

Application News

Hyper Vision™ HPV™-X3 High-Speed Video Camera
HITS™-TX High-Speed Tensile Testing Machine

DIC Analysis in High-Speed Tensile Test of CFRP

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User Benefits

- ◆ The HPV-X3 is suitable for observation of fracture of brittle materials such as CFRP because it has a maximum recording speed (framerate) of 20 Mfps.
- ◆ The HPV-X3 provides improved DIC analysis performance, as its resolution is 3 times higher than that of the conventional high-speed video camera.
- ◆ The HITS-TX impact testing machine enables testing at a maximum speed of 20 m/s.

Introduction

Carbon fiber reinforced plastic (CFRP) is a material with particularly high specific strength, even among composite materials, and used in various applications such as transport aircraft, taking advantage of its excellent mechanical properties. Because CFRP consists of carbon fibers and resin, it shows complex fracture behavior, and brittle fracture progresses from damage as the point of origin. Since fracture proceeds instantaneously, a high-speed video camera with a high recording speed is necessary when observing fracture of CFRP. One method for measuring strain in a high-speed tensile test is Digital Image Correlation (DIC), which visualizes the distribution of strain at the specimen surface by comparing a random pattern on the specimen surface before and after deformation. Thus, a high-speed video camera with a high resolution is also necessary in order to improve the DIC performance.

Newly-developed Hyper Vision HPV-X3 high-speed video camera is extremely well-suited to DIC analysis of CFRP, as its recording speed is 2 times faster and its resolution is 3 times higher than the conventional HPV-X2. In this experiment, a high-speed tensile test of CFRP was conducted using a HITS-TX high-speed tensile testing machine. The condition of the test was observed with the new HPV-X3, and the strain distribution of the CFRP test piece was clarified by a DIC analysis of the recorded images.

Test Piece and Test Instruments

A CFRP quasi-isotropic laminate was used as the test piece. Aluminum foil was glued to the back side of the test piece, and the timing when the electrical conduction of the aluminum foil was interrupted by fracture of the test piece was used as the trigger for video recording. The HITS-TX was used in the high-speed tensile test. The HPV-X3 was used in fracture observation, and for comparison, the fracture process was also recorded with the conventional HPV-X2 camera. Fig. 1 shows the condition of the test, and Table 1 and Table 2 show the equipment composition and test conditions, respectively.



Fig. 1 Condition of Test

Table 1 Equipment Composition

Instruments	: HPV-X3 HPV-X2 (for comparison) HITS-TX
Load cell	: 10 kN
Lens	: 105 mm macro lens
Lighting	: Strobe
Test jig	: High-speed grip for flat plate samples
DIC analysis software	: VIC-2D

Table 2 Test Conditions

Framerate	: 20 Mfps (HPV-X3: 300 kpx) 10 Mfps (HPV-X2: 100 kpx, HP mode)
Test speed	: 10 m/s
Test piece	: CFRP quasi-isotropic laminate

Comparison of DIC Analysis Results

Fig. 2 shows a comparative example of the DIC analysis results with the new HPV-X3 and the conventional HPV-X2. In comparison with the analysis results with the HPV-X2, the HPV-X3 analysis results clearly captured the condition of strain concentration immediately before a crack occurred. Because the three-fold increase in the resolution of the HPV-X3 supports improved performance in the DIC analysis results, the HPV-X3 is suitable for use in DIC analyses.

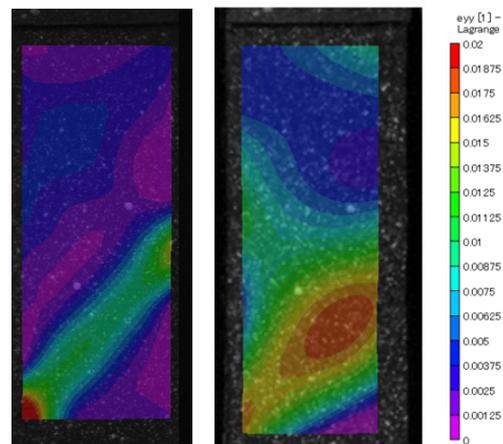


Fig. 2 Comparison of DIC Analysis Results (Left) HPV-X3, (Right) HPV-X2

■ DIC Analysis Results in High-Speed Tensile Test

Fig. 3 shows the DIC analysis results in the high-speed tensile test. The color bar was set to display the color purple at around 0% strain and red at around 2% strain. Fig. 3 (1) is an image at the start of the test. After the test started, strain in the 45° direction concentrated from the lower left to the right central area, as can be seen in Fig. 3 (2). Then, as the test progressed, a condition of increasing strain in the initial area of strain concentration can be seen in Fig. 3 (3) to (9). A crack occurs in Fig. 3 (10), and strain decreases in the crack area. Following this, the test piece fractured completely in Fig. 3 (11) and (12), and a decrease in the strain in the area around the crack could be observed.

■ Conclusion

A high-speed tensile test of CFRP was conducted using a HITS-TX high-speed tensile testing machine and the newly-developed HPV-X3 high-speed video camera, and the strain distribution at the time of test piece fracture was visualized by a DIC analysis. Because the HPV-X3 offers a 3 times higher resolution and a 2 times faster recording speed than the conventional device, it is a suitable high-speed video camera for fracture observation and DIC analysis in impact tests of brittle materials such as CFRP.

The measurement system introduced in this Application News article is a useful tool for the development of composite materials.

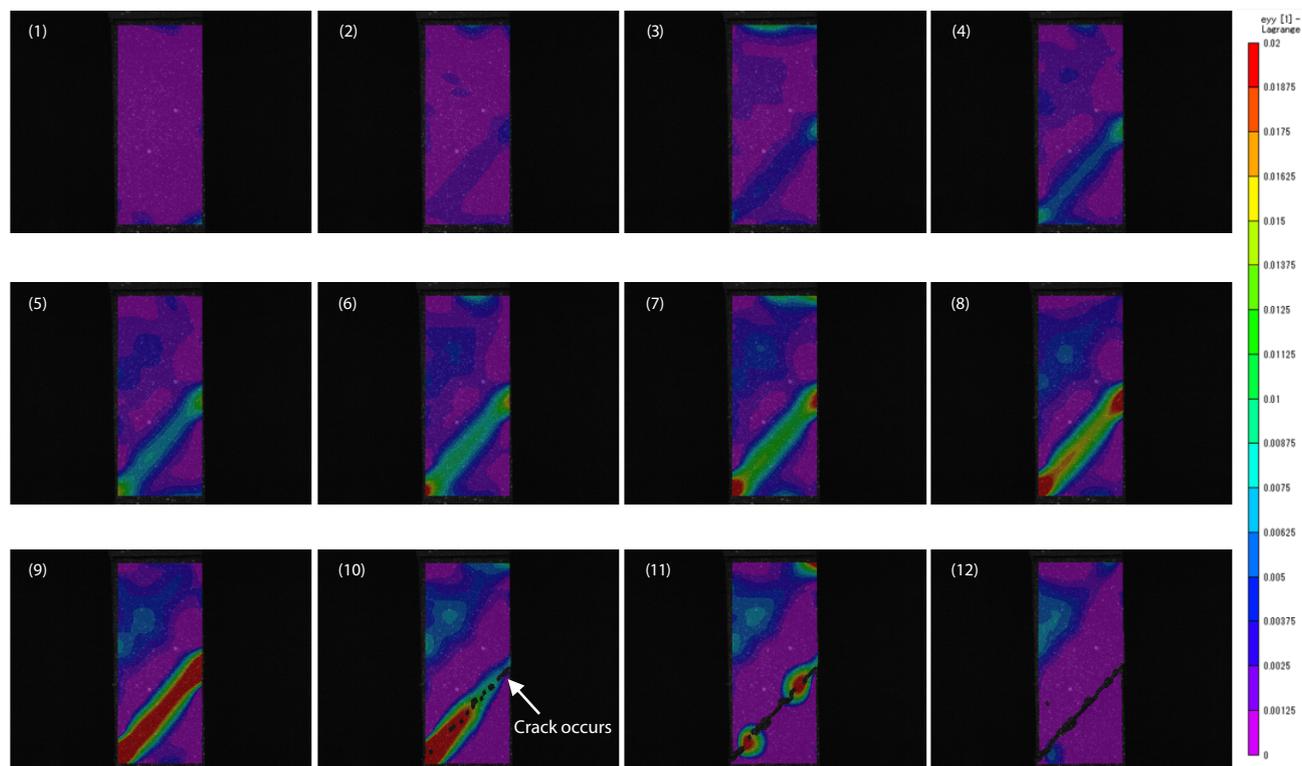


Fig. 3 DIC Analysis Results (Time Interval between Images: 1 μ s)

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