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A LOW BACKGROUND PULSED NEUTRON POLYENERGETIC BEAM AT THE ET-RR-1 REACTOR.*

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ABSTRACT

A low background pulsed neutron polyenergetic thermal beam at ET-RR-1 is produced by a rotor and rotating collimator suspended in magnetic fields. Each of them is mounted on its mobile platform and whose centres are 66 cm apart, rotating synchronously at speeds up to 16000 rpm .

It was found that the neutron burst produced by the rotor with almost 100 % transmission passes through the collimator,when the rotation phase between them is 28.8^{o} . Moreover the background level achieved at the detector position is low, constant and free from peaks due to gamma rays and fast neutrons accompaning the reactor thermal beam .

INTRODUCTION

Time-of-flight spectrometer have been developed into an important tool for the investigations of solid-state physics, chemistry and biology (1-4).

A very high resolution is often required for such experiments. Usually all steps towards improving the resolution are accompanied by losses in intensity (5). In order to increase the neutron intensity in TOF spectrometers at a required resolution, rotors having curved slots were used (6).

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It was shown by several authors (7,8), that for a required wavelength resolution and rotor radius, the obtained neutron intensity is high at high angular velocity. However the strength function of the rotor material together with the dynamic forces, present serious limitations to the maximum neutron intensity obtainable.

To avoid the enumerated difficulties, Egelstaff (9) and Kalebin(10) reported a phased rotor systems. Egelstaff's system consists of two similar curved slot rotors, placed at a suitable distance from one another and rotating synchronously at the same speed. Egelstaff's system produces pulsed monoenergetic thermal neutron beam.

Kalebin's system consists also of two synchronously rotating rotors having straight slots where the slot width of one of the rotors is more wider than the other one.Kalebin's system produces polyenergetic neutrons with energies up to 1 Kev. Kalebin (10) reported that the function of the rotor with the wider slot is to decrease the background level during the flight time of the neutron burst. Thus this rotor can be considered as a rotating collimator.

Recently Wahba(11) reported the design principle of a phased rotating collimator for a pulsed-thermal neutron spectrometer.

The present work deals with performance of using a rotating collimator,applying Wahba's design,for the spectrometer which is in operation at the ET-RR-1 reactor.

COLLIMATOR DESIGN PRINCIPLES:

The phased rotating collimator's dimensions were selected to match the curved slot rotor of the spectrometer which is in operation at the ET-RR-1 reactor. The rotor ; 32 cm in diameter , is suspended in a magnetic field , spinning at a maximum spead of

16000 rpm producing bursts of polyenergetic neutrons. It has two curved slots of 1 cm height. The slot has a radius of curvature of 65.65 cm and a 7 mm x 10 mm cross sectional area.

Let a well collimated neutron beam (width 2h, height H) be incident on the rotor and the rotor (diameter 2r) has two curved slots with radius of curvature R and width 2h. For simplicity, let the rotating collimator (diameter also 2r) has only one slot of width 2h at the center and be fixed at a distance L from the center of the rotor (Fig.1).

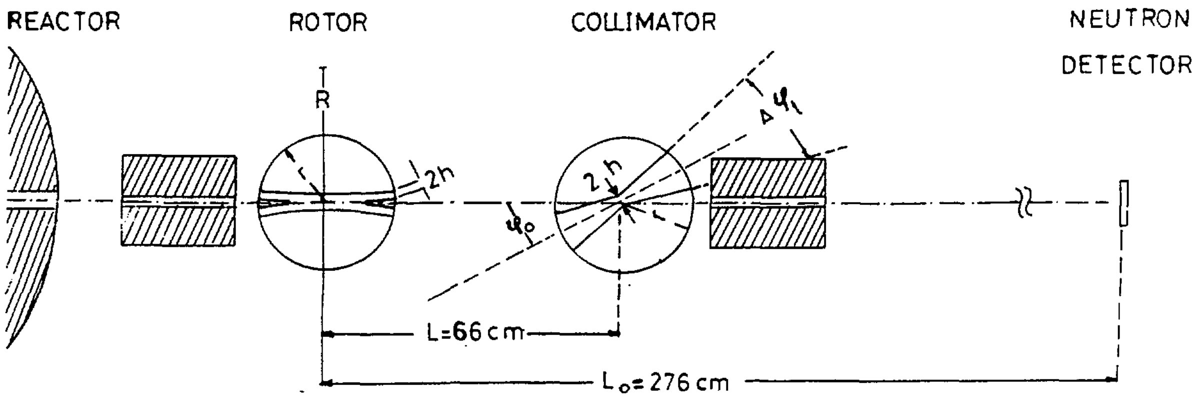

Fig.(1) SCHEMATIC DIAGRAM OF THE ROTOR-COLLIMATOR FACILITY AT THE ET-RR-1 REACTOR

Following Wahba (11), the total angular window of the slot opening $\Delta\varphi_t$ is given by:

$$\Delta\varphi_t = 4Lh/r^2 + \arcsin(r/2R - 2h/r) + \arcsin(r/2R + 2h/r) \quad .....(1)$$

Equation (1) holds when the rotation phase between the curved slot rotor and the rotating collimator is :

$$\varphi_o = L/2R \quad ......(2)$$

In the present design, the distance L was selected to be 66 cm. Consequently $\Delta\varphi_t$ and φ_o were calculated and found to be 34.66^o and 28.8^o respectively.

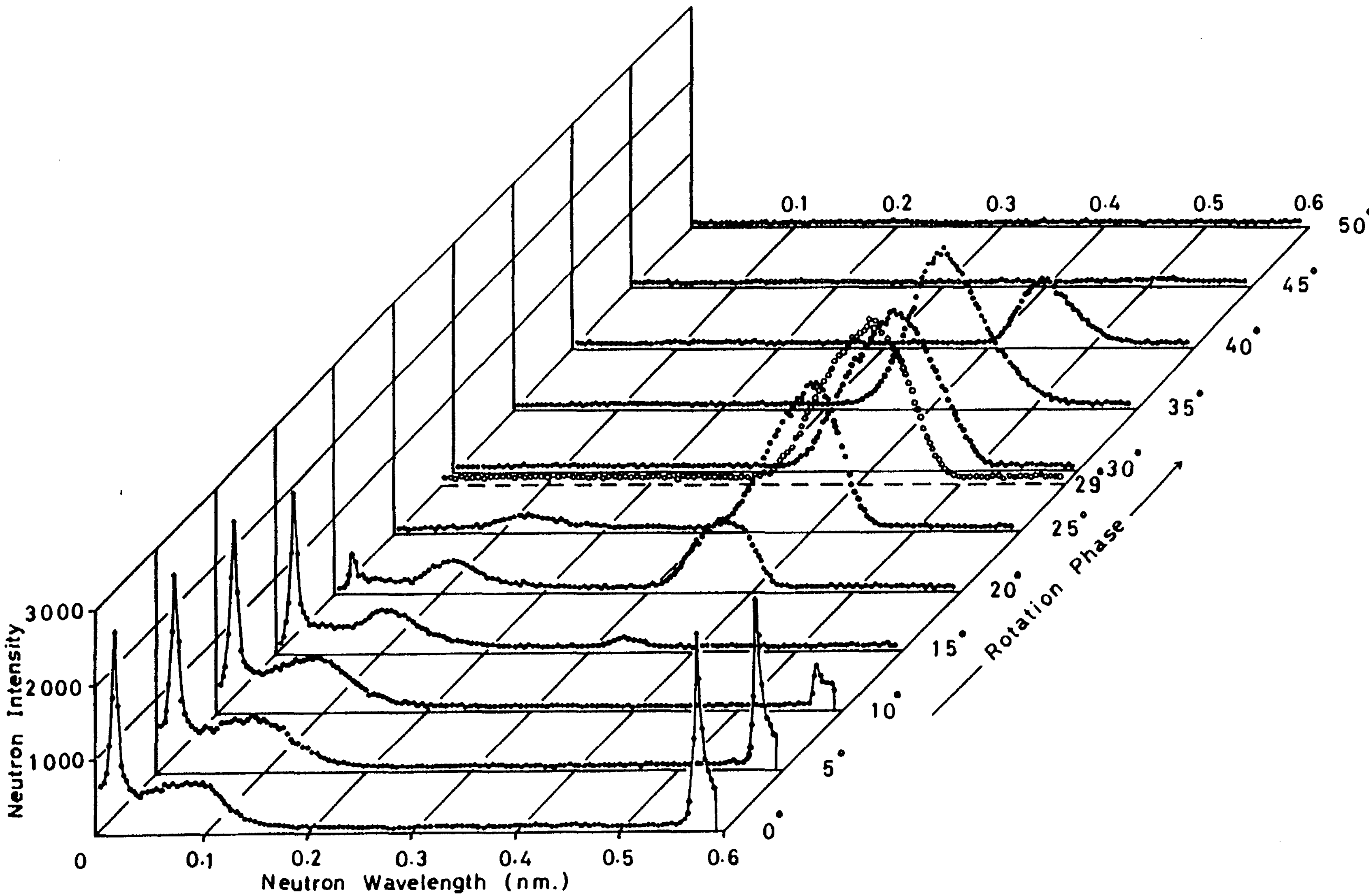

Fig.(2) OBSERVED NEUTRON SPECTRA AT DIFFERENT ROTATION PHASES.

In order to improve the background condition in the present design $\Delta\varphi_t$ was selected to be 27^o. The rotating collimator was manufactured from a nickel alloy whose strength function was 1180 N/mm^2.

The dynamic stability of the collimator was studied during rotation,both when suspended in the magnetic field and in an emergency situation, when the collimator should rotate on the landing bearing like a gyroscope(10).In order to achieve this,the collimator was supplied with a balancing blade .

The jitter phase between the rotor and collimator was measured at different rotation rates up to 16000 rpm and was found not to exceed $\pm$ 1 μsec (12).

SPECTROMETER FACILITY:

The facility consists of the curved slot rotor and the rotating collimator, each of which is mounted on its mobile platform. The whole facility was adjusted to the neutron beam and covered with a biological shield. The analyzing flight path Lo was 2.76 m. A helium-3 neutron detector was mounted at the end of the flight path.A Personal Computer Analyzer operating in its MCS mode was used during the measurements. The schematic diagram of the rotor-collimator facility is shown in Fig.(1).

SPECTROMETER PERFORMANCE :

In the design and operation of the collimator , both transmission and background characteristics have been emphasised. Fig.(2) shows the observed neutron spectra as a function of neutron wavelength while measured at different rotation phases between the rotor and rotating collimator. Where each of them is spinning with speed of 7272 rpm.From Fig.(2),one can observe that the transmitted neutron spectrum is maximum at $(29.06 \pm 0.04)^o$ rotation phase, while it vanished at zero phase. Depending upon

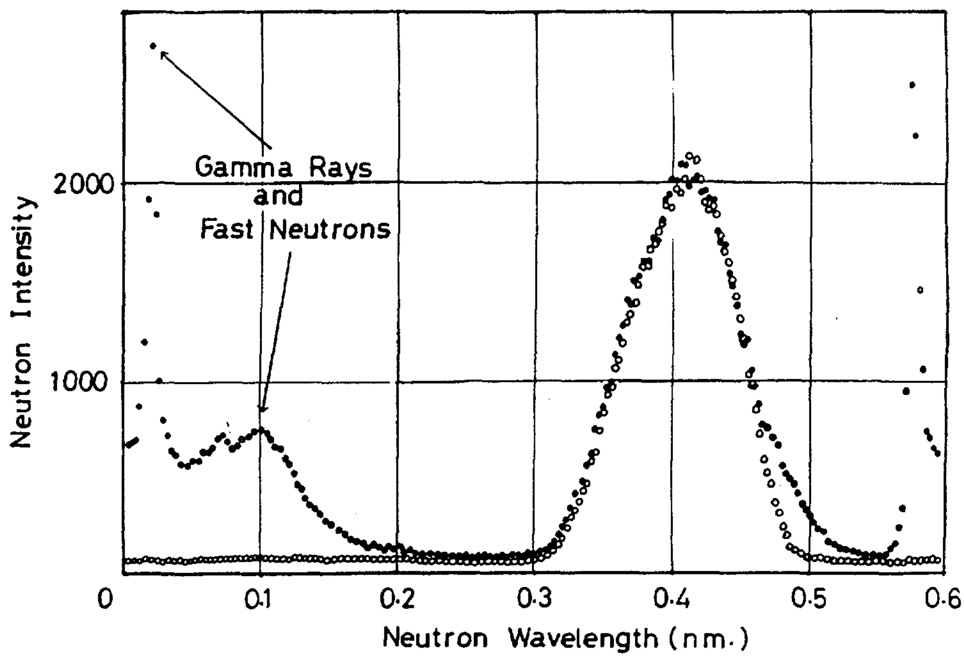

Fig.(3) OBSERVED NEUTRON SPECTRA BEFORE AND AFTER COLLIMATOR.

which rotation phase is selected, any intermediate spectrum can be obtained.

The maximum neutron transmission observed at 29^{o} rotation phase was found to be in a good agreement with the predicted φ_{o} value of 28.8^{o}.

In order to estimate the efficiency of applying the rotating collimator for reducing the background, the neutron spectrum was measured before and after its installation in way of the neutron beam. Fig.(3) presents the measured neutron spectrum (as closed circles) as a function of neutron wavelength before the installation. For comparison, the transmitted spectrum through the rotating collimator at rotation phase of 28.8^{o} (as open circles) is also displayed. From Fig.(3), one can see that the gamma rays and fast neutron peaks are completely eliminated by the rotating collimator. Moreover, the background level everywhere is constant and less than before its installation. However, one can also notice that the neutron transmission at wavelengths longer than 0.46 nm is less than 100 % . Such behaviour is mainly due to the fact that the selected total opening window of 27^{o} is less than the optimum value of 35^{o} given by Wahba (11).

CONCLUSION:

The measured parameters of the rotor-collimator facility showed that there are good prospects for research using scattered neutron, in particular, for research using this facility as small angle neutron scattering spectrometer. The small angle neutron scattering spectrometer should results in significant improvement in the experimental infrastructure for research and applications using neutrons at the ET-RR-1 reactor, and to meet the needs of upgrading the measuring systems at the new planned ET-RR-2 reactor.

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