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Ultrasonic High Temperatures Fatigue Characteristics of GFRP (PA66+GF30%) Depending on Fiber Orientation

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1. Introduction

PA66+GF30% is an engineering plastic used for radiator tank, and GF is a short glass fiber used at 120℃ where high cycle fatigue strength is an important property. In order to secure stability in inferior environment various analysis techniques (such as extrusion, structure, fatigue) are applied based on realistic test evaluation and overall evaluation basis from product material need to be obtained. PA66 + GF 30 (Glass Fiber 30%) used in vehicle radiator tank is required to have resistance to vibration of engine and stable durability life up to 120℃. But there is not enough quality control and reliability evaluation on physical and mechanical characteristics of material suppliers, so application method of fatigue analysis using domestic developed ultrasonic accelerated fatigue test method was developed. So fatigue behaviors of extruded GF with different orientation (0˚, 45˚, 90˚) at each 25℃, 70℃, 120℃ were analyzed.

2. Specimen Preparation and Fatigue Test

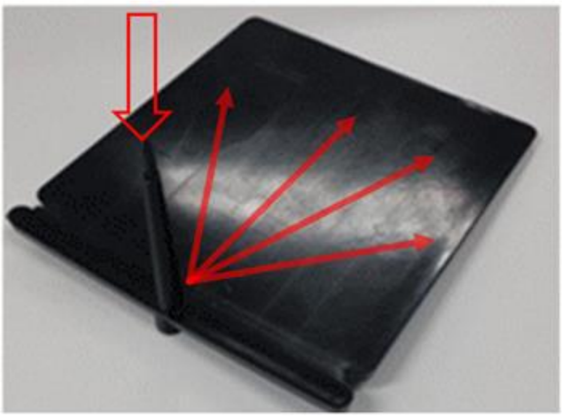


Fig. 1 Glass fiber orientation of injection molded

Fig.1 shows the GF orientation of extruded material depending on extrusion gate. Each specimens were obtained according to extrusion direction and dynamic elastic modulus was measured and then ultrasonic fatigue test specimens were prepared for 3 different temperatures (25℃, 70℃, 120℃).

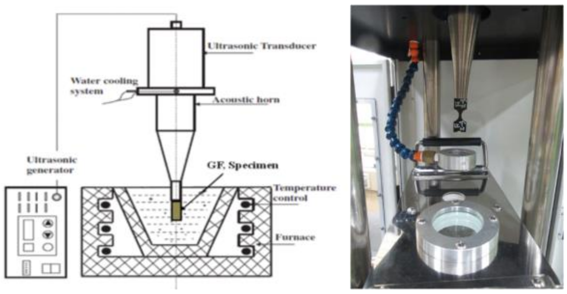


Fig. 2 Systematics for ultrasonic high temperature fatigue test

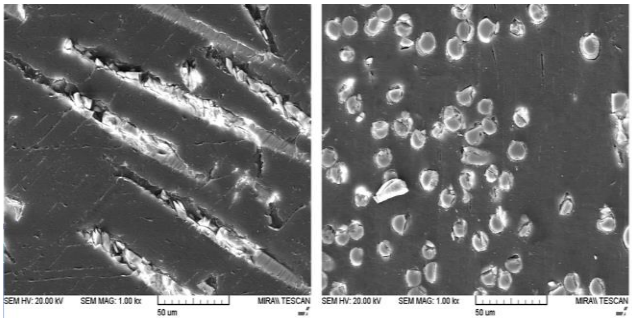
Fig. 2 shows a system for ultrasonic high temperature fatigue test of polymer materials. This is fabricated as high temperature shield type with specimen and horn connected together and located inside with some distance to keep the temperature, and the state of specimen and test progress were monitored through window of strengthened glass.

Table 1 Test conditions of ultrasonic fatigue

Loading frequency [kHz]	Stress ratio	Stress [MPa]	Mode [sec]	Temp. [℃]
20	R=-1	25~60	0.3 - 3	25, 70, 120

Table 1 shows test conditions for ultrasonic fatigue test with frequency of 20kHz and stress ratio R=-1 of tension-compression. Test was conducted under pulse and pause (0.3ms-3ms) mode to prevent thermal softening. When fatigue failure occurs during test, ultrasonic resonance is deviated and test is stopped automatically, and the cycle is recorded. Test was conducted according to set temperatures of RT, 70℃ and 120℃ after holding for 15 minutes at the set temperature. Thermocouple was located near the center of specimen to set the real temperature around the specimen.

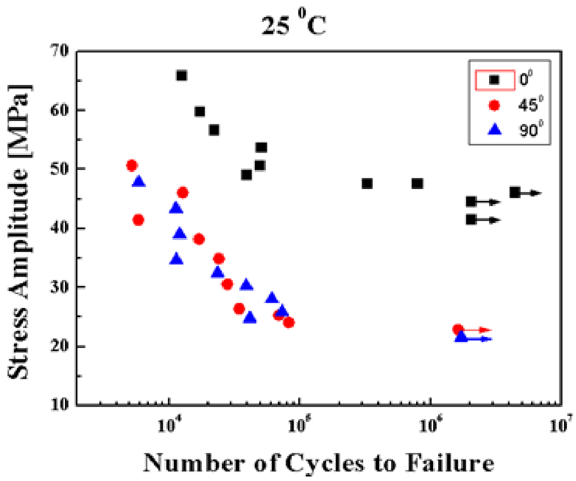
3. Test Results and discussion

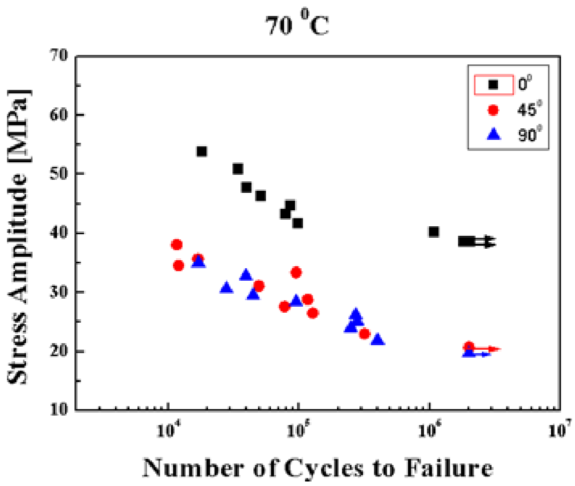


(a) Top View (b) Cross Section

Fig. 3 SEM image of glass fiber

Fig. 3 shows overall orientation by combination of TP(Top View) and CS(Cross Section) micrographs after polishing through electron microscopy examination. And it was identified that GF's of about 10 ㎛ diameter and 100 ㎛ length were distributed. Fig. 4 shows the ultrasonic fatigue test results of GF with different orientation at 25℃, 70℃, 120℃. 0d showed overall high fatigue limit compared to 45° and 90° at all temperatures.





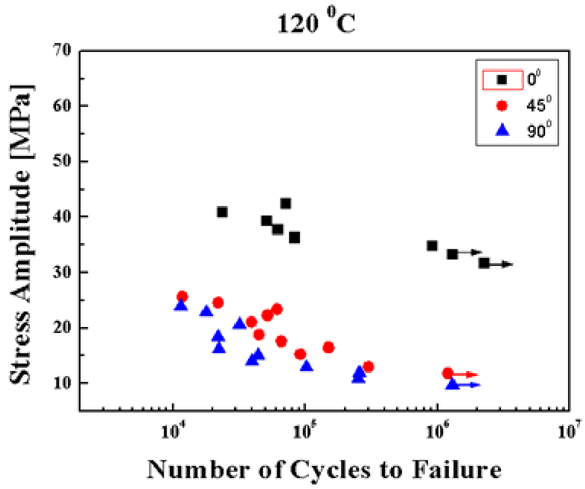


Fig. 4 Ultrasonic fatigue test result with different orientation at various temperatures (20KHz, R=-1)

But GF of 45° and 90° showed similar S-N diagram with small difference. This is thought to come from similar stress concentration related to GF orientation. And S-N showed abruptly decreased slope with increasing temperature, and showed fatigue limit at above 10^6 cycles. Photographs of fracture surfaces of specimens after ultrasonic fatigue test showed that overall fatigue fracture propagated in 45° direction, and showed combination of micro ductile and brittle fractures.

Acknowledgment

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