Preliminary thermal-hydraulic analysis of the EU-DEMO Helium-Cooled Pebble Bed fusion reactor by using the RELAP5-3D system code

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In view of the development of the EU-DEMO fusion reactor, to fulfil its potential features in terms of low accident potential and good operational safety, it has to be considered as pivotal to incorporate the needed provisions to improve the overall plant safety and reliability performances as well as to analyse possible mitigation action.

To this purpose, within the framework of EUROfusion Safety and Environment actions, an intense research campaign has been launched in order to develop a model, at thermal-hydraulic system code level, for the EU-DEMO Helium-Cooled Pebble Bed (HCPB) Breeding Blanket (BB) concept, aimed at characterizing its response both under normal operational conditions and during accidental scenarios.

Preliminarily, the research activity has been focused on the representative and safety relevant cooling loop of the HCPB BB Primary Heat Transfer System, purposely selected by the safety team, in order to assess its thermal-hydraulic behaviour during normal operational conditions (ramp-up/down and steady state). Thereafter the model has been extended in order to investigate the thermal-hydraulic consequences of both an in-vessel and ex-vessel LOCA accidental scenarios and to figure out the capabilities of the mitigation systems intended to withstand such events.

The research activity has been carried out following a theoretical-computational approach based on the finite volume method adopting the RELAP5-3D system code along with a computational fluid dynamic code, which were properly integrated to achieve a more detailed and realistic simulation of the EU-DEMO reactor thermal-hydraulics.

The obtained results provided significant information highlighting open issues and suggesting the pertinent improvements to the model aimed to obtain a more accurate description of the EU-DEMO reactor performances. Additional outcomes of this preliminary study are herein also presented and critically discussed.

Keywords: EU-DEMO, HCPB, RELAP5-3D, Thermal-hydraulics, Safety and Environment

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