# NEUTRON BEAM APPLICATIONS AT APSARA, INDIA'S FIRST RESEARCH REACTOR

**A.M. Shaikh, A.K. Patra, S.S. Desai, J.N. Joshi,**
Bhabha Atomic Research Centre, India

## ABSTRACT

Apsara, India's first research reactor at Trombay completed forty years of successful operation in 1996. This swimming pool type, 1MW power(thermal) reactor was first commissioned in August 1956. A variety of neutron beam experiments such as thermalisation study, total cross section measurements, double Bragg effect, magnetic diffraction of simple structures, development of neutron spectrometers, velocity selectors and control units were conducted around this low flux ($10^{12}$ n/cm$^2$/sec) reactor. The experience gained with Apsara proved to be of great value in preparing utilization of other reactors built in the centre. The Apsara reactor, nowadays is used for two major neutron beam applications namely neutron detector development & testing and Neutron Radiography. A large variety of neutron detectors both $BF_3$- and $^3$He-filled with excellent characteristics and long shelf life , in the range of 0.2 c/nv to 60 c/nv and having high energy resolution(8%-25% FWHM for $BF_3$- and 11%-20% for $^3$He-filled) are routinely fabricated and are in use for nearly three decades. Recently emphasis has been put on the development of 1-dimensional (linear) and 2-dimensional (area) Position Sensitive Detectors (PSDs) for neutrons. These are high pressure $^3$He detectors with suitable additive gases for reducing intrinsic position resolution. The linear PSD uses a resistive anode and a charge division method for position encoding. Various spectrometers at Dhruva reactor such as profile analysis spectrometer, high Q spectrometer, Quasi-elastic spectrometers are equipped with linear PSDs. These PSDs have an excellent position linearity and uniformity of response over 90% of the detector length and an average position resolution of 7 mm FWHM. A test facility has been developed at beam hole-9 for QA of these detectors. A 365mm x 365mm area detector is under development for small angle neutron scattering facility at Dhruva reactor. A 150mm x 150mm prototype of this detector has been fabricated and tested with neutron beam of Apsara. Small angle pattern for alumina and micelle samples have been successfully recorded using this prototype.

A well developed Neutron Radiography facility at beam hole-6 of Apsara reactor is functioning since early 1970. The facility is based on converter screen and film techniques and has a L/D ratio of 90 with a neutron flux of $10^6$ n/cm$^2$/s at the sample position. It is used for applications in nuclear engineering, aerospace, ordnance and metallurgical industries. Recently study of formation of zirconium hydride blisters in zircaloy pressure tubes using neutron radiography has been undertaken. Neutron radiography facility at Apsara has been used effectively to investigate the pressure tube/calandria tube (PT/CT) contact location for presence of hydride blisters. Upgrading of the NR facility is in progress to include real time neutron radiography, which will be used for static and dynamic studies. This paper deals with the details of the applied neutron beam research and development activities around the Apsara reactor.