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Application News

No. V27

High-Speed Video Camera

3D-DIC Analysis of a Metal Specimen Following an Impact Compression Test by the Hopkinson Bar Method

Understanding the properties of materials is important in designing products. For this reason, there are various testing standards such as tensile testing, compression testing, and bend testing. Regarding transport aircraft, the possibility of sustaining impact loads must be taken into account, meaning that in order to accurately understand the properties of a material, impact properties must be grasped in addition to static properties. In particular, impact testing is necessary since the stress-strain characteristics of a material may differ between when it is subjected to a static load and when it is subjected to an impact load. The Hopkinson bar method is one method for impact testing. Proposed by Bertram Hopkinson, this method deforms a specimen by impact. A striker bar is fired against an input bar by a bar launcher, transmitting a compressive elastic wave through the input bar to apply a sudden force to the specimen which is contacting the input bar.[1)] A schematic of the Hopkinson bar method is illustrated in Fig. 1.

In this study, an impact compression test was conducted on an aluminum alloy specimen by the Hopkinson bar method. The strain distribution on the surface of the specimen was visualized by recording the test with two HPV™-X2 high-speed video cameras (hereinafter referred to as HPV-X2) and performing 3D digital image correlation (DIC) analysis.*1

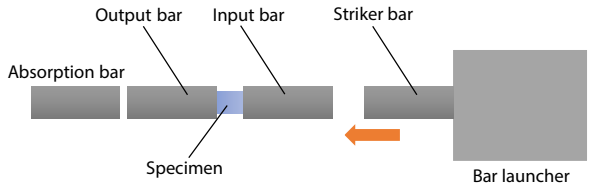

Fig. 1 Schematic Diagram of the Hopkinson Bar Method

*1 DIC analysis
This technique compares a random pattern on the surface of an object before and after the object is deformed to investigate the amount of pattern movement. The random pattern used here was printed on a transfer sticker and the sticker was attached onto the surface of the specimen.

Measurement System

Recording an impact compression test from two directions using two HPV-X2 high-speed video cameras enables three-dimensional displacement measurement. Since a cylindrical specimen was used in this study, a three-dimensional displacement measurement was required. Accordingly, the test was recorded synchronously from two directions. Figs. 2 and 3 show the observation and test setup. The equipment used for recording the test is shown in Table 1. The video recorded by the HPV-X2 cameras were analyzed using the VIC-3D DIC software to determine strain distribution. Since VIC-3D can control HPV-X2 cameras, calibration and analysis can be performed easily.

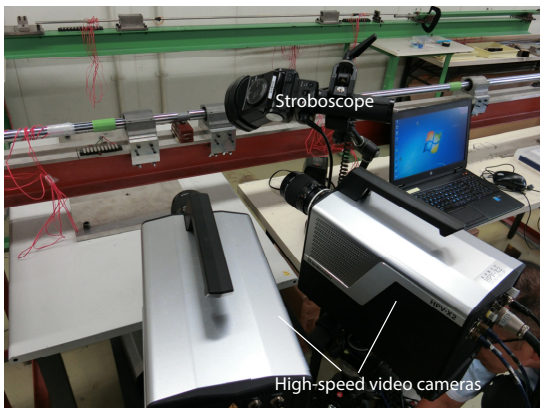

Fig. 2 Setup of Recording Equipment

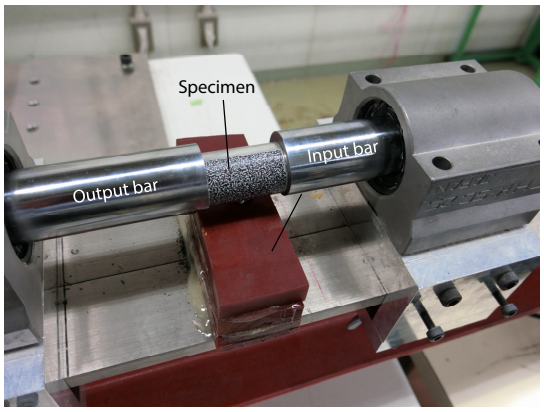

Fig. 3 Test Setup with Specimen Inserted

Table 1 Recording Equipment

High-Speed Video Camera	: Two HPV-X2 cameras
Lens	: Two 105 mm macro lenses, two teleconverters
Illumination	: Stroboscope
DIC Software	: VIC-3D

Measurement Results

The test was recorded at 500,000 frames per second. Fig. 4 shows the results of 3D-DIC analysis. The analysis results indicate strain in the test direction. Since the specimen was compressed while constrained by the input bar and the output bar, strain in the tensile direction, though slight, is observed at both ends of the specimen. The results also show that as the test progressed, strain in the compression direction concentrated at the top of the specimen. This indicates that this test turned out not to be a genuine compression test and deformation was concentrated on one side.

Conclusion

Two HPV-X2 high-speed cameras were used for 3D-DIC analysis of a compression test by the Hopkinson bar method. In order to conduct a 3D-DIC analysis of an impact test, high-speed cameras that have a high recording speed and high resolution while also capable of synchronized recording from two directions are necessary. Equipped with all these features, the HPV-X2 is the optimal high-speed video camera for 3D-DIC analyses of impact tests.

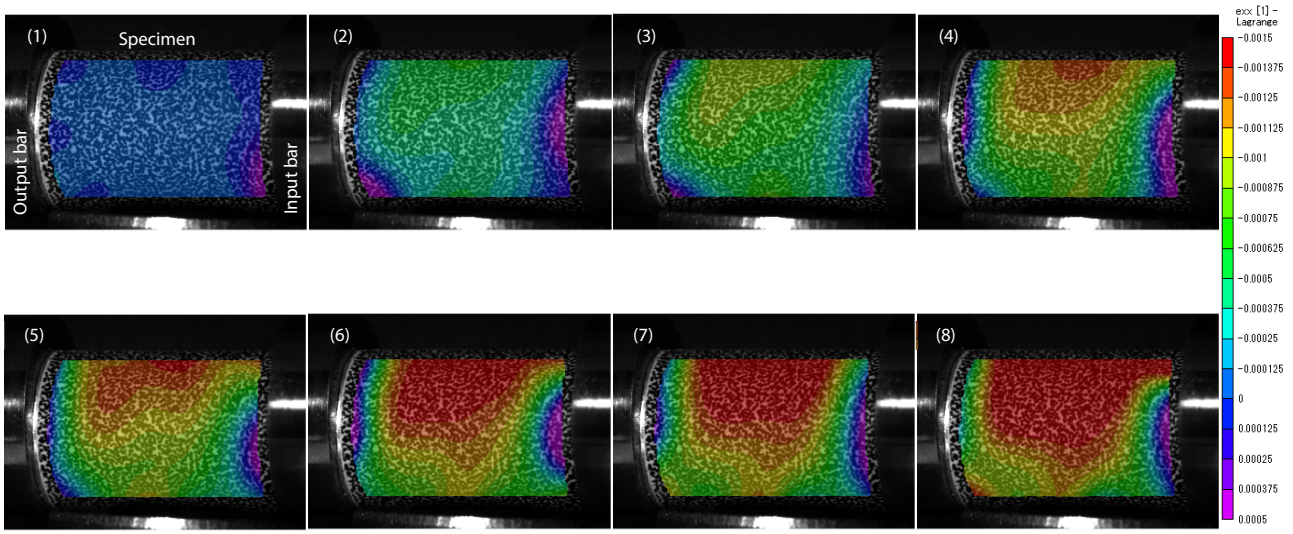

Fig. 4 Results of 3D-DIC Analysis (Time interval between images: 32 µs)

The test was recorded in collaboration with the Structural Mechanics Laboratory in the Department of Mechanical Engineering, Faculty of Science and Engineering at Ritsumeikan University.

Reference

1) Kichinosuke Tanaka and Yoji Adachi, Aeronautical and Space Sciences Japan, Volume 21, Issue 230 (1973)

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