Comparative Analysis of Disposal Container for Spent Resin Waste from Heavy Water Reactor

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1. Introduction

The radioactive nuclide ^{14}C is mainly generated fr om $^{17}O(n,\alpha)^{14}C$ reaction in cleaning of deuterium ox ide in a reactor system [1]. Oxygen of inflow air (N_2, O_2) is activated into radioactive carbon during t he cleaning process in the system. Ion-exchange resi n is used for removal of ^{14}C nuclide with ion-excha nge characteristic, where it can remove over 95% of generated ^{14}C nuclide and thus becomes radioactive wastes after ion-exchange of HCO_3^- with cations in resin. Spent resins of 46,600 L have been produced in Wolsong NPP Unit 1 for recent 5 years. They ar e classified into low and intermediate level radioacti ve wastes in terms of disposal.

Total radioactivity of ^{14}C in spent resins from Wo lsong NPP is about 1.48×10^{15} Bq, which exceeds th e limit for the cave disposal site, 1.66×10^{14} Bq. The refore, the technology development for separation of ^{14}C nuclide in the contaminated spent resin and wast e volume reduction is being tried for its suitable dis posal. Also, the volume minimization of secondary waste is required, where it must satisfy standard of radioactive waste disposal regulation on total volume of radioactive waste and radioactivity concentration. At present, the disposal container of High-Integrity Container (HIC) is considered for storage of the ^{14}C containing spent resin waste reflecting physical prop erties of HIC. In this paper, characteristics according to kinds of HIC will be compared and analyzed for the most proper disposal container to ^{14}C containing spent resin waste.

2. Characteristics of HIC materials

HIC is one of the commercialized special containe r for waste disposal. It is defined as waste disposal container preserving integrity over 300 years, where the integrity is the ability to maintain mechanical str ength and isolate inner part of wastes [2]. When ma terials of HIC container are chosen, its economy, th ermal and radiation stability, mechanical characteristi cs have to be considered. The materials of the conta iners are mainly composed of polyethylene, stainless or carbon steel, fiber-reinforced plastic or concrete.

Polymeric material like polyethylene has commonly superior corrosion resistance, economics, productivity but mechanical strength is poor. Stainless steel mater ial or carbon steel have superior structural stability, mechanical characteristic but poor corrosion resistanc e to chemical reaction. On the other hand, cement c oncrete or ferroconcrete material have superior econo

Table 1. Physical Characteristic Comparison between Polymer Concrete and Cement Concrete

Classification	Unit	Polymer Concrete	Cement Concrete
Specific Gravity	g/cm^3	2.4	2.4
Compression strength	kgf/cm^2	1000~1500	200~400
Flexural strength	kgf/cm^2	200~350	40~100
Tensile strength	kgf/cm^2	100~150	10~30
Shear strength	kgf/cm^2	100~300	20~40
Impulse strength	kgf/cm^2	1.8~2.4	1.5~2.0
Absorption rate	%	0.05~0.2	4.0~6.0
Thermal conductivity	W/m·K	1.1~1.2	1.5~1.8
Elastic modulus	$\times10^n$ kgf/cm^2	1.5~3.5	2.4~4.0
Freeze-thaw resistance	Cycle	300	100
Roughness coefficient	N	0.011	0.013

-mics, but they have poor tensile strength and water -proof. Polymer concrete material is a kind of speci al concrete without any cement and water. In Table 1, polymer concrete has superior tensile, flexural, co mpression strength compared to general concrete wh ere its mechanical strength is 2.5~7 times as high a s general cement concrete material [3]. Because of i ts high compression strength, maximum 75% volume reduction effect compared to existing cement concret e material could directly give rise to the reduction o f disposal cost.

3. Results and Discussions

In Table 2, PE (Polymer Ethylene) HIC needs extr a packing because of its weak mechanical structure in long-term aspect.

Table 2. Advantages and Disadvantages of Developed HIC Container

HIC type	Advantage	Disadvantage
PE-HIC	very cheap, light, good corrosion resistance, abundant supplier	poor long-term structural integrity, additional radiation protection needed, limited disposal depth
SFPIC	strong structure, relatively cheap	heavy, complex lid connection
PC-HIC	high compression strength, superior durability, watertightness, chemical resistance	poor thermal resistance, poor fire resistance

SFPIC (Steel Fiber-reinforced Polymer Impregnated Concrete) has complex process and it needs dry ce ment concrete material. It makes expensive manufact uring cost. Also, it is hard to control the depth of i mpregnation [4]. On the contrary, PC (Polymer Con crete) HIC has diverse superior advantages including physical and chemical characteristics such as strengt hs of compression, high resistance about chemical, water, corrosion compared to existing concrete produ ct. It turned out to have proper property of matter a s high integrity container through material integrity a ssessment. Therefore, the performance of PC-HIC is suitable for the safe disposal of ^{14}C containing spent resin waste. Especially superior compression strength can reduce the volume of the waste by one-fourth c ompared to existing cement concrete material, which leads to the relaxation of the characteristic requireme nts of the waste to be stored.

4. Conclusions

The characteristics of several disposal containers fo r storage of ^{14}C containing spent resin waste were c ompared and analyzed. The PC-HIC was thought to have the most suitable property for volume minimiz ation of the waste. It is expected that the analytic a pproach in this paper could be extended to the opti mization of the disposal for the low and intermediat e radioactive waste of spent resin. Further study on the disposal container would be carried out for the efficient practice of long-term safe disposal.

5. References

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