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SOME SAFETY FEATURES OF ADTT SYSTEMS

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According to our opinion only such a nuclear energy technology will be invited to the 21st century that will be safe enough to exclude any severe nuclear accidents like "Chernobyl". So, from the very beginning "safety" has to be the first priority in any new nuclear system development. This paper summarize some remarks having relations to the safety features of Accelerator Driven Transmutation Technology (ADTT) systems. The basis of the information presented is the search [2] from INIS sources made in 1995.

The idea to use an accelerator driven transmutation technology in nuclear engineering is not new. Due the past few decades, however, the motivation for its development has rapidly changed. Originally ADTT was developed to produce fossil materials, namely Pu239 from U238 or U233 from Th232 in a secret project "Material testing accelerators" at Livermoore laboratories at the end of the forties [1]. The significance of ADTT fuel production was independently confirmed by Lewis [3], who also carried out the first experiments using interaction of cosmic rays and heavy metals to get first nuclear data on the split reactions. But only further discoveries in accelerator technology (gained mainly as a product of the "Strategic Defence Initiative – SDI program") have started a new wave of interest in using ADTT not only for the nuclear fuel production [3], but also for transmutation of long-lived radionuclides [4]. After the end of the "cold war" another strong impetus to develop ADTT has appeared: destruction of surplus weapons-grade plutonium. The conclusion of an agreement between Russia and the USA for significantly reducing the number of nuclear warheads has made the effective peaceful use of the stockpiles of weapons-grade plutonium a very urgent problem. One of the most promising ecologically pure and safe method of plutonium conversion is to use it in subcritical accelerator-driven power reactors simultaneously for two aims – energy production and waste burning.

The safety features and characteristics of any new nuclear systems have to be explored from the perspective of the fundamental nuclear safety objectives that any reactor type system should address. At present this exploration is only qualitative in nature and uses current vintage solid fueled reactors as a baseline for comparison. New nuclear systems should be capable of meeting the fundamental nuclear safety objectives. In addition, they should be able to provide the safety robustness desired for advanced reactors. However, the manner in which safety objectives and robustness are achieved is very different from that associated with conventional reactors. Also, there are a number of safety design and operational challenges that will have to be addressed for the safety potential of such systems to be credible. At present **the main parameters and engineering design of ADTT systems** are not yet reliably defined. Studies and evaluations performed to date at many laboratories and research centers have led to a current focus on a fluid-fuel, fission system operating in a neutron source-supported subcritical mode, using molten salt reactor technology and accelerator-driven proton-neutron spallation.

The safety features of the reactor part of such a system may be summarized as follows: • subcriticality, safe system reacting; • strong positive temperature dependency of the reactivity driven by the plutonium resonance; • no passive shutdown caused by the negative reactivity feedback as in critical reactors; • small changes in Pu concentration lead to large changes in reactivity (change of 0.1 mole percent of Pu lead to 1 dollar changes in reactivity); • low inventory of ra elements - always small amounts of actinides and fission products in reacting volume; • risks of the radioactive waste handling; • system operates at low pressure and moderate temperatures; • absence of the first two barriers between environment and ra wastes in the fluid fuel systems (fuel pellets and fuel tubes).

Safety approach and engineered safety systems of accelerator. The main problem of accelerator safety is to ensure with high confidence that a beam trip will occur and adequate cooling will be provided if the target/blanket parameters deviate from the design operating range. The safety approach should uses redundant and diverse systems to ensure high reliability for tripping the beam and removing the decay heat and active- and passive-engineered safety systems to meet or exceed the requirements.

Questions and problems. Accelerator-driven subcritical blankets have recently reattracted attention due to the acknowledgment of increased importance of their main safety advantage -impossibility of run-away accidents. But there still are safety, economy, neutronics and technology problems to be solved and questions to be answered before embarking on large-scale projects. Most serious of those problems are: • coupling accelerator, reactor and separation techniques; • already melted fuel in fluid-fuel concept; • rates of radiation damage, hydrogen production, and helium production in a target window and in the surrounding vessel.

According to some scientist a full spectrum of accident initiators considered, the overall safety behaviour of ADTT systems can neither be concluded to be worse nor to be better than advanced reactor designs which rely on inherent and passive safety features, and, it is difficult to find a sound motivation for the transmutation of fission products with accelerator-driven systems. The use of ADTT systems could become a "meaningful" option only if nuclear energy were banned completely.

References:

[1] LAWRENCE, E. O.: *Status of the MTA Proces.* LRL - 102, USA, 1954.

[2] HEŘMANSKÝ, B.: *Safety features of ADDT Systems (in English).* Report of Nuclear Reactor Department, FNSPE CTU Prague, 1996.

[3] HEŘMANSKÝ, B.: *Podkritické množivé systémy s protonovým urychlovačem.* Jaderná energie, 35, č. 2, str. 71, 1989.

[4] TUČEK, K. - HRON, M. - ZEMAN, J. - MATĚJKA, K.: *Neutronic Analysis of proposed ADS core characteristics.* CTU WORKSHOP 97, Prague, January 1997.

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