Portable stress analyzer SmartSite RS

—Rapid data acquisition with the world's smallest stress analyzer—

1. Introduction

X-ray stress measurement permits the non-destructive measurement of residual stress, primarily in the surfaces of metallic components or structures, and is a common measurement method for material strength, lifetime prediction and other estimations in the industrial field.

However, applications have been limited as measurement objects are often structures that cannot be brought into a laboratory, or large parts that cannot be measured due to work space limitations.

SmartSite RS can be brought to the measurement site and has made stress measurement possible even in cases as those described above. In addition, quantification of retained austenite can be performed with an optional attachment. The device is powered either by plugging into a 100–240 VAC socket or by battery, enabling measurements at various locations. Transport, even to remote sites, is easy as the entire system readily fits into the included carrying case.

2. Features

2.1. The world's smallest and lightest* instrument design

The world's smallest measurement head with dimensions of 114 (W)×248 (D)×111 (H) mm and a weight of 3 kg (Fig. 1) enables residual stress measurement from the inner surface of a 200 mm bore (Fig. 2).

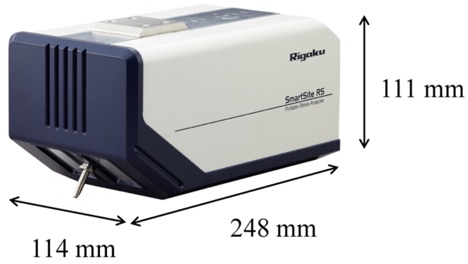

Fig. 1. SmartSite RS head unit appearance and dimensions.

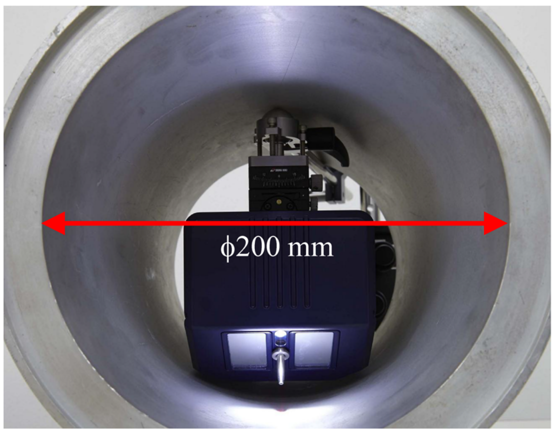

Fig. 2. Example for a residual stress measurement from the inner surface of a 200 mm bore.

* As of December 2014.

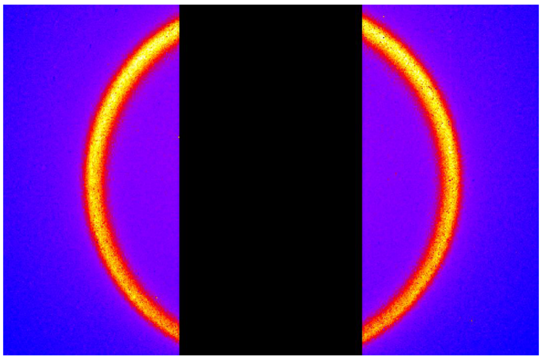

Fig. 3. Debye-Scherrer ring obtained by SmartSite RS.

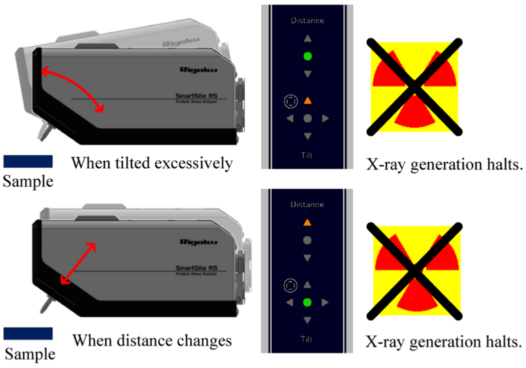

Fig. 4. Examples for halting of X-ray generation.

2.2. Rapid data acquisition

X-ray power is 50 W, which is high for a portable device. Combined with using a novel 2-dimensional semiconductor detector installed on the left and right side of a collimator in the center and utilizing a stress analysis method using one Debye-Scherrer ring (Fig. 3) obtained by single-exposure method, this allows for rapid data acquisition in 60 seconds for general samples. For samples with high crystallinity, a 10-second measurement is enough to obtain sufficient measurement data.

2.3. Safety design

The head unit incorporates a laser displacement meter and an accelerometer which will halt X-ray generation if the distance to the sample (camera length) and the inclination of the head unit exceed the specified ranges (Fig. 4). An optional shield box is also available as safety feature.

2.4. Sample setting

Using laser displacement meter and accelerometer, camera length and the inclination of the head unit are displayed on both an indicator located at the upper face of the head unit (Fig. 4) and the PC screen (Fig. 5) in real time. Furthermore, the CCD camera integrated in the head unit allows for easy sample setting while observing the measurement point on the tablet PC screen (Fig. 5).

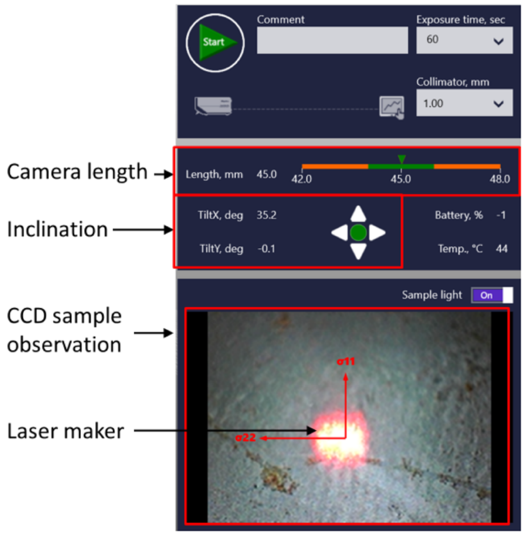

Fig. 5. PC screen (Control area).

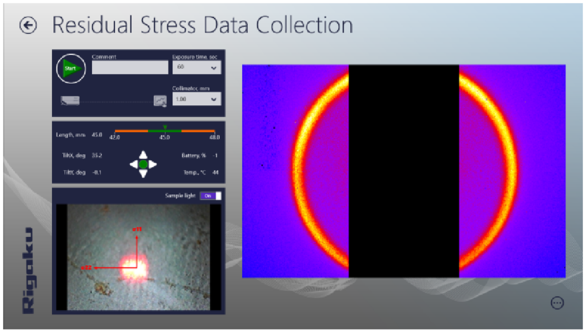

Fig. 6. PC screen (Residual Stress Data Collection).

2.5. Simple operation

With Wi-Fi (wireless LAN) communication between control PC and SmartSite RS, the equipment can be controlled at any places. As the control PC, a Microsoft Windows 8.1 Pro tablet is employed, which offers easy and simple operations on site (Fig. 6). Fully automatic software from measurement to analysis is incorporated in the control PC. Reports can also be created by the software. It is designed so that anybody can perform stress analysis easily.

3. Measurement example

3.1. Applied strain measurement by 4-point bending testing machine

Measurement conditions are indicated in Table 1. Figure 7 shows a picture of the applied strain measurement performed with the 4-point bending testing machine.

SUP9 (JIS) steel was used as sample. A strain gauge was attached to the back face of the measurement point. Applied strain was measured with a static strain indicator. The results of the applied strain measurement by the 4-point bending testing machine (x-axis) and the values of the residual stress measurement using X-rays (y-axis) are indicated in Figure 8. From this result it is understood that a proportional relationship exists, indicating that the residual stress values obtained by SmartSite RS describe the increase of the applied strain correctly. The time required for this measurement was 6 minutes (sample setting excluded), allowing for many measurements in a short period of time.

Table 1. Measurement conditions.

X-ray tube	Cr-Kα
Tube voltage, tube current	30 Kv–1.7 mA
Measurement diffraction	α-Fe211
Collimator diameter	1 mm
Young's modulus	223300 MPa
Poisson's ratio	0.276
Exposure time	60 sec.

Fig. 7. Applied strain measurement by 4-point bending testing machine.

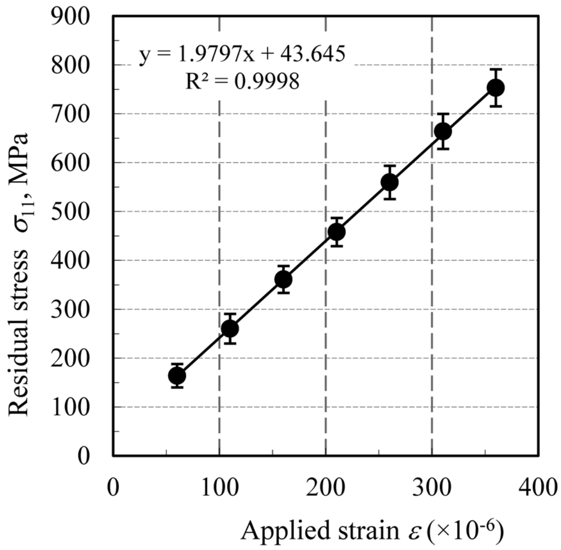

Fig. 8. Results of applied strain measurement by 4-point bending testing machine.