POSTER

HIGH-TEMPERATURE BONDING OF PARTS MADE OF CARBON AND CARBON-CERAMIC MATERIALS

G.A.Kravetskii, L.T.Anikin, A.V.Demin, G.M.Butyrin

NIIGrafit Research Institute; 2, Electrodnaya St., Moscow, 111524 Russia

INTRDUCTION

A great number of methods have been deve loped to date for bonding articles made of carbon and carbon-ceramic materials (C-CM), which may be classified in terms of the distinctions of forming a bonding seam and physico-chemical processes occu ring meanwhile. Methods of bonding C-CM may be conventionally divided into 3 ma-in classes characterizing under which conditions the joint is formed: solid, liquid or vapor phases [1].Wide applicat ion for bonding C-CM was found by a high -temperature, exothermal, and diffusion welding, as well as CVD methods [2]. For the high-temperature (HT)soldering of CM there have been developed solders based on Ti, Zr, Nb-alloys making it possible to bond CM between themselves or with re fractory metals (W, Mo,Nb) at temperatu-res of 1500 to 2450 oC in vacuum or cont rolled media using a furnace or induct-ing heating.The exothermal soldering al-lows essential reduction of power consum ption owing to heat emission in the exo-thermal reaction and secures short time at soldering temperature under reducing conditions typical of an exothrmal reac-tion. The most promising HT adhesives (HTA) for joining CM are glue composi-tions based on polimeric carbonizable bin-ders [3].The main creteria when develop-ing the adhesive formulations,were found to be a compatibility with the materials to be joined, a high resistance to ther-mal and chemical destructions in wide temperature range. It is found that such requirements are met by glue composi-tions based on phenolformaldehyde (PFR)and furan resins and powder fillers forming refractory compounds during the carboni-zation of the glue base.Depending on the filler material it is possible to form a C-composition glue seam or one based on high-melting chemical compounds:mixtures of carbides with borides or silicides as well as mixed composition,such as C-car-bide,C-carbide-boride,C-carbide-silicide

EXPERIMENTAL

As a subjects of investigations were ta-ken HTA based on PFR differing in the po wder filler composition as follows:K gra de (Si), VK (B,Si), SVK (B,Si,ZrB2), and UVK (B,Si, ZrB2, C) which ensure a long-term service life of HTA joints in the temperature range of 1400 to 2000 oC and short-term at 2000-2800 oC in vacuum or inert atmosphere.In oxidizing media adhe sive joints are serviceable up to the te mperatures from 1600 to 1700 oC for a li mit period of time [4].

Subject to investigation were: behavior of adhesively bonded samples of graphite and steel as well as siliconized graphi-te at different temperatures, and in 20% NaOH and H2SO4 solution at 20 and 90 oC for 30 days;behavior of HTA compositions in distilled and sea water for 90 days.

As the performance criterion were taken changes in the adhesively bonded sample strength and in HTA composition mass du-ring exposure. The results are presented in Tables 1, 2. Adhesive joints based on the HTA K are highly resistant to distil lated and sea water, to 20 % H2SO4 both at 20 and 90 oC (Tables 1 and 2).To bond CM working at temperatures between 1400 and 1700 oC HTA VK grade have been deve-loped.Its composition hardens at tempera ture of 130+20 oC for 3-4 h.The spreadab le life of the HTA K is up to 5 days.Due to boron presence HTA VK is superior to the K adhesive in refractoriness in the temperature range from 800 to 1600 oC as well as in strength in the low temperatu re range. The most universal are HTA of the SVK and UVK grades.Due to introduct-

ion high-melting borides into their filler,a number of technical properties of these HTA exceed those of the HTA VK the limiting working temperature which is 1900 oC. The SVK and UVK adhesives ensure a long-term serviceability of the bonded structures made of CM up to the temperature of 1800 to 1900 oC in inert gases or under vacuum of 0.13-0.01 Pa, and a short-term serviceability at temperatures up to 2700 oC. The UVK adhesive composition is distinct from the SVK one in that the filler contains C components in the form of PFR coke having different HTT which it cheaper without marked decrease in its strength characteristics as indicated below:

Temperature, oC	Ultimate strength, MPa, at: tear-off	shear
	V-1 graphite + V-1 graphite	
20	10 to 15	10 to 12
1800	9 to 12	8 to 10
2000	3 to 4	2.5 to 3.0
2300	1.2 to 2.0	1.5 to 2.0
	V-1 + 1Cr17Ni14Mo2Ti steel	
20	8 to 12	5.5 to 7.5
600	2 to 3	-
800	0.5 to 1.0	-

The HTA SVK and UVK are highly resistant in distilled and sea water; their corrosion resistance markedly exceeds that of the K and VK adhesives.

Table 1. Mass loss (Δm) of the adhesive compositions in H2SO4 (*) and NaOH (+) 20 % solutions

Adhesive composit.	Δm, %,at 20 oC and exposure for (day) 5	15	30	Δm, %,at 90 oC and exposure for (day) 5	15	30
	0.3	0.7	1.4	n/ch	1.2	1.5*
K	63.5	65.0	67.5	69.5	74.5	80.0+
	1.0	1.35	1.8	3.4	5.5	13.0*
VK	39.8	40.5	42.0	42.0	45.5	56.0+
	0.65	1.05	1.65	n/ch	n/ch	2.8*
SVK	16.0	17.5	19.0	18.5	21.0	27.5+
	0.3	0.6	1.0	n/ch	0.7	1.0*
UVK	23.0	23.5	24.0	25.5	31.5	43.5+

CONCLUSIONS

Oxidation resistance of the HTA compositions in air increases with the content increase of the components ensuring the formation of borosilicate protective films of the ZrO2-SiO2-B2O3 system upon reacting with O2. The corrosion resistance of the cured HTA compositions and the adhesive joints in NaOH increases with the increase of carbide phases and decrease of free Si content therein but in an acidic medium it is markedly higher than in an alkaline one and more essentially depends on the medium temperature. The resistance of the HTA compositions and the adhesively bonded joints on their basis is markedly higher in distilled water than in sea water.

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Table 2 Resistance of the adhesive materials and joints in distilled and sea water after exposure for 90 days

Adhesive composition	Mass loss, % Distil. water	Sea	Tear-off strength loss, % Distil. water	Sea
K	1.15	1.25	8.5	36.0
VK	1.35	1.20	8.2	28.0
SVK	1.10	0.75	1.65	24.0
UVK	0.80	0.80	1.65	25.0