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Analysis of neutron absorption from nbr rubber type without and with gd and b_4c fillers.

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Analysis of neutron absorption from nbr rubber type without and with gd and b4c fillers.

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Abstract.
The attenuation coefficient of Neutron shielding made of rubber based has been carried out using neutron radiography and gamma spectrometry facility. The samples were Nytrile Butadiene Rubber (NBR), without and with fillers, Gd (Gadolinium), and B4C (Boron Carbida) each composition has 5% by weight. Attenuation values obtained from the smallest, as follows, NBR without filler, NBR + 5% by weight Gd and NBR + 5% by weight of B4C. is **2,032, 3,772, 4,359**

1. Introduction

This paper is an initial study of the use of rubber as a shield for neutron radiation. Indonesia is one of the largest rubber producing countries in the world, beside that a rubber neutron shielding, can be made flexible, in accordance with the shape of the space that must be protected from neutron radiation. Neutron radiation is the process of releasing energy from an object in the form of particles or waves. Included in corpuscular radiation. Based on the Regulation of the Head of the Nuclear Energy Surveillance Agency Number 4 of 2013 concerning Radiation Protection and Safety in Utilizing Nuclear Power. That there must be an average effective dose limit for radiation workers, [1,2]. Although Polyethylene resin effective and is the most popular for neutron shielding, but poor heat resistant. Concrete is more effective for neutron rays and gamma rays and can withstand high temperatures, but is not suitable for additional protection in tight and confined spaces such as the tokama fusion device, which is a torus-shaped reactor capable of confining plasma. [3]. Natural rubber producing from Indonesia is around 1.4 million tons per year. Indonesian raw natural rubber is sold at a relatively cheap, while it from the raw natural rubber production is only 10% is used for the product in the country for industrial tires, gloves, foam rubber, conveyer belts and rubber hoses. [4] Latex consists of a long chain of pure rubber (polyisoprene) whose monomers are (-C5H8-) n. In general, rubber can be divided into natural rubber and synthetic rubber. [5,6,7] Concrete is one of the right materials and is commonly used as a shield of neutron and gamma radiation but heavy and massive concrete. Radiation shielding aims to reduce the danger of radiation so that it is safe enough and does not exceed a standard dose. The level of radiation is influenced by the distance of the radiation source, the length of time the radiation is exposed, and the neutron shield factor. [8,9,10] The use of local rubber as a neutron shield is expected to be a protective material replacing foreign-made neutron shields . Sampling begins with rubber mixing carried out at the Bogor Rubber Research Institute, *hot-press* processes *are* carried out at BATAN Pasar Jum'at, and Neutron testing is carried out at the

Siwabessy RSG-GAS Nuclear Reactor. Data analysis of the test results was carried out in the NAA laboratory which is a Nuclear Laboratory facility at PSTBM BATAN Serpong.

1.1. Neutron Interaction with Material
Neutrons are classified by their energy. High-energy Neutrons , energies exceeding 0.1 MeV can be called **fast neutrons**. Thermal neutrons have the same kinetic energy distribution as gas molecules in their environment. In this case, thermal neutrons cannot be distinguished from gas molecules at the same temperature. In areas where the energy is between fast neutrons and thermal neutrons, it can be called intermediate neutrons, resonance neutrons, and slow neutrons. This naming is adjusted according to the context discussed . Neutrons have proven to be very effective in producing nuclear transformations because without an electric charge, neutrons are more powerfull to penetrate the nucleus than proton, deutron, or alpha particles. [11, 12 , 13].

1.2. Neutron Radiography
Radiography is a test to determine the internal structure of a material without damaging it . Neutron radiography is a non-destructive test that uses neutrons as its source. Neutrons have the property to be absorbed by elements with small atomic numbers such as boron, carbon, hydrogen, etc. While neutrons will be passed by heavy elements such as lead, nickel, iron, etc. So when an object is tested using radiographic neurons an image can be formed that can be used to determine damage from material. [14, 15]. The neutron radiographic facility consists of several parts, namely the source of neutrons from the Siwabessy multipurpose reactor AS, *iner collimator* and *outer collimator* which aims to align the neutron beam, as well as the *shutter* , and the test object holder. When the object is exposed to neutrons, the escaped neutron beam will be captured by the converter and will blacken the film. So each different neutron beam will produce a different density on the film. [16]

1.3. Gamma Spectrometry
Spectrophotometer -γ is a device that uses pulse signals from the interaction of light -γ and detectors. Where the pulse height produced by the detector is proportional to the energy of the photons γ that interact with the detector. Two types of calibration that need to be done are energy calibration and efficiency calibration. Energy calibration is done by chopping several standard radioactive sources that have known their energy correctly. Efficiency calibration is done by finding the detection efficiency value at the detector [17, 18 , 19] :

2. Research Methods
2.1. Materials and tools
The materials used in this research are synthetic rubber: Acylonitrile Butadiene Rubber (NBR), Au foil, Gd, and B4C powder. Neutron Radiography facility, XRD, SEM/EDS, FTIR, hot-press machine, and rubber mixing mill facilities. The absorption data analysis process uses Gamma Counter.

2.2. Sample Preparation
Some steps of preparation carried out in this study include, this rubber mix with of Gd, and B4C with a mass percentage of 5% of the mass of the rubber. The rubber mass used is 400g, the rubber is mixed using a *rubber mixing mill* and after that the rubber surface is leveled using a *hot-press machine* . This mixing will produce a sheet-shaped rubber with six different thicknesses , as shown in Table 1 . Samples were tested for neutron absorption by using neutron radiographic facilities, absorbing testing was carried out for NBR type rubber without and with *filler* , the sample was prepared into six different thickness differences. Samples are placed on metal plates arranged in a circle with a diameter of 25cm and at the both sides of the sample are attached to pieces of Au, as a monitor of neutron radiation . Metal plates are placed in the radiographic room in a position perpendicular to the neutron tube to obtain neutron exposure.

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Tabel 1. Composition.

No	Rubber type	Gd	B_4C	thikness (cm) 1	2	3	4	5	6
1	NBR	-	-	0,2	0,5	0,8	0,9	1,3	1,6
2	NBR1	5%	-	0,2	0,5	0,8	0,9	1,3	1,6
3	NBR2	-	5%	0,2	0,5	0,8	0,9	1,3	1,6

2.3. Calculation of attenuation coefficient (μ)

In a material that is not too thick, the particles only experience one collision or at least several before it is absorbed. The relationship between attenuation coefficient and neutron flux can be described through the following equation:

$$\Phi=\Phi_0 e^{-\mu x} \tag{1}$$

Where:

Φ = Flux neutron after passing the samples (Partikel/cm^{-2}s^{-2})

Φ_0 = Initial flux neutron (Partikel/cm^{-2}s^{-2})

μ = Attenuation coeffisien

x = sample thickness (cm)

2.4. Enumeration of Radiation Flux Samples

Au metal placed in the sample will be chopped using *Gamma Counter* to get the value of chopped per second using *Gamma Acquisition & Analysis* software . The data is processed using Microsoft Excel to get a comparison of the intensity before and after exposure to neutron radiation (I / Io) and attenuation coefficients.

3. Results and Discussion

The attenuation coefficient (μ) is calculated using a comparison of the flux before and after the neutron beam through the sample . Flux values will be calculated using gold plates which will be activated if exposed to neutrons . The absorption graph of NBR type rubber material without and with filler is shown in Figure 1-3.

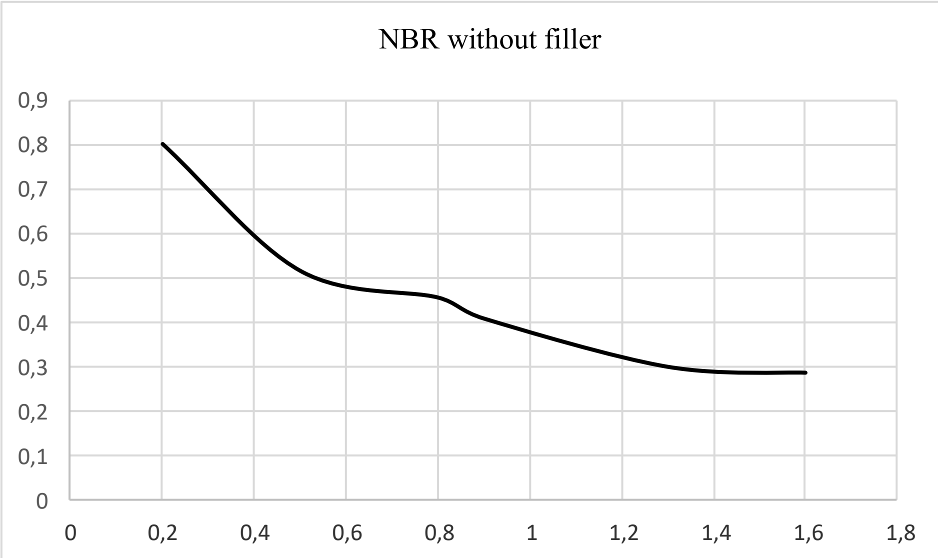

Figure 1. Grafik (I/Io) Vs ketebalan dari sampel NBR tanpa filler.

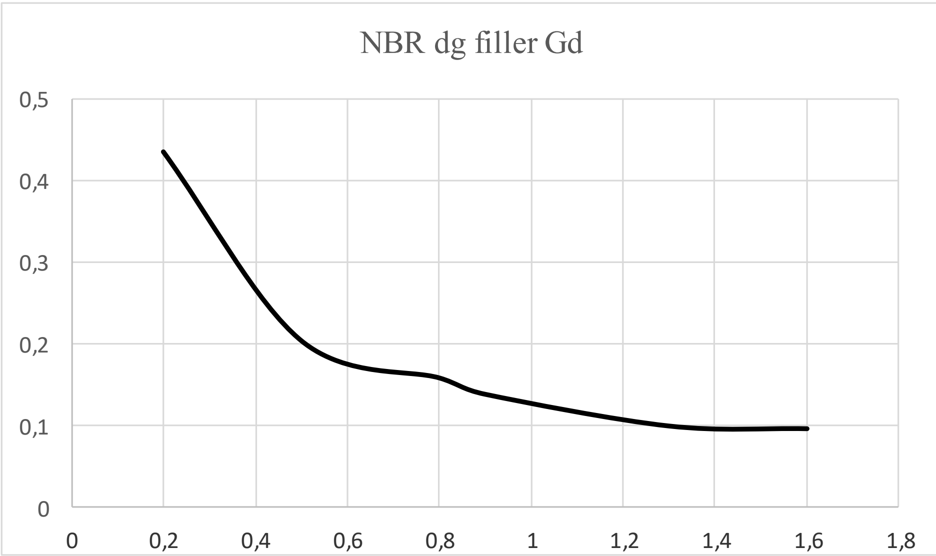

Figure 2. Grafik (I/Io) Vs thickness by Gd filler.

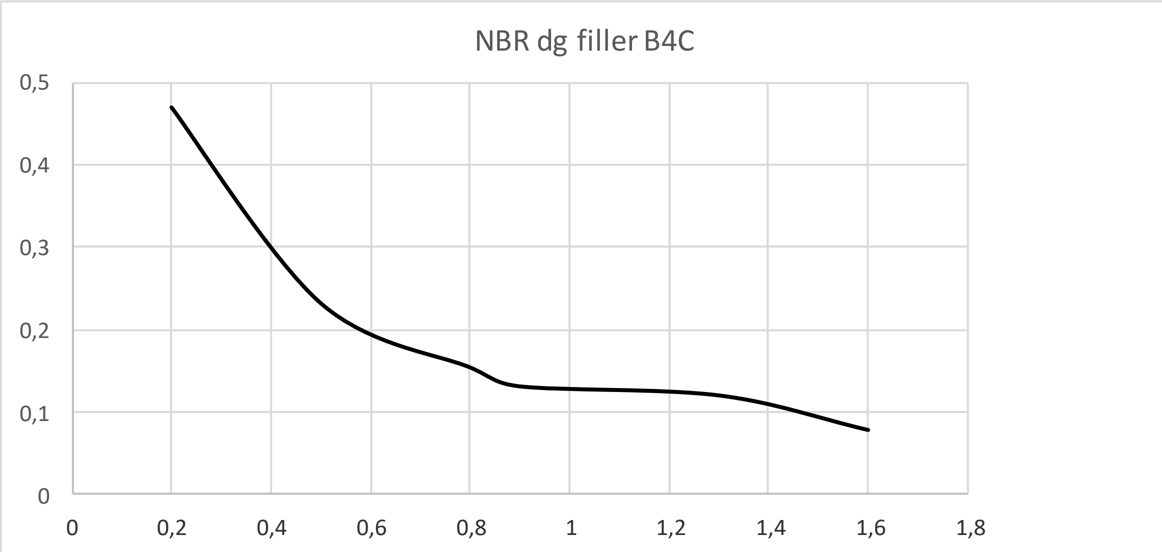

Figure 3. Grafik (I/Io) Vs thikness NBR with B4C filler.

From the 3 graphs above the result that the decrease in the neutron intensity after absorbing NBR rubber sample, in samples with B4C fillers appear to decrease faster compared with NBR shielding without fillers and with Gd fillers. This is because Boron is a better neutron absorbent than Gd.

From the calculation results based on data I and Io data obtained from experiments, the results of the average attenuation coefficient of the NBR sample without filler is 2.032. the attenuation coefficient of NBR samples with Gd filler is 3.772. and the attenuation coefficient of the B4C sample is 4.359.

4. Conclusions
Attenuation coefficient of rubber-based neutron shields can be analyzed using neutron radiography and gamma spectrometry facilities. The results obtained from the attenuation coefficient of NBR rubber samples without filler, with Gd filler and B4C filler found that the greatest attenuation coefficient on NBR rubber with B4C filler.

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