Spatial Correction for reactivity measurement in Accelerator Driven Sub-critical Reactor

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Abstract

The reactivity measured by Area Ratio Method for a subcritical assembly is spatially dependent and must be corrected. Bell and Glasstone proposed a steady state numerical simulation method to evaluate the spatial correction factor. This paper deals with the reactivity measurements for BRAHMMA (**B**eO**R**eflected **A**nd**H**DPe**M**oderated **M**ultiplying **A**ssembly) subcritical assembly in India using Area Ratio method and evaluation of spatial correction factors using Bell Glasstone Method.

Introduction

Area ratio method is one of the traditional methods to measure subcriticality level in a subcritical or near-critical assembly.The measured reactivity however depends on the detector location.In order to remove this spatial dependence we need to correct the measured reactivity by a spatial correction factor[1, 2].

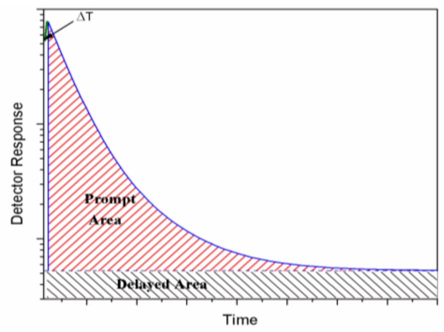
The Bell and Glasstonespatial correction factor for area ratio method is given as

$$f = \left(\frac{\rho_{cri}}{\rho_{src}}\right) = -\left(\frac{A_p}{A_d}\right)\left(\frac{1}{\beta_{eff}}\right)\left(\frac{k_{eff}}{1-k_{eff}}\right) ......(1)$$

In the above Eq., $A_p$is the prompt area, A_d is the delayed area, ρ_{cri} is the reactivity calculated by computer codes in criticality mode and ρ_{src} is the reactivity calculated by computer codes in source mode with the external neutron source. In area ratio method ρ_{src} (in \$) is calculated as the ratio of prompt area to delayed area.For evaluating ρ_{src} two different approaches are followed. The first is the dynamic (time dependent) method in which a single neutron pulse is simulated and the detector reaction rate is counted till the pulse vanishes. This detector reaction rate is superimposed several times till the delayed neutron contribution becomes constant. The detector reaction rate is now integrated to find out the total and delayed areas. The prompt area is the difference between these two. The second approach is the Static method (time independent) where two separate simulations are done with steady state external neutron source, one with total neutrons and other will delayed neutrons suppressed. Detector reaction rates determine the total area and prompt area respectively.

Reactivity Measurement and its Spatial Correction

Area Ratio method (1) was used for experimental measurement of reactivity in BRAHMMA[3] subcritical assembly using both D-D and D-T neutron source.Fig(1) demonstrates the Area Ratio Technique.For D-T source, miniature ^{3}He detectors (Active length: 70mm; Diameter: 6.2 mm; Sensitivity: 0.01 cps/nv) was used in experimental channels EC1 – EC3. The experiments were carried out at neutron yield of 1 X 10^{10} n/s. For D-D source, the neutron yield was 1 X 10^8 n/s. The measurement was carried out in one of the lattice channels (LC-C3) by replacing the fuel rod with a long ^{3}He detectors (Active length: 450mm; Diameter: 25mm; Sensitivity: 65 cps/nv).



Fig(1) Area ratio method for reactivity determination

The measured reactivity will be spatially dependent and hence we evaluated the spatial correction factors by Monte Carlo simulation technique. For evaluating spatial correction factor in experimental channels (EC1 – EC7) miniature ^{3}Hedetectors (Active length: 70mm; Diameter: 6.2 mm) and for lattice channels (LC-C3) long ^{3}He detectors (Active length: 450mm; Diameter: 25 mm) were simulated. The detector material has not been taken into account and is replaced by air.

Table 1 shows the uncorrected and corrected reactivity values together with the correction factor in various experimental channels. It can be observed that the uncorrected reactivity values are quite different for all the three cases. They follow a general decreasing trend from EC1 to EC3. Thus we see that the measured reactivity is spatially dependent. Evaluated correction factors show a general increasing trend from EC1 to EC3 which is quite justified because EC1 being closest to the source has much more contribution from prompt area and thus lowest correction factor(see from eqn.1).Prompt area has contribution from both source and fission neutrons while delayed area has only from fission neutrons. The corrected reactivity values are nearly constant which shows the significance of correction factors.

Table 1: Experimental reactivity values at different detector locations

Neutron Source	Experimental Channel	ρ (uncorrected) (in $)	Correction factor f	ρ (corrected) (in $)
D-T	EC1	- 28.03	0.62	- 17.38
	EC2	- 19.04	0.92	- 17.52
	EC3	- 16.61	0.99	- 16.45
D-D	LC-C3	- 13.34	1.16	- 15.47

Conclusion

The reactivity measurement in a subcritical assembly using the Area Ratio method depends upon the spatial position of the detector. The Bell and Glasstone spatial correction is used to correct this spatial dependence. This paper evaluates the spatial correction factors in the context of BRAHMMA subcritical assembly.The correction factors have been applied to experimentally measured reactivity values. The corrected reactivity values show significant reduction in spatial dependence.

References

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