INFLUENCE OF PTFE FIBER CONTENT ON THE TRIBOLOGICAL PROPERTIES OF HYBRID KEVLAR/PTFE FABRIC SELF-LUBRICATING COMPOSITES

Yingyi Liu and Dongxing Zhang*

Carbon Fiber Reinforced Plastics Laboratory, Harbin Institute of Technology, harbin 150001, China
*Corresponding author:dongxingzhang@163.com

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ABSTRACT

Hybrid Kevlar/PTFE fabric self-lubricating composites specimens were prepared with different content of Polytetrafluoroethylene (PTFE) fiber and Kevlar fiber (DuPont, USA) by hand-knitting machine. The friction and wear tests were conducted under dry sliding conditions at various speeds under a load of 50N. The results showed that the content of PTFE fiber was effective in reducing the wear of the hybrid PTFE/Kevlar fabric composite, the higher PTFE fiber content the fabric had, the lower the friction coefficient was. Whereas it was unfavorable for improving the wear resistance [1-3]. For the fabric of the PTFE fiber content was 30%, as the rotational speed of the friction was rising, the coefficient of friction was higher, and for it was 80% on the contrary, the higher the rotational speed of friction, the lower the coefficient of friction. the sample which PTFE fiber content was 80%, the rotational speed of friction was 400r/min or 500r/min, has the lower friction coefficient as 0.16, while the sample which PTFE fiber content was 30%, the rotational speed of friction was 100r/min, has the minimum wear amount as 9.6mg.

1 INTRODUCTION

Hybrid Kevlar/PTFE fabric self-lubricating composite materials which not only retain the low friction coefficient, but also have high mechanical strength, have recently generated extensive interests as a new type of solid self-lubricating material to be a lubricating layer between the inner and outer rings of spherical plain bearings, they are widely used in the aerospace, automotive and heavy machinery due to the excellent properties as self-lubricating, wear resistance, light weight, high strength and wide performance tailor ability[2-5]. PTFE has the lowest coefficient of friction (0.27) among the known material due to its surface layer is subjected to shear stress after plastic deformation, resulting in fracture and shedding parallel to the surface, while forming a sheet-like product wear and abrasion occurs, resulting in a high rate of wear (1427.4×10^{-6}) and poor abrasion resistance as its mainly disadvantage[6-7]; Kevlar fiber is a kind of production developed by DuPont with good thermal stability, abrasion resistance, chemical resistance, and high strength and modulus to maintain the strength of the fabric composites. The hybrid Kevlar/PTFE fabric with two fibers are used to combine the benefits of each fiber into the single composite having both tribological and mechanical properties optimization, the face of hybrid fabric rich in PTFE fiber was subjected to wear due to its low-friction property, which the other face rich in Kevlar fiber kept the strength and adhered onto the substrate. This kind of fabric self-lubricating material has good friction reduction, wear resistance, and high load capacity as the same time [8-10].

2 AIMS

This paper will design comparative tests, and control the content of PTFE fiber in this composite as a single variable, compare the surface of the specimen wear areas morphology observed by scanning electron microscopy (SEM), analyze changes in morphology and structure of the material after the friction test to research PTFE lubrication mechanism and how its content impact wear resistance of the composite material. The paper should be written following the format of this template. The file has to be translated into Portable Document Format (PDF) before submission.

3 TEXT

3.1 Materials and equipment

The hybrid PTFE/Kevlar fabric was woven out of PTFE fibers (fineness: 200 Denier) produced by Shandong Senrong plastic industry technology Co., Ltd and Kevlar fibers (fineness:440 Denier) purchased from DuPont Plant USA. Two kinds of fibers above were used forming the fabric through waving machine made in japan, which was stuck to the 45 steel as substrate by epoxy resin as adhesive. In this experiment, MMW-1 universal friction and wear machine produced by Jinan Jincheng Test Services Ltd was used to record changes of sample friction coefficient with time, and the amount of wear was determined through weighing the specimens before and after the test by precision electronic balance.

3.2 Preparation of hybrid Kevlar/PTFE fabric composite

To research the influence of the content of PTFE fibers on the friction and wear behaviors of fabric composite, we choose different content of PTFE fibers as weight fraction of PTFE to Nomex 3:7 and 8:2 for PTFE/Nomex fabric composite (sample PTFE 80%, sample PTFE 30%).

The adhesive formulation: Epoxy 7.5g and phenolic resin 6g are mixed and heated to 60°C, adding butyl phthalate 2.5g, stir to mix evenly, after leaving the mixture to cool to room temperature add ethylene diamine 1g and stir. The surface of the metal substrate (45 steel) processing: ingot sample size was 25mm × 125mm × 13mm, polished it with 600# water-proof abrasive papers to smooth sequentially, after cleaned with water and acetone, placed in a constant temperature oven drying. Bonding: the 45 steel sample preheated to 50-60°C, its surface coated with adhesive formulated above with a brush evenly, until the bubbles disappear sufficiently diffuse adhesive on the metal surface penetration (approximately half a minute), pasted the PTFE / Kevlar fibers fabric on it with pressure $1kg/cm^2$, solidified more than 8 hours at room temperature.

3.3 Friction and wear test

Mainly through friction coefficient measured by tester which collected changes of friction coefficient each time point and wear amount to show the friction and wear properties of fabric. Sliding wear tests were conducted under dry sliding conditions at various speeds from100 to 500min/h under a load of 50N, with 45 steel flat circle with a diameter of 50mm as the friction pair material for 1 hour. At the end of each test, the corresponding wear weight loss of the composite was obtained by precision electronic balance. The wear performance was expressed by wear rate. scanning electron microscope (SEM: JSM-5600LV) was used to observe the worn surface morphology of the fabric composites.

4 RESULTS AND DISCUSSION

Figure 1a shows the variation coefficient of friction of the sample which content of PTFE fiber is 30%. It can clearly be seen in the beginning of the test phase, due to the need to improve the speed slowly, so the friction coefficient is not stable. And speed to meet the requirements to be stabilized, the friction coefficient gradually stabilized. Observed that as the speed increases, the friction coefficient increases. Each coefficient curve fluctuations are large, a large variance. Figure 1b shows the variation coefficient of friction of the sample which content of PTFE fiber is 80%. The friction coefficient is not stable at the beginning of the test as well. And as the speed to meet the requirements, the friction coefficient gradually stabilized. Change at different speeds friction coefficient obvious rule: the higher the speed, the lower the coefficient of friction. And (400r / min, 500r / min) or less coefficient of friction at a high speed, almost the same. And friction coefficient at high speed significantly lower than the sample 30% PTFE, and the fluctuation value is not smaller variance. Figure 1c shows the steady state friction coefficient of two kinds of hybrid fabric composites.

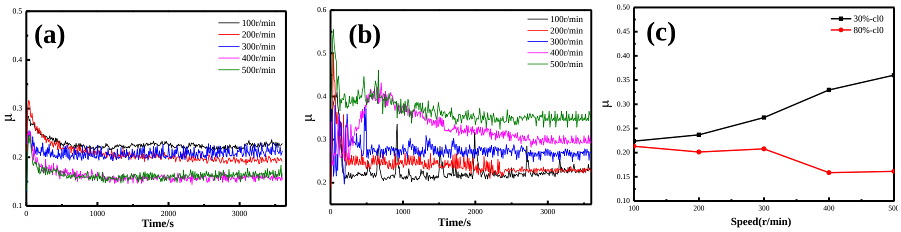

Figure 1: Friction coefficient under different speed of sample PTFE fiber
(a)80% (b)30% (c) steady state friction coefficient of two kinds of hybrid fabric composites

The amount of wear of sample PTFE 30% is little and with increasing speed, the amount of wear to be reduced and then increased slightly. While it of sample PTFE 80% is larger, with the increase of the rotational speed the wear continued to increase as Figure 2 shows.

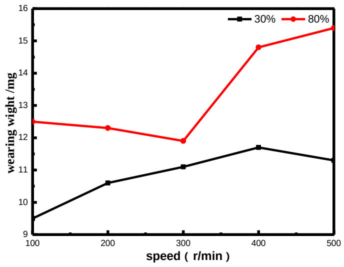

Figure 2: Wear weight of two kinds of hybrid fabric composites under different speed

The fracture surfaces of sample PTFE 80% composites under different rotational speeds (100r / min, 200r / min, 300r / min, 400r / min, 500r / min) are shown in Figure 3. As can be clearly observed increase in friction speed, gradually PTFE fiber is ground to form a thin film, Figure 3c, the speed at 300r / min, the fibers almost ethylene interconnected to form a continuous film, Figure 3d-e at 400r / min and 500r / min speed PTFE fibers have been polished and partially coated aramid fibers. This reasonable explanation for the lower coefficient of friction the faster the speed of the phenomenon. The faster the speed, the more complete the PTFE transfer film is formed, the stronger self-lubricating effect, the lower the coefficient of friction.

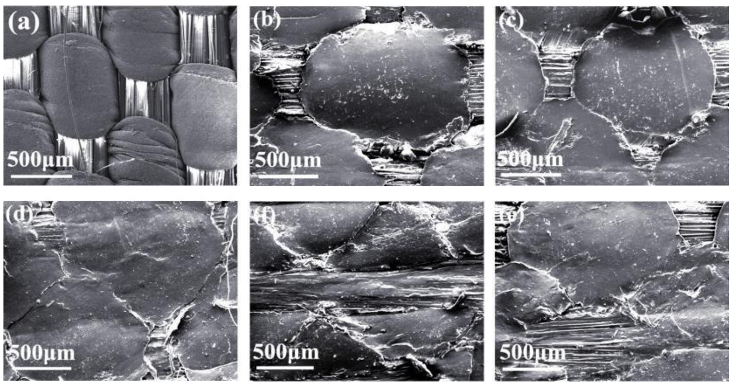

Figure 3: SEM images of the worn surfaces for sample PTFE 80% at speed of
(a)0r/min (b)100r/min (c)200r/min (d)300r/min (e)400r/min (f)500r/min

Figure 4 shows the friction surface of sample PTFE 30% under different speed. Where in the figure 4a shows, PTFE fiber can be seen a little wear phenomenon under rotational speed of 100r/min, since the PTFE content is too low to form, under the speed of 200r/min woven began to have a small amount of damage as Figure 4b shows. Figure 4c-d shows PTFE fibers have been observed to wear at the speed of 300r/min, Kevlar fibers have a small amount of damage. Figure 4e-h is a photograph of the surface at speed of the friction 400r/min, the fibers have been observed to milled polyethylene, Kevlar fibers also have obvious broken. Figure 4i-j is the friction surface at speed 500r/min, it has been hardly observed a complete polyethylene fiber, Kevlar fibers appear a lot fracture phenomenon. The normal text should be written single-spaced, justified, using 11pt Times in one column. The first line of each paragraph must be indented 0.5cm.

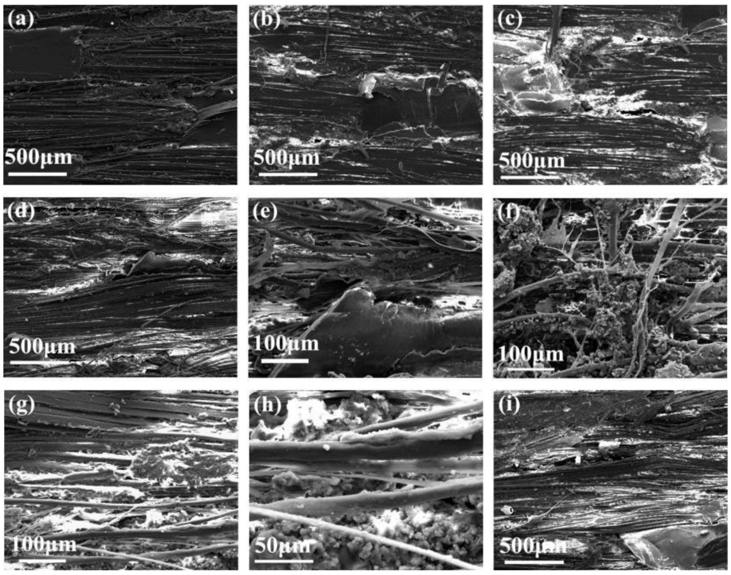

Figure 4: SEM images of the worn surfaces for sample PTFE 30% at speed of (a)0r/min (b)100r/min (c)200r/min (d)300r/min (e)300r/min (f)300r/min(g)400r/min (h)400r/min(i)500r/min

5 CONCLUSIONS

As the speed increased friction, PTFE is gradually depleted, Kevlar fibers wear harder, friction coefficient increased. And the friction coefficient of sample PTFE 30% significantly higher than that of sample PTFE fiber 80%. This is due to the mechanism of mixed slippery Teflon self-lubricating PTFE is formed when the friction transfer film, transfer or mixed fiber friction coupling, filling potholes and cracks knitting fibers even on metal friction. PTFE fiber content is low when, PTFE component is not enough to fill the gaps and holes on the metal friction even mixed fibers, so the higher coefficient of friction.

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