Measurement of Neutron Shielding Materials Property for the Spent Fuel Cask

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1. Introduction

In the spent fuel storage system (cask), the neutron shielding has technical importance and high value. Currently, there are no commercial technologies in South Korea, the development of technologies is necessary. Develop products that use a polymeric resin that is easy to secure long-term integrity according to demands from markets. In addition, it is necessary to solve the difficulty of resin compound in the manufacturing process and to meet the requirements of domestic and overseas markets in the future.

In this study, we have been choosing polyester resin as the basic material for neutron shielding, considering shielding performance, thermal and mechanical properties. We fabricated neutron shielding material that can effectively shield neutrons by mixing additives such as flame retardant, a reinforcing agent in polyester resin. The mechanical properties of shielding materials were then evaluated. [1]

2. Methods and Results

2.1 Basic Material (Polyester Resin)

The Unsaturated type of polyester resin is the most widely used thermosetting resin and it is cured in a liquid or solid state under normal conditions. The main components of polyester are made of acid, glycol and monomer, and their properties vary depending on the type of components. Fig. 1. Shows the ideal chemical structure of a typical polyester. The ester group (CO-O-C) between the molecular chains and the (C=C) position of the reactor were marked.

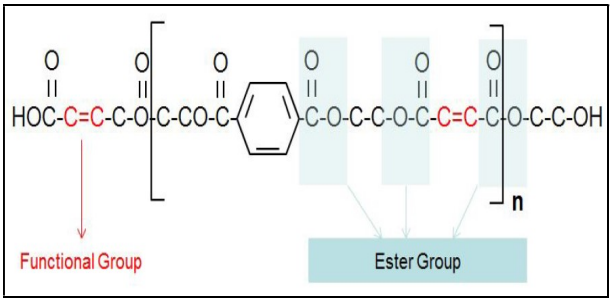


Fig. 1. Chemical structure of polyester

2.2 Additive Agent and Composition

The neutron shielding materials are an unsaturated polyester cross-linked with styrene, which is about 50 w/o mineral and reinforcement. The components are polyester resin, styrene product, aluminum oxide etc. The neutron shielding material provides neutron and gamma shielding. The shielding performance is entirely a function of density and chemistry. In order to satisfy design assumption, cured neutron shielding material must have a density of $> 1.55 g/cm^3$, and a composition as shown in the table I. [3]

Tabel I : Element Composition

Element	Wt%	Method analysis
Al	11.94	ICP-OES
B	0.84	ICP-OES
C	28.1	Element Analyzer
H	4.04	Element Analyzer
O + X(balance)	35.07	Element Analyzer

* We are not open to the type and quantity of specific chemicals (flame retardant, reinforcements etc) added to the polyester resins for patent applications and business secret protection

2.3 Fabrication of Neutron Shielding Material

We have set the experimental apparatus and fabrication procedure as shown in Fig. 2. A variable speed mixer was used to mixing liquid resin, curing agent, and powder-type additives, which are the basic materials for making neutron shielding materials. In case of mixing, each compound is prepared at a specified weight ratio and mixed at an equivalence ratio. The composition ratio of neutron shielding fabricated taking into account the atomic density of hydrogen and additives, ease of processing and the characteristics of neutron shielding materials is shown in Table I.

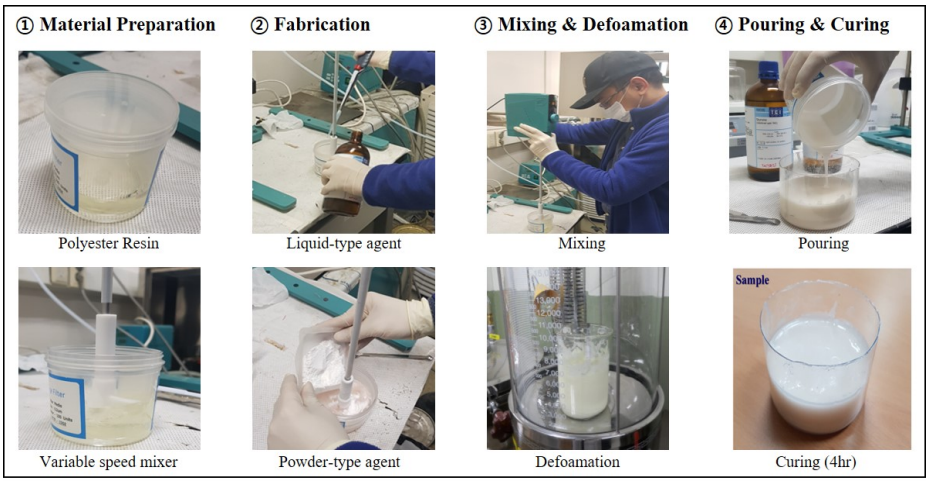
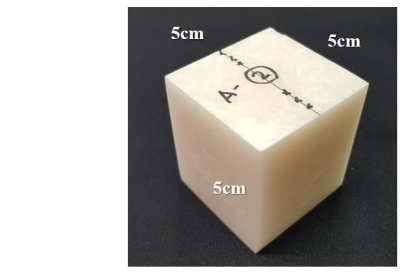


Fig. 2. Experimental apparatus and fabrication procedure

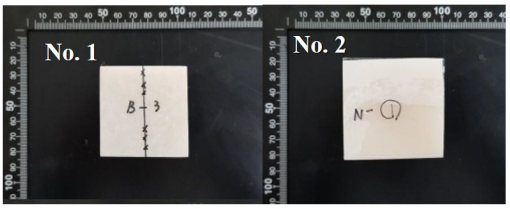
2.4 Results

The density of neutron shielding resin mixture shall be measured. The specimens shall be about 5cm x 5cm x 5cm (regular hexahedron). After the specimen has cured at least 12 hours, determine the density of the neutron shielding resin by weighing the sample dry and weighing it immersed in water. Use ASTM D792 for guidance.

We have requested an authorized agency (Korea polymer Testing & Research Institute) to verify the property of the shielding materials fabricated. We obtained the results of the density measurements carried out by ASTM D792 method and the results are shown in Table II.



(a) specimen



(b) test specimen

Fig. 3. Polyester compound resin specimen (neutron shielding material)

Table II. ASTM D792[1)] test methods and results

Specimen	Results	Method analysis
#1	1.60 g/cm^3	Electronic densimeter (Alfa Mirage, MD-300s)
#2	1.58 g/cm^3	

1) Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastic by Displacement

2) Temperature: 23±2℃

3. Conclusions

We evaluated the performance of neutron shielding materials in spent fuel storage(cask) based on the polyester resin that is mixing with flame retardants and other compouds. First, the density was measured, and the results showed a 1.58 g/cm^3, 1.6 g/cm^3 respectively. This value shows similar values compared to conventional shielding materials (ex. NS-4-FR), But further research is needed to improve performance. Therefore, additional test for tensile, compressive strength and thermal safety will be carried out. Further studies will improve neutron shielding performance, thermal safety, and mechanical properties compared to existing products and technology to fabrication uniformly distributed polyester of compounds.

REFERENCES

[1] ASTM International, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement, ASTM D792

[2] NUREG/CR-6407, Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to safety.

[3] H. Issard, Radiation protection by shielding in packages for radioactive materials, Safe and Secure Transport and Storage of Radioactive Materials, pp.123-140, 2015