한국산학기술학회논문지
Vol. 8, No. 2, pp. 226-231, 2007

Development of Image Processing Software for UT-NDE of Steam Generator of Nuclear Power Plant

Young-Seock Lee[1*] and Myoung-Woo Nam[2]

핵발전소 증기발생기의 초음파 비파괴 평가를 위한 영상처리 소프트웨어 개발

이영석[1*], 남명우[2]

Abstract This paper describes a development of ultrasonic examination analysis software to analyze steam generator of nuclear power plant. The developed software includes classical analysis method such as A, B, C and D-scan images. This software provides the information of shape, depth, size and position of flaws. To do such, we obtain raw data from specimens and/or real pipeline of power plants and, modify the obtained ultrasonic 1-dimensional data according to prepared software design schedule. The developed analysis software is applied to specimens containing various flaws with known dimensions. The results of applications showed that the developed software provided accurate and enhanced images of flaws on various specimens.

Key Words : ultrasonic examination analysis, nuclear power plant, A, B and C scan images

요 약 본 논문은 핵발전소의 초음파 비파괴 평가를 수행하기 위하여 구현된 초음파 신호 분석 소프트웨어에 관한 것이다. 구현된 소프트웨어는 1차원 초음파 신호뿐만 아니라 이를 가공하여 B, C 및 D 스캔 영상으로의 확장이 가능하고 각 스캔 영상으로부터 의미 있는 파라메터를 측정할 수 있는 기능을 갖추고 있다. 구현된 소프트웨어는 이미 알고 있는 시편의 결함에 적용하여 프로그램의 정확성을 검증하였다.

1. Introduction

Ultrasonic examinations can be conducted prior to material being put into service to identify processing type discontinuities or after being put into service to detect service related discontinuities. This is highly beneficial as material deficiencies can be identified prior component failures or subsequent processing problem.

When an ultrasonic wave encounters an internal reflector, several interactions take place between it and wave. These interactions result in a complex phenomenon based on flaw geometry, frequency and angle incidence of the wave among other variables as in fig. 1. The obtained ultrasonic signal patterns contaminated with speckle noises and system noises, etc [1].

So the observer who measures size, depth and shape of flaw, is lead to confusion for decision of flaw or non-flaw. In order to clear decision of existence of flaw, observer requires more information about status of flaw. From this point of view, various scan types are developed such as A, B, C and D-scan. As a minimum, these views include a single plan B-scan image, composite C-scan image and composite D-scan image. Illustrations of views are provide in figure 1 and are defined as [2]:

- A-scan: the ultrasonic data is generated and presented with time on X-axis.

This research is supported by Chungwoon university research fund in 2004.

[1]Dept. of Digital Broadcasting & Electronics Eng., Chungwoon Univ.
[2]Dept. of Electronic Design and PCB, Hyejeon College
*Corresponding author : Youngseock LEE: (yslee@chungwoon.ac.kr)

- B-scan: the ultrasonic data is generated and presented with the scan direction on X-axis, time on the Y-axis, and index direction on the Z-axis.
- C-scan: the ultrasonic data is generated and presented with the scan direction on X-axis, index direction on the Y-axis, and time on the Z-axis.
- D-scan: the ultrasonic data is generated and presented with the time on the X-axis, index direction on the Y-axis, and the scan direction on the Z-axis.

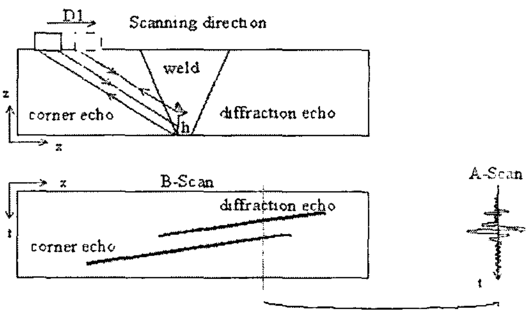


Fig 1. Ultrasonic Examination

2. Functions of Analysis software

To design analysis software, various requests are discussed with engineers in ultrasonic evaluation fields. The analysis part of A-scan includes an absolute value of RF signal, maximum value of observed signal, FFT routine, the part of B, C and D-scan includes the measure tools of distance, depth and size of flaw, and also zoom in/out tool, color palette tool, etc. All analysis parts are controlled by system file which has all parameter information about the obtained and modified ultrasonic signal such as gate, material velocity time of flight, location of flaw and angle of transducer[3,4,5].

The location of flaw in the material can be accurately calculated using known and measured parameters. The angle at which the energy is transmitted in the material is a known as it can be accurately measured. The time of flight of the energy in the in the material can be accurately measured. Material velocity is known. Therefore using time of flight, material velocity, and such unit angle the location of flaws can be identified. Table 1 shows the design schematics to develop software.

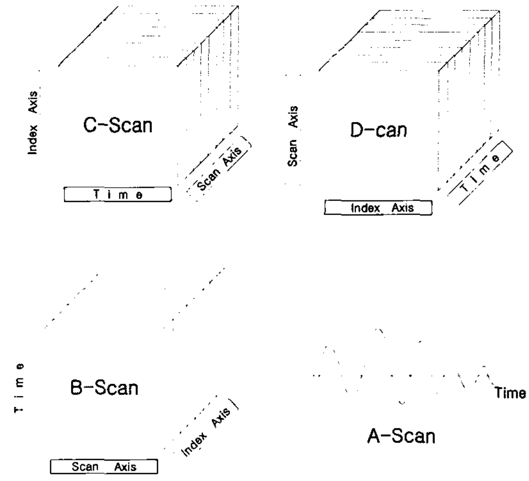


Fig 2. Schematic review of A, B, C and D scan images in the developed software

In the Table, the shape extraction and edge detection routines applied high pass filter(Sobel algorithm) and the size evaluation routine is direct calculation from image data. And also the area calculation routine was resulted in direct calculation based on the shape extraction and size evaluation routine. The scan triggering tool means that the position of each scan is synchronized by movement of coordinate of C-scan image. Color palette designed for manual color control by user and it has default color palette. The manual gate can use for manual gating the all images or signal and it has distance, size, depth, area calculation routines in gated interval.

By [2], the B-scan, C-scan and D-scan cab be adjusted to present either a single plane image or a composite image. A single plane image presents a single slice of Z-axis data in a single view. The single plane image provides the advantage of high resolution.

However, only a limited amount data is presented its effectiveness. The composite image presents multiple Z-axis single plane images together as a single composite image. The content of the composite image is controlled by gating the Z-dimension data within that view. This view provides a rapid method of identifying flaws contained in the data and their extents. However, it sacrifices resolution. Both of this image types are generated for use in this data analysis method.

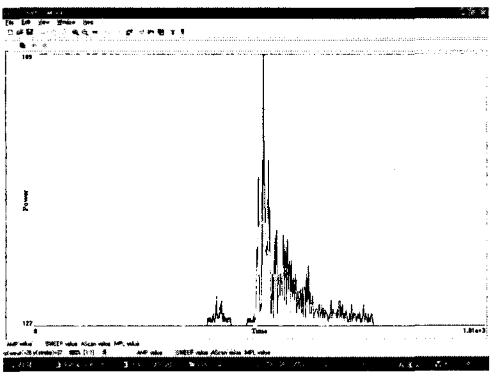
Table 1. Image Processing Functions in each scans

	A-scan	B-scan	C-scan	D-scan
MAX value	O	O		O
FFT	O			O
Distance	O	O		O
Depth	O	O		O
Shape	O	O	O	O
Size	O	O	O	O
Edge	O	O	O	O
Area	O	O	O	
Color	O		O	
Scan	O		O	O
Gate	O		O	O
Trigger	O		O	
System				
▪ File name ▪ Date/Time ▪ transducer ▪ gate				
▪ A/D conversion rate ▪ Annotation ▪ File length				

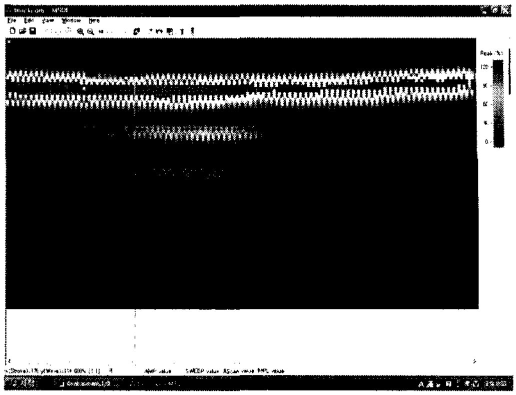
3. File structure

The file system of our analysis software is organized 7 files which are following as:

- System file: All information about data acquisition is contained
- RF file: Raw A-scan data obtained from transducer is contained.
- C-scan file: The C-scan data related to the obtained RF data is contained.
- Analysis file: Analysis result of underlying RF data is contained.
- Palette file: Color information about image representation of underlying data is contained.
- Zoom file: Zoom-in and zoom-out images of underlying data are contained.
- Note file: Palette file: Color information about image representation of underlying data is contained.

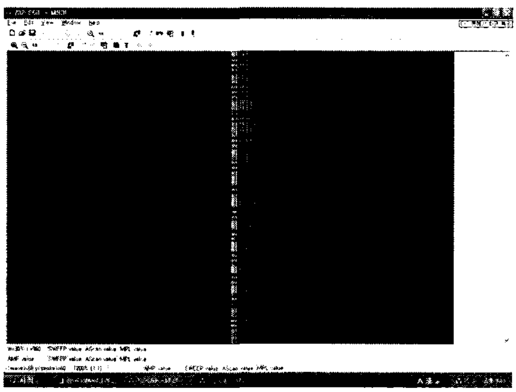


(a)



(b)

(c)



(d)

Fig 3. mono- mode display of analysis software, (a) A-scan image, (b) B-scan image, (c) D-scan image and (d) C-scan image

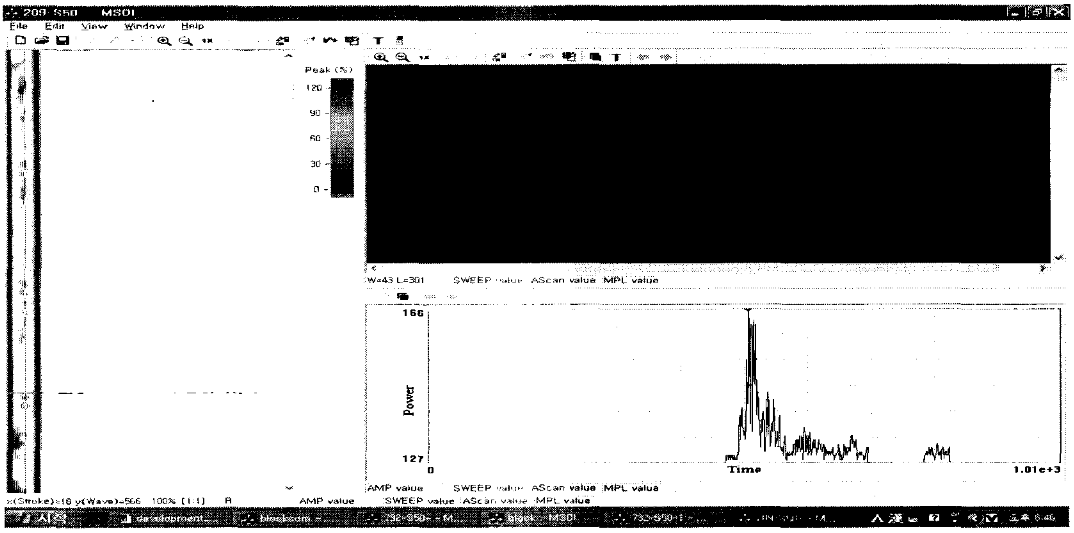


Fig 4. Sub-window mode of analysis software, A, B and C-scan images or A, B and D-scan images are represented on full screen.

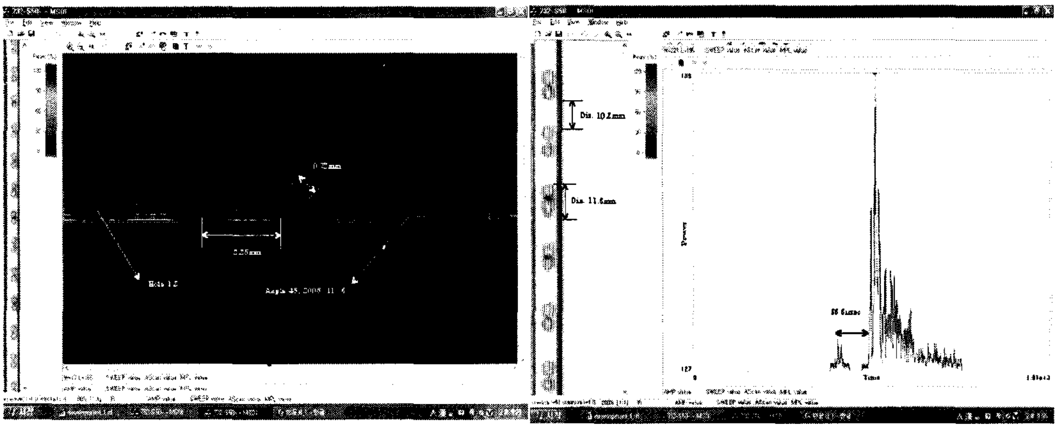


Fig 5. Evaluation of measurement function. Analysis software includes measurement functions such as depth(B-scan), interval(C-scan), time(A-scan) and distance(All scans).

4. Screen arrangement of scanned images

The window space of our analysis software is separated 3 sub-windows. Each sub-window represents an A, B and C-scan image and also the sub-window of B-scan image alternates between B and D-scan image.

5. Performance of analysis software

To verify the developed analysis software, it is applied to examination of various known specimens. Fig.3 shows mono-mode of analysis software which is assigned to only one scan image in full screen of monitor.

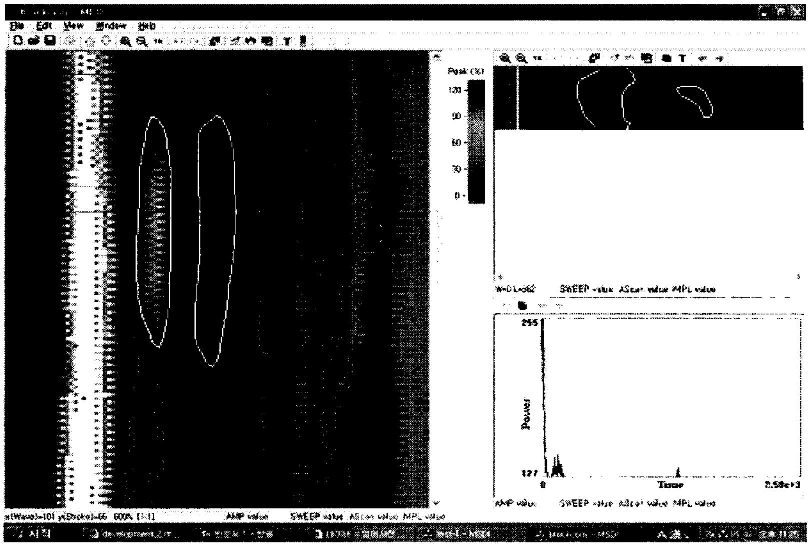


Fig 6. Edge detection and area calculation procedure, the white lines are results of edge detection algorithm and the interior part of closed loop is area calculation results.

In order to observe 3 types of images, our analysis software can separate window screen to 3 sub-windows as shown figure 4.

To evaluate functions of analysis software, we prepared a known test block as specimen and the obtained data analyze from the software. Figure 4 (a) and (b) show analysis procedure. The arrow lines denote the interval of two points and the characters denote results of calculation about the depth and distance between two points.

One of the properties of developed analysis software is possible to perform area calculation through edge detection algorithm. Figure 5 shows the edge detection procedure and area calculation procedure in crack. The result of area calculation depends on area of crack as object. In experiment the performance of area calculation tolerates ±15% error ranges.

6. Conclusion

In this paper, we design and implement the analysis software to evaluate ultrasonic nondestructive testing for power plant. The developed software displays A, B, C and D-scan images of flaw and also includes measurement functions which can analyze and calculate the depth, size and shape of flaw. In experiment to verify the developed analysis software, Good performance is proved for prepared specimen. Further study is to apply real NDE filed and complete adding 3-dimensional image of flaw in analysis software.

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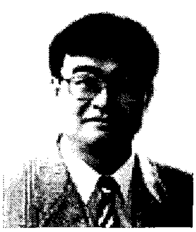
Young-Seock Lee [Regular Member]



- Feb. 1993 : Dept of Electronics Engineering, University of Seoul(bachelor)
- Feb. 1995 : Dept of Electronics Engineering, University of Seoul(Master of Engineering)
- Feb. 1998 : Dept of Electronics Engineering, University of Seoul (Ph. D)
- Mar. 1998- : Dept. of Digital Broadcasting & Electronics(Professor)

<Interesting Area> : Embedded system, SoC, Image Processing

Myung-Woo Nam [Regular Member]

- Feb. 1992 : Dept of Control & Measure Engineering, University of Seoul(bachelor)
- Feb. 1994 : Dept of Electronics, University of Seoul(Master of Engineering)
- Feb. 2001 : Dept of Electronics, University of Seoul(Ph. D)
- Feb. 2003 : LG Inno Technology(Senior researcher)
- Mar. 2003 - : Dept. of Digital Electrical Design, Hyejeon College(Professor)

<Interesting Area> : Voice Recognition Signal Processing, Circuit Design