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Application News

Tabletop Dynamic and Fatigue Testing System Servopulser EHF-L Series

Fatigue Testing of Carbon Fiber Reinforced Thermoplastic (CFRTP)

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User Benefits

- It is possible to evaluate fatigue of carbon fiber reinforced thermoplastic (CFRTP) by using the Dynamic and Fatigue Testing System Servopulser, EHF-L Series and newly developed gripping teeth for composite materials.
- High-accuracy dynamic control can be achieved with the Servo Controller 4830.

■ Introduction

Carbon fiber-reinforced plastic (CFRP) has a higher specific strength and stiffness than metallic materials and is expected to contribute to reducing the weight of transport equipment. On the other hand, it faces issues such as complicated manufacturing, processing, and recycling, along with high costs, which restrict its application to aircraft and specific types of transport vehicles. Carbon fiber-reinforced thermoplastic (CFRTP) has attracted attention as a material that could solve these issues. Thermoplastic resin, which is the base material of CFRTP, softens when heated and hardens when cooled, making it suitable for mass production such as injection molding and press molding. Due to its high moldability, it offers excellent cost performance and recyclability, and is expected to be used in mass-produced automobiles. However, when it is used as a structural material for automobiles, it is often subjected to repeated loads over long periods, which may cause fatigue failure. In particular, fatigue failure in transportation equipment has the risk of causing a serious accident, so appropriate evaluation by fatigue tests is necessary to ensure product reliability.

In tests on composite materials, it was easy for failure to occur from defects or notches, and clamps with conventional file teeth tended to cause failures at the grips. In this article, fatigue tests were conducted on CFRTP using newly developed gripping teeth for composite materials. The newly developed gripping teeth makes it possible to reduce damage to the test specimens and decrease the risk of failure at the grips.

■ Sample Information

Randomly oriented CFRTP was used for the measurements. Randomly oriented CFRTP is a carbon fiber-reinforced composite material formed by cutting unidirectional (UD) tape, consisting of a carbon fiber bundle impregnated with thermoplastic resin, into fixed-length pieces and randomly orienting them (Fig. 1). In these tests, UD tape of 6 to 8 mm width based on thermoplastic epoxy was cut into 26 mm pieces and pressed to form a material plate of 3 mm thickness. The plate was also cut into pieces measuring 250 mm in length and 25 mm in width to provide test specimens.

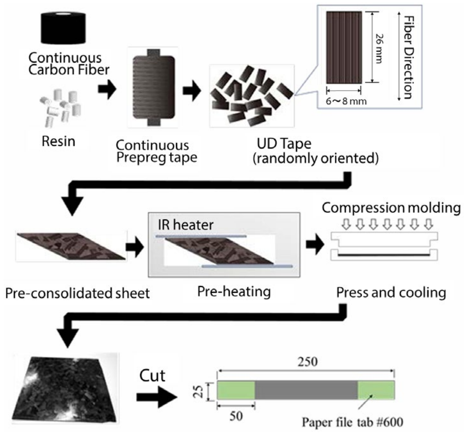

Fig. 1 Molding Process and Specimen Geometry of Randomly Oriented CFRTP[1)]

■ Measurement System

Table 1 shows the instrument configuration. A tabletop dynamic and fatigue testing system, Servopulser EHF-L, was used in this test. The test setup is shown in Fig. 2.

Table 1 Instrument Configuration

Testing Machine	: Servopulser EHF-LV20k1A
Load Cell	: 20 kN
Actuator Stroke	: ±25 mm
Control Unit	: Servo Controller 4830
Software	: Windows Software for 4830
Test Jig	: Non-shift screw-type grips
Grip Face	: Fine file teeth

Fig. 2 View of the Tests

■ Static Test Results

Static tensile tests were performed to set the fatigue test conditions. Table 2 shows the test conditions for the static tensile tests. Fig. 3 shows the stress-displacement diagram for each specimen. Table 3 shows the average ultimate tensile strength of the specimens from the results of the static tests.

Table 2 Static Test Conditions

Test Speed	: 1 mm/min
Number of Specimens	: n = 3

Table 3 Static Test Results

Static Ultimate Tensile Strength (average) [MPa]	Standard Deviation	Coefficient of Variation (CV)
191.3	11.7	0.06

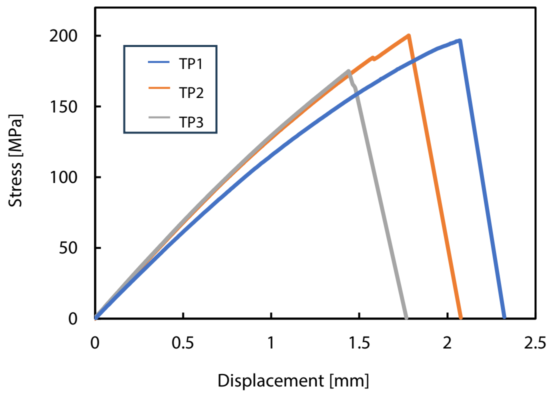

Fig. 3 Stress-Displacement Curves

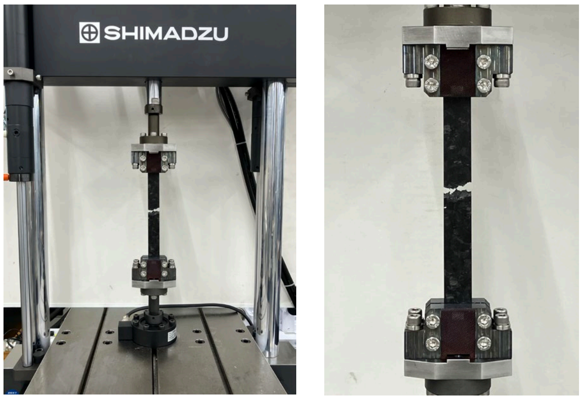

Fig. 5 Failure of a Specimen

■ Fatigue Test Results

Table 4 shows the conditions for the fatigue tests. The maximum loading stresses in the fatigue tests were set at five levels, ranging from 35 to 55 % of the tensile strength measured in the static tensile tests.

As an example of the test waveform, Fig. 4 shows the time waveforms of stress and displacement at 1000 cycles, under a maximum loading stress of 105 MPa. From Fig. 4, a stable sine wave was observed, demonstrating that the loading was well controlled. In addition, Fig. 5 shows a specimen at failure. By using the newly developed gripping teeth for composite materials, the specimen failed at the center as intended. Fig. 6 shows the relationship between the maximum loading stress and the number of cycles to failure (S-N diagram).

Table 4 Fatigue Test Conditions

Maximum Loading Stress	: The percentages of static ultimate tensile strength were as follows. 35, 40, 45, 50, 55 % (67 to 105 MPa)
Stress Ratio	: 0.1
Maximum Cycles	: 1×10^6 cycles
Frequency	: 10 Hz
Number of Specimens	: n = 2
Test Temperature	: 23 °C
Distance between Grips	: 175 mm

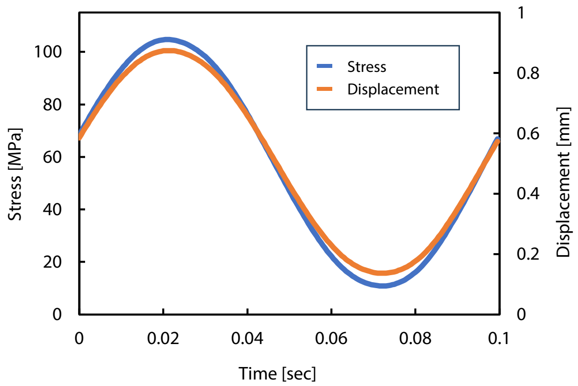

Fig. 4 Time Waveform of Stress and Displacement at 1000 Cycles
(Under Maximum Loading Stress 105 MPa)

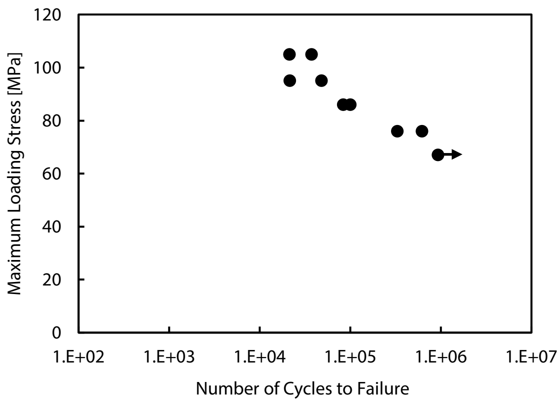

Fig. 6 S-N Diagram

■ Conclusion

In these tests, the fatigue characteristics of thermoplastic CFRP were evaluated using a dynamic fatigue testing machine, Servopulser EHF-L. Additionally, by using newly developed gripping teeth for composite materials, damage to the gripped portion of the specimen was reduced, and the specimen failed at the center as intended.

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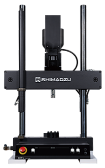

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