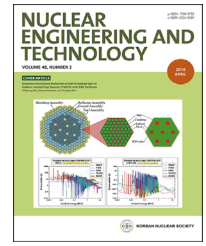
Nuclear Engineering and Technology 48 (2016) 304—317

Available online at ScienceDirect

Nuclear Engineering and Technology

journal homepage: www.elsevier.com/locate/net



Original Article

Monte Carlo Analysis of the Accelerator-Driven System at Kyoto University Research Reactor Institute

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ARTICLE INFO

Article history:
Received 9 July 2015
Received in revised form 3 November 2015
Accepted 7 November 2015
Available online 17 December 2015

Keywords:
Accelerator-Driven System
Kyoto University Critical Assembly
Monte Carlo

ABSTRACT

An accelerator-driven system consists of a subcritical reactor and a controllable external neutron source. The reactor in an accelerator-driven system can sustain fission reactions in a subcritical state using an external neutron source, which is an intrinsic safety feature of the system. The system can provide efficient transmutations of nuclear wastes such as minor actinides and long-lived fission products and generate electricity. Recently at Kyoto University Research Reactor Institute (KURRI; Kyoto, Japan), a series of reactor physics experiments was conducted with the Kyoto University Critical Assembly and a Cockcroft—Walton type accelerator, which generates the external neutron source by deuterium—tritium reactions. In this paper, neutronic analyses of a series of experiments have been re-estimated by using the latest Monte Carlo code and nuclear data libraries. This feasibility study is presented through the comparison of Monte Carlo simulation results with measurements.

1. Introduction

An accelerator-driven system (ADS) is a design concept that comprises a subcritical reactor and a high-energy proton accelerator [1,2]. The reactor in the ADS needs an external neutron source to sustain fission chain reactions because it is operated in a subcritical state. In general, the external neutron source is provided by the spallation of a heavy nuclide such as

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http://dx.doi.org/10.1016/j.net.2015.12.001

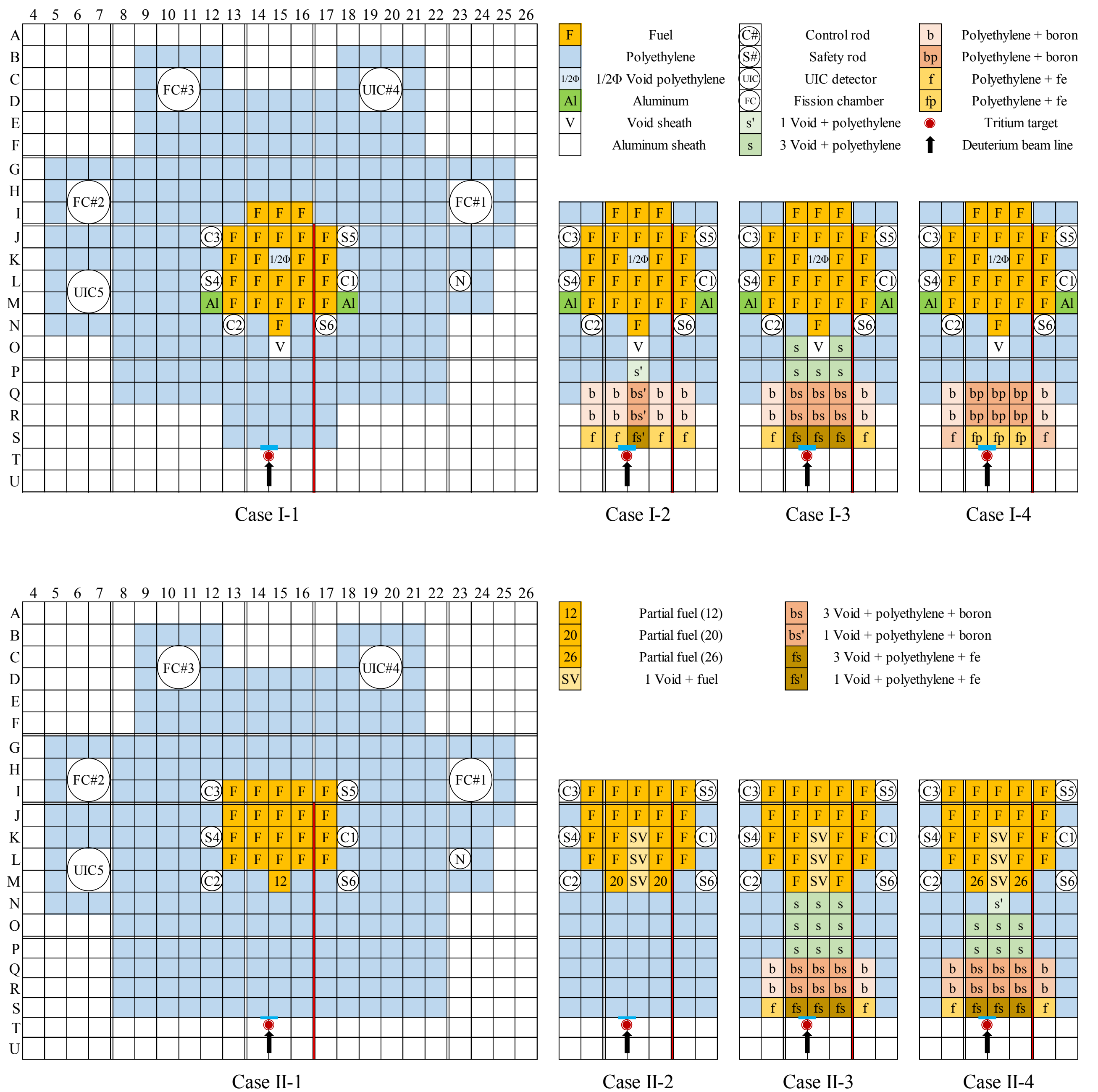

Fig. 1 – Plan view of the Kyoto University Critical Assembly Core configuration. Rods are indicated by “f”, “b”, “bs”, “s”, and “s′”. F, normal fuel; N, neutron source; SV, special fuel.

lead (Pb) that is induced by a high-energy proton beam generated in an accelerator. Because the external neutron source is provided, flexible compositions and isotopes can be utilized in the ADS. Another feature of the ADS is that it can be used for effective transmutation of the minor actinides and long-lived fission products. However, the main advantage of ADS is in ensuring its own intrinsic safety when operated under subcritical conditions. The ADS can be stopped when the beam current supply into the accelerator is turned off so that it prevents a reactor from a supercritical accident. In March 2009, ADS experimental research at Kyoto University Research Reactor Institute (KURRI) was launched to establish measurement techniques for neutronic parameters with the use of the Kyoto University Critical Assembly (KUCA). A series of reactor physics experiments were performed by using the KUCA A-type core, which uses polyethylene as the moderator and reflector. The KUCA A-type core is combined with a Cockcroft–Walton type accelerator to generate an external neutron source. Instead of the neutron source being derived from the spallation of a heavy nuclide, a 14.1 MeV pulsed neutron beam produced by deuterium–tritium (D–T) fusion reactions is injected into the core where highly enriched uranium is loaded [3,4]. The neutronic parameters have been investigated in a series of KUCA experiments, and an