News Release

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SANYO SPECIAL STEEL

Development of Cleanliness Evaluation Technology for Greatly Improved Reliability of Special Steel Products

—Contributing to Smaller and Lighter Machine Parts toward Carbon Neutrality—

Sanyo Special Steel Co., Ltd. (Representative Director and President: Higuchi Shinya; Head Office: Himeji) has developed new cleanliness evaluation technology capable of greatly improving the reliability of special steel products.

This technology establishes a method for quickly and accurately measuring the cleanliness of special steel (which is a measure of small traces of unavoidable nonmetallic inclusions in steel) which impacts the reliability of bearings and other machine structural parts. By combining this method with the extreme value statistics method, Sanyo Special Steel has made it possible to estimate the size of the largest inclusion in steel with an unprecedented level of accuracy.

The contributions expected from this technology include the development of manufacturing technology that further improves the cleanliness of special steel products, and the optimization of part designs based on quantitative predictions of fatigue strength as derived from the size of the largest inclusion.

As carbon neutrality drives the widespread use of wind power generation, bearings, which are a key component, will require an even higher level of reliability.

■ Development Background

The needs for further improvements to the reliability of special steel products are becoming increasingly strong against the backdrop of initiatives aimed at carbon neutrality, such as the push for electrified automobiles and the expansion of wind power generation. Sanyo Special Steel has already established steel manufacturing technology that boasts the world's highest level of cleanliness for reducing nonmetallic inclusions in steel. However, raising that reliability to the next level calls for the development of manufacturing technology that further reduces the size of inclusions that can become the starting point for fatigue fracture. When developing technology, the methods and technology for evaluating the current status and improvement benefits with high accuracy are indispensable. Moreover, because the probability that large inclusions will exist in a given volume is low, it is necessary to examine a larger volume to achieve high accuracy evaluations. Nevertheless, it is difficult to quickly and accurately evaluate the largest inclusion, including its size and type, with the current widely used methods for evaluating cleanliness, such as microscopic observation (microscopy) and ultrasonic testing. Additionally, the method for measuring the largest inclusion on the fractured surface exposed through means of fatigue testing is ill-suited to examinations of large-volume test pieces because of the difficulty of fracturing test pieces unless they are small.

■ Key Points of Development

Sanyo Special Steel overcame these problems by developing the technology for quickly and accurately measuring the largest inclusion in steel for evaluating larger volumes. This technology uses an enlarged proprietary test piece, and a proprietary method for causing rapid fatigue fracture by combining hydrogen-induced embrittlement with ultrasonic fatigue testing. By applying the extreme value statistics method to the measurement results of multiple tests using this method, it is now possible to estimate the size of the largest inclusion potentially found in steel with unprecedented accuracy.

It can be expected that this will allow us to help our customers optimize their part designs (see Note) through the development of manufacturing technology that affords further reliability improvements to our special steel products, and quantitative fatigue strength predictions based on the size of the largest inclusion.

Note: Mechanical parts subject to heavy loads such as bearings and drivetrains are designed so as to avoid short-life risks posed by breakage or the like by weighting the assumed maximum stress with a specific safety factor. Quantitative predictions of fatigue strength in special steel, the raw material for these products, improves its reliability and thus enables this safety factor to be reviewed (or, reduced), which leads to smaller and lighter part designs.

Amidst strong calls around the world for reduced CO_2 emissions aimed at achieving carbon neutrality, we will strive to develop and supply more reliable special steel products by making active use of this newly developed evaluation technology, and contribute to the improved energy efficiency of automobiles and the expanded use of wind power generation and other carbon-free power sources through the use of smaller and lighter parts.

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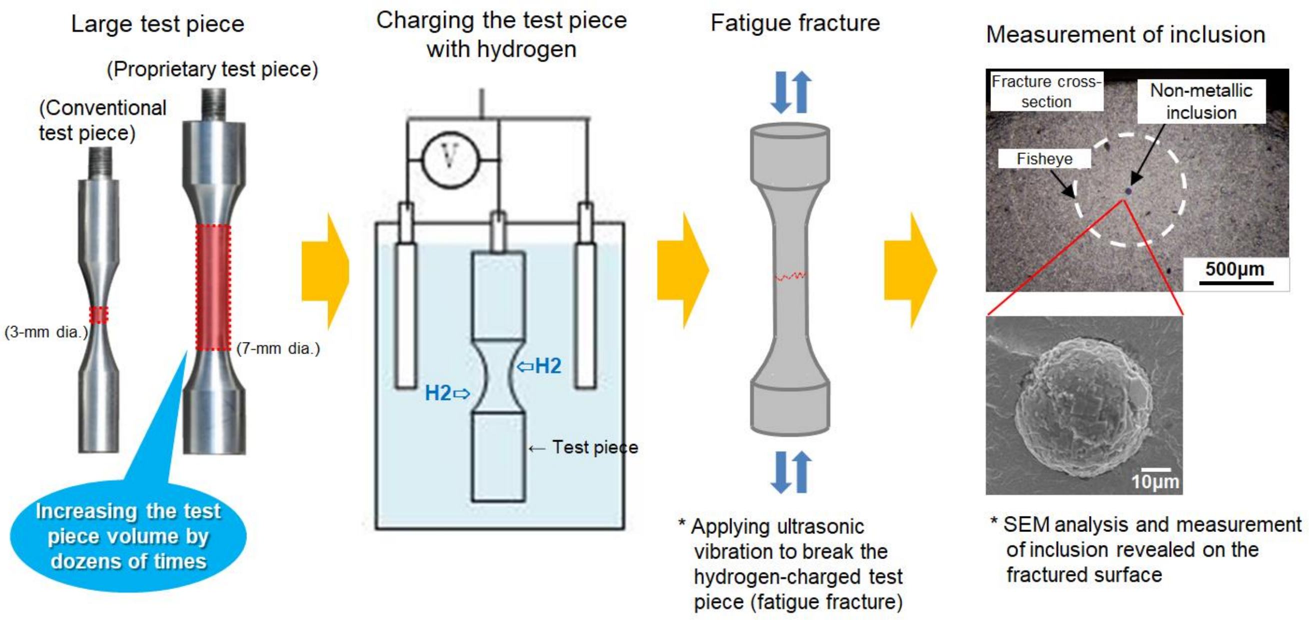
[Reference information]

(Table) Comparison of Existing Evaluation Method and Sanyo Special Steel's Evaluation Technology for Inclusions

	(Existing inclusion evaluation method)			Our proprietary technology (Fractured surface observation of large test pieces)
	Microscopy (Micro testing)	Ultrasonic testing (Macro testing)	Fractured surface observation (Micro testing)	
Summary of evaluation method	1. The polished surface of a test piece is observed with an optical microscope. 2. The size and other properties of the detected inclusion are measured. 3. Based on a plurality of the above measurement results, the size of the largest inclusion within a given volume is estimated using the extreme value statistics method.	1. Ultrasonic waves are irradiated into steel and other materials by an ultrasonic detector. 2. The reflected echo waves are analyzed and the size and distribution of inclusions in steel and other materials are detected.	1. Fatigue fracture (breakage) of the test piece is induced by ultrasonic vibration or other means, which reveals the largest inclusion in the evaluation volume. 2. An electron microscope or the like is used to analyze the size, type, and other properties of the inclusion on the broken surface. 3. Based on a plurality of the above results, the size of the largest inclusion within a given volume is estimated using the extreme value statistics method.	1. The proprietary test piece is charged with hydrogen. 2. Fatigue fracture (breakage) of the hydrogen-embrittled test piece is induced by ultrasonic vibration, which reveals the largest inclusion in the evaluation volume. 3. An electron microscope is used to analyze the size, type, and other properties of the inclusion on the fractured surface. 3. Based on a plurality of the above results, the size of the largest inclusion within a given volume is estimated using the extreme value statistics method.
Speed	**Fair** Because the observation range is limited, an enormous number of observations is required to measure large inclusions that have a low probability of existence.	**Good** Quick detection of large inclusions over a broad range	**Good** Fatigue fracture of the test piece reveals the largest inclusion in the evaluation volume on the fractured surface.*	**Good** Fatigue fracture of the test piece reveals the largest inclusion in the evaluation volume on the fractured surface.*
Accuracy	**Good** Microscopy allows for accurate measurements.	**Fair** Non-destructive inspection does not lend to accurate identification of the size and type of inclusion. The sizes of inclusions that can be detected are also limited. (Very small inclusions are difficult to detect.)	**Good** Inclusions that appear on the fractured surface can be measured accurately.	**Good** Inclusions that appear on the fractured surface can be measured accurately.
Evaluation volume	**Fair** Because the observation range is limited, an enormous amount of test piece observations is required to evaluate large volumes.	**Good** Macro inspections enable evaluation of the entire steel piece	**Fair** Test piece must be small enough to be fractured to reveal the inclusion.	**Good** Hydrogen charging makes it possible to easily fracture even large-size test pieces to reveal the inclusion.

* Repeatedly applying load to the test piece with ultrasonic vibration or other means causes fatigue fracture that originates where the largest inclusion exists within the evaluation volume.

(Figure) Cleanliness Evaluation Process Developed by Sanyo Special Steel



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