CARBON-CARBON COMPOSITES MADE OF HIGH MODULUS GRAPHITE FIBRES

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INTRODUCTION

Advanced fibre reinforced carbon matrix composites are achieving acceptance as engineering materials for design and manufacturing of high performance structural components [1,2]. They have found increasing fields of application because of their superior physical and chemical properties such as high specific strength and stiffness maintained to high temperature, low thermal expansion, fatigue and chemical resistance [3]. The composite properties are influenced by fabrication conditions, kind of reinforcement (high strength, high modulus fibres), internal architecture (1D,2D,3D) and method of densification [4,5]. This paper presents some preliminary results on manufacturing thin plates made of C/C composites suitable for high energy physics. The effect of two types of fibre reinforcement (medium and high modulus fibres) on the mechanical properties of 1D and 2D carbon composites is shown.

EXPERIMENTAL

Phenol - formaldehyde resin (Novolak T) was used as a matrix precursor. High modulus graphite fibres (P-100S 2) have been used **for reinforcing organic matrix.** For comparison medium modulus PAN - based carbon fibres (AGH-IWCh) experimentally manufactured in our laboratory were applied [6]. **Their tensile strength was 3.1 GPa and Young modulus was equal to 230 GPa.** The unidirectional sheet prepregs consisting of carbon fibre rovings and phenolic resin were used to obtain thin specimens in the form of plates. The prepregs were laid up in 3 layers. Two types of the layer arrangement have been made -1D and 2D (for 2D fibrous architecture internal layer was oriented perpendicularly to the sample length). Medium modulus carbon fibres in the form of tissue were also applied to manufacture 2D composites. The specimens were pressed under 5MPa, cured at 160°C and subsequently heat - treated in argon to 1000°C. Carbon composites were then subjected to densification by means of CVD technique using a gas mixture of methan and argon for 2 hours. The flexural strength, Young's modulus, and work up to fracture were measured in three-point bending mode (l/d>16:1) by means of a Zwick testing machine 1435.

RESULTS AND DISCUSSION

Table 1 gives the values of Young's modulus for C/C composites made of medium modulus carbon (PAN based - carbon fibres) and high modulus graphite fibres (P-100S). According to these results for C/C composite consisting of PAN-based carbon fibres the best elastic properties for 2D reiforcement (roving) were achieved.

The measured average Young's modulus attained the theoretical value evaluated from the rule of mixture taking into account the volume fraction of fibres oriented along the plate. Low translation of elasticity (derived from the ratio of measured composite modulus over theoretical values precalculated by the rule of mixtures) for 1D composite may be a consequence of splitting up between the carbon bundles (rovings) in the carbon matrix without transversal reinforcement. Such a tendency was also observed for 1D-C/C composite made of high modulus fibres. Only for 2D composite Young's modulus was found to be similar as the value calculated by rule mixtures according to the fibres content.

The determined flexural strength and work up to fracture were 513 MPa and 10 kJ/m^2, respectively.

The results confirm an influence of carbon fibres elasticity and their arrangement in carbon matrix on mechanical properties of C/C composites

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Table 1 - Type of arrangement of carbon fibres and Young's modulus of C/C composites

type of fibre	reinforcement	volume fraction of fibres, [%]	Young's modulus [GPa]
AGH-IWCh	1D	29.6	55.6 ± 4.8
	2D(tissue)	V_x=21.3 V_y=21.3	31.5 ± 3.9
	2D(roving)	V_X=36.2 V_Y=18.3	78.6 ± 12.7
P-100S-2k	2D(roving)	V_x=42 V_y=21	292.5 ± 27