

THE ROLE OF TEMPERATURE ON FRACTURE STRENGTH OF ARAMID FIBER

Eitoku NAKANISHI, Yoshihiro ANDO and Seiji MAKI

Dept. of Mech. Engg., Fac. of Engg., Mie University, Kurima machiya-cho 1577, Tsu, Mie 514-8507, JAPAN

Introduction

The Aramid fiber has outstanding thermal stability and low flammability and excellent mechanical properties [1] [2] and it is used for very widely. And it may be very useful to clarify the role of temperature on the fracture strength of Aramid fiber. In this paper, the fracture load and failure characteristics at high temperature of surroundings are determined. We carried out the tensile test of single Aramid fiber under the some temperature conditions they are from room temperature to 500 degree. At room temperature and low strain rate [1], almost of all the Aramid fiber will fracture with some fibril, and by SEM observation of fractured Aramid fiber, we tried to characterize the fracture mode of fiber that is fractured in higher temperature. Furthermore, to clarify the reliability or "safety" of use the Aramid fiber at the high temperature, we summarized the experimental results by using the weibull plot.

Experimental

We chose Aramid fiber (Kevlar49) as a specimen. A single Aramid fiber is situated center axis of a small electrical furnace. The end of fiber is fixed to cantilever for measuring the load by load cell and the other end is fixed to electrical motor through the micrometer. The test speed is controlled by the motor and it kept as 7.5 mm/min. Temperature of furnace is controlled by using SLIDAC. We measured the time, temperature of furnace and load of fiber during tensile test. We carried out three types of experiments as follows.

Test 1: Tensile test at given temperature (room temp., 100, 200, 300, 400 and 500 degree).

Test 2: Aramid fiber has been pre-heated at given temperature (100, 200, 300, 400 and 500 degree) before test and let cool in room temperature. And then the tensile test is carried out at room temperature.

Test 3: Aramid fiber is under a given tensile load and heated until the fiber fractures.

Results and Discussions

Figure 1 shows the experimental result. Test 1 and Test 3 show the almost same result. It derives that the tensile strength of fiber at high temperature is determined by a combination of load and outer temperature in very simply.

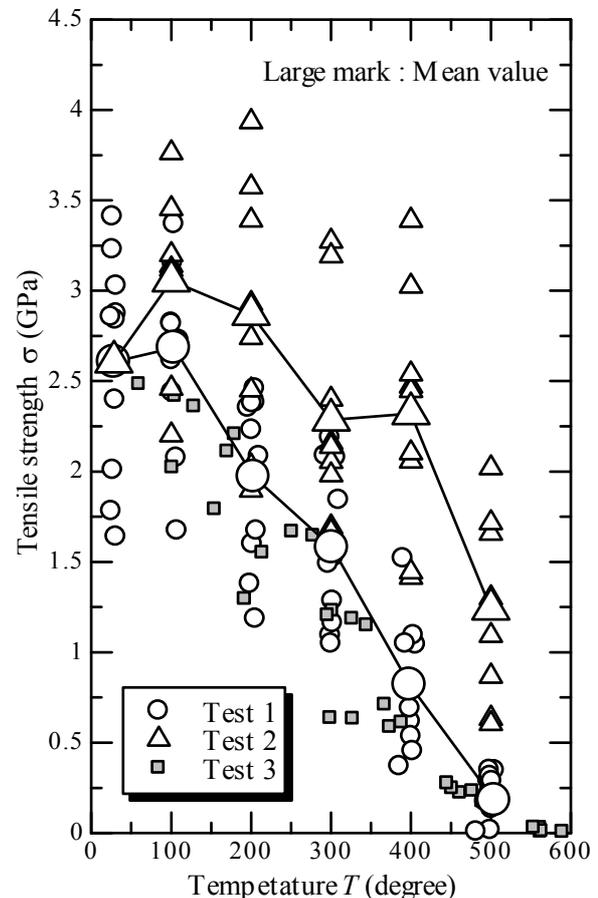


Fig.1 Role of temperature on tensile strength

Mean value of tensile strength of fiber decreases rapidly with temperature in Test 1 over 100 degree of test condition. On the other hand, tensile strength of Aramid fiber is improved at 100 and 200 degree in Test 2. It is reduced in strength over 200 degree, and there is a sudden fall of strength over 400 degree. It indicates that the heat treatment of Aramid fiber is useful and its maximum temperature is about 200 degree [3]. Once the Aramid fiber is heated over 400 degree, it loses the excellent mechanical property. Because, there is significant weight loss of Aramid fiber at 450 degree and Amid linkage may be disconnected at this temperature [4]. In Fig.2, up to 450 degree, Aramid fiber fracture with large splitting. And there is no fraying at fracture end of fiber at 500 degree in both tests and they look like "prismatic structure". It also suggests that the Amid linkage is broken and the fracture surface become perpendicular to the fiber axis at this temperature [2]. Further, weibull plots of Test 1 and Test 2 are much different as shown in Fig.3 and 4. Weibull plots obtained from test2 indicate the reliability of applying the heat

treated fiber for something structure at room temperature. And, when pre-heating temperature is 100 degree, weibull modulus m becomes larger than others. It suggests that the tensile strength of Aramid fiber that is heat treated at 100 degree does not scatter and has higher reliability than others. The reliability of tensile strength of Aramid fiber under elevated temperature decreases with temperature and it become half a result obtained at room temperature.

Conclusion

The role of the temperature on fracture strength and its reliability of Aramid fiber are investigated. Tensile strength of Aramid fiber at high temperature can be determined by a combination of load and outer temperature in very simply and the reliability of the tensile strength of fiber decreases with temperature. And pre-heating the Aramid fiber at 100 degree can improve the reliability of tensile strength. Finally the unique fracture shape of the fiber that is fractured at 500 degree or pre-heated at 500 degree can be observed by SEM.

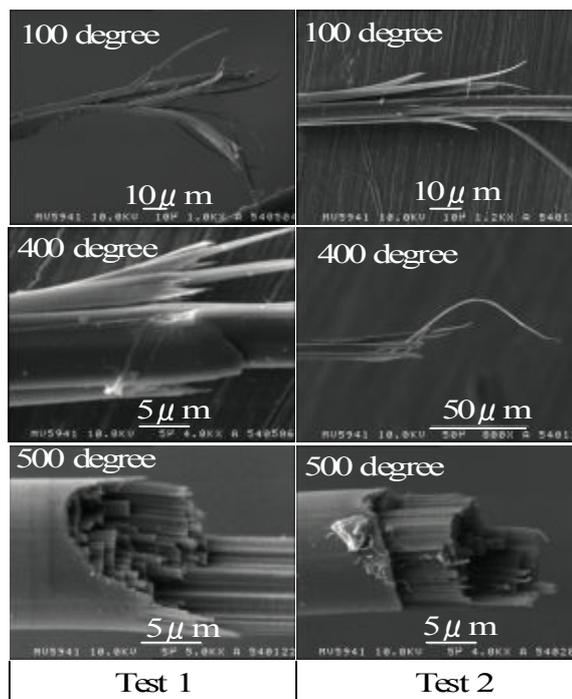


Fig.2 Fracture morphology of Aramid fiber at high temperature

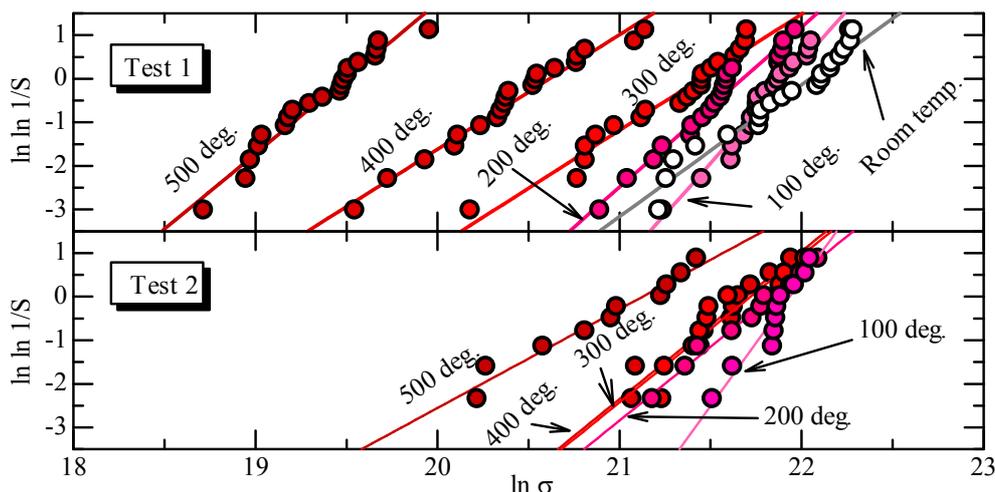


Fig.3 Weibull plot obtained from tensile test with heating and from tensile test of pre-heated fiber

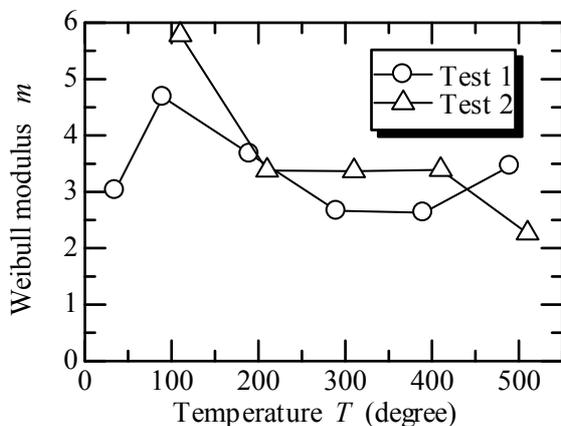


Fig.4 Weibull modulus m

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