A methodology for macroscopic multigroup constants for accelerator driven system core calculation

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Until now the main drawback in the nuclear power production has been relating with the safe disposal and isolation of either spent fuel from reactors or, if the reprocessing option is used, wastes from reprocessing plants. These materials must be isolated from the biosphere until the radioactivity contained in them has diminished to a safe level. These preoccupations arise from the fact that the radioactivity of spent fuel after service is due primarily to the radioisotopes generated by fission, despite the activity levels of the fission products rapidly decrease because of their short half-lived, for most of them. On the other hand, a small amount of transuranic waste is generated by successive neutron capture in uranium, most of them α-emitters, in comparison with fission products, which are β- and γ-emitters. Spent fuel consists of radionuclides with different half-lives ($2.9x10^1$ – $4.5x10^9$ years) and toxicities, basically composed by highly radioactive fission products and transuranic elements. Based on a dose of 20 Sv, reference to acquire mortal cancer with 100% certainty, the most toxic among them are: ^{90}Sr, ^{99}Tc, ^{129}I, ^{135Cs}, ^{137}Cs, fission products, and, ^{237}Np, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{241}Am, ^{243}Am, ^{244}Cm, and ^{245}Cm, the transuranics (TRUs). Because of their small production during transmutation, some of these transuranics are called Minor Actinides (MAs): Np, Am, Cm. The high-level wastes are stored in facilities above ground or shallow repositories, in close connection with its nuclear power plant, which can take almost 10^6 years before the radiotoxity became of the order of the background. While the disposal issue is not urgent from a technical viewpoint, it is recognized that extended storage in the facilities is not acceptable since these ones cannot provide sufficient isolation in the long term and neither is it ethical to leave the waste problem to future generations. A technique to diminish this time is to transmute these long-lived elements into short-lived elements. The approach is to use an Accelerator Driven System (ADS), a sub-critical arrangement which uses a Spallation Neutron Source (SNS), after the separation of minor actinides and long-lived fission products (LLFP), to convert them to short-lived isotopes [1]. Most of the facilities for transmutation are envisaging for using of some MAs as fertile-free fuel, like $(Pu_{0.4}, Am_{0.5}, Cm_{0.1})O_{2-X} - Mo$. As an advanced reactor fuel, still today, there is a few data around these types of core systems. In this paper we generate macroscopic multigroup constants of using in calculations of a typical ADS fuel, take into consideration, the ENDF/B-VI data file [2]. Three energy groups are chosen to collapse the data from ENDF/B-VI data file by PREPRO code. A typical MOX fuel cell is used to validate the methodology. Additionally, the results are used to calculate one typical sub-critical ADS core, as in the Table I and the Table II.

Table I. Macroscopic group constants at core region.

g	1	2	3	4
χ_g	0.76	0.22	0.02	0.0
χ_{sg}	1.0	0.00	0.00	0.0
ν_g	4.4638	2.9044	2.8389	2.8327
$\Sigma_{cg}(cm^{-1})$	$9.57x10^{-4}$	$3.75x10^{-3}$	$3.51x10^{-3}$	$1.42x10^{-2}$
$\Sigma_{fg}(cm^{-1})$	$2.98x10^{-3}$	$8.06x10^{-3}$	$7.1x10^{-3}$	$1.731x10^{-2}$
$\Sigma_{cg\to g+1}(cm^{-1})$	$1.21x10^{-5}$	$5.71x10^{-5}$	$1.05x10^{-4}$	-
$D_g(cm)$	1.84	1.64	0.989	0.878

Table II. Macroscopic group constants at target region.

g	1	2	3	4
$\Sigma_{cg}(cm^{-1})$	$1.79x10^{-2}$	$1.11x10^{-2}$	$1.36x10^{-2}$	$3.51x10^{-2}$
$\Sigma_{cg\to g+1}(cm^{-1})$	$2.38x10^{-4}$	$1.37x10^{-3}$	$2.20x10^{-3}$	-
$D_g(cm)$	2.09	1.66	1.08	0.640

References

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