System studies on fusion-fission hybrid reactors and its fuel cycle

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One of the most priority task for nuclear energetics is to create a closed nuclear fuel cycle that provides utilization of nuclear energy for a long time (more than 1000 years) and to improve the safety and ecological of nuclear technology. This problem includes the problem of spent nuclear fuel (SNF) and radioactive waste (RW) management. Minor actinides (MA) (Np, Am, Cm), that is about 0.1% of SNF mass, have high radiotoxicity and a relatively long half-life. They provide the main contribution to the long-term radiotoxicity of radioactive waste in case of their disposal. The radiotoxicity of fission products (FP) declines much faster: it reaches the radioactive equilibrium with respect to uranium ore in about 300 years. In this way, partitioning & transmutation (P&T) of MA by fission seems reasonable. Although a pretty hard spectrum is required for MA fission due to the threshold character of fission cross-section for most of MA. One of the most perspective ways to solve this problem is an application of a fusion reactor as a high energy neutron source. In this paper, the application of such type of hybrid reactors for MA transmutation has been studied.

The study includes two interconnected investigations. The first is study of fuel inventory evolution in the blanket of fusion-fission hybrid reactor with metallic fuel that is zirconium and MA alloy. Three hybrid reactors supposed by the road map of NRC "Kurchatov Institute" project are investigated: demo reactor, pilot-industrial and industrial reactors. Performance parameters are compared for different coolants (H_2O and CO_2) in transmutation zone. The design of the reactor with H_2O as a coolant is chosen as basic.

The second part of the study is system analysis of the development of nuclear energetics in Russia with involvement of the hybrid reactors that was mention up here. The study conducted by USM-1 model that was created at ITCP «PRORYV».