CFD SIMULATION OF THE COOLING SYSTEM OF A CALORIMETER DETECTOR

JADERNÉ DNY 2020 na ZČU v Plzni
23. 9. - 27. 10.

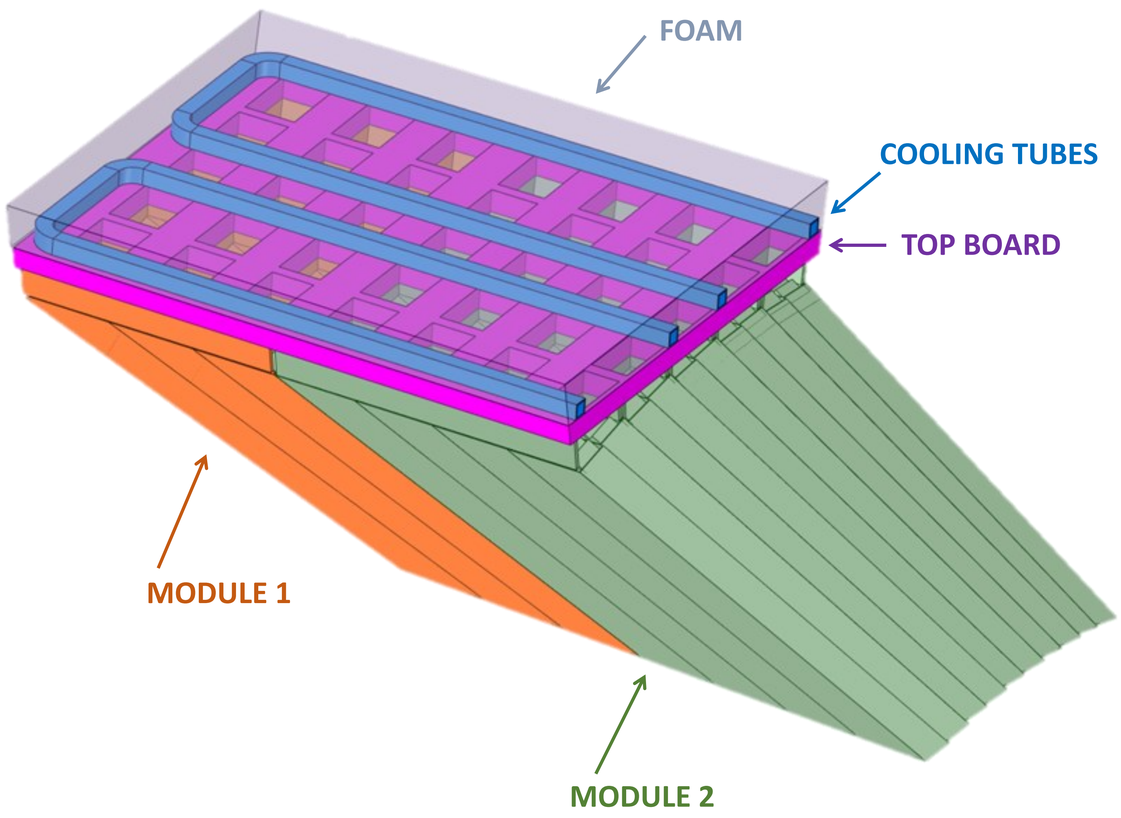
INTRODUCTION

The research project is devoted to **steady-state simulations of a cooling process of crystals**, adjacent APFEL asics and other parts (holders, casings etc.) of the PANDA EMC detector.

As the light yield of $PbWO_4$ scintillation crystals increases with decreasing temperature, **it is crucial to keep these crystals at lower temperatures**. Moreover, the noise produced by the amplification and read-out electronics also decreases with temperature. Similarly, as the light yield and decay time vary with a temperature, it is important to keep the temperature as stable as possible. It follows that the main object of the research is **to determine whether the current design of the cooling system is able to reliably cool down the crystals to the desired temperature of 25 °C.**

COMPUTATIONAL DOMAIN

The computational domain consists of two modules, a top board, cooling tubes and foam. Apart from these solid bodies, there are two fluid domains. The first one represents cooling fluid, whereas the second one is used for the fluid (i.e. air) surrounding the solid bodies (crystals, APFEL asics etc.).



BOUNDARY CONDITIONS

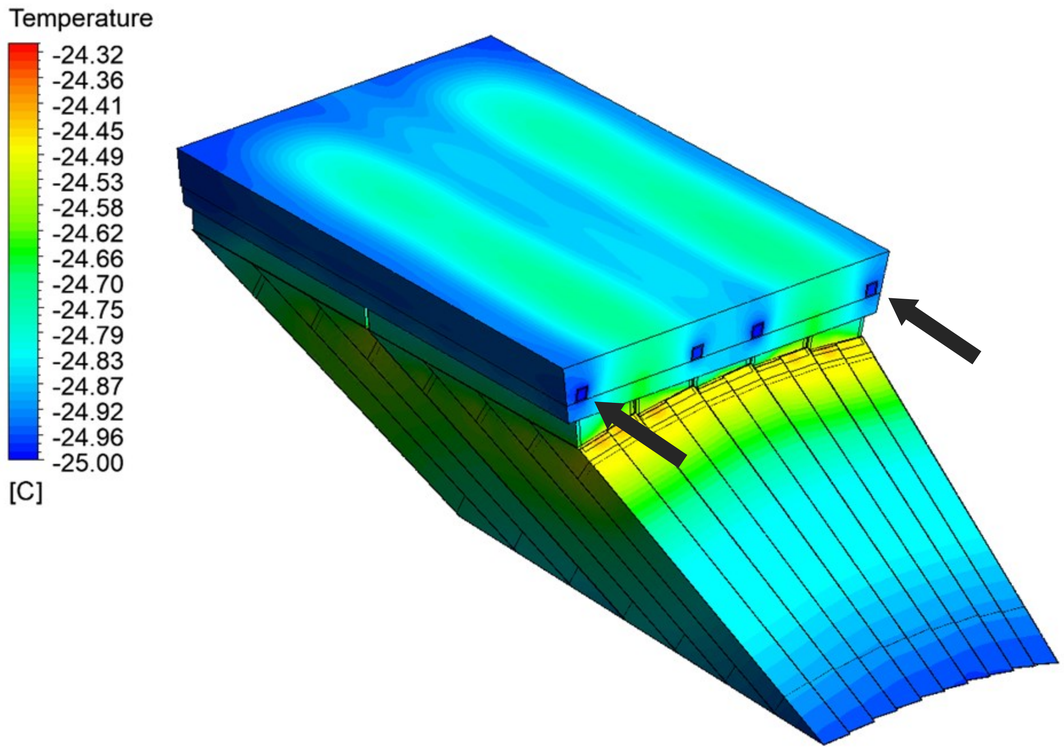
To define a computation fluid dynamics problem, both boundary and initial conditions are required. Since this research is focused on steady state simulations, only the boundary conditions are provided.

The **reference pressure** for the cooling fluid is set to **0 [atm]**, so that it is not necessary to distinguish between reference and absolute pressure when defining the pressure boundary conditions. The turbulence model used for modelling the fluid flow in this fluid domain is **two-equation eddy-viscosity model SST k-ω** ("Shear Stress Transport") with a generic 5% turbulence intensity at inlets. Bear in mind that **gravity is not considered**.

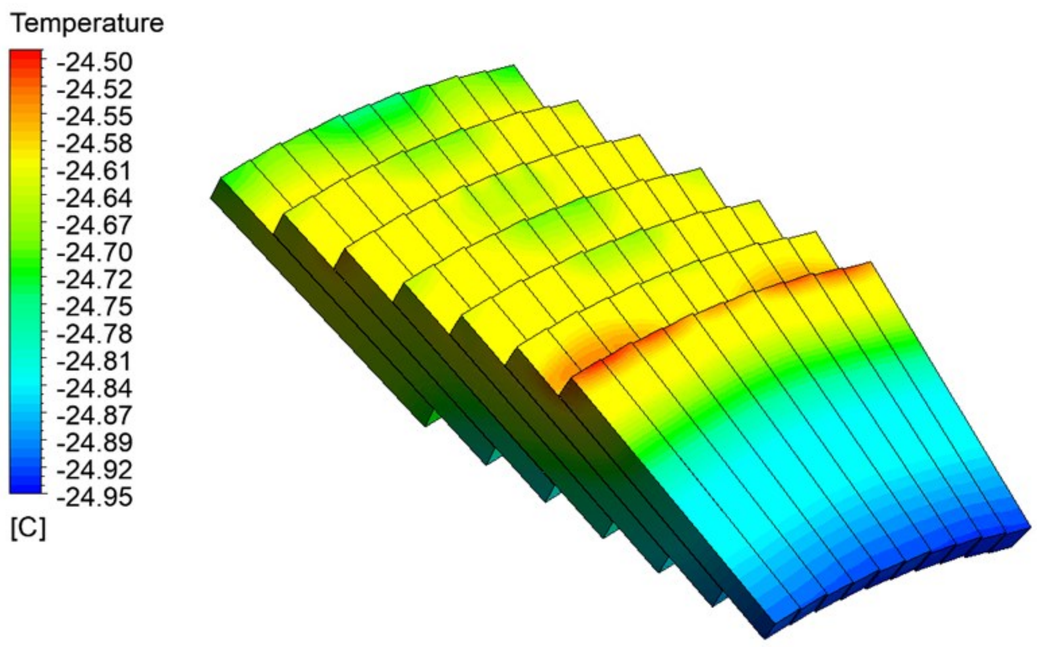
The cooling medium is set as a mixture of water and methanol. At the **inlets**, there is a temperature of **-25 [°C]** with a mass flow rate of **0.0723 [kg s^{-1}].** At the **outlets**, there is assumed a pressure of **1 [atm].**

Regarding the **heat source**, the heat produced by the electronics inside **one APFEL asic** is assumed to be **150 [mW]**. This heat power is applied in the form of heat flux on the inner walls in the APFEL asics.

RESULTS



It can be observed that **the temperature field appears to be symmetrical although no symmetrical boundary condition was applied**. The explanation lies within the applied boundary conditions for cooling fluid, because there were assumed the same temperatures at the inlets. It should further be noted that there seems to be very **low temperature** (i.e. very good cooling) **at the back of the foam**. This is due to the turning of cooling tubes in this space (i.e. more cooling fluid in comparison with other sections of the foam) and thus the heat is drained off better in the said part of the domain.



CONCLUSION

The **main task of this research** is to cool down the crystals to the temperature of -25 [°C] in such a way that the **difference between the maximum and minimum temperature does not exceed 1 [°C] for all crystals** and at the same time the **difference between maximum and minimum temperature within each single crystal does not exceed 0.1 [°C].** It is obvious that **former of the customer's requirements is**, as of now, **fulfilled** since the difference between maximum and minimum values of temperature within all crystals in SUPERMODULE7 does not exceed 0.55 [°C]. The latter **requirement is not fulfilled** in the first row of crystals and thus further research is required.

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