Reactor Physics Study on the TRU-Loaded HYPER Core

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Abstract

An accelerator-driven system (ADS) called HYPER (Hybrid Power Extraction Reactor) is being studied for the transmutation of transuranics (TRUs) and long-lived fission products (LLFPs). HYPER is a 1,000 MWth lead-bismuth eutectic (LBE)-cooled ADS with a central spallation source. In this paper, the neutronic design characteristics of HYPER are described and its transmutation performances are assessed for an equilibrium cycle. The core is loaded with a ductless fuel assembly containing transuranics (TRU) dispersion fuel pins.In HYPER, a relatively high core height, 150 cm, is adopted to maximize the multiplication efficiency of the external source. In the ductless fuel assembly, 13 non-fuel rods are used as tie rods to maintain the mechanical integrity of the assembly. Due to the large burnup reactivity swing, a half-year cycle length is utilized in the HYPER core. In order to reduce further the reactivity change, a B4C burnable absorber is employed. It has been shown that the burnable absorber could reduce the reactivity swing by about 47% with a cost of about 27% reduction in the fuel discharge burnup. Consequently, the required proton current could be reduced from 35 mA to 23 mA. Additionally, control rods are also utilized to reduce the accelerator current below 20 mA, which a maximum allowable proton current in the HYPER core. The control rods holds about 1.0 %k reactivity at the beginning of cycle and the maximum accelerator current was cut down to 18 mA. The long-lived fission products (LLFPs) Tc-99 and I-129 are transmuted in the reflector zone of the HYPER core such that their supporting ratios are equal to that of the TRUs. A double-annular LLFP target has been developed for efficient incineration of Tc-99 and I-129.