

# Application News

## Hardness Measurement of Welded Materials by Micro-Vickers Hardness Tester

Tomoya Matsushita, Tsubasa Yamamoto, and Fumiaki Yano

### User Benefits

- ◆ The stage viewer function provides an overall image of the sample and allows the stage to be moved to an arbitrary position.
- ◆ Pattern setting enables all measurement positions to be set at once.
- ◆ Continuous testing based on pattern settings and automatic indentation size acquisition is supported.

### Introduction

Welding is a fundamental technology that supports the reliability of structures across various industries, including automotive, construction, and energy, and plays an essential role in ensuring the safety of critical infrastructure. In welded joints, differences in heat input and cooling conditions cause the metal microstructure to become non-uniform, resulting in changes in mechanical characteristics in the base metal, heat-affected area, and weld metal. Thus, hardness measurement is essential as an indicator of strength, toughness, and crack susceptibility. In this application, hardness testing of a welded material was performed using the HMV-G31-FA™ Micro-Vickers Hardness Tester, and the weld area was characterized using the hardness distribution map obtained from multi-point continuous measurements.



Fig. 2 HMV™-G31-FA

### Test Sample and Measurement System

Sample information is shown in Table 1, the sample in Fig. 1, and the tester in Fig. 2. The sample was produced by TIG welding two metals, SUS304 and SS400 (dimensions 18 mm length × 4 mm width × 3 mm thickness) as used in an earlier [Application News<sup>1</sup> report](#). The welded joint was chamfered (C1) and welded around the entire circumference. The sample was embedded in resin, and its surface polished to facilitate observation of indentations.

Measurement was carried out using the HMV-G31-FA Micro-Vickers Hardness Tester. This apparatus, equipped with a motorized XYZ stage and dedicated software, enables stage movement and focus adjustment via PC control. The stage viewer function makes it possible to create an overall image of the sample and move the stage to an arbitrary position. By setting the measurement pattern in the software, the software can automatically evaluate the hardness distribution from multi-point measurements.

Table 1 Sample Information

|                 |  |
|-----------------|--|
| Sample:         | SUS304, SS400                            |
| Welding Method: | TIG welding (TG308 φ1.2 mm)              |
| Dimensions:     | Length 36 mm, Width 4 mm, Thickness 3 mm |

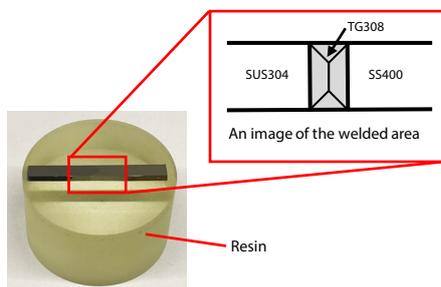


Fig. 1 Test Sample

### Test Conditions

Test conditions are shown in Table 2. In the sample, the X-axis was set along the long side, and the Y-axis along the short side. A total of 1111 indentations were made: 101 points in the X direction and 11 rows in the Y direction. Using the dedicated software's pattern setting function enables such continuous indentations to be set. Measurement positions were arranged in a grid pattern with 200 μm spacing to ensure sufficient separation between indentations and prevent interaction effects. A diagram of the measurement pattern is shown in Fig. 3.

Table 2 Test Conditions

|                               |  |
|-------------------------------|--|
| Tester:                       | HMV-G31-FA Micro-Vickers Hardness Tester |
| Indenter Type:                | Vickers Indenter                         |
| Force:                        | 980.7 mN (HV 0.1)                        |
| Holding Time:                 | 14 sec                                   |
| Number of Measurement Points: | 1111 (101 points × 11 rows)              |

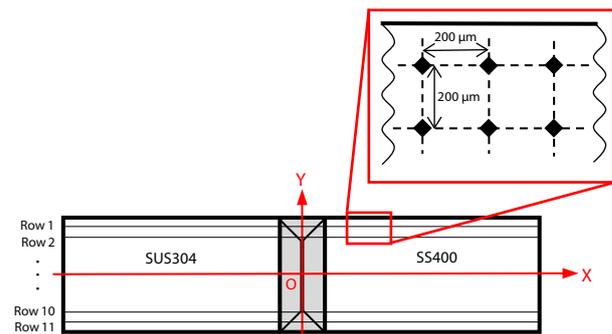


Fig. 3 Measurement Pattern

## Test Results

Fig. 4 shows a magnified section of the sample image obtained using the stage viewer function. From Fig. 4, it can be seen that the indentations were made at regular intervals. Indentations were made in 11 rows along the Y-axis. Fig. 5 shows the hardness graphs for 3 representative rows. Profile (a) is row 2 in the upper part of the sample, (b) is row 6 in the middle, and (c) is row 10 in the lower part. All of the graphs show that the hardness on the left side is relatively higher than on the right side, with a tendency for the hardness to decrease in the central area. However, in (a) and (c), there were points within the welded material where the hardness was locally higher.

The size of the indentations was automatically read by the dedicated software. Fig. 6 shows the indentation images for 2 representative points. Image i) and ii) correspond to the points marked as i) and ii) in profile (c) of Fig. 5.

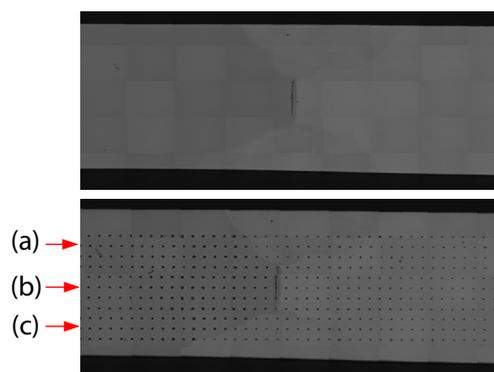


Fig. 4 Sample Image Obtained Using the Stage Viewer Function (Upper: Before Indentation, Lower: After Indentation)

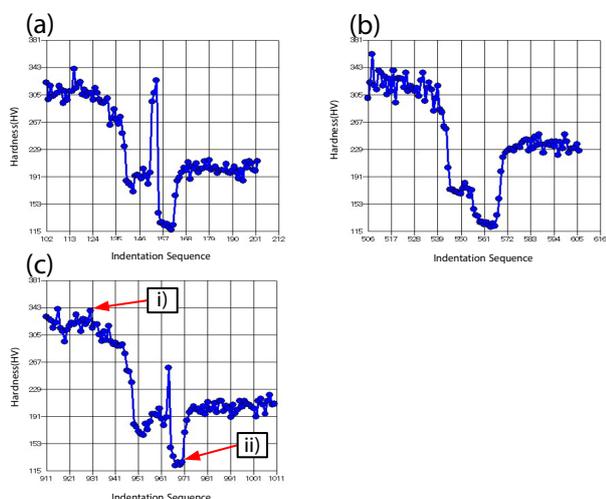


Fig. 5 Hardness Profiles along X-axis ((a) 2nd, (b) 6th, (c) 10th)

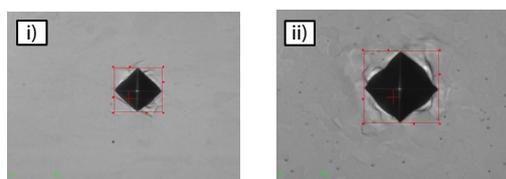


Fig. 6 Indentation Image (Left: 930th, Right: 970th)

## Hardness Distribution Map

A hardness distribution map (Fig. 7) was generated from data obtained via multi-point measurements using the pattern setting function. As shown in Fig. 7, the SUS304 region exhibits hardness values of approximately HV300-350, the SS400 region HV200-250, and the TG308 weld region about HV200.

In the TG308 weld metal region, localized regions of increased hardness were confirmed near the boundaries contacting the SUS304 and SS400 base metals. These regions correspond to the areas of locally elevated hardness shown in Fig. 6. This phenomenon is considered to result from microstructural changes caused by rapid heating and cooling during welding. Meanwhile, both the SUS304 and SS400 base metals exhibited a slight decrease in hardness in the areas adjacent to the weld metal. These regions correspond to the heat-affected zone, and the reduction in hardness is presumed to be due to grain coarsening and changes in residual stress induced by the welding heat.

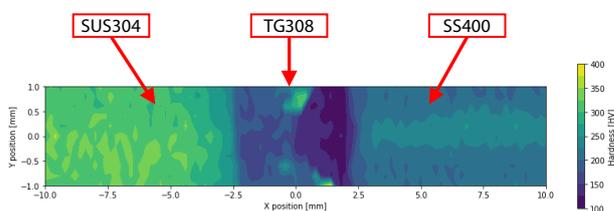


Fig. 7 Hardness Distribution Map

## Conclusion

In this application, the hardness differences among SUS304, SS400, and weld metal were evaluated using the HMV-G31-FA Micro-Vickers Hardness Tester. A sample welded with SUS304 and SS400 using TG308 was used, and the hardness distribution around the weld area was investigated. The stage viewer function and pattern setting function enable the generation of a hardness distribution map by capturing an image of the entire sample and performing multi-point measurements.

### Related Applications

1. Three-Point Bending Fatigue Tests of Welded Material Using the SEM Servopulser  
[Application News No. 01-00792](#)

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