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Digital Transformation of Shot Peening Machines Utilizing Total Inspection

INTRODUCTION

Industries are now managing detailed information in order to build production processes that not only improve productivity, but also protect the environment. Shot peening is a process in which shot particles are applied to the surface of a work piece at high velocity. The equipment structure is simple and has been used in a wide range of industries. In particular, Japanese automobile manufacturers have been actively shot peening automobile parts such as gears and springs to improve fatigue life and stress corrosion cracking characteristics. However, if the processing conditions are not controlled, these required effects may not be obtained. Hence, it is vital that these processing conditions are well controlled.

The management of information has become essential for these industrial processes particularly based on the concepts of "IoT" and "DX". As a result, the importance of all kinds of information related to production is increasing enormously.

The current quality evaluation method for the shot peening process is based on the control of processing conditions and intensity. In addition, to evaluating the quality of the product, a sample part is taken out and inspected for roughness, residual stress and/or hardness.

Currently, even if the machining conditions are controlled, it is not possible to control the quality of the product after shot peening. It is also difficult to evaluate the residual stress and hardness required for shot peening on all products. In order to solve these problems, we would like to propose the evaluation of each product after shot peening. In order to confirm the quality of all the products, it is necessary to evaluate all the parts inline and non-destructively to avoid defective products while reducing costly production waste and significantly reducing the impact to our environment.

However, in order to achieve in-line and full inspection, a short, compact, and non-destructive inspection device is necessary. Therefore, we have developed a surface evaluation technology—Sightia™—which can evaluate all the products of shot peening.

NON-DESTRUCTIVE EVALUATION (SIGHTIA™)

As mentioned above, there are several issues in the current management and evaluation of peening. Surface evaluation techniques include:

1. Eddy Current Non-destructive Inspection **(ECNI)** systems and
2. X-ray stress measurement **(PSMX)** systems have been developed to solve these problems

ECNI test equipment

ECNI uses an eddy current measurement method to evaluate the surface, and it can judge whether the peening process is pass or fail.

ECNI consists of a signal processing unit, a display unit, and a probe. Changes in the antimagnetic field created by eddy currents in the conductor due to the magnetic field are measured as changes in the electrical characteristics such as impedance and phase of the coil. The entire treated surface surrounded by the probe can be evaluated.

In addition, it is possible to measure and judge whether the product is good or bad in as little as three seconds. Therefore, if this unit is installed in a shot peening machine, then the quality of each can be compared inline against pass or fail criteria. Also, by changing the eddy current characteristics, the depth direction of the product can be evaluated.

Residual stress measuring unit PSMX

The main purpose of shot peening is to improve fatigue strength by adding residual stress. The X-ray stress measurement device **PSMX-II**, developed by our company, is compact and can measure residual stress values in about 10 seconds. Therefore, it can be integrated into an automated shot peening machine effortlessly if the evaluated products are of the same material and shape.

FROM PROCESS CONTROL TO FULL INSPECTION

In order to achieve the goal of zero outflow of quality defects, we propose a shot peening process that records and utilizes all evaluation and process data which has been difficult in the past.

Full inspection before and after shot peening

In the shot peening process, the one-piece flow process is becoming the mainstream for quality control and traceability. At this time, it is necessary not only to satisfy the quality after the peening, but also to understand the characteristics before the peening. If there is a defect in the product before shot peening treatment, the quality of the product will not be satisfied even if it is processed by a correctly controlled shot peening method.

Again, one-piece flow process represents mainstream quality control and traceability so we believe it is beneficial to not only satisfy the quality after the peening, but also to understand the characteristics before the peening. An efficient automated process eliminates waste while improving value stream and traceability.

The shot peening machine integrated with Sightia™ can evaluate the product even before it is peened to determine if it is unsuitable for peening. Since it can evaluate and record the product after peening, it can easily record the quality of the product after machining. Overall, the reliability of the manufacturing process can be improved more than before.

Combination of evaluations

The above mentioned PSMX measures the local residual stress. On the other hand, ECNI evaluates the finish of peening of the entire surface, although it cannot obtain actual physical quantities such as stress. Therefore, we would like to propose that both measuring devices be integrated into the shot peening machine where possible.

Effects of shot peening machine integrated with evaluation equipment (Sightia™)

Normally the processing conditions are controlled in shot peening machines. Therefore, by using ECNI and PSMX to evaluate the product after processing, the outflow of defective products can be eliminated.

DATA RECORDING AND UTILIZATION IN SHOT PEENING PROCESS

Data recording

When a defect occurs, the stored data can be analyzed to easily identify the cause. If the condition of the product before peening is also recorded, the cause can be more easily identified. In addition to the easy quality control, a large cost reduction can be expected.

Use of measurement data

Feed-forward to peening conditions

If the evaluation before the peening is unacceptable, the product is obviously rejected. We would like to propose that the peening conditions should be automatically changed when the evaluation result is close to the lower limit of the acceptance criteria. (Feed-forward)

Feed-forward conditions provides a method of investigating the impact of shot peening on each product well in advance.

Feedback on shot peening conditions

All data measured after shot peening are used for post-processing trend analysis. If the trend analysis predicts that the material will be out of specification in the near future, the equipment will issue a warning or automatically adjust the peening conditions. (Feedback)

Shot peening machines with these features can not only satisfy the quality after peening, but also eliminate the outflow of product defects.

PROSPECTS FOR DATA UTILIZATION

Traceability

By marking the products with laser markers and linking them with the accumulated data, it is possible to track them later. Thus, it is possible to manage products differently than before.

The Next Generation of Shot Peening Machines

As we have discussed, integrating an evaluation device into a shot peening machine would make it easier to control product quality and prevent defects from leaking out. As a result, it will be possible to save manpower.

The mechanical properties after shot peening change significantly depending on the conditions of shot peening. It is up to the equipment manufacturer to investigate these changes in more detail and to reflect them in the shot peening equipment.

So far, we have mainly discussed the quality improvement after shot peening. On the other hand, the improvement of productivity and the reduction of total running cost are also important themes.

In recent years, data collection and analysis technologies and equipment control technologies have been improving. It will be possible to perform the minimum amount of processing while satisfying the standards required by customers.

In addition, individual shot peening machines will be able to send information to the customer's overall factory management in order to optimize the entire manufacturing process.

In any case, digitalization is required for shot peening machines.

SUMMARY

In this paper, we have proposed a process of total inspection using Sightia™ before and after shot peening.

We believe this process can be applied to various concepts that have been proposed in recent years, such as "Industry 4.0", "IoT", and "Big Data".

We would like to contribute to our customers by analyzing the production processes of individual customers and proposing optimal systems.