Reactivity Measurement in BRAHMMA Subcritical Assembly using Slope-Fit method

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Abstract

Different techniques of reactivity measurement have been investigated at subctitical system BRAHMMA at BARC, India. These techniques are developed for online reactivity measurement for safe operation of accelerator driven system (ADS). This paper describes the Slope Fit method investigated with D-T neutron generator. Preliminary results of reactivity measurements using Slope-Fit techniques are in good agreement with the theoretical value.

Introduction

An Accelerator Driven System [1,2]consists of a subcritical assembly which produces fission power without achieving criticality; it uses neutrons from an external source. ADS have several attractive features such as superior safety, waste transmutation, energy amplification etc. An intensive research program investigating the physics of ADS is required. Accurate monitoring of subcritical reactivity value is one of the central operational and safety issues of ADS. However, conventional methods of subcriticality monitoring are no longer valid in ADS. It needs new kind of reactivity determination technique, for example, Pulsed Neutron Source (PNS) and noise methods. This work is dedicated to study the reactivity determination of a zero power subcritical reactor with a pulsed neutron source using Slope Fit method.

BRAHMMA Subcritical Facility

BRAHMMA (**B**eO **R**eflected **A**nd **H**DPe **M**oderated **M**ultiplying **A**ssembly) [1] is a thermal subcritical assembly coupled to a D-D / D-T neutron generator. The core consists of metallic natural uranium as fuel with high density polyethylene moderator and beryllium oxide reflector (Fig.1). The target end of the neutron generator is located in the central cavity such that the neutron emission is at the centre of the target. Three axial experimental channels (EC1, EC2 and EC3) of diameter 10.0 mm have been provided for measurement. EC1 is close to the source whereas EC3 is near the reflector. Four experimental channels of 7.0mm diameter have been provided perpendicular to the beam direction.

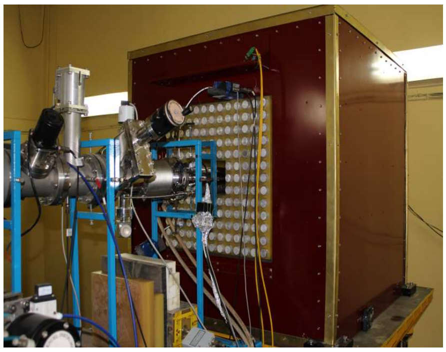

Fig.2. BRAHMMA subcritical core coupled to neutron generator

Slope Fit Method

In slope fit method [3], reactivity is determined by investigation of neutron flux decay by large number of neutron pulse insertions at constant frequency. This makes the delayed neutron background constant and the prompt neutron will decay after each neutron pulse. The decay of prompt neutrons gives the decay constant α . So neglecting the delayed neutron background the point kinetic equation in absence of source can be written as:

$$\frac{dn_p}{dt} = \alpha * n_p \tag{1}$$

where n_p is the prompt neutron level, α is the prompt neutron decay constants defined as

$$\alpha = \frac{\rho - \beta_{eff}}{\Lambda} \tag{2}$$

Where ρ is the subcritical reactivity, β_{eff} is the effective delayed neutron fraction and Λ is the neutron generation time. By measuring α experimentally, reactivity can be found using simulated value of β_{eff} and Λ.

Experimental Result

For the PNS experiments, ^{3}He (70mm active length, 6.2 mm diameter) detector has been used. The detector was placed at middle of the experimental channels (EC1-3). The 14MeV D-T neutron source was operated at frequency of 100Hz and pulse width of 50micosec. Pulse response of the system was obtained by registered the detector signals after each pulse. Figure 2 shows the pulse response of the system. The effective delayed neutron fraction β_{eff} and prompt neutron generation time are obtained theoretically. The measured k_{eff} values at experimental channels are given in Table 1. It can be seen that the experimental k_{eff} values are in good agreement with the theoretical estimate of 0.890.

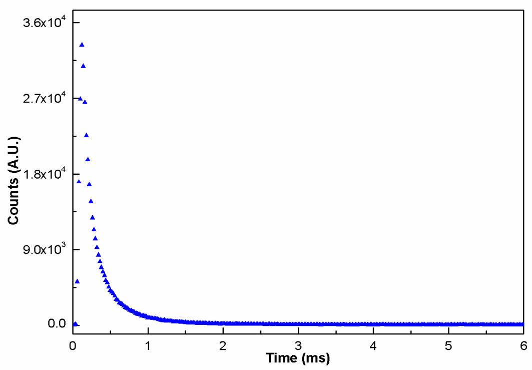

Fig.2. Experimental plot for Slope Fit method.

Table 1. Slope Fit Results

Experimental Channel	Decay constant (α) ms^{-1}	k_{eff}
EC1	-2.246	0.887
EC2	-2.318	0.884
EC3	-2.346	0.883

Conclusion

Slope Fit method has been investigated by applying it to the BRAHMMA subcritical assembly. The results of Slope Fit method are in good agreement with theoretically estimated K_{eff}. The limitation of Slope Fit method is it cannot be used without disturbing the system.

References

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