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Application News

Autograph AGX™ -V2

r-Value Determination with Video-Type Non-Contact Extensometer (ISO 10113:2020)

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User Benefits

- Related standards include ISO 10113, ASTM E517, GB/T 5027, IS 11999, and JIS Z 2254.
- The video-type non-contact extensometer enables simultaneous determination of other tensile test properties as well as the r-value.
- The regression method is effective for materials that exhibit inhomogeneous behavior in the plastic region, such as Al-Mg alloys.

■ Introduction

Thin materials like high-tension steel have been gaining attention in terms of improving fuel efficiency by reducing vehicle weight, especially in the transportation equipment industry. However, high-tension steel is prone to shape defects after press forming, posing a significant challenge in terms of time and cost required for the production of press molds. Recent advancements in computer aided engineering (CAE) analytical techniques and the computational speed of computers have improved high-precision simulation of press forming for high-tension steel. That has enabled prediction of the ideal shape of press-formed products, leading to substantial reductions in the development time and cost of press molds.

The realization of high-precision press forming simulation requires reliable determination of the Lankford value, referred to as the r-value, which is one of the indicators representing the formability of sheet metal. The r-value serves as a quantitative indicator of the ductility of a material in the thickness direction and corresponds to the material's drawability, which contributes significantly to press formability. In ISO 10113, revised in 2020, three different r-value determination methods have been standardized (the manual method, the semi-automatic method, and the automatic method). The automatic method uses extensometers for the gauge length and width, enabling the r-value to be determined for any given plastic strain after completion of standard metal tensile testing in accordance with ISO 6892-1. Therefore, this method is very useful for determining other tensile property values (e.g., tensile strength) at the same time. Details of each determination method and a case study of r-value determination with contact extensometers are described in a previous Application News article[1].

Measurements with contact extensometers involve attaching and removing the extensometers to a test piece for each test. In contrast, TRViewX video-type non-contact extensometers achieve more convenient testing by recognizing gauge length and width values in captured images. This article describes a case study of r-value determination in accordance with the automatic method specified in ISO 10113 by using the AGX-V2 universal testing machine and a TRViewX extensometer.

■ Testing System

In this demonstration, an Autograph AGX-V2 precision universal testing machine and a TRViewX video-type non-contact extensometer were used. The other instrument configurations are indicated in Table 1.

Table 2 provides test piece information. The type of the test piece and gauge length are required to satisfy ISO 6892-1: 2019, Annex B. In addition, the parallel length must be equal to or greater than $L_0 + 2b_0$, where L_0 is the original gauge length and b_0 is the original gauge width.

Two types of test pieces were prepared: An SUS304CP type that deforms homogeneously in the plastic region and an A5052P type that exhibits inhomogeneous behavior. The r-values were calculated by applying the automatic "single point method" to the former and the automatic "regression method" to the latter, respectively.

The test conditions and a view of the test are shown in Table 3 and Fig. 1 (left), respectively. The test speed complied with ISO 6892-1, which is the standard for metal tensile testing. Fig. 1 (right) illustrates the gauge length and width recognition on the TRViewX. The accessory sticker-type gauge markers enable easy recognition. In addition, width measurements at multiple points within the range indicated by a pink box and the subsequent average value calculation ensure highly reproducible test results.

Table 1 Instrument Configuration

Testing Machine:	AGX-100kNV2
Load Cell Capacity:	100 kN
Grips:	100 kN manual non-shift wedge-type grips
Extensometers:	TRViewX video-type non-contact extensometer
Software:	TRAPEZIUM™ X-V

Table 2 Test Piece Information

Shape:	ISO 6892-1 Annex B: 3
Dimensions of the Parallel Section:	Length 100 mm Width 25 mm Thickness 1 mm
Material Properties:	SUS304CP, A5052P
Orientations Relative to the Rolling Direction:	0 deg.

Table 3 Test Conditions

Test Speed:	ISO 6892-1: Method B
Original Gauge Length:	50 mm
Distance between Grips:	210 mm
Number of Tests per Orientation:	n = 5

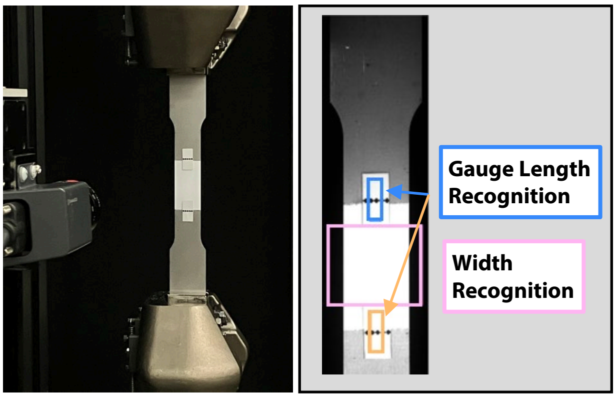

Fig. 1 View of the Test (left) and Recognition of the Gauge Length and Width

■ Test Results

Single point method – SUS304CP

Fig. 2 shows well-overlapped stress vs. strain curves (upper) and width strain vs. length strain curves (lower) for the SUS304CP sample obtained from this demonstration. Contact extensometers must be removed after reaching a certain strain that is sufficient for determining the r-value[1], whereas the TRViewX enables running the test until failure without pausing the crosshead movement.

Table 4 shows the average and standard deviation values obtained from test results, which are automatically calculated by the dedicated software, TRAPEZIUMX-V. The curves in Fig. 4 (lower) imply that the test pieces experienced homogeneous strain in the plastic region. In such cases, it is common to apply the single point method, which allows a single instantaneous r-value to be obtained for every row of test data, such as force, extension, and instantaneous width reduction value. For reference, Table 4 also presents the results of the r-value determined using contact-type extensometers by the same method as described in the previous Application News article[1]. The fact that the r-value determined by the TRViewX and contact-type extensometers are comparable and sufficiently reproducible emphasizes the high reliability of this testing method.

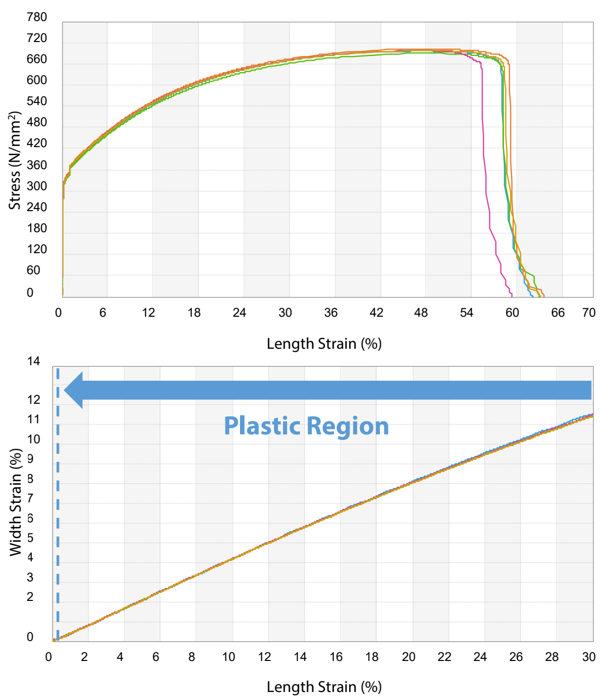

Fig. 2 Stress Versus Strain Curves (Upper), and Width Strain Versus Length Strain Curves for SUS304CP (Lower)

Table 4 Averages and Standard Deviations of the Test Results for SUS304CP

20 % r-Value*1 TRViewX	20 % r-Value*1 Contact-Type Extensometers	0.2 % Proof Stress [MPa]	Tensile Strength [MPa]
0.861 ± 0.0078	0.855 ± 0.012	325 ± 3.3	696 ± 4.2

*1 20 % r-value indicates the r-value calculated at the point where 20 % plastic strain is reached.

Regression method – A5052P

Fig. 3 shows width strain vs. length strain curves obtained from the A5052P sample. Owing to the inhomogeneous behavior in the plastic region, applying the single point method causes variations in the r-value for each row of the test data. In this case, the regression method is the preferable method to apply. The method applies linear regression to $\varepsilon_{\mathrm{p\_b}}$ vs $\varepsilon_{\mathrm{p\_L}}$ values, where $\varepsilon_{\mathrm{p\_b}}$ is the true plastic strain in the width direction and $\varepsilon_{\mathrm{p\_L}}$ is the true plastic strain in the tensile direction, over the entire evaluation range to determine the reliable r-value. The TRAPEZIUMX-V software also enables automatic calculation of r-values based on the regression method.

Table 5 shows the average and standard deviation values for the A5052P sample. The results measured with the contact-type extensometers are also included for reference. The regression method also produced comparable results using TRViewX and contact-type extensometers.

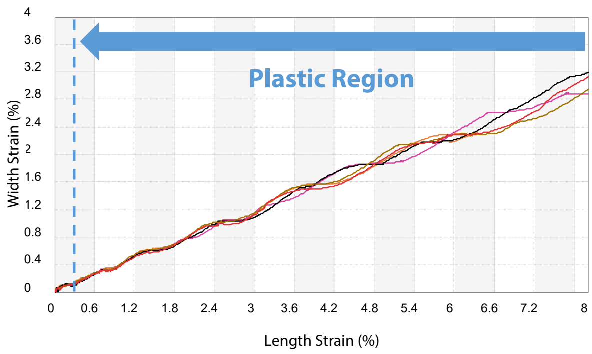

Fig. 2 Width Strain Versus Length Strain Curves for A5052P

Table 5 Average and Standard Deviation Values from A5052P Test Results

20 % r-Value*2 TRViewX	20 % r-Value*2 Contact-Type Extensometers	0.2 % Proof Stress [MPa]	Tensile Strength [MPa]
0.705 ± 0.023	0.710 ± 0.019	208 ± 2.5	251 ± 2.4

*2 The evaluation range of r-value is 0.5 to 5.5 % of plastic strain length.

■ Conclusion

The Autograph AGX-V2 precision universal testing machine and the TRViewX video-type non-contact extensometer achieve convenient r-value determination in accordance with ISO 10113:2020. TRAPEZIUMX-V software enables both the single point method and regression method involved in the automatic method. Furthermore, it enables the comparison of each calculated r-value and subsequent statistical processing, such as calculation of mean and standard deviation values.

TRViewX and TRAPEZIUMX-V functionality are completely integrated, enabling full operability using only the software, replaying videos of tests coupled with resulting curves, and displaying a test screen coupled with point-picking.

Related Applications

1. ISO 10113:2020 r-Value Determination
   Application No.01-00615

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