ICANS-XV
15th Meeting of the International Collaboration on Advanced Neutron Sources
November 6-9, 2000
Tsukuba, Japan

18.13

Neutronic Performance of Decoupled Poisoned and Unpoisoned Composite Moderators for High Resolution Experiments

Tetsuya KAI*, Masahide HARADA, Noboru WATANABE,
Makoto TESHIGAWARA, Hideaki SAKATA, Yujiro IKEDA

Japan Atomic Energy Research Institute, Tokai 319-1195, Japan
*E-mail: kai@shield4.tokai.jaeri.go.jp

Abstract

We studied decoupled poisoned and unpoisoned composite moderators consisting of 20 mm thick hydrogen and 30 mm thick light water. The neutron pulses from unpoisoned one were much broader with longer decay times than a simple decoupled hydrogen moderator in 50 mm thickness. It was also found that the poisoned composite moderator provides higher pulse peak intensities relative to the hydrogen moderator (poisoned at 20 mm) below several tens meV with no penalty of pulse width.

1 Introduction

A decoupled composite moderator, which consists of hydrogen(H_2) and light water (H_2O), has been proposed as an alternative of a high resolution liquid methane moderator at MW-class short pulse spallation neutron sources. [1] The pulse shapes are considered to be broader than a simple decoupled H_2 moderator because of a coupling between the H_2 and H_2O in spite of a higher time-integrated intensity in a range 50 - 100 meV. Therefore, we studied decoupled poisoned composite-moderators aiming at narrower pulses and shorter decay times. A poison sheet, such as gadolinium (Gd), is interleaved between H_2 and H_2O. We compare the pulse characteristics of the poisoned composite and poisoned H_2 moderators.

2 Calculation

The calculations were performed with NMTC/JAM [2, 3] and MCNP/4A [4]. For a mercury, cross sections evaluated at JAERI [5] were used. The general parameters of the calculation model are tabulated in Table 1. Figure 1 shows the target-moderator-reflector system consisting of a mercury target, a beryllium (Be) reflector and moderators. The moderators are a simple H_2 of 50 mm in thickness, 50 mm H_2 poisoned at 20 mm from moderator surface, an unpoisoned composite and poisoned composite moderators. The widths and heights of all moderators are 120 mm. The details are tabulated in Table 2.

Table 1 General parameters for calculational model

Proton beam	
Power	1 MW
Energy	3 GeV
Repetition rate	25 Hz
Current density profile	Rectangular (flat distribution)
Cross section	130×50 mm^2
Target	
Material	Mercury (Hg)
Dimension	$400^W \times 80^H \times 750^L$ mm^3
Reflector	
Material	Beryllium (Be)
Shape	Cylinder
Dimensions	600 mm in radius, 1200 mm in highet

Table 2 Calculation model of moderators

	Simple H_2	Poisoned H_2	Unpoisoned composite	Poisoned composite
Material and thickness (mm)	H_2 (50)	H_2 (50)	H_2 (20) $+H_2O$ (30)	H_2 (20) $+H_2O$ (30)
Poisoned material	No	Gd	No	Gd
Poisoned position	No	20 mm from viewed surface	No	between H_2 and H_2O

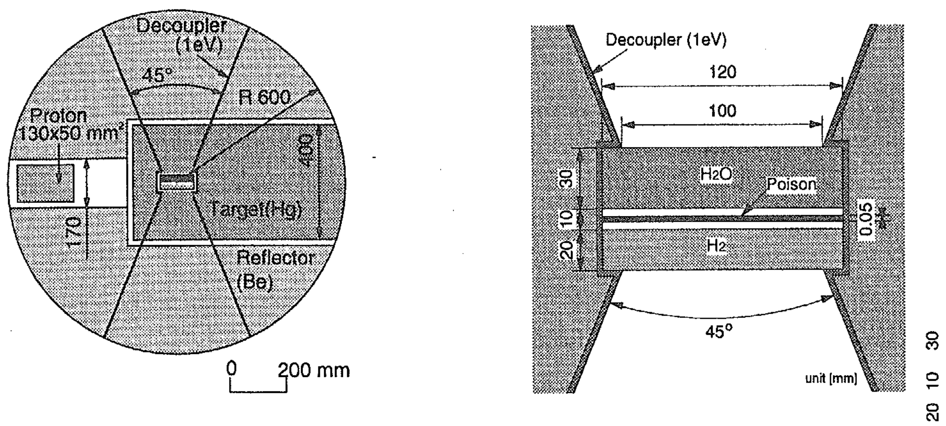

Fig. 1 Calculation model for target-moderator-reflector system (left) and a detailed discription of a composite moderator (right).

For all cases, moderators are decoupled at 1 eV by B_4C layers.

The pulse characteristics from the moderators are discussed by pulse peak intensities (I_{pk}) and a pulse widths in full width at half maximum (FWHM).

3 Unpoisoned composite moderator

It is clearly shown in Fig.2 that the time-integrated neutron intensities from the unpoisoned composite moderator are somewhat larger than the simple decoupled moderator between 20 and 100 meV. The pulse shapes are shown in Fig.3 for neutron energies at 20, 50 and 100 meV. It is obvious that the pulse shapes from the unpoisoned composite are broader than the simple decoupled H_2 with long decay times in this neutron energy range.

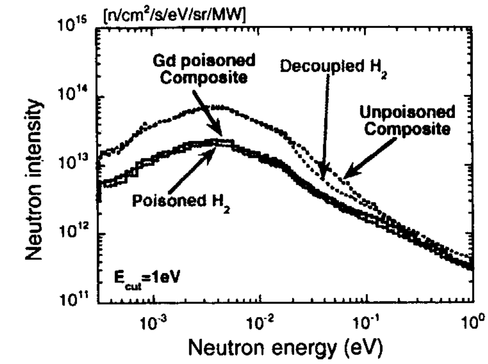

Fig. 2 Time-integrated neutron intensities from a simple decoupled H_2 (50 mm), unpoisoned and poisoned composite moderators.

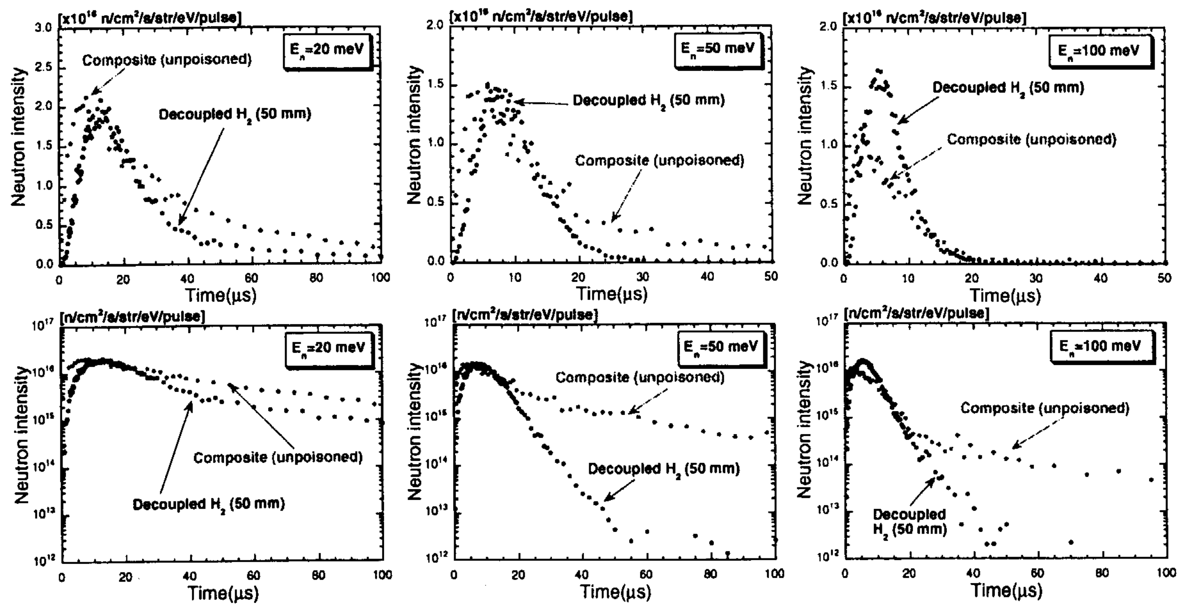

Fig. 3 Pulse shapes of 20, 50 and 100 meV neutrons from a 50 mm thick H_2 and an unpoisoned composite moderator. The decoupling energy is 1 eV.

4 Poisoned composite moderators

Figure 4 shows the pulse shapes of 20, 50 and 100 meV neutrons from Gd-poisoned composite moderator. Those for the H_2 moderators poisoned at 20 mm are compared in the figure. The Gd-poisoned composite provides narrower pulses with shorter decay times than the simple decoupled H_2 ; much narrower pulse widths and shorter decay times when compared with the unpoisoned composite in Fig.3.

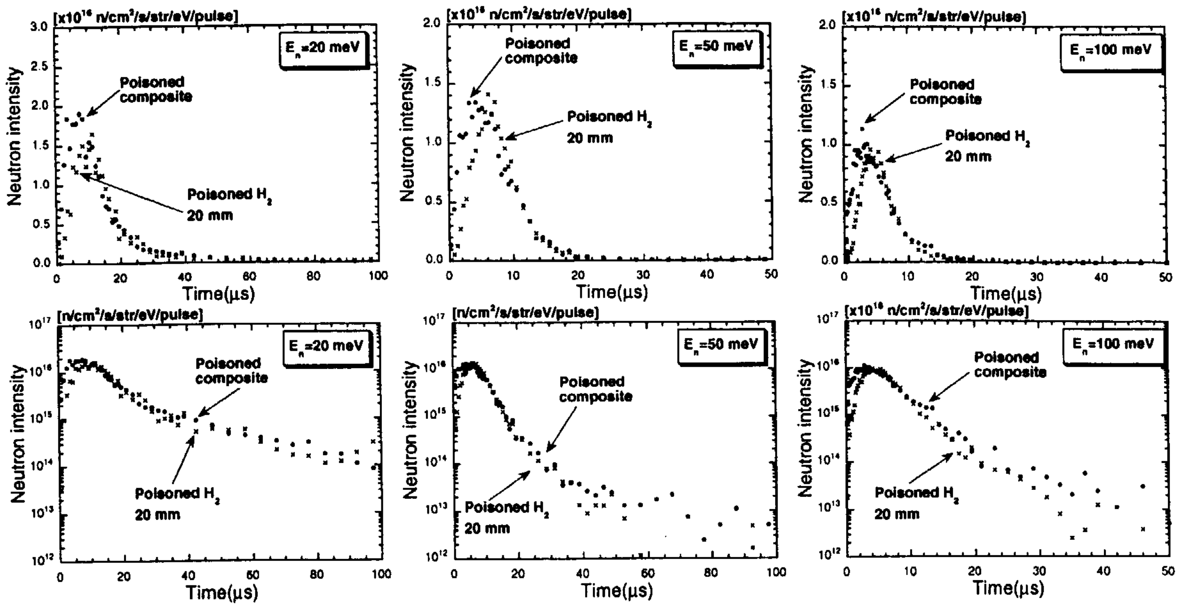

Fig. 4 Pulse shape of 20, 50, 100 meV neutrons from poisoned composite moderator and poisoned H_2 (20 mm). The poisons are Gd, the decoupling energy is 1 eV.

In Fig.5, the pulse width (FWHM) for composite moderators poisoned by Gd are shown as a function of neutron energy. The figure also shows those from decoupled H_2 moderators (poisoned at 20 mm from the moderator surface). At the energies below 100 meV, the energy dependences of the pulse widths are almost similar. This result shows that the pulse widths in the neutron energy below 100 meV depend on the thickness of viewed H_2 in spite of the difference of backside material. In the energy region above 100 meV (higher than the poisoning energy of Gd), the pulse widths from the poisoned composite are slightly wider than the poisoned H_2 because of the H_2O effect in the backside.

On the other hand, the pulse peak intensities are shown in Fig.6 for the poisoned moderators (H_2 and composite) mentioned above. The pulse peak intensities of poisoned composite are larger at energies below several tens meV ($\sim$15% larger at 5 meV). At energies above 100 meV, the pulse peak intensities are almost same between the poisoned composite and the poisoned H_2.

5 Results

The unpoisoned composite moderator provides broader pulses with longer decay times than the simple decoupled H_2 (50 mm) moderator in the neutron energy region between 20 and 100 meV.

In the neutron energy region below 100 meV (nearly above E_{poi}), the pulse widths of the poisoned composite moderator are almost same to the H_2 poisoned at 20 mm, however, the pulse peak intensities are larger. The reason why the pulse peak intensities are enhanced is the premoderating effect of H_2O layer and actually it was proposed aiming this effect.

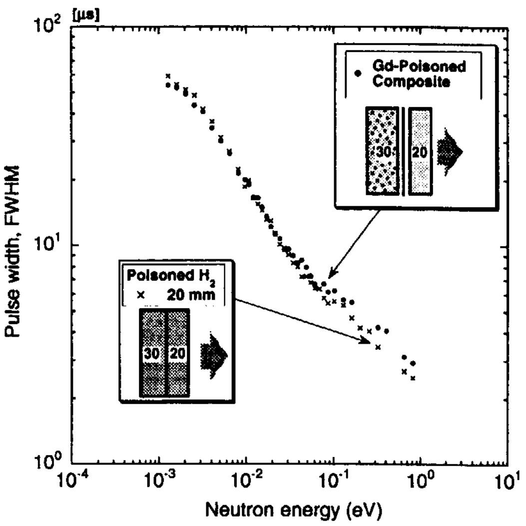

Fig. 5 Pulse widths (FWHM) for the poisoned composite moderator and the poisoned H_2 at 20 mm.

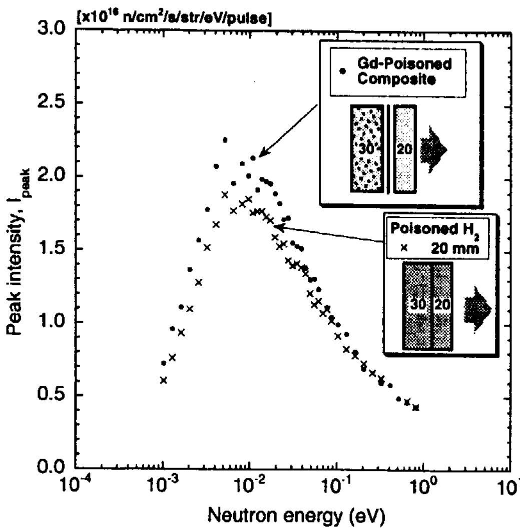

Fig. 6 Pulse peaks for the poisoned composite moderator and the poisoned H_2 at 20 mm.

6 Conclusion

The unpoisoned composite moderator is not suitable for high resolution experiments because of the broader pulse widths with longer decay times in spite of the larger time-integrated intensities between 20 and 100 meV.

It should be mentioned that the larger pulse peak intensities can be obtained relative to the poisoned H_2 in the energy range below 100 meV without any increase of pulse widths. by using the poisoned composite moderator. Therefore, we concluded that the poisoned composite moderator can be a candidate for high resolution experiments below several tens meV.

Acknowledgement

The authors appreciate the staff of "Information Systems Operating Division" about the arrangement and the operation of "PC cluster" parallel calculation system.

References

[1] L. A. Charlton, B. D. Murphy, "Moderator Optimization for the Spallation neutron source", Proc. of 8 th International Conf. on Nucl. Engineering (April 2-6, 2000, Baltimore, MD USA) (2000) 8662.

[2] Y. Nara, N. Otuka, A. Ohnishi, K. Niita and S. Chiba, "Study of relativistic nuclear collisions at AGS energies from p+Be to Au+Au with hadronic cascade model", Phys. Rev. C., **61** (2000) 024901.

[3] K. Niita, Y. Nara, H. Takada, H. Nakashima, S. Chiba, and Y. Ikeda, "Analysis of the Proton-Induced Reactions at 150 MeV $\sim$ 24 GeV by High Energy Nuclear Reaction Code JAM", JAERI-Tech 99-065 (1999) [in Japanese].

[4] J. F. Briesmeister (Ed.), LA-**12625**, "MCNP -A General Monte Carlo N-Particle Transport Code" (1993).

[5] K. Shibata, T. Fukahori, S. Chiba, N. Yamamuro, J. Nucl. Sci. Technol., **34** (1997) 1171.