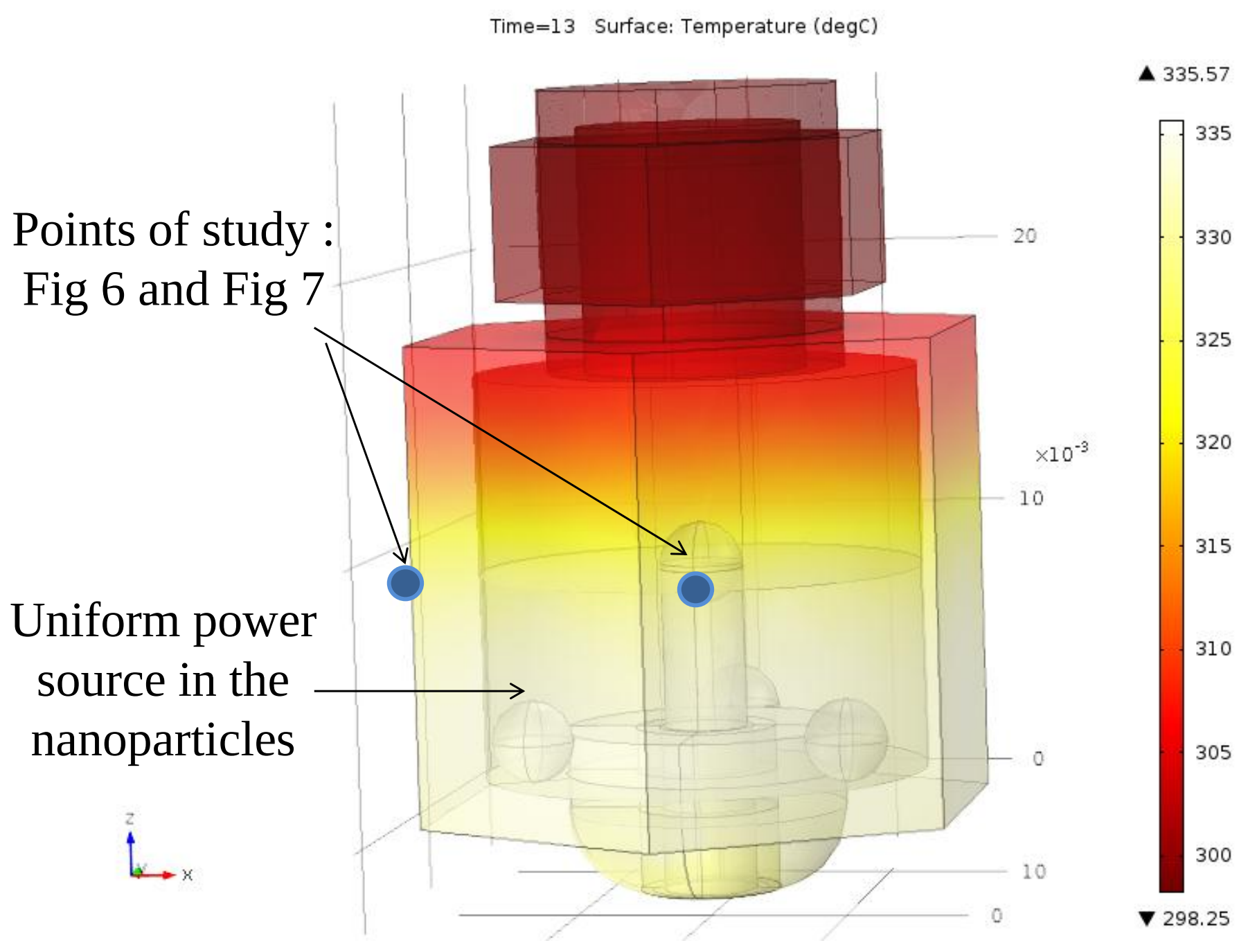

Figure 8. Temperature field at the temperature peak : t= 13s, Simulation corresponding to Fig 6.

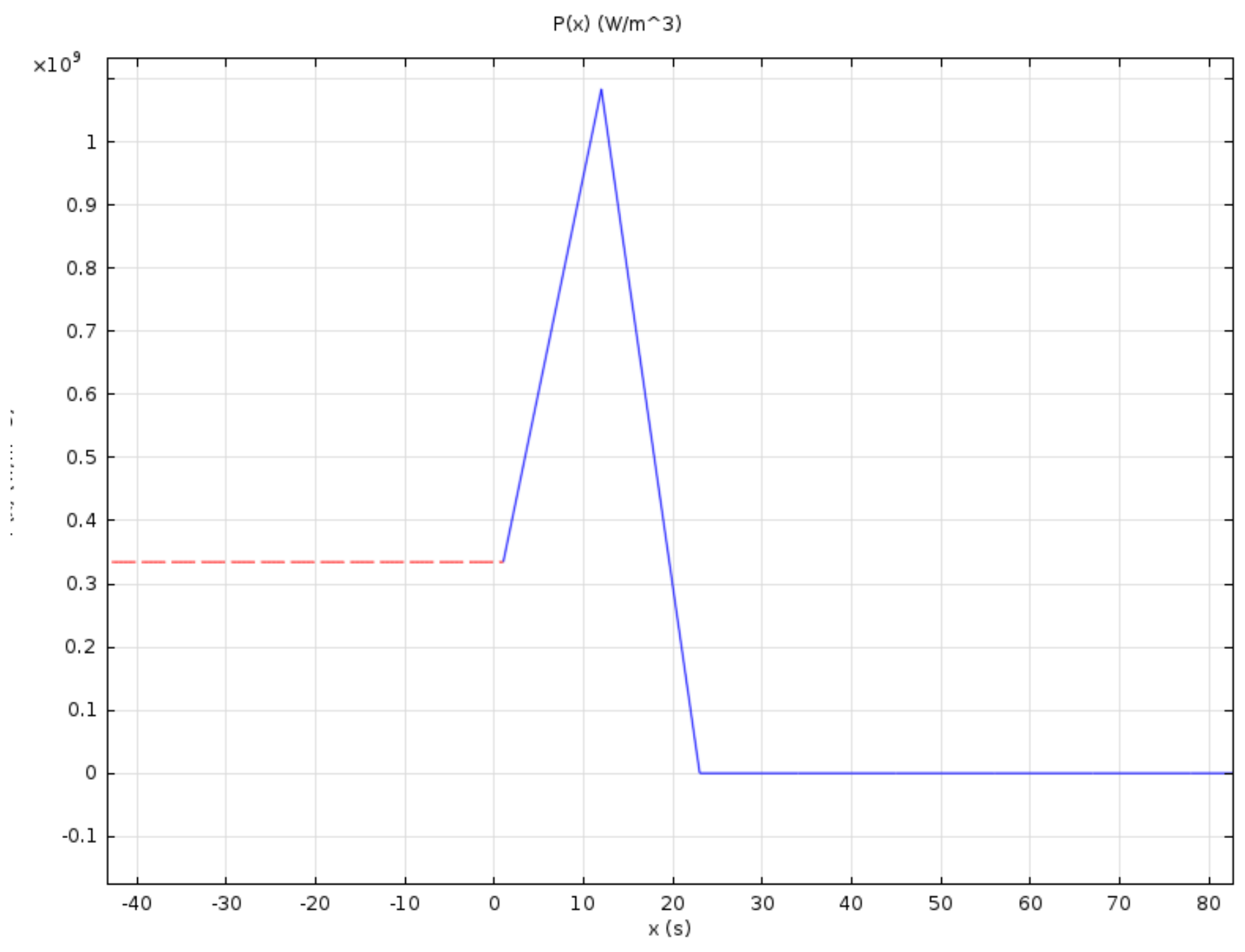

Figure 9. Power produced as a function of time, Pmax = 50W, Energy produced : 550J.

c. Remarks

The pressurization simulations do not exactly match the experimental data. Parametric studies and supplementary hypotheses are needed to reach a high level of correspondence. Tens of other experimental results with different parameters are waiting to be simulated with this calibrated model.

5. Preliminary conclusions and future work

Varying input parameters has already produced results on which we can draw conclusions.

- The thermal conductivity of the nanoparticles is actually lower than expected.
- From physical considerations and simulation results, the heat source is not uniformly distributed.

The team will now focus on developing a more accurate model of heat and power release due to the pressurizations. These heat and power outputs will be compared to the maximum theoretical chemical potential. If these modeled heat and power releases are higher, we will have strong evidence suggesting that the nano-particles undergo LENR type reaction.

References
[1] Miley, G. (2013, July). *Distributed power source using LENRs*. Presentation delivered at International Conference on Cold Fusion 18, University of Missouri, Columbia
[2] Patel, T., et. Al. (2013, July). *Recent results from gas loaded nanoparticle-type cluster power units*. International Conference on Cold Fusion 18, University of Missouri, Columbia