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Optimization process for the design of the DCLL blanket for the European DEMOnstration fusion reactor according to its nuclear performances

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The neutronic radiation coming from the fusion plasma of large machines as the foreseen DEMO could severely affect the stability and the lifetime of the components which constitute the reactor. Nevertheless neutrons are fundamental to allow the reactor to reach the tritium self-sufficiency and to generate and extract enough nuclear power. This means that in the nuclear design of a kind of facilities it is essential to achieve and keep the delicate balance among fuel sustainability and power efficiency vs. radiation shielding.

The research study presented has focused on the neutronic design optimization and analysis of one of the options for a fusion reactor designed as DCLL (dual coolant lithium-lead). The main objective has been to develop a new, reliable, efficient and technologically viable modular DCLL blanket using the DEMO generic design specifications and operational (pulsed) conditions established in the frame of the EUROfusion Programme.

By coupling the design tools with the neutronic transport Monte Carlo simulations, it has been developed a 3D fully heterogeneous neutronic design and it has been determined the behaviour of the components under the real operational conditions of a DEMO reactor adopting then the most adequate actions to improve their performances.

The final neutronic design has to attend the requirements of: tritium self-sufficiency; BB thermal efficiency; preservation of plasma magnetic confinement; temperature limits imposed by the materials; and, furthermore, radiation limits to guarantee the largest operational life for all the components. Therefore, the neutronic assessments here presented have been specially focused on: Tritium Breeding Ratio; Multiplication Energy Factor and power density distributions to give inputs for thermal-hydraulics and mechanical assessments; damage/shielding responses to determine if the components are keeping their structural integrity or their functionality as the case of the Toroidal Field coil superconductivity.

The paper describes the progress in the DCLL nuclear design in light of the observations and requirements explained above. New design choices to improve the BB performances are discussed. Moreover, the previous mentioned nuclear responses and their different distributions relevant for the global design choices have been also analysed and are described in the paper.

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