

INFLUENCE OF GRANULAR CARBON AND PITCH COMPOSITION ON CARBON BRAKES PERFORMANCE

A. Méndez, R. Santamaría, J. Bermejo and R. Menéndez

Instituto Nacional del Carbón, CSIC. Apartado 73, 33080-Oviedo, Spain

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Introduction

Carbon composites find their main application as carbon brakes in the aeronautical industry. Their use in other fields related with brakes and clutches is limited by economic considerations. Carbon brakes have demonstrated over the years their high performance due to the combination of good mechanical, thermal and tribological properties. In order to extend the field of applications for carbon materials it is necessary to reduce the cost of both the precursors and manufacturing processes involved in their preparation. Granular carbons are a possible alternative for producing low-cost carbon composites but their performance has to be tested.

This paper deals with carbon composites prepared with graphite and anthracite and the influence of graphite addition on the structural, mechanical and tribological properties of anthracite composites.

Experimental

Four pitches were used as matrix precursors: a commercial coal-tar pitch (D0), the same pitch air-blown for 18 h (G18), and D0 thermally treated for three (D3) and five hours (D5). The carbon fillers employed were a commercial graphite (GR) and a Spanish anthracite (AT). The preparation of the carbon composites involved three steps: mixing, moulding and carbonisation. Mixing was carried out by kneading the components at a temperature where the pitch melts (100 °C higher than the softening point of the pitch).

The mixtures obtained were sieved to under 1mm and moulded in a conventional way (axial pressing at 80 MPa). After being removed from the mould, the resultant pellets were carbonised to 1000 °C, at a constant rate of 1 °Cmin⁻¹. The pitch/filler proportion for each carbon composite had been selected in a previous study. The carbon composites obtained were characterised in terms of porosity, volume variation and optical texture.

Compressive strength tests were performed according to the ASTM C 695-81 standard. The

friction coefficient of the composites was determined in cylindrical pellets of 30 mm diameter using a laboratory-constructed equipment which consists of a metallic disc, connected to a rotor by means of a clutch ¹.

Results and discussion

Table 1 shows the main properties of the pitches used as matrix precursors. Pitches D3 and D5 contain mesophase while D0 and G18 are entirely isotropic. D5 has a high softening point that makes it difficult to mix with the carbon particles used as filler.

Table 1. Properties of pitches used as matrix precursors

Pitch	SP	CY	Mes	TI	C	H	C/H
D0	97	37.6	0	21.8	92.5	4.5	1.7
D3	169	61.3	30	51.6	94.1	4.0	2.0
D5	336	69.7	50	65.0	94.3	3.8	2.1
G18	180	53.7	0	46.7	92.8	4.2	1.8

SP: Softening point (°C)

CY: Carbon yield (wt %)

Mes: Mesophase (Vol %)

TI: Toluene insoluble content (wt %)

C: Carbon content

H: Hydrogen content

C/H: Carbon/hydrogen ratio

Table 2 shows the properties of the carbon composites. The first important difference between the two types of composites is that the one with anthracite admitted a higher proportion of pitch than the graphite.

Mechanical strength is higher for the anthracite composites due to the greater hardness of the anthracite. The best compression value is obtained with commercial pitch (D0) and anthracite, in spite of the high porosity developed during the carbonisation process.

Carbon Composite	Compressive strength (MPa)	Open Porosity (%)	Volume variation (%)
D0AT 25/75	94.2	37.0	-17.0
D3AT 30/70	63.0	16.9	-18.8
G18AT 30/70	47.2	22.3	-17.9
D5AT 25/75	39.4	25.4	-19.5
D0GR 20/80	17.0	32.1	6.4
D3GR 20/80	24.9	20.0	0.9
G18GR 25/75	26.9	19.5	-3.6
D5GR 15/85	25.4	13.0	3.9

Optical microscopy of the green composites shows that mesophase pitches in combination with anthracite result in mixtures of bad quality due to the coalescence of mesophase spheres. The affinity of anthracite for primary QI (Figure 1a) seems to be responsible for this behaviour during the mixing step. On the other hand, graphite particles do not present a good affinity for primary QI as shown in Figure 1b.

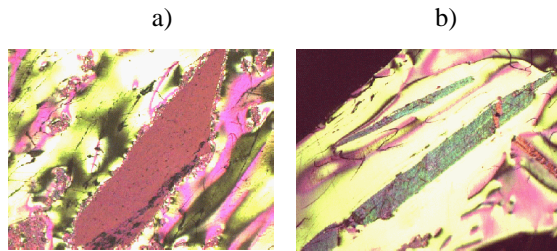


Figure 1. Optical micrographs of D3AT(a) and D3GR(b) heated to 700°C.

The variations in the volume of anthracite composites during carbonisation (Table 2) are due to a high shrinkage. For the graphite composites shrinkage is observed only when G18 is used as matrix precursor.

The friction coefficient values of these materials are shown in Figure 2. In general, values are more invariant for the graphite composites than for the anthracite composites. With anthracite the friction coefficients obtained are too high for conventional applications.

In order to improve the tribological properties of anthracite composites, 2.5 and 5 wt % of graphite was added to the initial mixture, thus giving rise to a new ternary carbon composite. These materials were characterised and compared with the original binary composites of anthracite. Initially, it was necessary to reduce the proportion of D3 and G18 due to the deformation of the composites during the carbonisation step. This is because of the lower amount of pitch required by the graphite.

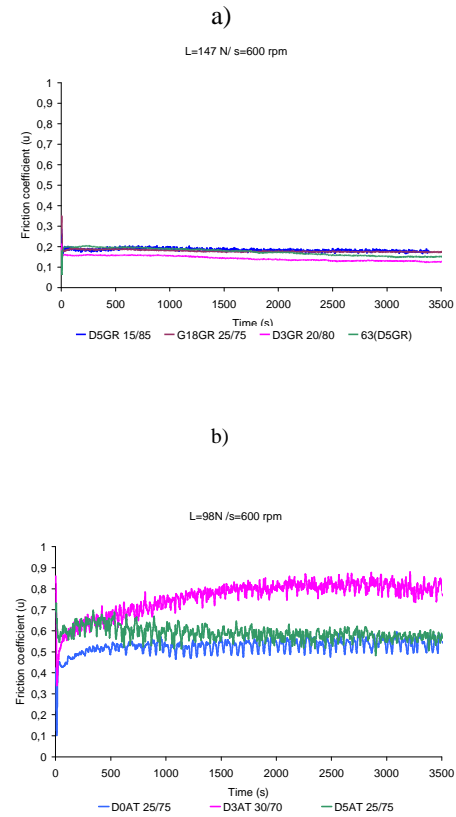


Figure 2. Friction coefficient of (a) graphite and (b) anthracite composites

Table 3 shows the properties of the ternary composites. In general, graphite addition decreases the porosity of these materials while the variation in volume during carbonisation hardly changes.

Table 3. Properties of ternary composites

Carbon composites	Compressive strength (Mpa)			Open porosity (%)			Volume variation (%)		
	0%	2.5%	5%	0%	2.5%	5%	0%	2.5%	5%
D0AT 25/75	94.2	93.3	63.9	37.0	27.6	29.0	-16.9	-14.3	-15.3
D3AT 30/70	63.0	*	*	19.0	19.7	19.5	-18.8	-12.4	-13.7
G18AT 30/70	47.2	*	*	24.2	26.0	17.4	-17.9	-4.3	-13.8
D3AT 25/75	25.8	111.8	94.0	25.9	15.9	18.7	-15.7	-17.9	-16.8
G18AT 25/75	28.5	126.8	128.1	26.2	19.3	19.8	-16.5	-16.4	-17.1

* Deformation during carbonization

The most important result is the high values of compressive strength for these ternary composites, especially when modified pitches are used as matrix precursors. In order to determine the reasons for the improvement in the mechanical properties, the samples were

analysed by optical microscopy after a series of compression tests (Figure 3). Crack propagation does not occur through the interfaces of the matrix-filler (Figure 3a) which is an indication of good bonding. The most noticeable effect occurs at the interfaces of the matrix with the graphite particles, where the propagation of cracks stops resulting in an improvement in the compressive strength of these materials (Figure 3b).

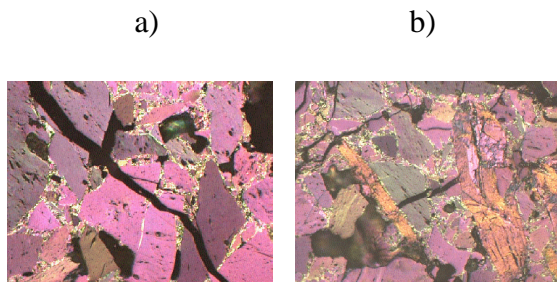


Figure 3. Optical images of carbon composites after compression test.

Conclusion

For anthracite composites, the addition of graphite improves the mechanical properties, lowering and stabilising the friction coefficients. This effect is more pronounced when the pitches used as matrix precursor are modified previously by thermal or air-blown treatment.

References

1. A. Méndez, R.Santamaría, J. Bermejo and R. Menéndez "Granular reinforced carbon composites to be used in brake systems", World Conference on Carbon. July 2000, 957-958.