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COMSOL Multiphysics® Simulation of Heat Generation from Hydrogen/Deuterium Loading of Nickel Alloy Nanoparticles

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1. Introduction

A key issue for development of a LENR power unit is concerned with the measurement of the energy output of the reaction. Our team is currently studying a *gas loaded nanoparticle-type cluster power unit* [1] which pressurizes various nanoparticle alloys with either D_2 or H_2. The nanoparticle alloys are composed of Ni, Pd and Zr, with each alloy containing different percentages of these elements. A large energy release occurs upon pressurization with H_2 or D_2 to 1-10 Atm. The research is currently focused on determining excess energy output due to LENR reactions vs. chemical energy release due to gas absorption. [2]. The complexity results from the various heat transfer interactions between the reactor, piping, insulation and pressure vessel.

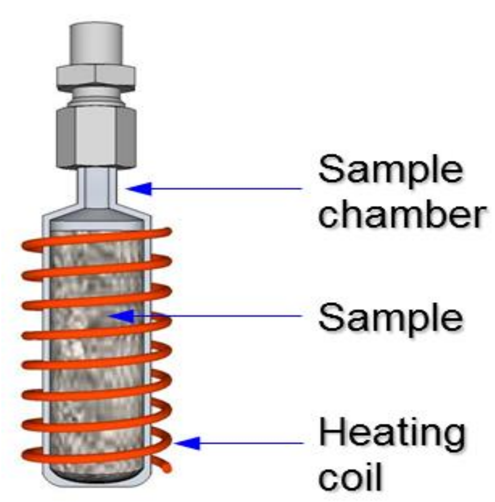

Figure 1. Schematic of one of our reaction chamber

Therefore, a Comsol Multiphysics model of the whole apparatus has been created in order to simulate the pressurizations. Figure 2 shows the final geometrical model.

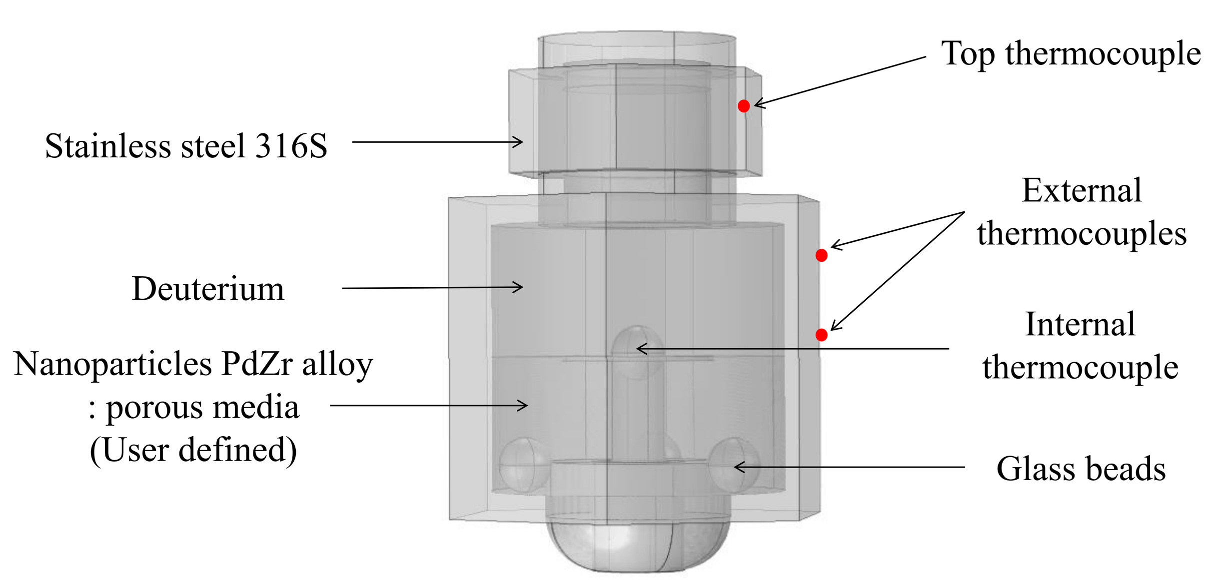

Figure 2. Geometrical model of the internal thermocouple chamber

3. Computational methods

a. Approach

Using the thermal measurements taken on a non-reactive chamber during a cooling process, we want to try to calibrate 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

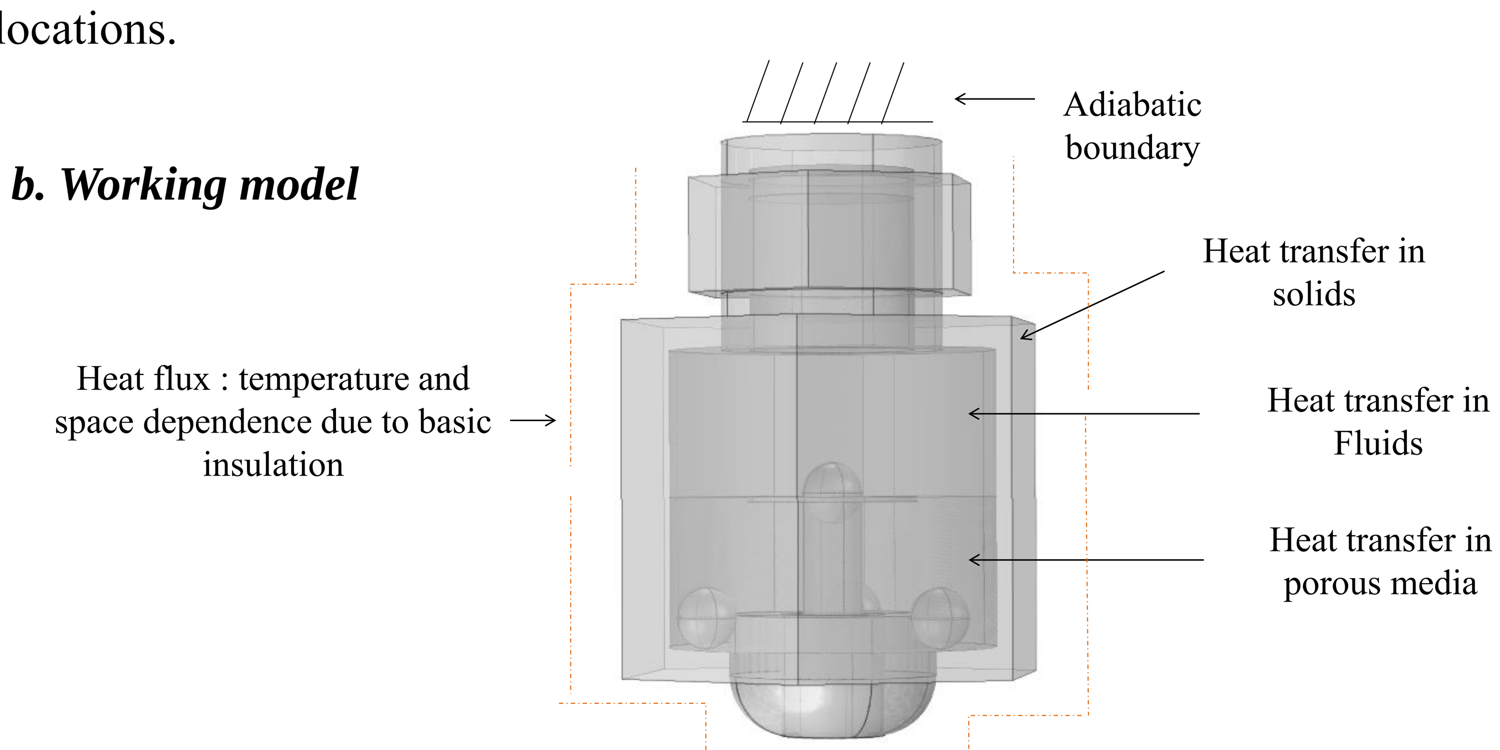

Figure 3. Physical model of the internal thermocouple chamber

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 the fluid dynamics is far less influent on the temperature field and the energy transfers than the heat transfer phenomena.
- Calibration : Find the profile of the exterior heat flux was hard.

d. Reproduction of the pressurizations

In order to reproduce pressurizations, we vary parameters : the location of the heat source, the conductivity of the nanoparticles and the intensity of the time dependent profiles of the heat production. All these parameters influence simultaneously the thermal profiles. Therefore coherent hypothesis are needed.

4. Results

a. Calibration

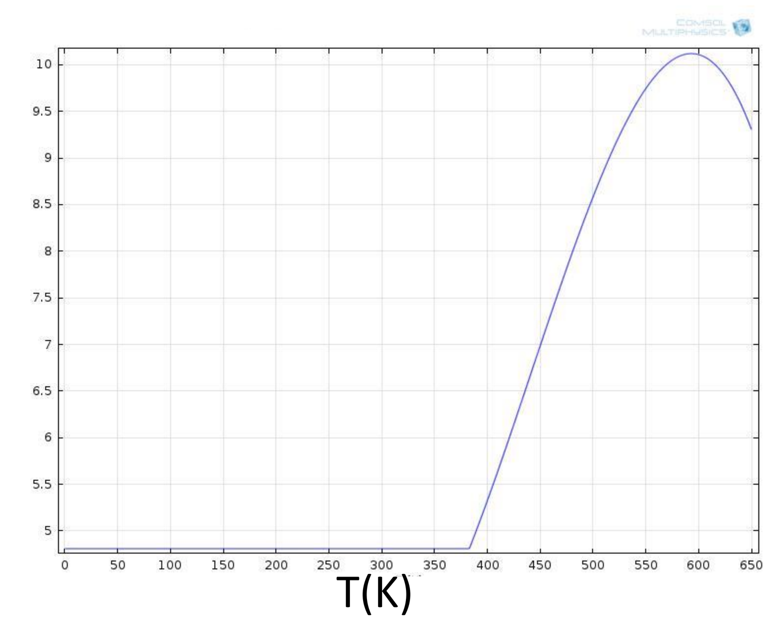

Figure 4. Profile of the exterior thermal transfer coefficient

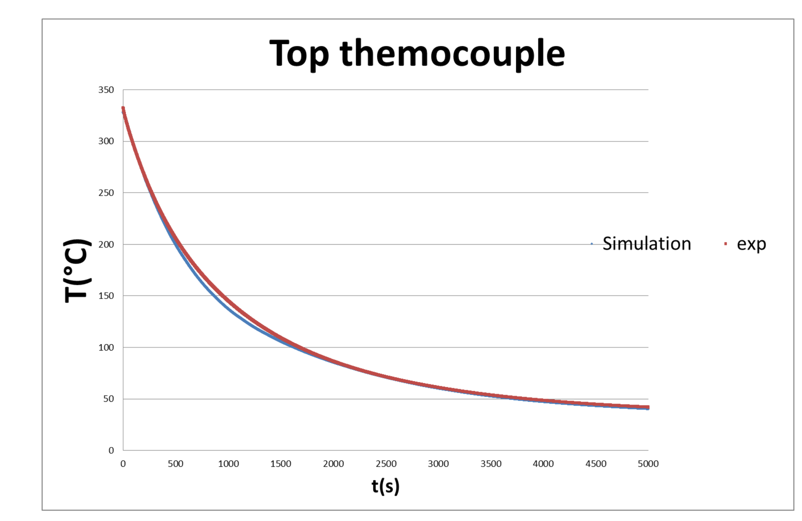

Figure 5. Example of correspondence for one thermocouple between the simulation and a reference experiment for the calibration

b. Pressurization

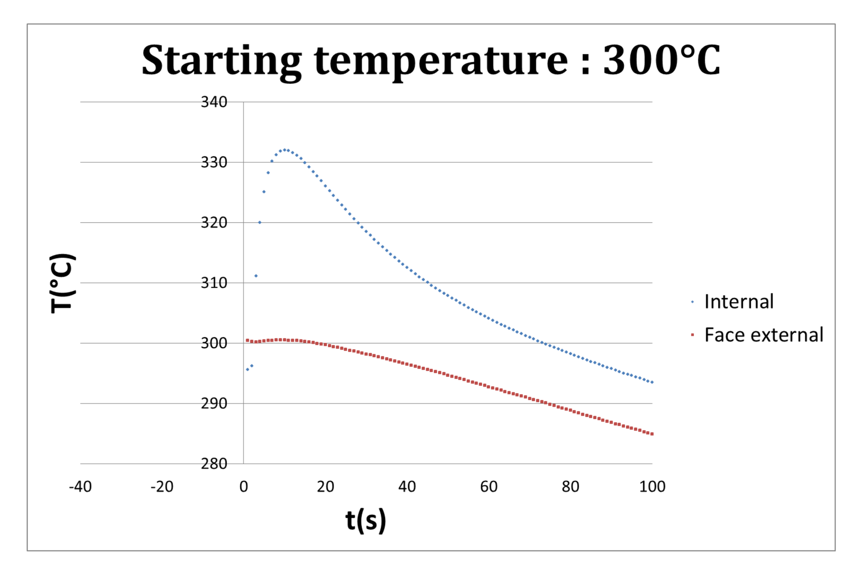

Figure 6. Example of temperature profile to reproduce

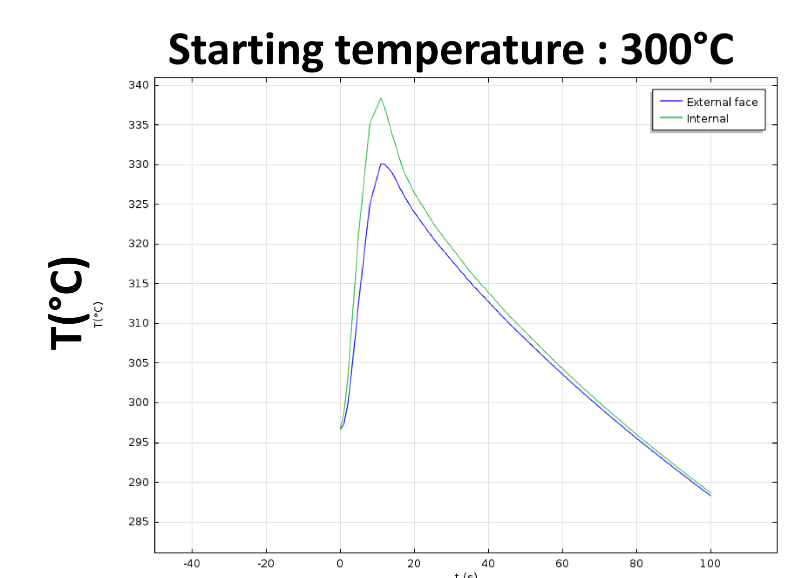

Figure 7. Result with uniform power source and a nanoparticle conductivity of 50W/(mK)

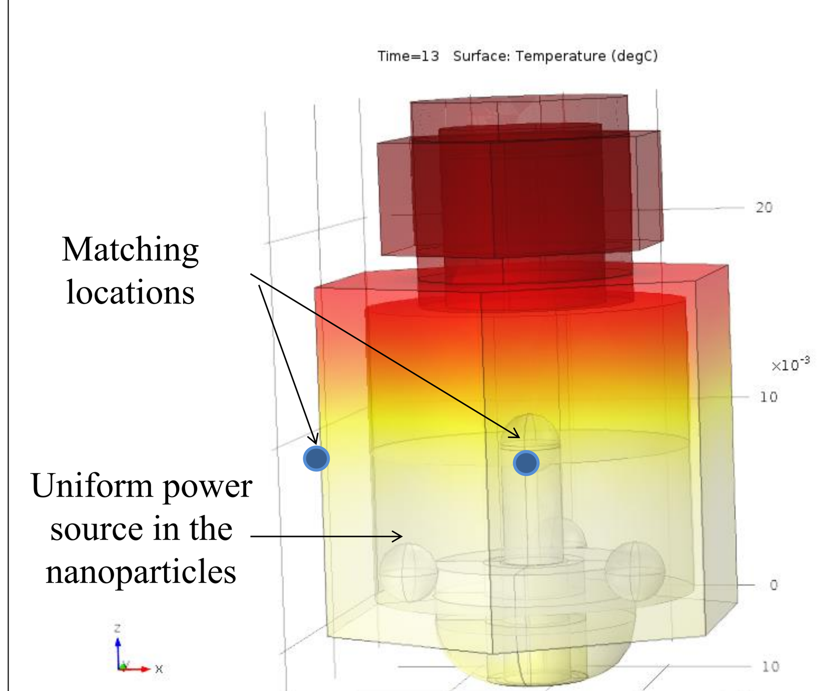

Figure 8. Temperature field at the temperature peak : t= 13s, Simulation of Figure 6

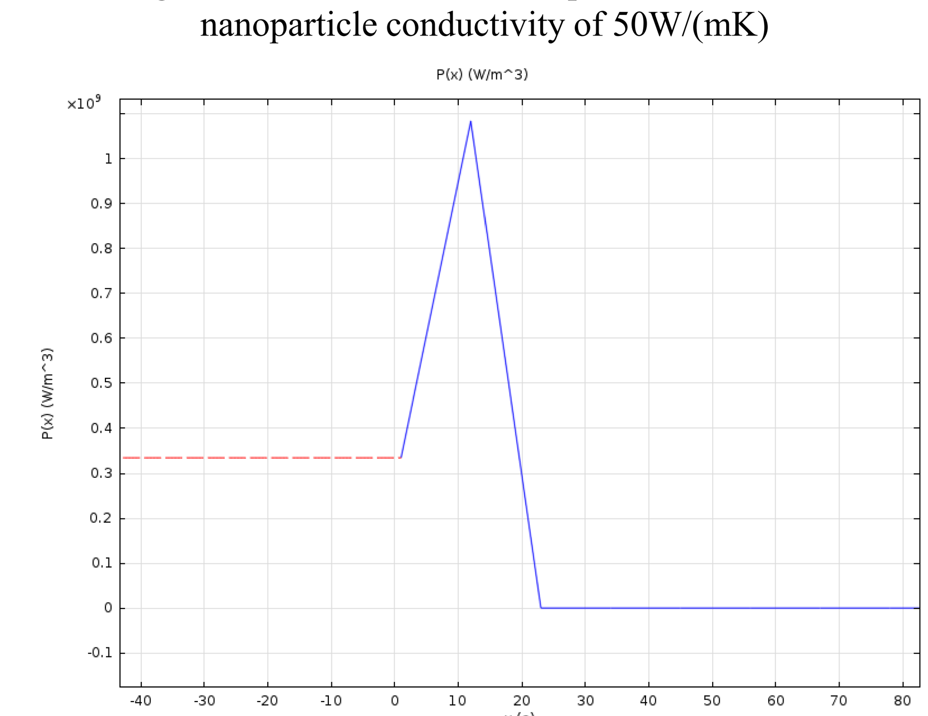

Figure 9. Power produced as a function of time : input for the model : Pmax = 50W, Energy produced : 550J

c. Remarks

The pressurization simulations do not match exactly to the experimental data. Parametric studies and supplementary hypothesis 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 next steps

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

- The thermo conductivity of the nanoparticles is actually lower than expected
- From physical considerations and simulations results, the heat source does not uniformly come from the nanoparticles in the chamber.

Next, we will focus of obtaining the best match possible for all our runs.. We will hopefully get accurate figures for the power that the pressurizations release and compare it to the potential chemical heat. If the pressurization releases are consistently higher, we will have a concrete argument to say that the pressurized nano-particles provide a reproducible source of a low energy nuclear 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