Simulation of transients in ADS reactors in three-dimensional geometry

J. R. N, Carneiro[1], A. C. Gonçalves[2], Z. R. de Lima[3]
E-mail: jrnc@hotmail.com, alessandro@nuclear.ufrj.br, zrlima@ien.gov.br

[1]*PPGIEN,*[2]*COPPE/UFRJ,* [3]*SETER/IEN*

Keywords: Accelerator-Driven System, spatial kinetics, transients.

Accelerator-Driven System, ADS, belong to the new generation of advanced reactors being developed that promise to drastically reduce the life of radioactive waste by, for example, the transmutation process. The purpose of this work is to simulate transients associated with ADS. It adopted the neutron diffusion model that leads the spatial kinetics equations. These equations are solved by the known numerical method of finite differences. The simulations are performed considering transients related to the variations in the intensity of the proton flux provided by the particle accelerator acting in a sub-critical reactor in three-dimensional geometry for two energy groups and six groups of delayed neutron precursors [1]. In order to test the numerical method, a computer code programmed in FORTRAN language was implemented. The code solves equations of spatial kinetics with or without external neutron source in three-dimensional geometry for two energy groups and up to six groups of precursors. Using the codes, two types of transients associated with an ADS reactor will be simulated and will focus on the proton accelerator perturbations, causing variations in the intensity of the proton beam and consequently the intensity of the external source of neutrons. The first transient corresponds to the accelerator beam interruption (ABI) for a short period of time and the second transient to be addressed describes the occurrence of accelerator beam over-power (ABO). A homogeneous whole nucleus was considered in the shape of a cube of 200 cm of edge, without reflector, with two groups of energy and a group of precursors. The spatial discretization in finite differences adopted was $\Delta x=\Delta y=\Delta z=10\,cm$, with twenty radial planes, each plane with 400 boxes, totaling 8000 boxes. Nuclear material properties and kinetic data are given in Table 1. Figures 1 and 2 show the behavior of the relative power, considering a simulation lasting 10 s.

Table 1 - Homogenous Reactor - Nuclear and Kinetic Parameters

Type	g	D_g (cm)	Σ_{ag} (cm)$^{-1}$	$\nu\Sigma_{fg}$ (cm)$^{-1}$	$\Sigma_{¿'}$ (cm)$^{-1}$	υ_g (cm/s)
1	1	1.35062	0.001382	0.00058322	0.0023	3.0×1
	2	1.08085	0.0054869	0.0098328	0.0	2.2×1

$\lambda_1 = 0.08\,s^{-1}$, $\beta_1 = 0.0064$

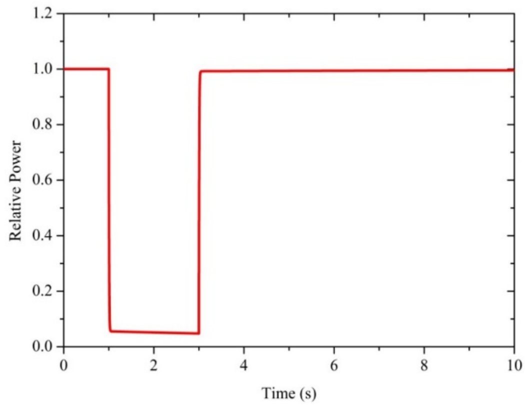

Figure1. Case ABI - Relative Power variation

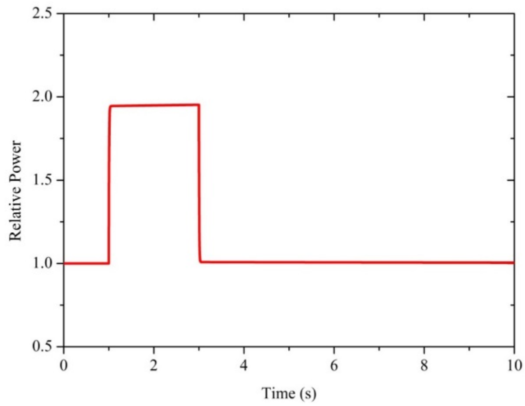

Figure 2. Case ABO - Relative Power variation

Although there are no other results in the literature to make a comparison, the results obtained are very similar to those obtained in simulations using a slab-type reactor and in two-dimensional geometry.

Reference

[1] J. R. N, CARNEIRO, Estudo Numérico da Solução das Equações da Cinética Espacial para Transientes em Reatores Subcríticos (ADS) Multidimensionais. Dissertação de Mestrado, IEN/CNEN, 2020.