An Annealing Characteristics of the Irradiated Graphite Block in KRR-2 Reactor

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Executing an annealing of a graphite in a realistic scale will be necessary to eliminate the Wigner energy and some other volatile radioactive gases from the irradiated graphite. A few reports in open literatures, however, has been suggested a plausible clue to solve the nuclear graphite waste management problems, especially in the respect of commercial scale annealing process for Wigner energy release[1]. The Wigner energy, as one of major considerations in nuclear graphite waste management, derived from the rearrangements of carbon structures caused by the neutron dose will effect a whole temperature profile in a mode of a thermal shock during annealing[2].

A thermal distribution of the irradiated graphite from KRR-2 research reactor during annealing was studied to investigate the thermal dissipation modes due to the release of Wigner energy in inside of the graphite block that is effected on its heat generation with an annealing heat source. A lump of the irradiated graphite in a shape of rectangular bar, caused by the longitudinal irradiation dose from the reactor core, has not only a radioactive content gradient in terms of surface effective dose rates but also a Wigner energy content gradient in terms of distorted energies between the graphite carbon matrices[3].

Fig. 1 shows two typical temperature difference(ΔT) profiles - that is between an inside and an outside temperatures of the graphite lump during annealing - of an irradiated fresh-graphite and an annealed-graphite. At an initial annealing period in Fig. 1, the temperature difference, ΔT, shows a linear slope approaching to 25 minutes in a batch-wise heat treatment and the maximum ΔT was nearly 110℃. The furnace temperature was controlled to keep on heating up until the chamber approaching to 300℃. When the furnace temperature was reached to a maximum, in this case 300℃, the furnace was keep up its maximum. After 30 minutes later at annealing the graphite block in furnace the temperature difference ΔT shows a rapid declination curve in Fig. 1(dotted black points).

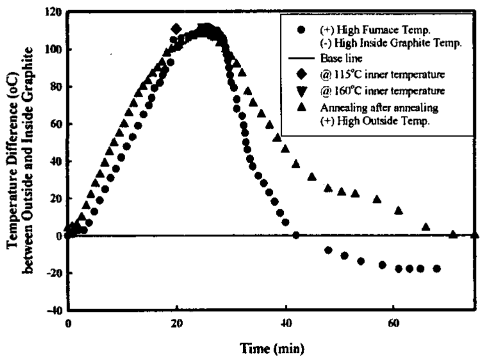
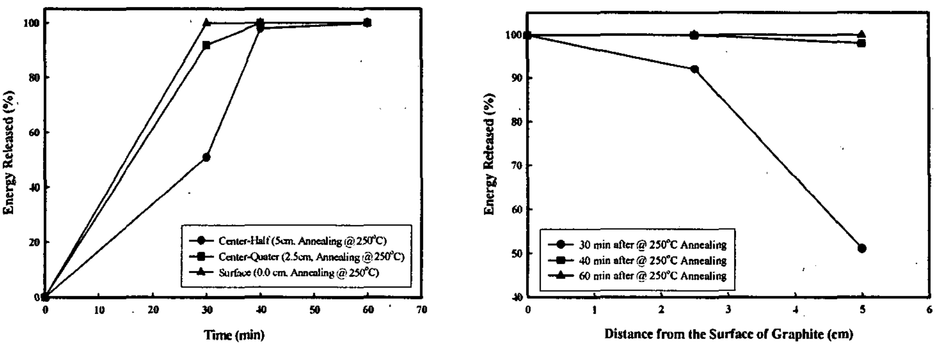


Fig. 1. Temperature difference profile between the inner and the outer of the graphite lump in KRR-2 research reactor during annealing.

The dotted black points after 30 minutes in Fig. 1 was revealed that the Wigner energy release of the irradiated graphite was overwhelmed with the outside temperature. Thereafter the ΔT of the irradiated graphite was profiled the minus values at about 40 minutes at annealing the graphite block. The maximum differences between the inner and outer temperatures in the graphite lump, since the outside temperature is assume to be same to the furnace temperature, was shown to be about 20℃. However, an another graphite sample having no Wigner energy content(i.e., this sample was once annealed) shows a typical time lag curve at annealing process(red colored, triangular points curve in Fig. 1). This graphite block, with no Wigner energy, has a broad temperature difference pattern during annealing and finally arrives an equilibrating period at 70 minutes' progress later. Inside temperature of the irradiated graphite that has some Wigner energy content, therefore, reveals a different type of temperature profile because of the Wigner energy release and/or in aspect of an overall heat release trend along with the ambient annealing rate at the given furnace temperature control.

In Fig. 2 a quantity of heat released or the heat released ratio(percent based on total Wigner energy content) was shown to be a function of (a) the depth in the irradiated graphite block, and (b) the time of heat treating at the same depth of the graphite block. On the basis of the results in Fig. 2 the time required for aging or completing the annealing process in a batch-wise heat control system might be considered in bulk scale operations.



(a) Based on time passed

(b) Based on the distance from the surface

Fig. 2. Wigner energy release characteristics of the irradiated graphite lump in KRR-2 research reactor.

References

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