Dr. Yuji Kobayashi | Sintokogio | www.sinto.co.jp

Evaluation and Control of Residual Stress Measurement Using Stress Standard Specimen

Introduction

Shot peening is a processing method in which particles of small size called media (shot) are made to impact the surface of a workpiece. It is often used on components such as gears and springs to improve fatigue strength. Residual stress is one of the parameters which represents the effect of shot peening. It helps prevent crack propagation.

Residual stress can be measured by an X-ray diffraction method. A commonly used technique is the $\sin^2 \psi$ method (with 0-dimensional or 1-dimensional detector).

On the other hand, a method using an image plate (two-dimensional detector) has recently been put to practical use. It is called the cosα method (Figure 1). This method reduces the size of the measuring device and reduces the measurement time in comparison to the conventional $\sin^2 \psi$ method.

Figure 1. Residual stress measurement device (cosα method).

Although there are many advantages, the data measured by the conventional method has differences, such as different X-ray penetration depths, so the presence or absence of correlation between $\sin^2 \psi$ method and cosα method differs depending on the user.

We propose using a standard specimen for residual stress measurement. The reference piece can be measured using devices with different calculation methods for comparison of each method or to simply compare results of multiple measuring devices. It can also be used for routine process control. This paper introduces the stress standard specimen and explains how to use it.

Concept of Stress Standard Specimen

Regarding residual stress measurement by X-ray, it is recommended to regularly check for zero stress with a powder sample in a non-strained state to check for any abnormality. It is often done as a daily check. Residual stress measurement by X-ray involves measuring the crystal lattice spacing of metal by X-ray diffraction and calculating the stress existing in the sample surface layer from the strain generated between the lattice planes. From an industrial point of view, materials that are greatly affected by processing and heat treatment are often targeted for residual stress measurement. Therefore, unlike laboratory use (where powder, etc. are used as reference), it is better to use what is actually handled at the factory. Typical materials to be shot peened are various gears and springs, which are also subjected to various heat treatment processes. If these materials are to be measured, a standard specimen subjected to shot peening after heat treatment is considered appropriate.

Application and Necessity of Residual Stress Standard Specimen

As described above, the stress standard specimen can be used for daily process control, alignment in the case of different calculation methods, and confirmation of machine differences. The setting of various conditions is important for residual stress measurement using X-rays. In particular, it is necessary to acquire the diffraction intensity distribution in a sufficient angle measurement range. The stress measurement conditions may need to be changed depending on differences in materials and heat treatments. Even when measuring the same type of material, measurement conditions may differ depending on the user's judgement.

Thus, caution is required in the handling of the measured stress values, which can vary depending on the measurement conditions even if the angle measurement range is the same. Since there is a possibility that the measured value may fluctuate for the above mentioned reasons, a method to confirm the certainty of that value is required. Therefore, we propose a stress standard specimen as such a method where it is necessary to measure the reference specimen on a daily basis or per lot and confirming that the residual stress measurement is performed reliably.

In addition, in order to grasp the differences in calculation methods and the variation in readings from different machines, it is necessary to use the same reference sample.

Introduction of Cosα Method

The cosα method is a method of stress measurement proposed by Taira et al. At first, the X-ray diffraction image was obtained by exposing the X-ray film. The peak of the diffracted X-ray was judged by the shading of the image.

With the development of detectors that acquire diffracted X-rays, Sasaki et al. proposed a method using an image plate (IP) which was then put to practical use.

Sinto, our employer, sells residual stress measuring instruments that adopt this method.

The measurement time is shorter than that of the conventional method because X-rays do not have to be incident on the measurement point multiple times.

In addition, since there is no need to move the X-ray irradiation position, a goniometer is not required and the apparatus can be miniaturized. In this method, since the entire circumference of diffracted X-rays (Debye-Scherrer ring) is acquired, diffracted X-rays can be visually confirmed (Figure 2).

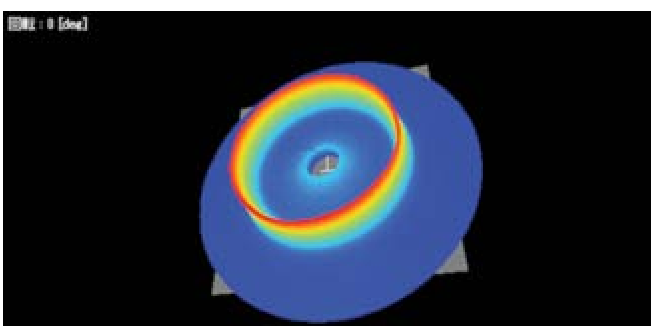

Figure 2. Example of DEBYE-SCHERRER ring (diffraction ring).

Introduction of Stress Standard Specimen

The stress standard specimen is given a target residual stress. The residual stress applied to the specimen is available in three levels, high, medium and low (-1600 MPa, -800 MPa, -400 MPa). An example is shown in Figure 3. The specimen size including the pedestal is 400 x 400 x 550 mm.

The measurement point is represented by a White circle at the center and the measurement direction is represented by a Black circle.

An inspection certificate is attached to this reference piece, and the stress value, written for such reference pieces, describes the measured value obtained by measuring the White circle portion. Applications may be daily management, adjustments in the case of different calculation methods, and confirmation of machine differences.

Figure 3. Standard specimen for residual stress measurement.

Example of Use: 1

As an application example, we show the comparative results of two different calculation methods, the $\sin^2 \psi$ method and the cosα method.

The $\sin^2 \psi$ method is a method often used for residual stress measurement. The results when measuring are shown in Figure 4 on page 18.

The vertical axis represents applied stress and the horizontal axis represents residual stress. In both the $\sin^2 \psi$ method and the cosα method, the changes in load stress and residual stress are linear. However, the actual residual stress values from both methods are not exactly the same. It considered that the trend the measurement result obtained from both methods should be confirmed by the reference piece.

In this case, the reference specimen can be used to confirm what kind of trend is shown by results from both methods (Figure 5 on page 18).

Example of Use: 2

If the measurement is made without noticing the difference in the parameters, the measurement result will not be certain. It is easy to notice if the measurement result is obviously wrong, but if the measurement result is not so large, it may be possible to perform the measurement without noticing it. Therefore, we think that daily management with the decided standard (standard piece) is important.

Conclusion

Residual stress measurement by X-ray diffraction is widely used in the automobile industry and other fields. Measurements can be done in a shorter time than before and more miniaturized devices have been put to practical use. Therefore, this technique is being applied to more products

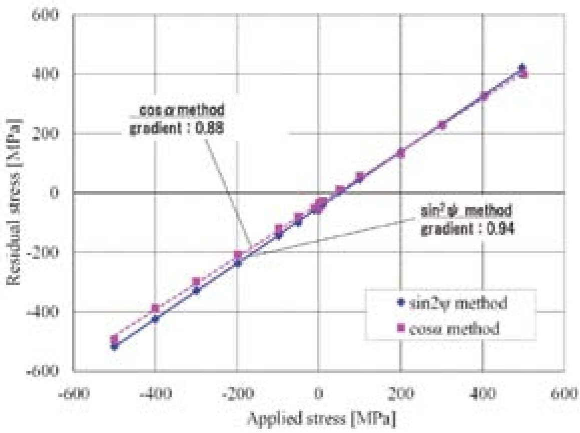

Figure 4. Comparison residual stress and applied stress.

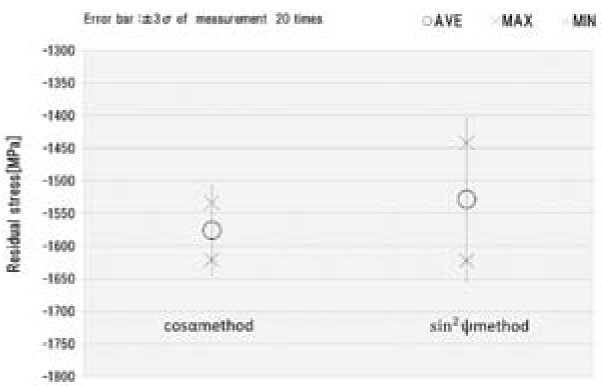

Figure 5. Comparison of measurement methods.

and fields than ever before. As the field of application becomes wider, X-ray diffraction measurement is gaining a wider acceptance as a common technique rather than being considered as a highly specialized technology.

Therefore, the certainty of the measurement result has become more important than ever. It would be highly advisable to use a stress standard specimen as a confirmation method for residual stress measurements.

About Sinto

Since its establishment in 1934, Sinto has accumulated numerous technologies related to the field of metal casting as a manufacturing and system engineering company of foundry equipment and plants.

Throughout these years Sinto has consistently followed its basic corporate philosophy of "Giving Form and Life to Process Materials" regardless of the expansion of its business fields.

Sinto's business operation has expanded to various fields of process materials industry through the advanced, integrated and applied technology based on its foundry-related technologies and accumulated know-how.

Saab's Global Defense and Security Company Lands in Indiana Near Purdue University

Global defense and security company Saab announced plans this spring to locate a new U.S. manufacturing operation in Indiana. The facility, located at Discovery Park District Aerospace on the west side of the Purdue University campus, will support production of the U.S. Air Force's next-generation T-X jet trainer and create up to 300 new jobs with hiring starting in 2020.

The expansion is a fundamental part of the company's strategy to grow its U.S. industrial and technology base. Saab also will collaborate with Purdue University to expand Saab's U.S.-based research and development within possible areas such as sensor systems, artificial intelligence and autonomous systems.

The Stockholm-based company will invest $37 million to locate and build an Indiana-based workforce in West Lafayette. Saab will construct and equip a facility to manufacture a significant portion of the Boeing T-X advanced pilot training aircraft, which will help train future U.S. Air Force pilots for generations to come. Saab is both a partner and supplier to Boeing on the program.

Construction of the facility is expected to begin in 2020 at the Discovery Park District Aerospace to support the rapid Boeing T-X production rate demanded of the program. Saab expects to begin hiring for assembly operators and airplane mechanics as well as for logistics, manufacturing engineering, and administration and management roles the same year.

Indiana Governor Eric Holcomb speaks before a crowd of more than 200 people during an event to announce that Sweden-based Saab Global Defense and Security Company is opening a $37 million facility in the Purdue University-affiliated Discovery Park District in West Lafayette, Indiana. Saab will conduct its contribution to the production of the U.S. Air Force's T-X pilot training program and other aerospace projects at the site. (Photo credit: John Underwood/Purdue University)