INVESTIGATION OF ACCIDENT CASES FOR HIGH PRESSURE, HIGH TEMPERATURE EXPERIMENTAL HELIUM LOOP USING RELAP5-3D CODE

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The Helium Loop Karlsruhe (HELOKA) is an experimental facility designed for testing the Helium Cooled Pebble Beds (HCPB) Test Blanket Module (TBM) under thermo-mechanical conditions/loads similar to what the TBM will face during the operation in ITER experimental nuclear fusion reactor [1]. The loop itself is, in fact, a helium cooling circuit that provides TBM inlet the required mass flow rate, temperature and pressure. The loop has been designed taking in account similar operating conditions as the future Helium Cooling System (HCS), which will be build in ITER to test HCPB TBM and the Helium Cooled Lithium Lead (HCLL) TBM as well.

During the design phase, the behavior of the loop under normal operating conditions has been investigated [2, 3] on the basis of a general system control strategy defined for controlling mass flow rate, temperature and pressure. The work presented in this paper is a continuation of the investigation and it is focused mainly on simulating accident situations that could cause an increase of pressure or temperature in the system, which might lead to structure damages. Following accident cases are simulated: failure of Pressure Control System (PCS), loss of helium flow (circulator stopped) and loss of water cooling.

The first case simulates the situation where the PCS is isolated from the helium loop. Thus the PCS is no longer capable of fulfilling is primary function which is to maintain the pressure level at TBM inlet by removing or introducing helium into the system. Since the TBM is heated (~700kW) the pressure in the loop will rise. The assumption for this simulation is that the heating of the TBM remains active, and the scope is to determine the maximum level of pressure in the system for two kinds of heating: a pulsed heating (ITER plasma pulse-like operation), and a continuous heating (infinite pulse).

For the second case, the helium circulator is assumed to accidentally stop and the helium flow through the loop is decreased from the nominal value to zero. The loss of the helium flow in the TBM means an overheating of the unit. The simulation investigates the temperature increase inside the test module under various heating conditions.

The third case refers to the loss of the flow in the secondary loop (water cooling circuit). The function of the water circuit is to control the temperature at circulator inlet (~50°C) by helium-water heat exchanger. Thus, losing the water flow might determine temperature increase at the circulator inlet. If the temperature exceeds certain limit the switching-off of the circulator will be initiated. In parallel, a heating power shut-down is triggered with some delay after the loss of the water flow. For this case the temperature increase at the circulator inlet as well as the evolution of the parameters in the TBM are going to be investigated.

[1] B.E. Ghidersa et al., Fusion Engineering and Design, 81, 2006, pp. 1471-1476
[2] B.E. Ghidersa et al., Fusion Engineering and Design, 83, 2008, pp. 1792-1796
[3] X. Jin, B.E. Ghidersa, The 8th International Topical Meeting on Nuclear Thermal-Hydraulics, Operation and Safety (NUTHOS-8), Shanghai China , October 10-14, 2010.