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Study on the Bending Fatigue Behavior of Single Aramid Fibers by a Novel Bending Fatigue Test Method

Guangming Cai [a,*], Wenfang Song [b], Xin Cui [c], Weidong Yu [a,c]

[a] *College of Textile, Wuhan Textile University, Wuhan 430073, China*

[b] *Department of Building and Real Estate, The Hong Kong Polytechnic University, Hung Hom Kowloon, Hong Kong, China*

[c] *College of Textile, Donghua University, Shanghai 201620, China*

Abstract

In this paper, we report a bending fatigue testing apparatus which can test the bending fatigue resistance of single Kevlar 49 fiber by setting the pretension and bending angle. The cyclic tension and the (number of cyclic bending of fiber) were recorded by this apparatus. The cyclic tension curve showed that the tension changes in periods during the bending fatigue process. The cyclic tension was theoretically analyzed and found that the bending angle had significant effect on the cyclic tension. The cyclic bending number N of Kevlar 49 fiber was plotted as a function of pretension S using S-N curves, which shows that the bending angle and pretension have a significant effect on the fatigue lifetime of a fiber. The bending fatigue morphologies of Kevlar 49 fiber explained the bending failure mechanism of the Kevlar 49 fibers.

Keywords: Test Method; Bending Fatigue; Kevlar 49 Fiber; Cyclic Tension; Fracture Morphology

1 Introduction

As we all know, aramid fibers have applied wide range of application in our day to day life. Kevlar fiber as a kind of aramid fibers, has an extensive application in aerospace, militant affairs and thermal protective materials in recent years. Although the aramid fibers have good tension strength, the compressive strength and shearing of aramid fibers are poor. The poor bending and shearing strength restrict their applications in many aspects [1]. An important method to evaluate the compressive strength of fiber is bending test, because the major fracture is caused by compressive and shearing force. There are many previous researchers who studied tensile fatigue of single fiber under different pretension [2-5], however, studies on bending fatigue are scarce. Hearle studied the flexural fatigue of Kevlar 29 fiber [6]. Liu XY studied the bending fatigue properties of single aramid fiber at different pretensions [7]. Burgoynet investigated the bending fatigue of aramid ropes [8] and Kazuto studied the effect of wet on the bending fatigue properties of single

*Corresponding author.
Email address: guangmingcai2006@163.com (Guangming Cai).

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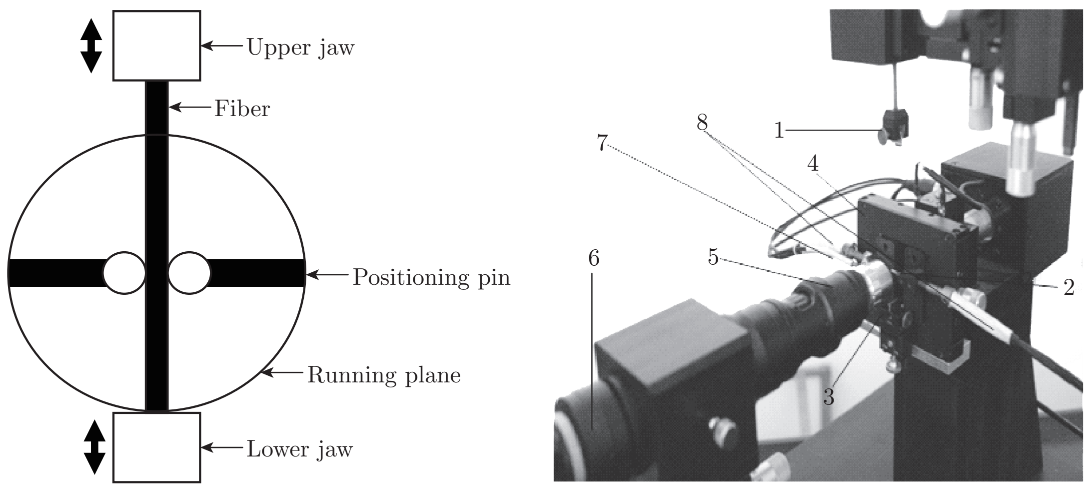
aramid fiber [9]. Kohji Minoshima discussed the bending fatigue behavior of single aramid fiber in vacuum and air environment and found that the aramid fiber has a better fatigue resistance in vacuum [10]. Cai used the sample bending fatigue apparatus studied the bending fatigue of some high performance fibers [11-12]. Overall, reporters characterize the bending fatigue of aramid fibers using different testing apparatus to provide the evaluation methods for bending fatigue of fibers. However, these studies only discussed the effect of pretension on fatigue life and had no report on the effect of bending angle on fatigue life. Also these devices can only record the number of bending fatigue, not observe fiber bending fatigue failure process of fiber and record the cyclic tension under fatigue process. When the pretension is the same, the amplitude of cyclic tension is larger at a large bending angle. So we need discuss the effect of bending angle on the fatigue life. At the same time, we can analyze the bending failure mechanism by observe fiber bending fatigue failure process of fiber..

This paper will study the bending fatigue properties of Kevlar49 fiber using a new testing apparatus which is developed by authors [13]. The bending fatigue behavior of single Kevlar49 fiber was measured and the effects of pretension, the bending angle on fatigue life of Kevlar49 fiber were discussed. The bending fatigue fracture ends of the Kevlar49 fiber were observed using an optical microscope, which can explain the fracture mechanism of Kevlar 49 fibers.

2 Experimental

2.1 Testing Apparatus

Fig. 1 (a) shows the principle of test apparatus and Fig. 1 (b) is test apparatus. The bending fatigue test system is comprised of eight parts: 1) The upper jaw, 2) The positioning pin, 3) The lower jaw, 4) The running plane, 5) The optical microscope, 6) The CCD camera, 7) The temperature sensor, and 8) The heater. The jaws are used to clamp the fiber. The positioning pin



(a) (b)

1 — Upper jaw; 2 — Positioning pin; 3 — Lower jaw; 4 — Running plane; 5 — Optical microscope; 6 — CCD camera; 7 — Temperature sensor; 8 — Heater

Fig. 1: The real photo of bending fatigue test apparatus (a) is the principle of test, (b) is test apparatus