Inspection Efficiency Technology Using Parts Damage Record

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In the parts repair service business, promptly determining the handling method, such as discard or repair, of a damaged part found during the inspection is one of the important factors to shorten inspection time. Mitsubishi Heavy Industries, Ltd. (MHI) has developed the technology to compare the damage status of a part with a database (DB) of discard/repair criteria and dynamically provide an inspection order for each part, which makes it possible to make an early decision to discard the part based on the accumulated damage records. We applied this technology to the in-house inspection of several products, and have confirmed that the time required for inspection could be reduced for certain products. With this technology, we will improve the efficiency of inspection in the parts repair service business and shorten the required time, which contributes to the shorter delivery time of parts received from customers.

1. Introduction

The parts repair service inspects a part, compares the damage status with discard/repair criteria, and discards/repairs the part according to the comparison results. However, when comparing the damage status of a part with the manual that describes discard/repair criteria, it is difficult for inexperienced inspectors to make an early decision to discard the part, which consequently leads to prolongation of the inspection time.

This report presents, as a means of early determining the handling method of a damaged part, such as discard or repair, a technology that dynamically defines the inspection order for making an early decision to discard the part and provides the inspectors with the defined order. In addition, this report describes the results of a trial application of this technology to our product inspections, as well as the future prospects.

2. Technology to improve inspection efficiency

2.1 Technology to record damage information and determine handling method

In order to improve the efficiency of inspection and shorten the required time, it is necessary to determine the handling method of a damaged part according to the damage status in the shortest possible time. Therefore, we first created a database in which damage conditions and handling methods are linked in order to automatically determine a handling method. The creation of this database began with the abstraction of (1) damage type, (2) damage severity input item, and (3) handling method determination criterion with respect to information specific to each product, which are necessary for damage recording and handling method determination. Damage types are categorized into fourteen types, such as cracks, thinning, deformation, etc., based on the type of material and nature of damage, and the typical recording item (length, depth, number of pieces, etc.) that should be recorded is organized for each damage type. The damage severity input item includes four input patterns based on the record item of similar damage: (1) numerical input, (2) true/false input, (3) enumeration input, and (4) character string input. The handling method for each

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type of damage comprises repair, discard, and no action required, which are determined for each part, part section, and damage type according to the damage severity. However, since there is a possibility that multiple damage severities exist for one type of damage (e.g., a case in which the length and width are recorded), the handling method determination criterion can be set by combining multiple damage severities under AND/OR conditions. Based on the damage type, the damage severity, and handling method determination criterion abstracted as described above, the handling method determination criterion for the record item and the determination results are set (**Figure 1**). When conducting an inspection, by recording the damage location on the part drawing and inputting the damage severity of the recorded damage, the handling method for the damage in question can be automatically determined based on the handling method determination criterion set in advance (**Figure 2**).

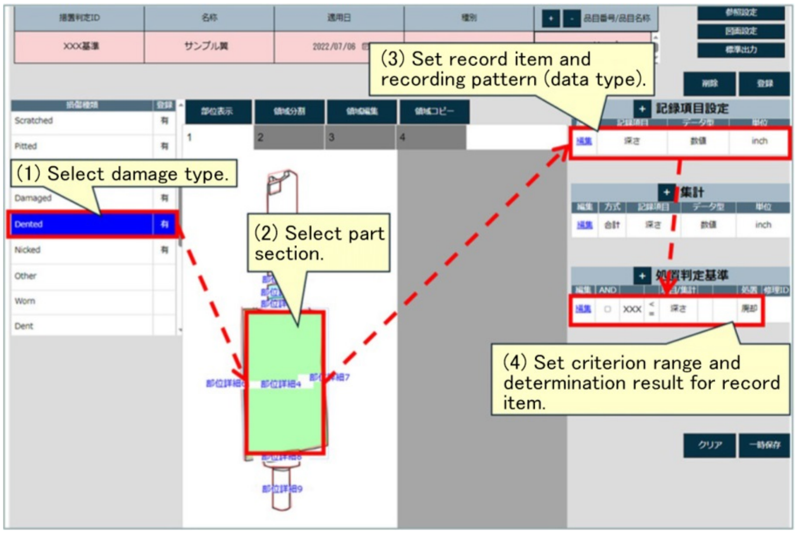

Figure 1 Screen for setting criterion range and determination result for damage record item

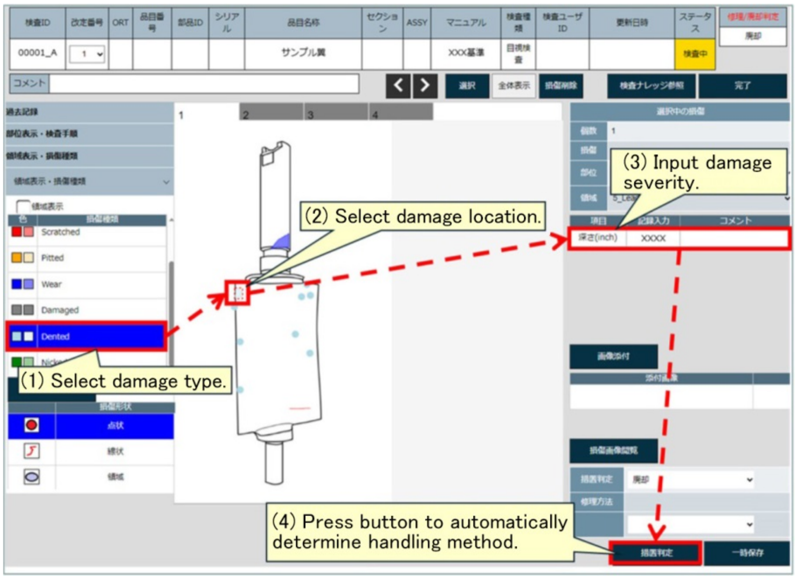

Figure 2 Screen for automatically determining handling method

2.2 Technology to indicate inspection order based on accumulated damage records

In order to improve the inspection efficiency by using the database of damage information described in Section 2.1, it is necessary to early locate damage to the part under inspection that leads to making a decision to discard the part. A decision to discard the part is made in the case where the damage severity exceeds the discard criterion or in the case where the total repair cost for each section of the part exceeds the specified limit. The inspection order for early finding damage that leads to making a decision to discard the part relies on the inspector's experience and intuition, and it is difficult for inexperienced inspectors to design an inspection order for making an early decision to discard the part. Therefore, we have developed a method to generate an inspection order with which damage to the part under inspection that leads to making a decision to discard the part can be found early based on the accumulated past damage records. **Figure 3** shows an overview of the developed inspection order calculation method.

The inspection order Xi with which damage to the part under inspection that leads to making a decision to discard the part can be found early is an inspection order with the smallest expected necessary inspection time value E(Xi). The expected necessary inspection time value E(X) is formulated in terms of the probability p(n) for each section (inspection unit) of the part under inspection that damage leading to making a decision to discard the part would be found and the cumulative inspection time T(n). The P(n) is calculated for the above-mentioned two cases that lead to making a decision to discard the part based on the past damage records. In addition, by including the T(n), the quickest inspection order that considers not only the probability for each section that damage leading to making a decision to discard the part would be found, but also the time can be obtained. Since the calculated time varies greatly depending on the N, number of inspection sections, the E(X) is calculated by an algorithm that combines a round robin calculation method and an optimization calculation method (random multi-start method and local search method), in consideration of the inspection time. Indicating the inspection order calculated by the above-mentioned developed method on the damage record screen (**Figure 4**) allows the inspector to perform the inspection of the part to be inspected in the optimal inspection order and to make a decision to discard the part earlier than before by indicating the inspection order calculated, which leads to a reduction in inspection time.

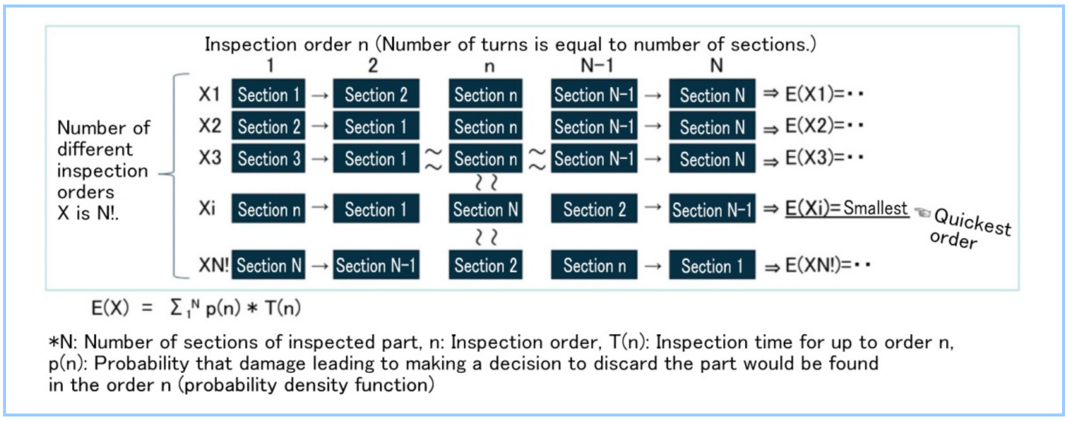

Figure 3　Overview of inspection order generation method

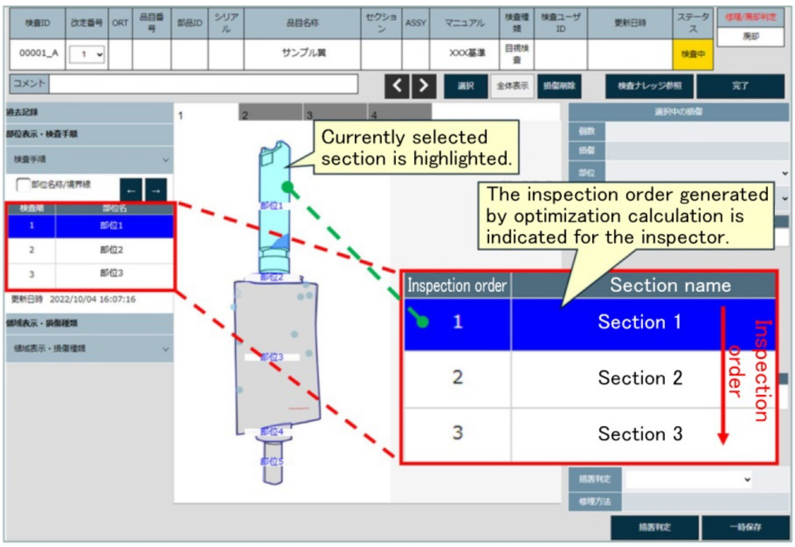

Figure 4　Screen for optimum inspection order indicated on damage record

3. Results of trial application to inspection operation

We made a trial application of the damage recording and handling method determination criterion technology and the inspection order technology to the inspection operation of two types of our in-house products. In this trial, two parts for the handling method of which would be "no action required" and for "discard" were prepared beforehand for each of the two types. **Figure 5** shows the results of measuring and comparing the inspection work time by the conventional method and by the developed technology. From the results for both part types, we confirmed that the inspection time could be reduced by applying the developed technology compared to the inspection time by the conventional method.

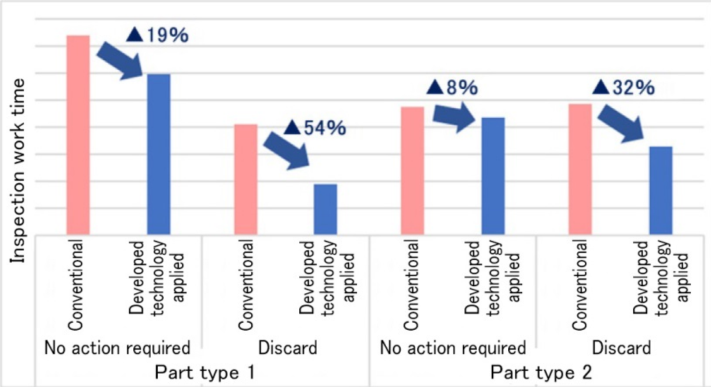

Figure 5 Comparison of inspection work time by conventional method and by developed technology

4. Conclusion

To shorten inspection time in the parts repair service business, we have developed a technology to record damage information and determine the handling method that automatically makes a decision to discard or repair the part, and a technology to indicate an inspection order that dynamically calculates the optimal inspection order and provides the inspector with it. We made a trial application of these technologies to our in-house product inspection operation and confirmed that these technologies are effective in improving the efficiency of the inspection operation.

Going forward, we will deploy these developed technologies in our parts repair service business to improve the efficiency of our inspection work, which will contribute to the earlier delivery time of parts received from customers.

References

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