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CASCADE ENERGY AMPLIFIER

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The technical problem of long-life fission product and minor actinide incineration and production of plutonium fuel in the prospective nuclear systems will arise at significant scales of nuclear power industry development. Subcritical nuclear reactors driven by external neutron sources («energy amplifiers») are considered as incinerators of toxicity of complete nuclear industry.

In the frames of this concept, the subcritical reactor part consisting of two coupled blanket regions (inner fast neutron spectrum core and outer thermal core) driven by external neutron source is discussed.

Two types of source are studied: spallation target and 14-Mev fusion burn of micropellets. Liquid metal Pb-Bi is considered as target material and coolant of inner fast core. Thermal core is a heavy-water subcritical reactor of the CANDU-type. The fast core is protected from thermal neutrons influence with the boron shield. All reactor technologies used in this concept are tested during years of operation and commercially available.

The system operates in steady-state or pulse-periodical modes as a two-cascade energy amplifier for neutrons of spallation source located inside inner core [1]. Because of special shield of the fast core, neutron coupling between these two subcritical regions has one-directional behavior. Using this "cascade amplifier" principle, it is possible to achieve in deeply subcritical (K_{eff}=0.95-0.96) coupled system more high power output (up to 10 times [2]) in comparison with traditional «single» core under the same multiplication factor, then the source requirements could be essentially reduced. It is very important feature for the feasibility of high voltage charge particle accelerators for accelerator driven systems and lasers of required super high beam energy for inertial confinement fusion systems (from economical point of view, too).

The coupled cores have a high level of inherent safety: the system is always deeply subcritical, neutron leakage from the system is very low, and it is not necessary to provide complex control and shielding systems. Further, the heavy-water core makes it possible to use uranium of natural enrichment.

The coupled blanket system utilizes the fast and the thermal cores in one reactor unit, which might be effectively used for energy production and burning/ transmutation of long-life fission products, minor actinides and weapon graded plutonium. Waste stream of this system might be separated into fast and thermal regions and have an optimum effect for the transmutation rates. For example, one of important features of this dual-spectrum system is reduction of inventory of neptunium and its impact to the long-term radiological hazard in comparison with the hard spectrum core.

Comparative analysis of several types of the coupled subcritical system with different thermal output was performed. The power parameters and neutronics of systems, which make it possible to provide the multiplication of source neutrons by 100, are studied in detail for both the steady-state and pulse-periodical operation modes using the methodology and codes for computation of neutronics (Monte Carlo method) and dynamic parameters, which were elaborated and experimentally tested at the IPPE on coupled reactor installations UKS-1M, BARS-6 and Stand B [3].

Thus, the cascade energy amplifiers have a set of advantages in comparison with traditional concepts: in energy production, in transmutation efficiency, and in economics.

References

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