

Nondestructive Inspection by Phased Array Ultrasonic Method for Steel Structures[†]

1. Introduction

In rolling mills, reduction gears of overhead traveling cranes, and other critical large-scale equipment in steel works, there has been an increasingly strong need in recent years to avoid decrease in production and reduce inspection costs by undismantling inspections, in which this equipment is inspected from the outside without dismantling. In place of the conventional ultrasonic method, the JFE Group developed an evaluation method which enables remote crack inspection from the shaft end, even in shafts with different diameters or shaft fittings, using the phased array ultrasonic method*, and is now expanding the application of this technology. A phased array ultrasonic device is shown in **Photo 1**.

2. Measurement Principle and Features

2.1 Measurement Principle

In conventional ultrasonic testing, flaw detection was performed with one transducer/transduce element per probe/search unit. Therefore, as shown in **Fig. 1**, only a 1-dimensional display was possible when a crack was detected.

With the phased array ultrasonic method (**Fig 2**),

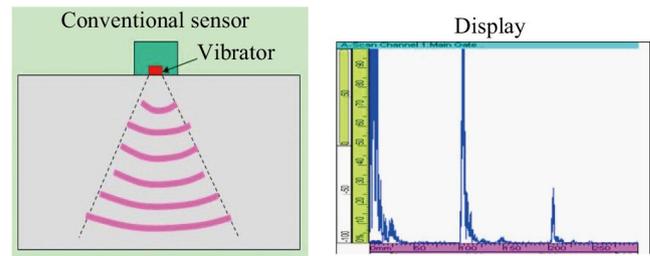


Fig. 1 Conventional ultrasonic testing

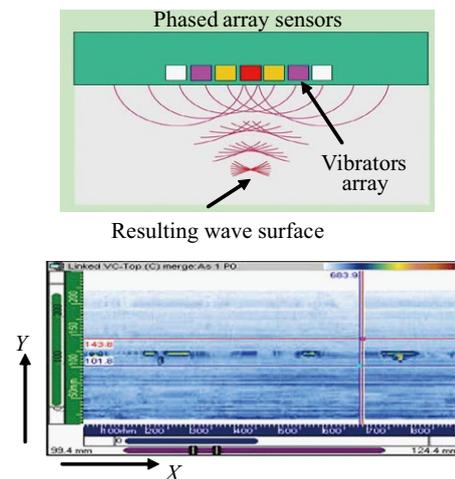


Fig. 2 Phased array ultrasonic testing

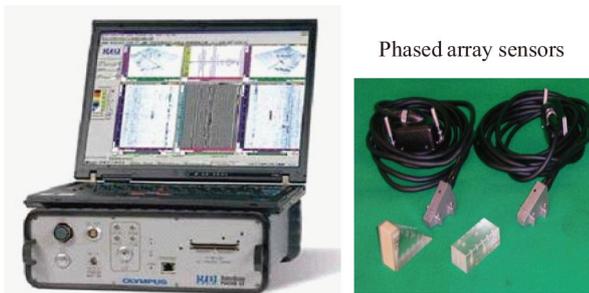


Photo 1 Phased array ultrasonic device

the probe/search unit comprises multiple transducer/transduce element arranged along a straight line, and the ultrasonic beam can be collected from an arbitrary inspection position by controlling delay time of each transducer/transduce element when transmitting ultrasonic waves. As a result, not only the crack position, but also its length, width, depth, etc. can be confirmed from a 2-dimensional image.

2.2 Features

The features of the phased array ultrasonic method are arranged below.

- (1) Has excellent directivity, and remote crack inspection is possible (can detect cracks with height 3 mm × length 30 mm at range of 1 000 mm).
- (2) The direction of ultrasonic beam can be changed freely, and the same defect can be detected from mul-

[†] Originally published in *JFE GIHO* No. 27 (Feb. 2011), p. 56–57

*The crack detection technology for parts with different diameters from the shaft end using the phased array ultrasonic method was developed jointly by JFE Steel Corp. and S.H.I Examination & Inspection, Ltd., and a patent application has been filed (Jpn. Kokai 2008-256624: Ultrasonic testing method for shaft members, ultrasonic testing method and ultrasonic testing system).

tiple positions, providing high crack detection capacity.

- (3) The shape and size of flaws can be judged easily by image processing.
- (4) Flaw detection of stainless steel welding points, casting steels, and other objects for which it is difficult to acquire ultrasonic wave profiles due to high attenuation is possible.

In particular, in the conventional method, crack inspection of different diameter parts of axial (shape) objects had been performed by dismantling the equipment and conducting ultrasonic inspection from a close distance. In contrast, use of the phased array ultrasonic method enables remote diagnosis from the shaft end.

3. Record of Use in Steel Works

3.1 Examples of Application

Table 1 shows examples of application of the phased array ultrasonic method in steel works.

3.2 Example of Inspection of Shaft with Different Diameters

Figure 3 shows an example of undismantling inspection of a shaft with different diameters.

3.3. Example of Inspection of Bolt Screw

Figure 4 shows an example of undismantling inspection

Table 1 Phased array ultrasonic testing application

Equipment	Content of inspection
Blast furnace	1. Tuyere hot blast injection tube: Weld point crack inspection 2. Conveyor pulley side plate: Weld point crack inspection
Crane	1. Main hoisting reduction gear shaft: Crack inspection 2. Winding drum side plate: Weld point crack inspection Ditto: Crack inspection of part with different diameters
Rolling mills	1. Roll drive shaft universal joint crossing shaft bearing: Crack inspection of fixing bolt 2. Universal joint: Weld point crack inspection 3. Screw down device: Crack inspection of bore 4. Screw down shaft: Crack inspection
Plate mill	1. Shearing shaft: Crack inspection 2. Descaling pipe: Weld point crack inspection
Wide flange mill	Breakdown mill pinion box fixing bolt: Crack inspection
UOE mill	Inner welder traveling wheel shaft: Crack inspection
All plants	Many examples of application, e.g., weld point crack inspection of frames, hydraulic cylinder supporting shafts, and other steel structures

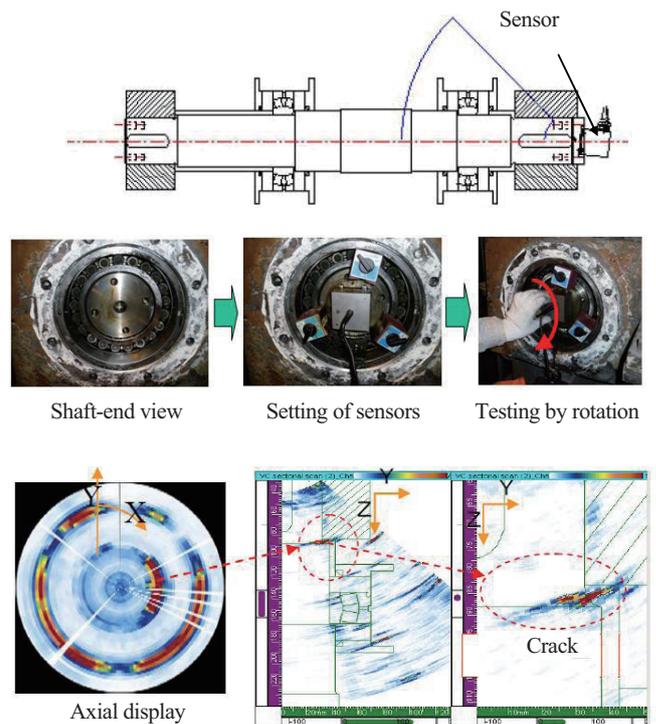


Fig. 3 Example of phased array ultrasonic testing from shaft-end

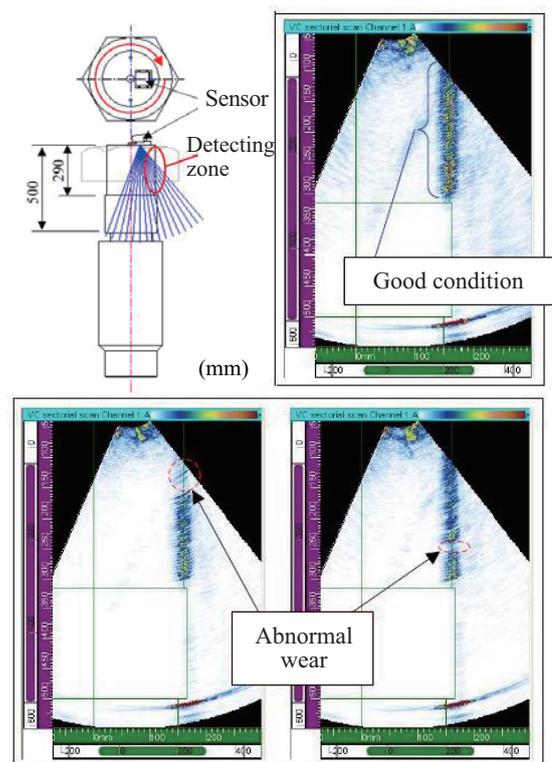


Fig. 4 Example of phased array ultrasonic testing for bolt screw

tion of a bolt screw part.

4. Conclusion

The JFE Group has realized accurate assessment of the condition of structures, prevention of serious trouble,

and optimization of maintenance costs using the phased array ultrasonic method, thereby enabling closed inspections of large-scale equipment.

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