EUROPEAN SPALLATION SOURCE

Interim report on in-monolith neutron guide heating

[Type the document subtitle]

Anders Olsson

5/30/2017

[Type the abstract of the document here. The abstract is typically a short summary of the contents of the document. Type the abstract of the document here. The abstract is typically a short summary of the contents of the document.]

The heat load on the copper substrate is achieved from the Neutronics group, see Figure 1. The highest curve is chosen and digitized according to Figure 2. Figure 3 shows this load applied on the first substrate. The total power on this part then becomes some 100 W.

For a 2 mm gap of helium the thermal conductance is calculated according to

$$\lambda := 0.14\ \frac{W}{K}\ \frac{1}{m} \qquad gap := 2\ mm$$

$$h := \frac{\lambda}{gap} = 70\ \frac{W}{m^2\ K}$$

The total area between the substrate and the insert is some 0.5 m^2 so the average temperature becomes only 3°C.

$$\Delta T := \frac{P}{A \cdot h} = 3\ K$$

If we accept a ΔT of 10°C the thermal conductance needs to be at least 21 W/m^2K. According to the following calculation this is achieved for a pressure of 1 mbar.

$$Steel-He-Copper \quad M_1 := 56 \quad m_1 := 4 \quad m_2 := m_1 \quad M_2 := 63$$

$$a_1 := \frac{4 \cdot m_1 \cdot M_1}{(m_1 + M_1)^2} = 0.249 \quad a_2 := \frac{4 \cdot m_2 \cdot M_2}{(m_2 + M_2)^2} = 0.225 \quad a_0 := \frac{a_1 \cdot a_2}{a_1 + a_2 - a_1 \cdot a_2} = 0.134$$

$$d := 0.002 \quad m \quad p_{mbar} := 1 \quad mbar \quad p := 100 \cdot p_{mbar} = 100\ pa \quad K_0 := 0.14 \quad T := 300$$

$$K_{He1} := K_0 \cdot \frac{1}{1 + \dfrac{2.1 \cdot 10^{-4}}{a_0 \cdot p \cdot \dfrac{d}{T}}} = 0.0417 \qquad h := \frac{K_{He1}}{d} = 21$$

In order to check the temperature in the wafers the simplified model used in the report ESS-0093306 has been used. Compared to that analysis four things are changed:

1. The model is 1 m instead of 250 mm long.
2. The material in the substrate is copper.
3. Heat load is applied on the copper substrate.
4. Since the length of the wafers is only some 30 mm a uniform heat load taken from the peak value of the wafer is applied in order not to overestimate the heat conduction in the axial direction of the wafers since they are continues in the model.

The model and heat load applied on the substrate is shown in Figure 5 and the temperature is shown in Figure 6. The conclusion from this analysis is that the temperature in the wafers more or less follows the temperature in the substrate.

The final conclusion from this study is that with a helium atmosphere with a pressure of at least 1 mbar and proper cooling of the surrounded steel shielding the temperature in the wafers and substrate will stay well below 60°C.

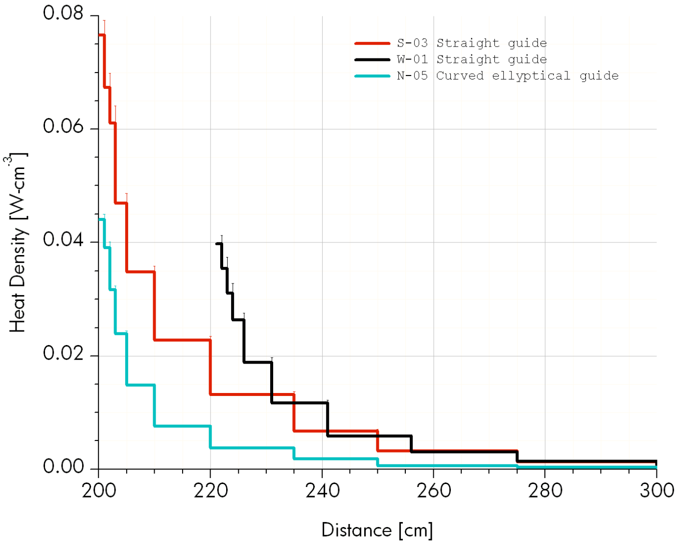

Figure 1 Heat load from the Neutronics group.

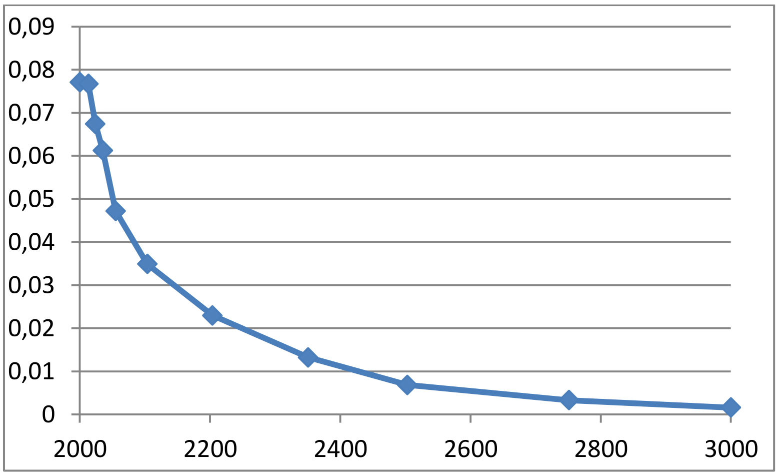

Figure 2 Heat load used in the analysis.

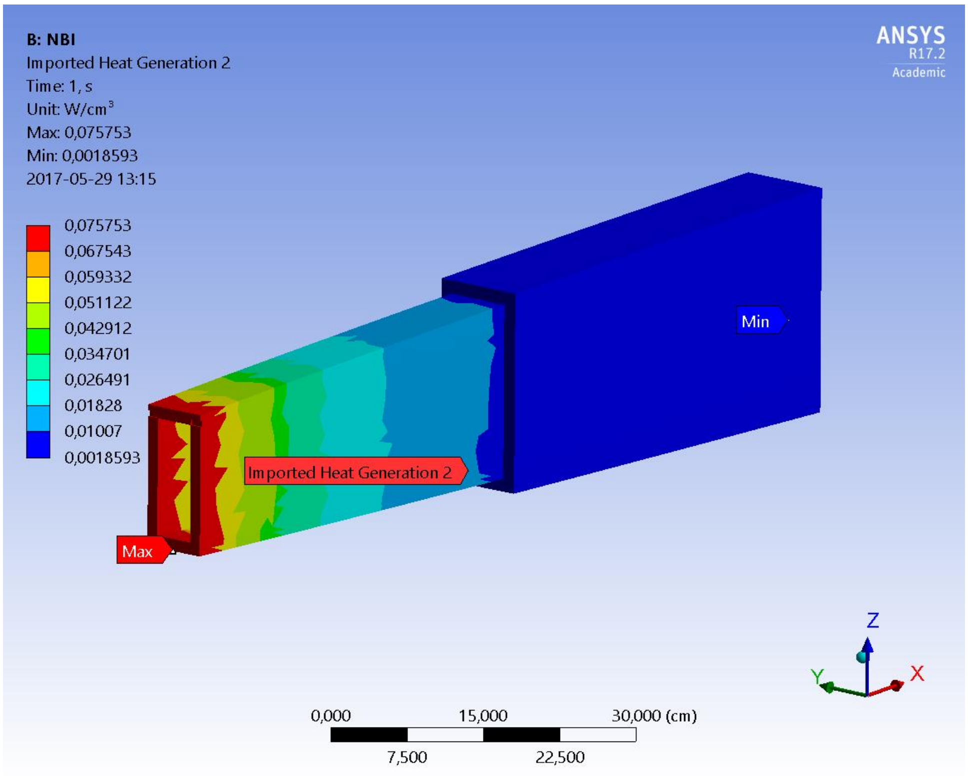

Figure 3 Heat load mapped on the first substrate.

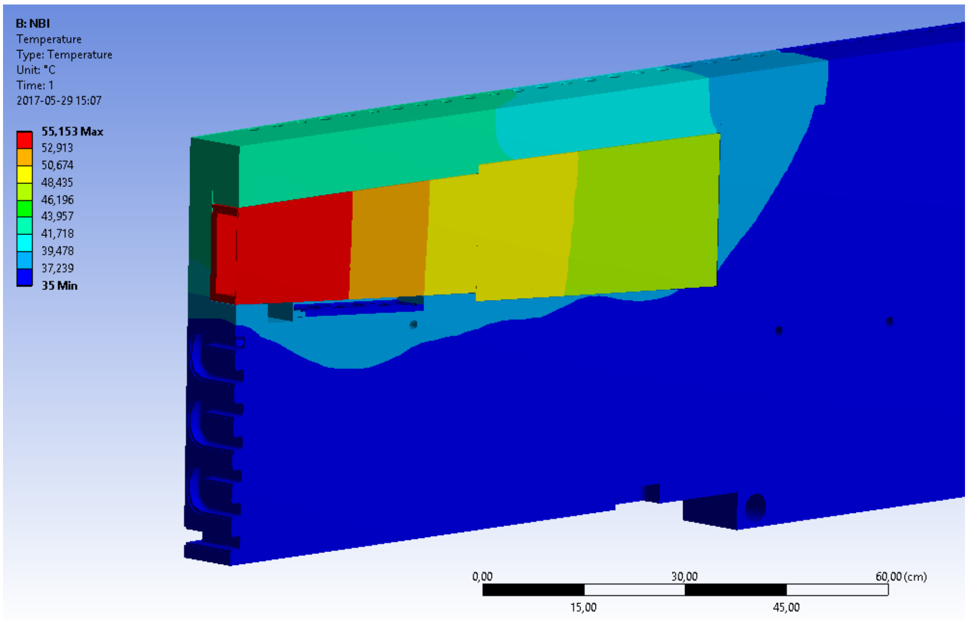

Figure 4 Temperature in the insert and substrate.

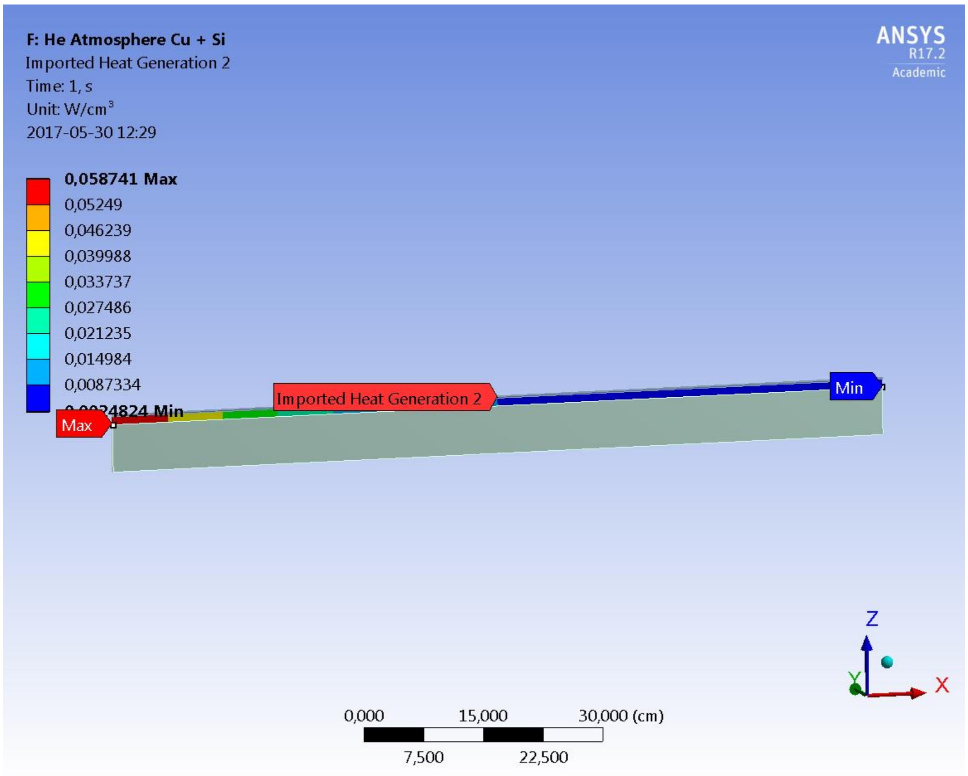

Figure 5 Applied heat load on the copper substrate.

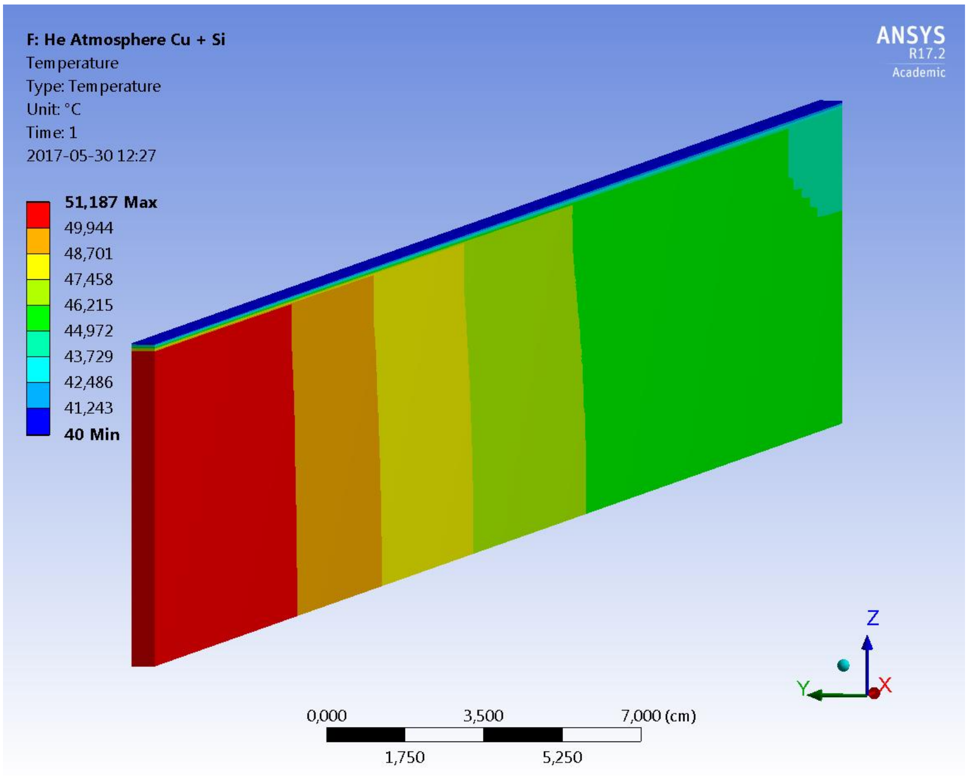

Figure 6 Temperature in the simplified model.