ANALYSIS OF THE CONCEPT OF A HYBRID ENERGY REACTOR BASED ON FUSION NEUTRON SOURCE (FNS) WITH THE WASTE URANIUM BLANKET

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The paper is aimed at a large-scale assessment of the possibilities of using tokamak DT reactors as sources of fast neutrons to irradiate waste uranium to produce energy. Since modern power plants use uranium enriched to 4.5% in U235, more than 90% of the natural uranium falls to waist, that is, it is never used in nuclear power engineering. The world’s industries have now accumulated more than 1 500 000 tons of waste U238 and further accumulation is likely with the progress in development of the nuclear energy on slow neutrons. The fast neutron reactors that could use the waste U238 are still at stage of development. According to the forecast of the IAEA in the second half of the 21st century, the extraction of natural uranium will begin to decline while the demand will continue to grow.

This will inevitably cause a rise in the cost of the nuclear fuel. Therefore, the possibility of using the depleted uranium along with the declining production of natural uranium can become extremely urgent. The development of technology for obtaining energy using waste uranium by irradiating it with fast neutrons of controlled DT fusion can mitigate this problem. At the same time, the proposed method of energy production will not require frequent reprocessing of irradiated fuel for reloading plutonium, as in the case of fast reactors with a closed cycle, and therefore it is less radiation hazardous. In addition, a hybrid power reactor of this kind operates in a deeply subcritical mode, consequently, it is safer in operation.

As the first sample of the required high-power source of fusion neutrons (FNS) we supposed a physical analogue of ITER - but using a blanket with waste uranium. The heat removal in such FNS is performed with a metallic coolant, not water, as in the case of ITER. This is necessary to keep the neutron spectrum as hard as possible, when the heat release rate in U238 is maximum. According to the estimates (materials of the ROSATOM Commission on the choice of the optimal development of thermonuclear energy in Russia based on TOKAMAK, 2009), such a source, surrounded by an ideal (20 cm) blanket of natural uranium, would be capable of producing 4 atoms Pu239 for each fission event (200 MeV). The depleted uranium may be used here instead. The estimates show that in the strady-state mode of operation (capacity utilization factor about 70%), the “ideal reactor” on the depleted uranium could supply about 1.5 GW of electrical power to the grid. Our analysis showed that the need of the tritium reproduction and internal energy consumption about three times reduce this value. A high value of CUF in such a FNS is planned to be provided by protecting its first wall from the hot plasma erosion by Li use.