ID 1216

Creep Fracture Strength of Carbon Fiber Reinforced Thermoplastic Polyimide

Satoshi Somiya and Yosiaki Kotaki
Faculty of Science and technology, Keio University
Yokohama, JAPAN (223-8522)

Keywords: CFRTP, Thermoplastic Polyimide, Creep Fracture strength, Reciprocation law, Crystallization

Introduction

Thermoplastic Polyimide was well known as a typical polymer having high heat resistance. When this was used in parts for airplanes and vehicles, it was sometimes strengthened by reinforcements such as carbon fibers and Aramid fibers. These FRTPs usually have high specific strength and modulus. But, visco-elasticity of resin matrix affects the long-term durability for structures. Recently, a few reports on creep behavior of CFRTP of polyimide resin have been presented. The purpose in this research is to make clear not only the effect of composed fibers but also the effect of crystallization on creep fracture strength.

Experimental method, Material and Procedure

Material was carbon fiber reinforced thermo-polyimide resin AURUM450 made by Mitsui-chemical Co. The fiber volume fraction of specimen was 15.6%. Two kinds of specimen were prepared on as-received CFRP, and crystallized material which crystallization(C%) was 31%. The crystallization of as-received material is about a few percents and it is very difficult to prepare non-crystallized material. The three-point bending creep test has been done under the temperature conditions; 220, 230,240 and 250ºC for as-received material, and 225,260,270 and 280ºC for crystallized materials.

Creep fracture strength of non-crystallized CFRTP

Creep fracture strength (creep fracture time t_c') under some applied stress conditions have been measured. It is founded that the relation between applied stress and creep fracture time t_c' showed a straight line on each test temperature as shown in Fig. 1(a). Increasing the applied stress, creep fracture time decreased on each temperature conditions. And to discuss the reciprocation law, the master curve was drawn shifting these lines to horizontal direction as shown in Fig. 1(b). The shift factors for drawing the master curve were plotted to the value of the absolute temperature T on an Arrhenius type graph. Because they made a straight line to the value of 1/T, it was confirmed that the creep fracture strength of CFRTP shows a linear viscoelastic behavior. Furthermore, for the relationship between fracture time and the strain at creep fracture, the same linearity on Arrhenius type was found too.

Effects of crystallization on Creep fracture strength

To control the visco-elasticity of CFRTP, the effect of crystallization of resin matrix on creep phenomena has been researched. The crystallized material with C=31% was prepared. C=31% is maximum value for this resin. Most of the same creep fracture process on crystallized material and non-crystallized material was recognized. But, creep fracture time t_c' on the crystallized material increased clearly and creep speed decreased. It means that crystallinity arrested the development of creep behavior under the each applied stress and each temperature. On non-crystallized material and crystallized material, new creep fracture criterion was found for the relationship between applied stress and fracture strain. The creep fracture strain depended only on the applied stress as follows;

$$\sigma_{applied}=\sigma_0+\alpha\varepsilon_f$$

σ_0 and α are material constants. ε_f shows the creep fracture strain.

Conclusions

The creep fracture strength of non-crystallized and crystallized material was evaluated and the effect of crystallization on viscoelasticity was discussed.

1) An Arrhenius type linear visco-elasticity for creep strength was found on both CFRTP.
2) The crystallization clearly arrested the creep behavior and elongated the creep fracture time.
3) The Creep strain depended straightly on applied stress.

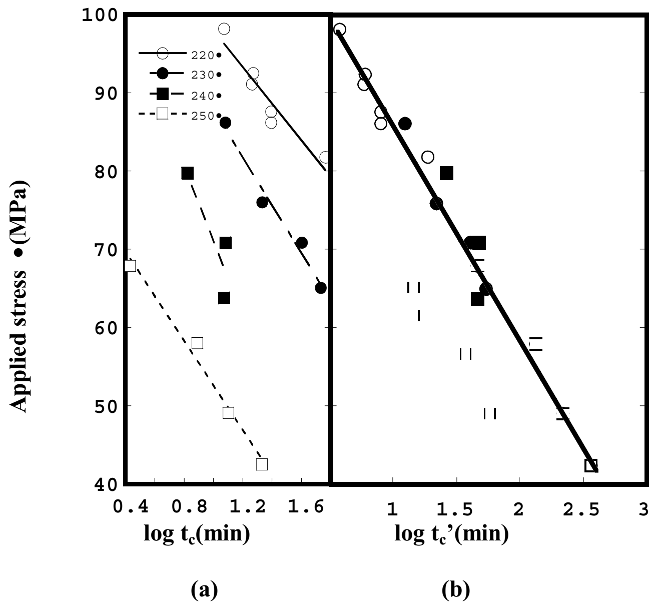

Fig.1 (a) Applied stress dependency of Creep fracture time on each temperature and (b) Master curve of Creep fracture times