Benchmark of the GETTHEM Vacuum Vessel Pressure Suppression System (VVPSS) model for a helium-cooled EU DEMO blanket

A. Froio, A. Bertinetti, L. Savoldi, R. Zanino
NEMO group, Dipartimento Energia, Politecnico di Torino

F. Cismondi, S. Ciattaglia
PPPT Department, EUROfusion Consortium

ABSTRACT

The EU DEMO tokamak will be the first fusion reactor to produce net electricity by 2050 (Romanelli, 2012).

For the operation of this reactor, one of the design-basis accidents (DBAs) to be analyzed is the in-vessel Loss-Of-Coolant Accident (LOCA), happening when the coolant is lost from the Breeding Blanket (BB) or from the divertor or the Vacuum Vessel (VV) into the VV, which must be kept at very low pressures (~ µPa) for tokamak operation.

On the other hand, the coolant is to be kept at high pressure values (~MPa), for the sake of heat transfer efficiency; consequently, if a rupture in the cooling system happens, the VV experiences a rapid increase of pressure. To avoid overpressure and rupture of the VV, which is also the first containment barrier for the radioactive products a Vacuum Vessel Pressure Suppression System (VVPSS) is designed, which should perform the double action of preserving the integrity of the VV and to safely store the coolant condensed there with the relevant radioactive products (tritium, corrosion products and dust).

During the last year, a system-level code for the analysis of thermal-hydraulic transients in tokamak fusion reactors, called GEneral Tokamak THErmal-hydraulic Modelling (GETTHEM), has been developed at Politecnico di Torino. It is a fast-running tool, based on the Modelica language, to evaluate the thermal-hydraulic behavior of the tokamak Primary Heat Transfer System (PHTS) and Balance of Plant (BoP); GETTHEM is able to cope with helium and water as working fluids, and currently contains the model for the cooling loops of the Helium-Cooled Pebble Bed (HCPB) and Water-Cooled Lithium-Lead (WCLL) BB concepts.

This paper presents the GETTHEM simplified model developed for the EU DEMO VVPSS, for the case of helium-cooled BBs. This model comprises the component relevant for VVPSS analysis, from the PHTS to the final Expansion Volume (EV); after an initial calibration, to determine the best values for the unknown parameters, the model is benchmarked against the validated CONSEN code (Caruso, 2016). The model showed acceptable accuracy in reproducing the pressure and temperature transient within all the relevant volumes, as reported by Figure 1 for the pressure, especially if looking at the pressure peak.

In view of the good results obtained, the model will be applied to perform a parametric study on the EU DEMO VVPSS layout, in order to understand which parameters affect mostly the transient and to identify the weak and strong points of the system.

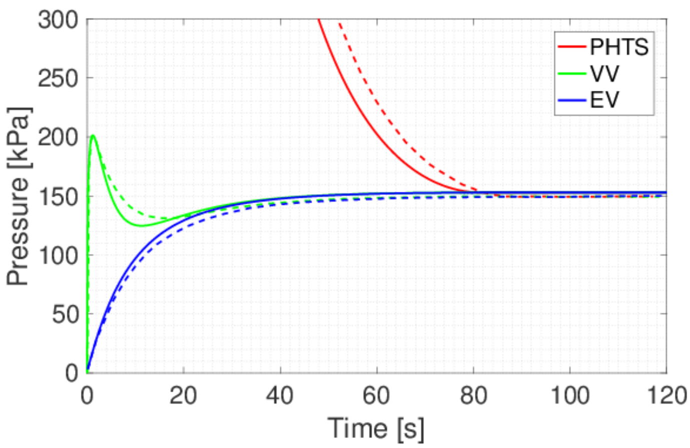

Figure 1: Evolution of the pressure in the three considered volumes for the benchmark scenario, computed by GETTHEM (solid lines) and CONSEN (dashed lines).

REFERENCES

Caruso, G. 2016. Preliminary design of the expansion system for a DEMO reactor based on a helium-cooled blanket. DIAEE-NU(16)-0802 – Rome (Italy).

Romanelli F. et al. 2012. Fusion Electricity – A roadmap to the realisation of fusion energy. ISBN 978-3-00-040720-8T : European Fusion Development Agreement (EFDA).