NUCLEAR GRAPHITES BASED ON COAL TAR PITCH BEHAVIOUR UNDER NEUTRON IRRADIATION BETWEEN 400 AND 1 400°C

P.MOTTET, A.FILLATRE, R.SCHILL, G.MICAUD
Commissariat à l'Energie Atomique, CEN Saclay(France)

J.LORE, P.CORNUAULT
Groupe Péchiney Ugine Kuhlmann, PARIS (France)

1. INTRODUCTION

Two semi-isotropic graphites based on coal tar pitch coke have been developed for use as a moderator in HTGRs. This paper summarizes the dimensional changes and the evolution of the physical and mechanical properties of P_3JHAN and P_3JHA_2N graphites under the effect of neutron irradiation.

2. MATERIALS

P_3JHAN and P_3JHA_2N graphites based on coal tar pitch coke are manufactured by extrusion according to a classical process. Their physical and mechanical properties are described in table I. The anisotropy factor of these graphites falls between 1.3 and 1.4, with coefficients of thermal expansion (CTE) between those of anisotropic petroleum coke graphites and gilsocoke graphites. If the thermal conductivity is slightly lower than that of petroleum coke graphites, the density and mechanical characteristics are improved due to the excellent compatibility between the filler and the binder /1/.

3. BEHAVIOUR UNDER NEUTRON IRRADIATION

More than 1200 samples of P_3JHAN, taken from both the axial and radial directions, have been irradiated in the Osiris (Saclay), HFR (Petten), and ORR (Oak Ridge) reactors. The maximum fluence thus far reached is 12×10^{21} n.cm^{-2} ϕFG* in the case of P_3JHAN and 4×10^{21}n.cm^{-2} for P_3JHA_2N. Irradiation temperatures for both graphites have ranged from 400°C to 1400°C.

3.1. Dimensional changes

The dimensional behaviour of P_3JHAN and P_3JHA_2N graphites is shown in figures 1 and 2. No significant effect of the impregnation has been observed between the two graphites.

The maximum axial shrinkage is 4,5% at 1350°C with a turnaround near 7.10^{21}n.cm^{-2} ϕFG. At lower temperatures, between 500 and 1100°C, shrinkage continues up to 10^{22}n.cm^{-2} ϕFG.

In the radial direction, the maximum shrinkage is about 2.2% at 1350°C and 5×10^{21}n.cm^{-2}. The turnaround occurs at higher fluences when the irradiation temperature is decreased. Expansions are observed above approximately 10^{22}n.cm^{-2} ϕFG as new porosity is generated /2/.

3.2. Evolution of physical properties

The CTEs measured between 25 and 425°C, increase slowly with fluence at low temperatures and decrease at temperatures higher than 700°C. The variation does not exceed 10%.

* graphite damage fluence =
1.25 fluence E > 0.18 MeV =1.85 EDN fluence

Figures 3 and 4 show the degradation of the thermal conductivity of P_3JHAN graphite in the axial and radial directions, respectively. A saturation appears at approximately 2×10^{21} n.cm^{-2} ϕFG. although the decrease in conductivity is smaller at increased irradiation temperatures.

3.3. Variation of mechanical properties

The fraction versus fluence for P_3JHAN graphite is shown on figure 5. The increase in the modulus of elasticity is greater when the irradiation temperature is lower.

Stress-strain curves have been drawn from irradiated specimens. We observed two different types of behaviour depending on the irradiation temperature. Between 500 and 900°C the graphite strains with a constant energy /3/, while above 900°C the energy changes without strain variation /4/.

4. CONCLUSION

The pitch coke graphites studied are less stable than petroleum coke graphites of comparable CTE and anisotropy. This seems to indicate that the fibrous structure of the coke has a preponderant effect under neutron irradiation. This study of characterization before and after irradiation has allowed to specificy the conditions under which these graphites may be used in HTGRs.

Bibliography

/1/ J.P. AUBERT, J.LAHAYE, A.BUSCAILLON
Mouillabilité des cokes par le brai
Carbon Conf. Baden-Baden
preprints p 375, 1972

/2/ G.B.ENGLE, J.C.BOKROS
10th Biennial Conf. on Carbon
Bethleem, Penn., 1971

/3/ J.S.OCHARD, H.H.W.LOSTY
Proc. fifth Carbon Conf.
Vol 1, p 519, 1962

/4/ M.R.E.EVERETT, F.RIDEALGH
Carbon Conf. Baden-Baden
preprints p 191, 1972

Table I

Physical and mechanical properties
of the P_3JHAN and P_3JHA_2N graphites

Graphite	P_3JHAN		P_3JHA_2N	
Direction	axial	radial	axial	radial
Bulk density $g.cm^{-3}$	1.73	1.73	1.79	1.79
Thermal expansion $\bar{\alpha}\ _{25°C}^{525°C}$ 10^{-6} $°C^{-1}$	3.05	4.21	3.08	4.23
Thermal conductivity $W\ cm^{-1}\ °C^{-1}$	1.54	1.18	1.70	1.29
Young Modulus daN mm^{-2}	1005	709	1143	772
Tensile strength daN mm^{-2}	1.12	0.76	1.44	0.98