Effect of the Forming Conditions on the Compressive Strength of Fuel Elements for HTGR

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1. Introduction

Generation-IV reactors have been developed for the safety, high burn-up, long-term irradiation cycle and the hydrogen production. High Temperature Gas-cooled Reactor (HTGR), one of the Gen-IV reactors, uses the fuel element which is manufactured by mixing and combining TRISO particles with graphite powder. The graphite powder is pressed with TRISO particles, previously formed with chemical bonding by pyrolizing with FB-CVD (Fluidized Bed-Chemical Vapor Deposition).

H-451 Graphite for HTGR was qualified by NRC in the past, but is no longer available. Therefore, the research for new graphite will be necessary. There are many candidates from the graphite powder suppliers such as SGL cop., Graftech and Toyo Tanso suggested by NRC.

The most important point of the graphite matrix is the strength for the high reliability, because the graphite matrix should be enable to protect the TRISO particles from the irradiation environment and the impact from the outside.

In this research, several kinds of graphite and PVB as binder were chosen and mixed with each other for strength test. The objective of this research is to evaluate and optimize the kind and composition of the graphites and the forming process.

2. Experimental Procedure

This experiment is the basic research using different preparation such as pulverization and mixing process from the commercial graphite forming process. Figure 1 shows the manufacturing flow diagram of the pellet-type graphite.

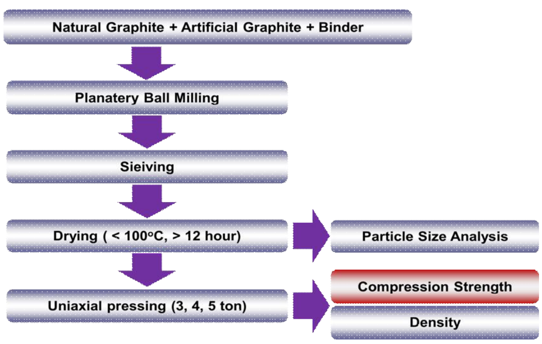


Fig. 1. Manufacturing flow diagram of pellet-type graphite sample

Table I : Compositions of the various mixing conditions.

Type of Graphite	G + S						R + A					
Contents of Binder	2 wt%			6 wt%			2 wt%			6 wt%		
Milling (hr)	2	4	6	2	4	6	2	4	6	2	4	6

(#) G & R : natural graphite, S & A : artificial graphite
Binder B : PVB

Four kinds of graphite among the several candidate graphites are chosen and mixed with each other within the binder B, respectively, by the planetary ball mill (Table. I). Figure 2 shows that the pellet-type graphite matrix is formed at the compression mould with different loading pressures (3, 4, 5 ton). The mechanical test was performed by the compression tester with the pellet-type graphite.

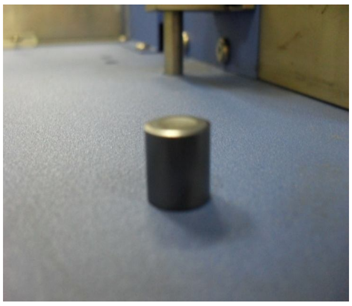
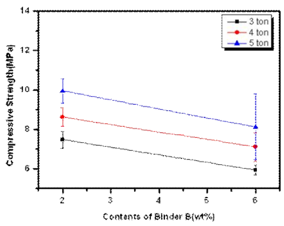


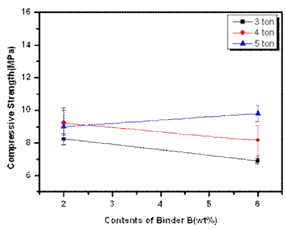
Fig. 2. The compressed pellet-type graphite sample

3. Result

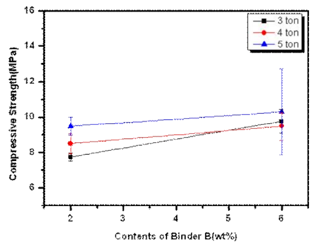
The compressive strength tests are performed for the various graphites having different contents of binder and milling hours. Figure 3 shows results of the compressive strength tests on the compressed pellet-type graphite matrix samples of (G+S) graphite and binder. Figure 4 shows results of the compressive strength tests on the compressed pellet-type graphite matrix samples of (R+A) graphite and binder.



a) 2 hour for milling

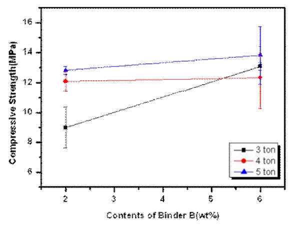


b) 4 hour for milling

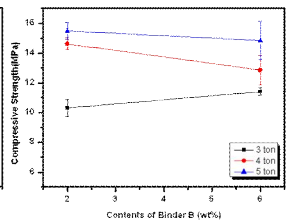


c) 6 hour for milling

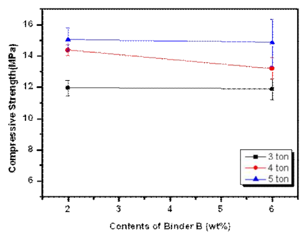
Fig. 3. Compressive strength with the contents of Binder B, the load pressure and the milling time of the pellet (G, S graphite and Binder B).



a) 2 hour for milling



b) 4 hour for milling



c) 6 hour for milling

.Fig. 4. Compressive strength with the contents of Binder B, the load pressure and the milling time of the pellet (R, A graphite and Binder).

The compression tests show that the compression strength is due to the type of graphite and the load pressure. The (G + S) graphite has normally lower strength than the (R + A) graphite mixture. Also, the mixture, pressed under higher load, has higher compressive strength than others. However, the role of the milling time on the strength is lower, if the mixtures are pulverized over 6 hours.

4. Conclusion

For the TRISO fuel elements, the compressive strength is one of the main factors for evaluating the mechanical properties of TRISO fuel elements for the Gen-IV reactors. From the mechanical test result, the compressive strength of graphite pellets was dependent on the various forming conditions such as load pressure, milling time and the contents of graphite. In this result, the contents of binder B, the loading pressure and the milling time are not a main factor for the compressive strength, but the kind of graphite mixture is the main factor for the compressive strength. To enhance the mechanical strength and optimize graphite matrix, the effect of various binders and graphites will be investigated for further study.

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