HIGH-TEMPERATURE MECHANICAL PROPERTIES OF DOMESTIC RAYON BASED CARBON FABRIC/CARBON COMPOSITES

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1 Introduction

The ablative materials exposed to high temperature are often fabricated from carbon/phenolic(C/P), carbon/carbon(C/C) composites. These materials serve as thermal active insulation in rocket motor components by absorbing energy through material degradation [1-3].

To utilize fully the potential of ablative materials in structural application, it is necessary to have a complete and accurate description of their high-temperature mechanical properties [4].

The aim of the present study is to understand the high-temperature mechanical behavior between polymer composites reinforced with domestic rayon based carbon fabrics. Present paper characterized the high-temperature mechanical behavior of rayon based carbon fabric reinforced carbon matrix (rayon C/C) composites because transformation phenolic matrix into carbon occurs at high temperature.

2 Experimental

2.1 Materials and Composites

Rayon fibers (Codenka T700, Acordis Co., Northland) for tire cord application were used as precursor fibers to fabricate rayon based carbon reinforcements. The rayon yarns were woven into a fabric form with 8H harness texture of areal density of over 800g/m^2. Table 1 shows the specification of rayon yarn and fabric used in this work.

The woven rayon fabrics were proprietarily carbonized up to 900℃ with a purging N_2 gas in a batch-type carbonization furnace and then graphitized at 2000℃ with a purging N_2 gas in a graphitization furnace.

Table 1. The specification of rayon yarn and fabric

Class		Specification Value
Yarn	Linear density(dtex)	1840
	breaking tenacity (mN/tex)	510
	No. of filaments	1000
Fabric	Fabric structure	8 harness satin
	Weight (g/m^2)	860
	Count (FxW) (threads/in^2)	50 x 50

Resol-type phenolic resin (SC-1008®, Monsanto Co. USA) was used as matrix for the composites used in this work. The resin content of the rayon based C/P composites after fabrication using a compression molding with vacuum bagging technique was about 32 wt%. Table 2 described the properties of the rayon based C/P composites as well as used carbon fabrics.

The composite plates to perform the high-temperature mechanical tests were heat-treated in a carbonization furnace up to 1000℃ for one hour. They are converted into undensified carbon/carbon plates.

2.2 Mechanical test at high temperature

Tensile specimen was designed as the shape of dog-bone type with a double step to diminish locally occasional failure.

Table 2. Properties of rayon based C/P composites

Class		Details
Carbon Fabric	Structure	8H satin
	Weight (g/m^2)	>330
Composite	Resin	Phenolic (SC-1008)
	Density (g/cm^3)	1.33
	Tensile strength (MPa)	63
	Compressive strength (MPa)	191

The compressive specimen was shaped to fit the special fixture for compression test that was designed to apply compression load to specimen under tensile mode. The mechanical test at high temperature is performed using a Universal Testing Machine (Instron Model 4496) equipped with an indirect heating system and a chamber with a water-cooling system. Fig. 1 shows the schematic for high-temperature mechanical testing system.

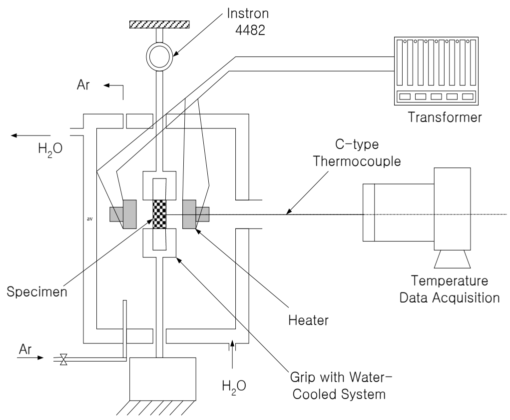

Fig.1. Schematic of high-temperature mechanical testing system.

The graphite heater is located at the distance of 1cm from the specimen. The heating rate was about 200℃/min. A steady argon gas flows at low rate is supplied during testing. An optical pyrometer was used to measure the temperature of over 1000℃ at the lateral center of specimens. Cross-head speed at high temperature is 10 mm/min. Test temperatures of 500℃, 1000℃, 1500℃ and 2000℃ as well as room temperature are chosen. Fig. 2 typically shows the curve of load-displacement of the rayon C/C composites.

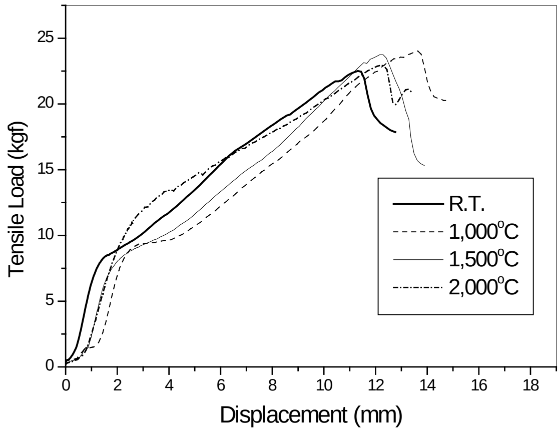

Fig. 2. Typical curve of load-displacement of the rayon C/C composites.

3 Results and Discussion

The high-temperature tensile properties of the rayon C/C composites are presented in Fig.3.

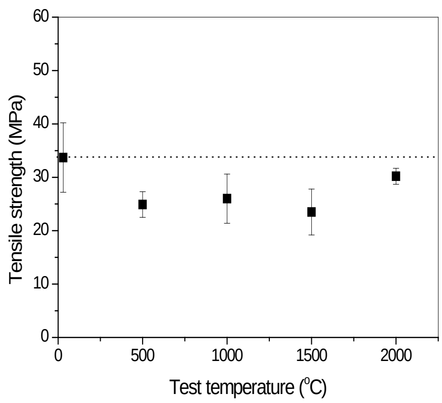

Fig. 3. High-temperature tensile strength of the rayon C/C composites as a function of test temperature.

It is found that the high-temperature tensile strength of the rayon C/C composites shows about 10~30% lower than room temperature tensile strength of them. This may be due to the thermal degradation of the rayon C/C composites at the range of test temperature.

At the fracture patterns of the rayon C/C composites after high-temperature tensile test, it is shown that a fracture mode of the rayon C/C composite exhibits completely a brittle facture as shown in Fig. 4.
This behavior causes the low tensile strength because there is no energy absorption by delamination[5]. This is consistent with the result of high-temperature tensile tests.

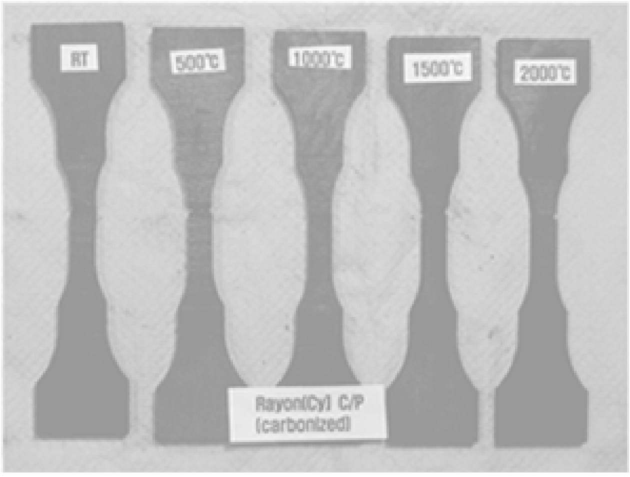

Fig.4. Fracture pattern of specimens after high-temperature tensile test

The high-temperature compressive properties of the rayon C/C composites are presented in Fig.5. It is found that the high-temperature compressive strength of the rayon C/C composites slightly increases with increasing test temperature. It is found that the rayon C/C composite has good dimensional stability with test temperature. This may be due to good interlaminar shear strength between carbon fiber and carbon matrix. The failure pattern of the rayon C/C composite under compressive loading at high temperature is observed as the brittle fracture as shown in Fig. 6. These phenomena are consistent with the results of high-temperature compressive strength.

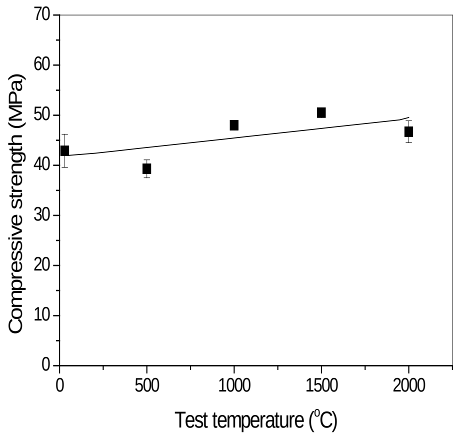

Fig. 5. High-temperature compressive strength of the rayon C/C composites as a function of test temperature.

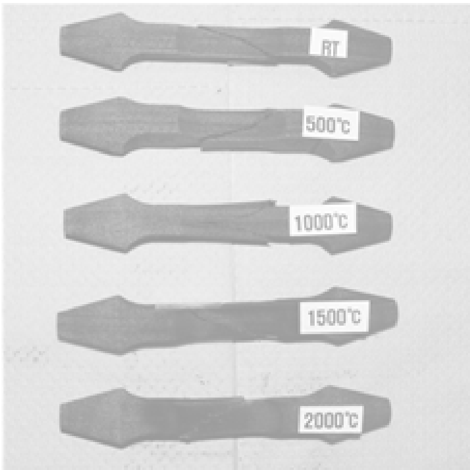

Fig. 6. Fracture pattern of specimens after high-temperature compressive test

4 Conclusions

High-temperature tensile strength of the rayon C/C composites shows about 10~30% lower than room temperature tensile strength of them. The high-temperature compressive strength of the rayon C/C composite slightly increases with increasing test temperature. The rayon C/C composite has good dimensional stability at high temperature.

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