Study on the low friction polymer fiber stitched carbon fiber/phenolic composite materials for journal bearing application

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Abstract
Composite journal bearings were fabricated using a carbon fiber/phenol composite by stitching the continuous carbon fiber fabrics along the thickness direction using a low friction polymer fibers to enhance the ILSS and the tribological properties.

1. Introduction

Journal bearings for turbine/generator application support the high rotating speed and heavy loading rotor, and white metal has been extensively used for journal bearing materials. However, in the case of the unexpected oil cut situation or insufficient oil film formation between the bearing and rotor, the conventional white metal bearing is immediately suspended and induces serious damage tothe rotor; this unfortunate situation is called the seizure problem.

Polymers are widely used in the parts of bearings, gears, and oil sealings to solve the seizure problems because of the lower frictional coefficient of polymers compared to that of metallic materials due to their self-lubrication properties. However, polymers have some inferior properties such as low mechanical properties, low thermal conductivity, and large thermal expansion. To overcome these inferior properties of neat polymers, carbon fiber is often embedded in polymers as reinforcement because of its high strength, high thermal conductivity, and low thermal expansion coefficients.

Carbon/phenol composites for bearing materials have been mainly investigated because the phenolic resin operates satisfactorily with steel and bronze rotors with lubricants such as oil, water,or other lubricant liquids. These composites are also inexpensive and have low friction coefficients compared to epoxy resins. One disadvantage of the phenolic resin is its low glass transition temperature(Tg), which induces low material properties under elevated temperature. Accordingly, the mechanical properties of the polymer composite materials degrade significantly when the temperature exceeds the glass transition temperature (Tg). The reduction in stiffness and strength from the degradation reduces the load carrying capacity, thus leading to structural failure under operational loads that are typically considered safe. When the oil supply is stopped, the rotor is in direct contact with the bearing, and heavy loading with large shear stress is applied to the bearing. Furthermore, direct contact between the journal and bearing generates an increase in the friction force, which increases the operating

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temperatures. Therefore, both high interlaminar shear strength(ILSS) and high material properties under the elevated temperature are important factors in the oil cut situation.

In this work, composite journal bearings were fabricated using a carbon fiber/phenol composite by stitching the continuous carbon fiber fabrics along the thickness direction using a low friction polymer fibers to enhance the interlaminar shear strength (ILSS) of the composite material and the tribological properties. Short beam shear tests were performed to measure the ILSS with respect to the stitching pattern. To estimate the wear resistance and friction coefficient, wear tests were performed at varying pressures and velocities. Based on the ILSS and tribological properties, optimum stitching pattern was suggested to apply the composite materials to the journal bearing.

2. Preparation and properties of carbon fiber/phenolic composite materials

2.1. Material preparation

Carbon fiber/phenol composite laminates were prepared by stitching with a low friction thermoplastic fiber along the thickness direction of laied up carbon fiber fabrics(plain weave) and then the impregnated and cured with a phenolic resin(resol type). A PTFE fiber having a low coefficient of friction was used as stitching yarn.

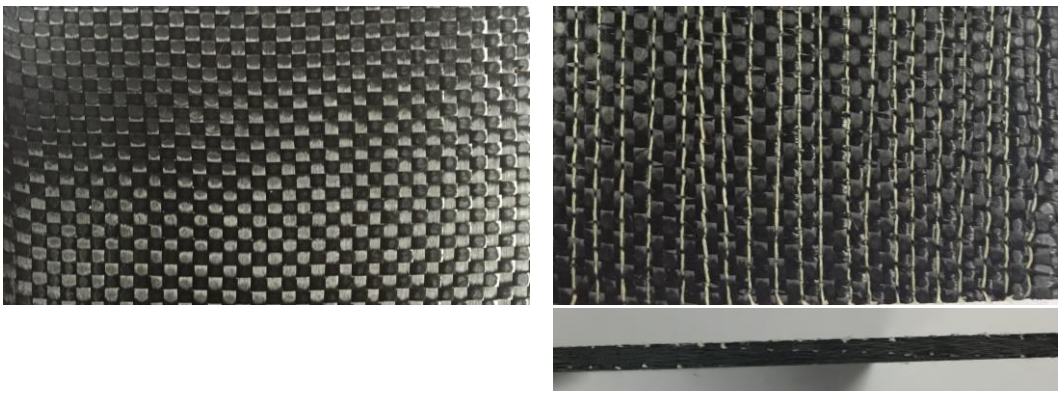

Figure 1. Composite laminates without and with stitching

2.2. Interlaminar shear strength(ILSS) and tribological properties

- **Short beam shear test**

Table 1. ILSS of the carbon fiber/phenolic composites.

	Without stitching	With stitching (along the thickness direction)	
		Fully	Density dradient
ILSS[MPa] at 25℃			
ILSS[MPa] at 150℃			

- **Wear test**

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3. Conclusions

In this work, composite journal bearings were fabricated using a carbon fiber/phenol composite stitched with a low friction thermoplastic fiber along the thickness direction to enhance the interlaminar shear strength (ILSS) and tribological properties of the composite material. Based on the ILSS and tribological properties of carbon fiber/phenol composite with respect to the stitching pattern, the optimum stitching pattern were selected to fabricate the composite journal bearing.

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