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Application News

No. i270

Precision Universal Testing Machine

Tensile Test of High Tensile Strength Steel

High tensile strength steel is a class of materials with increased strength in comparison with general structural steels, and materials with strengths of 1,000 MPa or more have also been developed. High tensile strength steel is mainly used in the automotive industry, where it has attracted attention due to heightened awareness of environmental problems and demands for collision safety. In particular, auto body weight reduction for improvement of fuel economy is one effective countermeasure for the global warming of recent years, and this increased the momentum toward adoption of high tensile strength steel, which makes it possible to obtain the same strength as general steel materials with thinner gauge products.

The evaluation items for metallic materials include tensile strength and elastic modulus. These mechanical properties are measured in accordance with the material testing standards ISO 6892-1 and JIS Z 2241. As described in this article, a tensile test of high tensile strength steel using strain rate control was conducted in accordance with JIS Z 2241 Annex JB. In addition, hydraulic flat grips with high gripping force were used to enable testing of the high tensile strength steel without slipping in the grips.

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Measurement System

In this test, a Shimadzu AGX™-V Series precision universal testing machine was used. Because the elastic modulus was also measured in this test, we used a Shimadzu SSG-H Series strain gauge extensometer, which enables highly accurate measurement of the elongation in the gauge length of the specimen. The specification of the test system used here is shown in Table 1, and the condition of this test is shown in Fig. 1.

Table 1 Specification of Test System

Instrument	:	AGX-100 kNV
Grip	:	Hydraulic flat grip
Extensometer	:	SSG50-10H
Software	:	TRAPEZIUM X-V

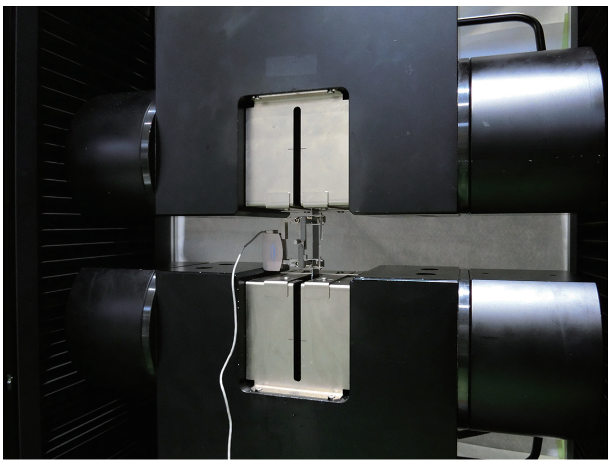

Fig. 1 Condition of Test

Measurement Conditions

According to JIS Z 2241 Annex JB, the test is performed at a strain rate of either 0.00007 s^{-1} or 0.00025 s^{-1} until the upper yield point appears or measurement of proof strength is completed. In case the upper yield point appears, it is necessary to perform the test at a predicted strain rate of either 0.00025 s^{-1} or 0.002 s^{-1} until the end of discontinuous yielding. After measurement of the required yield strength or proof strength, one of the predicted strain rates of 0.00025 s^{-1}, 0.002 s^{-1}, or 0.0067 s^{-1} is selected. In this test, the strain rate was set at 0.00007 s^{-1} until completion of proof strength measurement, and the predicted strain rate after the completion of proof strength measurement was set at 0.002 s^{-1}. Table 2 shows the detailed test conditions.

According to JIS Z 2241 Annex JB, the strain rate must be controlled within ±20 %. Unlike the conventional software, the software TRAPEZIUM X-V has a function for graphing the test speed during the test. This feature enabled easy confirmation that the test speed during the test satisfied the test standard.

Table 2 Test Conditions

Test speed	:	0.00007 s^{-1}
		0.002 s^{-1} (changed at 1 % strain)
Gauge length	:	50 mm
Number of tests	:	n = 3
Specimen shape	:	JIS Z 2241 No. 5 (thickness: 1 mm)
Specimen material	:	SPFC980

Measurement Results

Fig. 2 shows the actual strain rate. The part shown in gray is the ±20 % permissible error region. The strain rate error was ±10 % or less, indicating that testing can be performed with extremely high accuracy.

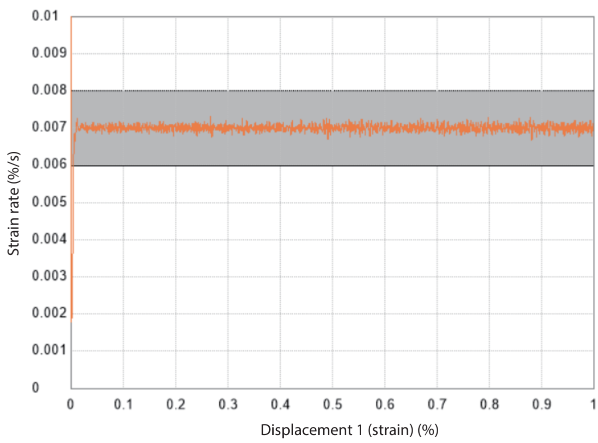

Fig. 2 Example of Strain Rate in Test

The stress-strain curve is shown in Fig. 3, and the test results are shown in Table 3. The average values of tensile strength, proof strength, and the elastic modulus are 982 MPa, 718 MPa, and 199 GPa, respectively. Thus, while the elastic modulus is the same as that of general steel, the tested material displays the distinctive feature of high tensile strength steel, namely, high tensile strength.

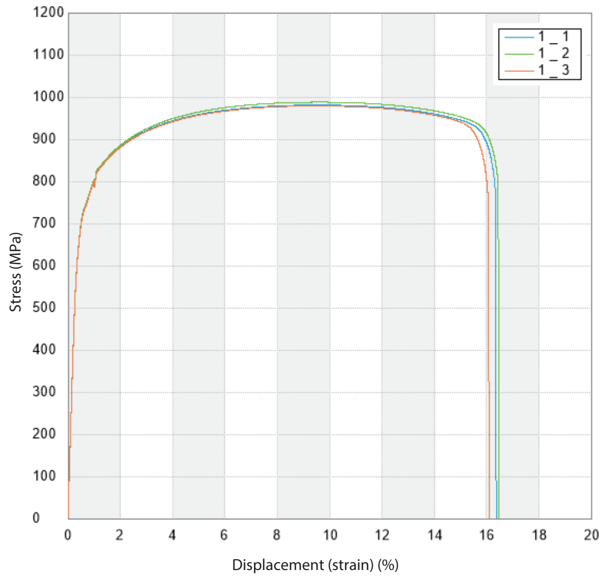

Fig. 3 Stress-Strain Curve

Table 3 Test Results

Specimen No.	Tensile strength [MPa]	Proof strength [MPa]	Elastic modulus [GPa]
1	980	717	200
2	988	721	199
3	979	717	198
Average	982	718	199

Conclusion

This article introduced an example in which a tensile test of high tensile strength steel using strain rate control was performed in accordance with JIS Z 2241 Annex JB. Because high tensile strength steel has high strength in comparison with general steel materials, it is known that testing is difficult with manual grips due to their inadequate gripping force. In this test, satisfactory testing until rupture was possible by using hydraulic flat grips, which have higher gripping force. Moreover, testing was possible with accuracy greatly exceeding the accuracy of ±20 % allowed by the standard, indicating excellent strain rate control.

These results demonstrated that satisfactory tensile testing of high tensile strength steel using strain rate control is possible by using the AGX-V precision universal testing machine, hydraulic flat grips, and extensometer.

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