LOW-COST C-C COMPOSITES FOR CYLINDER LINERS

By W. Kowbel[1], J.C. Withers[1], F. Demeree[1] and P.O. Ransone[2]
1. MER Corp., Tucson, AZ 85706
2. NASA LaRC, Hampton, VA 23681

INTRODUCTION

C-C composites exhibit excellent mechanical, thermal and tribological properties. Their commercial applications are greatly limited due to high cost (up to $3,000/lb) [1]. Recently, a novel one step, low-cost manufacturing method for 2-D C-C composites was developed, which offers a potential to produce C-C composites at just $50/lb [2]. The application of this new manufacturing technology to net-shape molded C-C pistons and valves was previously reported [3].

The full potential of a C-C piston can not be realized if the C-C piston is used in a cast iron block where the bores are lined with cast iron sleeves. This paper describes a novel approach to fabricate net shape C-C cylinder liners in one, low-cost manufacturing step.

EXPERIMENTAL

The C-C composite liners were made with a carbon fabrics impregnated with a thermoset resin/active filler slurry. The net shape carbon-polymer sleeve was formed using a flexible rubber molding at 180°C. A high temperature heat treatment (up to 2200°C) was used to convert the carbon-polymer sleeve into a C-C sleeve. A plasma-assisted CVD (PACVD) technique was used to coat the inner wall of the C-C liner with a Si coating. XPS was used to determine the coating chemistry.

RESULTS AND DISCUSSION

Figure 1 shows a net shape C-C cylinder liner obtained in one manufacturing step. The flange was obtained in-situ by spreading the pre-pregged fabrics on the mandrel.

The cylinder liner has a variable thickness (2mm upper half and 1mm lower half). The whole cylinder liner was fabricated in the net shape with no machining. Figure 2 shows the inner surface of the C-C cylinder liner. The ID of the cylinder liner is 7.5cm. The heat treated liner had a very good dimensional tolerance. Only a minor honing was employed to obtain small tolerance ±0.1mm. The C-C liner fabricated in one manufacturing step had 1.6 g/cm^3 density.

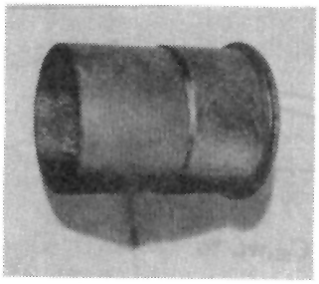

Figure 1. Net shape C-C cylinder liner.

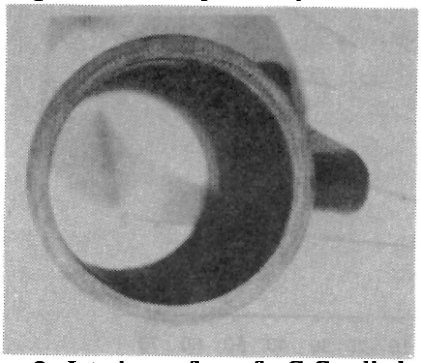

Figure 2. Interior surface of a C-C cylinder liner.

Figure 3 shows a C-C cylinder liner obtained via conventional phenolic resin-based processing. Four re-impregnations were necessary to obtain 1.55 g/cm^3 density. No net-shape molding capability was established in the case of the conventional processing. Thus, in order to produce a C-C liner with a flange machining was employed, Figure 4. The as-machined flanged had poor mechanical integrity (the structural integrity was controlled by low (0.7ksi)ILT. Thus, this paper reports a virtual breakthrough in the C-C manufacturing by

establishing the feasibility to obtain complex, net shape components in just one step using low-cost technology.

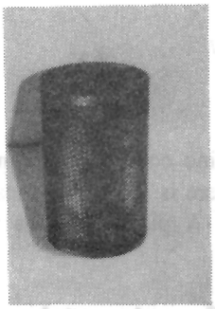

Figure 3. Conventional C-C cylinder liner.

Figure 4. Machined C-C liner made by conventional processing.

Tribological performance of C-C liners can be improved by the application of protective coatings to the inner cylinder surface.

Figure 5 shows the PACVD-Si coated inner wall of a C-C cylinder liner. The coating thickness was about 1μm. The coating was very smooth with no apparent cracks, Figure 6.

XPS was used to confirm the presence of stoichiometric Si, Figure 7.

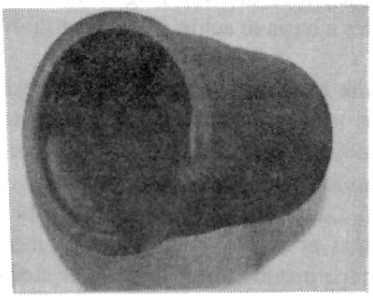

Figure 5. PACVD Si coated C-C liner.

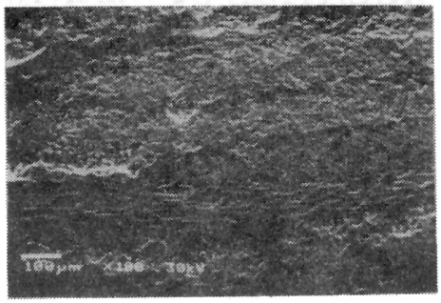

Figure 6. SEM of PACVD Si coating.

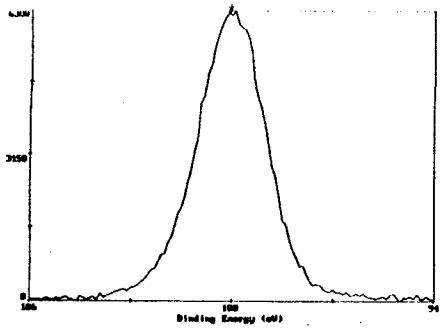

Figure 7. XPS of PACVD Si coating.

In summary, this work extends the novel, low-cost C-C manufacturing technology to complex, net shape components such as cylinder liners.

Acknowledgment

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References.

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