Contribution ID: **341** Type: **ORAL**

Evaluation of an increase of the power density for the French commercial Sodium Fast Reactor and optimization study at 1100 MWe with the SDDS tool

Friday 22 April 2022 11:54 (12 minutes)

In order to enhance the competitiveness and to reduce the construction cost of the future industrial Sodium Fast Reactors (SFR), several options are explored which need further R&D studies or design assessment. Among them, the possibility to reduce the size of the reactor vessel has been investigated through the reduction of the core diameter and the increase of the power density thanks to several optimisation studies conducted by the R&D department of EDF.

To this end, an in-house multi-physics optimization tool called SDDS has been used. The basis of the method is to predict the performance of a large number of core designs using surrogate models. The surrogate models are themselves created using the results of a parametric calculation scheme based on the following codes: ERANOS for the neutronic, MAT5DYN for the thermal-hydraulic transients and GERMINAL for the thermo-mechanical fuel performance.

A first optimization study has been performed in 2018 to define a compact core design for the 1000 MWe French commercial SFR. As a result, two designs were selected as they offered a good compromise between the safety criteria and a reduced core diameter: a twelve Sub-Assembly (SA) rings core with a smaller core diameter and a thirteen SA rings core with better safety margins.

This paper focuses on a second optimisation study which has been performed more recently on a 1100 MWe power reactor in order to evaluate the impact of an elevation of 10% of the nominal power on the results. The analysis of the results shows that the main trends (e.g. large pellet, large fertile plate height, etc.) are the same as the ones observed for the optimum designs in the 2018 study. However, the designs selected in 2018 do not meet some of the safety criteria anymore after the increase of their power density. Thus, a new core design with 13 SA rings has been proposed with a better compromise between safety performances and core diameter to operate at 1100 MWe.

Country/Int. organization

France

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Session Classification: 1.3 System Innovations

Track Classification: Track 1. Innovative Fast Reactor Designs