

## Principal Research Results

# Development of Advanced Ultrasonic Inspection System for High Energy Steam Piping

### Background

Type IV creep damage in welded high energy piping has been an industry problem over the years. Creep damage generally occurs in the weld metal itself or, more prevalently, in the heat affected zone (HAZ) of the base metal. The time of Flight Diffraction (TOFD) technique has come to be put into practical use because of its high accuracy of defect sizing. However, the TOFD technique can not detect cracks initiated in the HAZ, discriminating between inherent weld defects and cracks in the HAZ. Phased array techniques offer a means to reduce the scanning time by using an array probe instead of many different conventional probes and by simplifying the scan pattern. The automated, combined TOFD/phased array approach can be expected to be economical and reliable because it can be implemented quickly and can detect the crack with high accuracy.

### Objectives

The objective of this study is to develop an advanced ultrasonic inspection system to demonstrate the applicability of TOFD and phased array techniques to the detection and sizing of crack, and to develop a defect characterization approach in the HAZ in welded high-energy piping.

### Principal Results

1. The TOFD technique provided excellent measurement accuracy for height of surface/midwall cracks in the HAZ, while the phased array technique provided the location of cracks. By considering the above and the volumes of detection coverage as shown in Figure 1, a high accuracy defect sizing approach has been developed and can discriminate between inherent defects and cracks.
2. An advanced seam weld inspection system using combined TOFD and phased array techniques has been developed as shown in Figure 2. The combined approach is much more rapid and effective in discriminating between inherent and malignant defects, such as fabrication defects and type IV cracks, than the TOFD approach combined with pulse echo techniques. The use of this system makes it possible for the scanning time to be reduced by a factor of sixty.

### Future Developments

The approach proposed in this study will be applied to welded test specimens simulating actual piping with defects in the weld and HAZ, and will be validated.

**Main Researcher:** Hiroyuki Fukutomi, Ph.D.,

Research Scientist, Structural Materials Characterization Sector, Materials Scientist Research Laboratory

### Reference

- H. Fukutomi, et al., 2003, "Use of Ultrasonic Nondestructive Evaluation of Cracking in Thick-walled Piping: Part I", CRIEPI Report, T02048 (In Japanese)
- H. Fukutomi, et al., 2004, "Use of Ultrasonic Nondestructive Evaluation of Cracking in Thick-walled Piping: Part II", CRIEPI Report, T03071 (In Japanese)

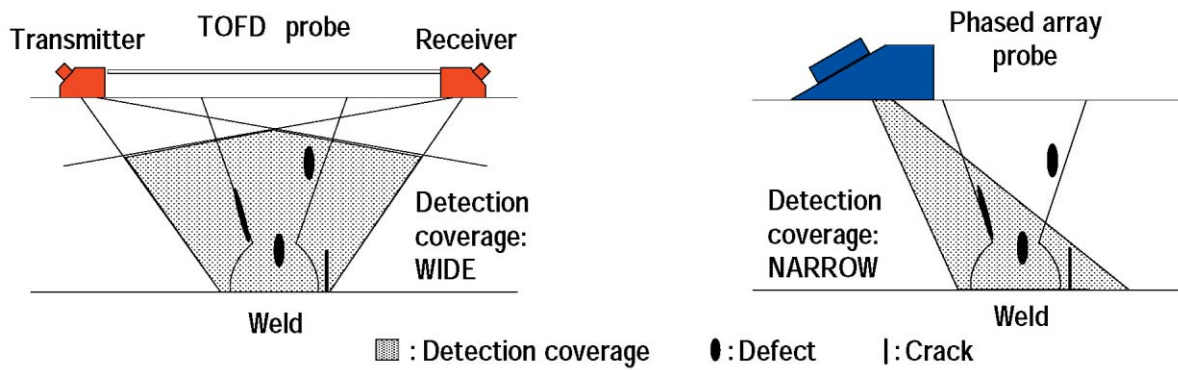


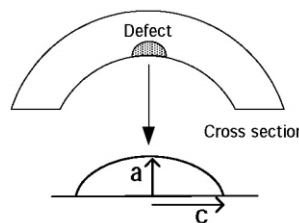
Fig.1 Volumes of coverage of TOFD and phased array techniques

Table Improvement of accuracy by combined array approach

	Measurement error (mm) *			
	Dimensions		Locations**	
	Height	Length	A	C
TOFD	0.36	4.42	-	1.44
Phased array	0.39	1.58	0.35	0.51
Combined	0.36	1.58	0.35	0.51

\* Root mean square error

\*\* Circumferential weld, A: Axial direction, C: Circumferential direction



1. Thickness of test specimen : 50mm
2. Inner surface crack like defect :
  - Semi-elliptical shape
  - Aspect ratio  $a/2c=0.2$
  - Dimensions (mm)  
Height(a), Length(2c)  
1, 5  
2, 10  
3, 15  
5, 25

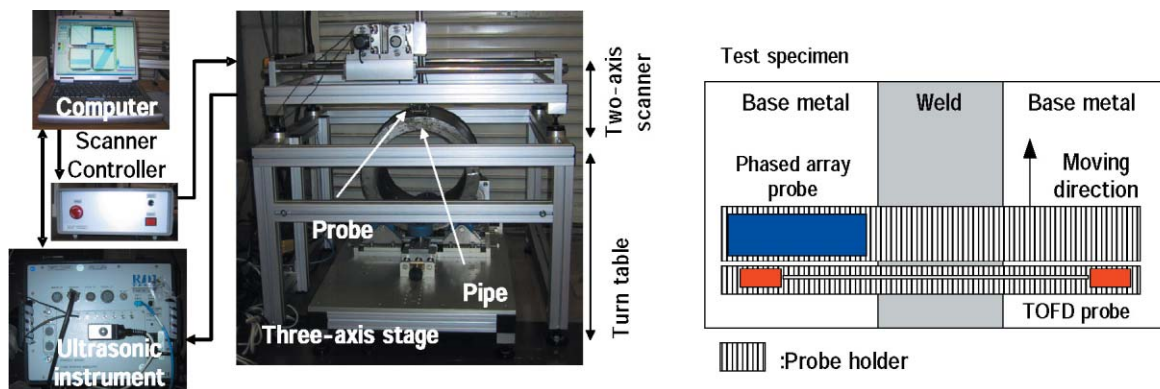


Fig.2 Advanced ultrasonic inspection system