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NEUTRONIC ANALYSIS OF PROPOSED ADS CORE CHARACTERISTICS

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A few years ago, several new nuclear reactor proposals were set out [1–2]. Mainly, such projects took into account (reacted on) low public acceptance of the present way of nuclear energy exploitation. Nuclear wastes (spent fuel) management and a fear of a repeating Chernobyl type accident are the main parts that contribute to this attitude. New projects, so called Accelerator Driven Systems (ADS), are trying to solve that problem in principle.

Firstly, such projects propose to use an accelerator of high energetic charged particles (e.g., protons). These particles cause spallation reaction in the target material. As a result of spallations caused by one 1 GeV energetic proton in the lead target one can get approximately 27 neutrons. These neutrons originated in the target form high intensity beams (fluxes) which are several times higher than in the present thermal nuclear reactors.

Secondly, the reactor system is proposed to be subcritical. Neutrons from the target serve as an external source that supplies a lack of neutrons in the core and helps to sustain a chain reaction there. So, the probability of an overcriticality of the ADS system is very low and the level of nuclear safety is very much increasing.

Both these system characteristics allow to achieve the main goal of such systems. This is the transmutation of dangerous radioactive nuclei from nuclear wastes (especially from present nuclear reactors spent fuel or weapon Pu) to the short lived and less radioactive isotopes. Such systems, if energetic, should also be able to gain energy from atomic nucleus, and at the same time reduce the dangerous radioactive products. These briefly described systems seem to be a good alternative to the present way of gaining energy from nuclei. Therefore, several analyses of such systems are needed to validate their properties.

An ADS core should be constructed according to the goals that are expected. One of the possible configurations focusing on a transmutation of spent fuel nuclear wastes and a proposal of an experimental module were presented in [3]. The core consists of cylindrical graphite blocks placed in a close triangular lattice. The fuel in the form of fluoride molten salts ($LiF:BeF_2:UF_4$) is carried along these blocks. To assess its physical-neutronic properties and draw up a proposal of its experimental validation, several computation analyses were carried out [4]. A Monte Carlo code MCNP [5] was mainly used as a powerful tool to obtain necessary results.

An analysis of criticality of the proposed experimental module shows that the security rule for handling the module during the transport or storage will be fulfilled even if the enrichment of uranium in the molten salt is around 4 %. To obtain an asymptotic behaviour,

several experimental modules should be coupled together. As even these configurations of experimental modules should be slightly subcritical, one should supply neutrons from an external source. This source cannot be placed inside the modules because of the destruction of an asymptotic region there. Therefore, an outside configuration of the external source ("driver") should be found. To set up the "driver" by fuel rods from the VVER-1000 fuel assemblies seems to be the best solution according to the possibilities.

The first experimental step, the measurement of the basic characteristics (k_{eff}, fluxes) should be followed by core dynamics and related technology testing. Coupling an experimental assembly with an accelerator can be the final step of an experimental validation.

It should be said that the research in that field is at a beginning stage. Nevertheless, a lot of things have already been done. The properties of the molten salt are more or less known from the operation of the molten salt reactor in Oak Ridge. An accelerator equipment is developed separately and it seems not to be impossible to obtain required parameters. Technology of secondary circuit will be rather similar to that used presently. Naturally, there is a lot of problems to solve - e.g., if a window separating the accelerator from the target, problems of chemical and isotopical separation technologies. Nevertheless, according to the present knowledge, gaining energy from atomic nucleus is a real possibility how to meet the need of energy in the world. ADS systems have unique characteristics (inherently safe operation due to subcriticality, capability of transmutation of nuclear wastes - spent fuel - from present nuclear reactors, in this way reduce the production of nuclear waste). Due to these properties, ADS systems have good ability to reduce public fear of nuclear energy exploitation and can be a good alternative to every present energetic system.

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