Conceptual Design of Fusion-Fission Hybrid Multi-Functional Experimental Reactor
(FDS-MFX)

Jieqiong JIANG1*, Yican WU1,2, Ming JIN1, Minghuang WANG1,2 and FDS Team

1 Institute of Nuclear Energy Safety Technology, Chinese Academy of Sciences, Hefei, Anhui, 230031, China
2 School of Nuclear Science and Technology, University of Science and Technology of China, Hefei, Anhui, 230027, China
Jieqiong.jiang@fds.org.cn

The proposed roadmap and testing strategy of fusion application was presented based on the assessment and design analysis of the developed series hybrid system concepts in China as well as a summary of the hybrid system design and R&D activities in China and in the world by FDS Team [1, 2]. The final goal is to achieve the demonstration (DEMO) reactor for Spent Fuel Burning (SFB). In this contribution, a fusion-fission hybrid multi-functional experimental reactor concept, i.e. Multi-Functional eXperimental Fusion Driven Subcritical system named FDS-MFX, has been proposed for checking and validating the DEMO reactor (SFB) relevant technologies based on the viable fusion and fission technologies.

The tokamak of FDS-MFX can be designed based on relatively easy-achieved plasma parameters extrapolated from the successful operation of the Experimental Advanced Superconducting Tokamak (EAST) in China and other tokamaks in the world. The subcritical blanket can be designed based on the relatively mature technology of fission power. Four-stage tests will be carried out successively, in which the tritium breeding blanket, natural uranium-fueled blanket, enriched uranium-fueled blanket and spent fuel-fueled blanket will be utilized respectively. And the purposes of the blanket loaded with natural uranium is for hybrid reactor principle validation phase in prior-period of the experiment, and enriched uranium and spent fuel from PWRs (uranium, plutonium and minor actinides) are for engineering validation phase in the late period of the experiment. In this contribution, the key stage experiment with enriched uranium was proposed to simulate the operation blanket environment of the DEMO stage FDS-SFB with the high power density (50~100 MW/m³) and high neutron flux in a helium-cooled blanket, to carry out the neutronics, thermal-hydraulics and safety experiments for demonstrating the engineering feasibility of the DEMO’ technology.

The results showed that the performance of the blanket loaded with enriched uranium was attractive and it could be promising to effectively obtain tritium self-sufficiency (TBR~1.05) and a high maximum average power density (~100MW/m³) while the blanket was loaded with the mass of 235U about 1 ton. The design and optimization of fusion plasma core parameters, blanket neutronics, blanket thermal-hydraulics, safety and environmental impact analysis, tritium system and auxiliary system had been presented. The performance analysis of design and optimization preliminarily demonstrated the engineering feasibility of the design.

Keywords: Fusion, Hybrid reactor, Multi-functional experimental reactor