Determination of Flaw Type and Location Using an Expert Module in Ultrasonic Nondestructive Testing for Weld Inspection

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Determination of Flaw Type and Location Using an Expert Module in Ultrasonic Nondestructive Testing for Weld Inspection

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Abstract. Nondestructive evaluation is explained as nondestructive testing, nondestructive inspection, and nondestructive examination. It is a desire to determine some characteristic of the object or to determine whether the object contains irregularities, discontinuities, or flaws. Ultrasound based inspection techniques are used extensively throughout industry for detection of flaws in engineering materials. The range and variety of imperfections encountered is large, and critical assessment of location, size, orientation and type is often difficult. In addition, increasing quality requirements of new standards and codes of practice relating to fitness for purpose are placing higher demands on operators. Applying of an expert knowledge-based analysis in ultrasonic examination is a powerful tool that can help assure safety, quality, and reliability; increase productivity; decrease liability; and save money. In this research, an expert module system is coupled with ultrasonic examination (A-Scan Procedure) to determine and evaluate type and location of flaws that embedded during welding parts. The processing module of this expert system is implemented based on EN standard to classify welding defects, acceptance condition and measuring of their location via echo static pattern and image processing. The designed module introduces new system that can automate evaluating of the results of A-scan method according to EN standard. It can simultaneously recognize the number and type of defects, and determine flaw position during each scan.

KEYWORDS: Ultrasonic Inspection, Expert Module System, A-Scan, Real-Time Signals, Echo-static Signal.

1. INTRODUCTION

A general definition of nondestructive testing (NDT) is an examination, test, or evaluation performed on any type of test object without changing or altering that object in any way ,in order to determine the absence or presence of discontinuities that may have an effect on the usefulness or serviceability of that object.[1] However the ultrasonic methods are still most popular because of its capability, flexibility, and relative cost effectiveness.[2] In industrial nondestructive evaluation (NDE) ultrasonic tests the ultrasonic waves travels in structural materials or components and the focus is often on evaluating flaws such as cracks while the results of the interaction of the sound with flaws can also be displayed as an ultrasonic image; a more common type of display used in industrial inspections is a received voltage versus time trace, VR(t), on an oscilloscope, called an A-scan. [2] Because of thoughtful tendency of industries to A-scan, some instructions have been offered by diverse standards such as ASME, AWS and EN to perform more accurate implementation and evaluation in the examination [3-7].

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Interpretation of ultrasonic NDT data can be a complex task, and interpreters must be highly skilled. When large engineering structures are inspected, the amount of data produced can be enormous, and a bottleneck can arise at the manual interpretation stage. Boredom and fatigue of operators can lead to unreliable, inconsistent results, where significant defects are not reported. There is therefore great potential for the use of computer systems to aid interpretation. If some of the tasks of the interpreter can be satisfactorily performed by computer systems, the overall process is made more reliable and the time required is reduced. Computer systems can aid interpretation in two ways: by processing the data and by improving its presentation [8]. Research groups have tried to establish special systems such as presenting hardwares and softwares or methods to play operator role in the assessments [9-11], doing researches on an ultrasonic NDT system for complex surface parts to achieve the goal, [12-13]. Systems have been introduced before, have several challenges. Some of them might be suitable just for corporations, applying B-scan or C-scan strategies to assessment, not A-scan. In addition, incompatibility between them and widespread software programs, being disable to detect flaws according to common standards in A-scan methods such as ASME, AWS and EN practical codes and being immoveable in some cases might be considered as other their disadvantages. In this study, an expert system with capability to find critical flaws in the welded components according to EN standard conditions (EN1712, EN1713, EN1714) or acceptance levels which are pointed out on contraction documents is presented. It should be noted that this software has been developed using Windows-XP-based MATLAB7.6.
Being able to warn the operator once serious defects are being detected is one of good characters of this system so that the operator can decide to stop the evaluation or continue it (time saving during detection). Furthermore, it is compatible with any operation system and A-scan ultrasonic instrument. It is also capable to drive signals exhibited on the monitors as images to the software (from the simplest to the most complex ones). In addition, it can determine type of defects using echo-static patterns (noted in EN1713) and image processing. In contribution to special pattern recognition and processing the images obtained from the screen, this opportunity is a very good in comparison with others studies that only work on real-time signals to processing or drawing 3D images of imperfection, they cannot struggle with signals exhibiting on the screen as images. At the end, must be noted the main assumption, there are no exhibited indication of the same defect in different signals acquired in various positions, i.e. each defect must appear itself indication on the screen images only one time. It has been easily to reach by setting scan parameters to suitable one. As illustrated in figure1 the probe position in second place is not true because defect1 (reflector1) interfere itself echoes in two screen images, while third position is a desired place because of respecting to the main assumption.

2. PROCEDURE PERFORMANCE OF SYSTEM

The following apparatuses are necessary for doing this research: PC, suitable connection ports between computer and ultrasound tool, an A-scan device with capability of capturing image, an ultrasound probe and a developed software. The main window of developed software can be seen in figure 2. Essential data and initial requirements which are necessary for this software is shown in figure 3. The ultrasound probe must be moved to drive the data. Meanwhile the software starts calculating, and if any non-acceptable defect is found, it will inform with showing a message on the computer monitor.

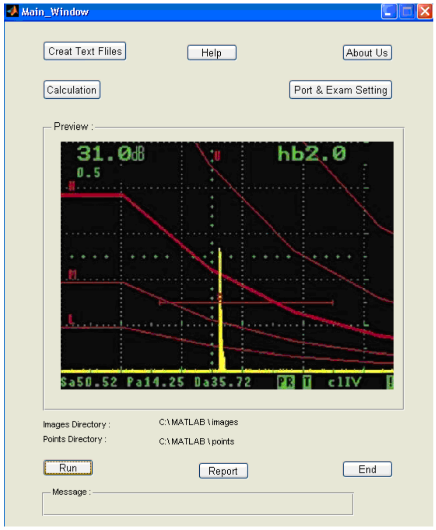


FIGURE 2. Main window of the developed software.

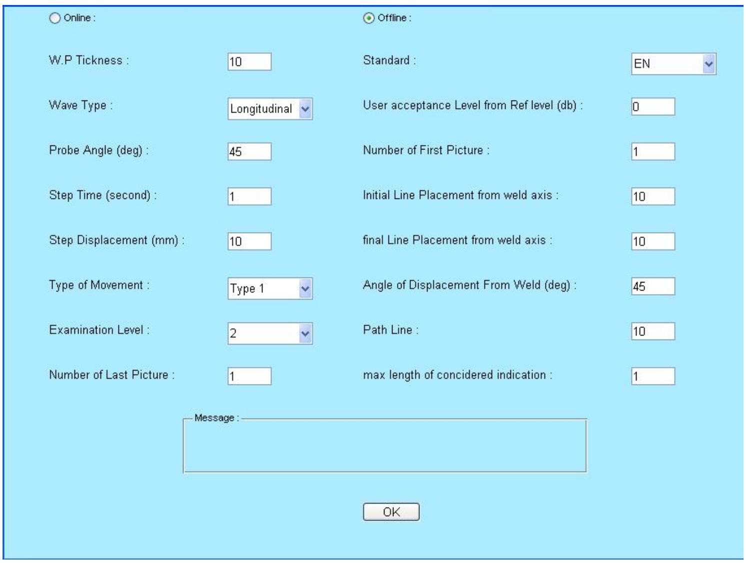
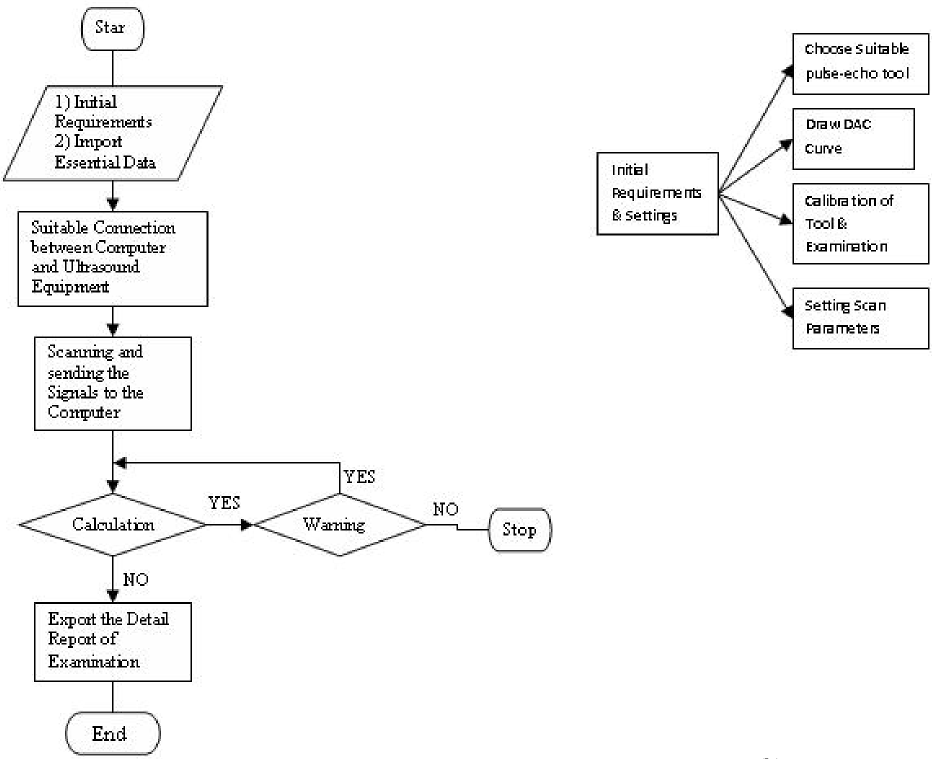


FIGURE 3. Parts of expert module software.

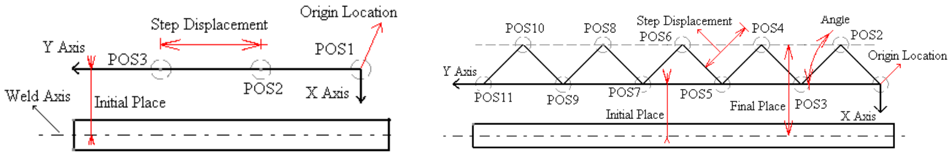
3. RESULS AND DISCUSSION

The aim of this study is to validate it for general uses, and to establish its value as a base for specialization in individual NDT applications. The system needs some initial requirements, first, the instrument must be calibrated. Second, images should be sent to this software. In addition, DAC curve must be drawn according to EN standard. The flow chains illustrate the working of the software as shown in figure 4. Interpretation of defects based on the image pattern of defect is difficult and requires an experienced specialist. However, by using the system developed in this project, the defect can be diagnosed easily. In this module the signal exhibiting on the monitor at probe places which depicted with (POS) symbol in figure 5 using a specific definition of coordinate system. The location of flaws will be determined according to initial position of probe, its origin location, step displacement and direction of probe scanning based on the system coordinate as shown in figure 5. Experiments were carried out for determination of defects in the weld block had prepared with special characters, joined by SMAW process and tested according to EN standard instructions, its thickness was 8 mm and weld section geometry before welding was V and its material, structural steel. The specimen is shown in figure 6. This module expert system adviser is used to diagnosis defects in the weld block.



(a) (b)

Figure 4. Algorithm for pattern recognition of weld defect a) Schematic flow chart for defect analysis b)Schematic flow chart for initial requirements



(a) (b)

FIGURE 5. Schematic measurement setup for one-dimensional scans: (A) Linear type (B) Zigzag type

FIGURE 6. Ultrasonic test for weld sample.

The final report shows detailed information of number, location, and types of both critical and acceptable imperfections. It is also able to classify the defects to planner and non-planner ones. A sample of results has been shown in Table1. The system struggles with some difficulties in practice. For instance, relying on scan parameters, optimization between two items of examination accuracy and time, can come out as a great problem. In other words, software calculation might be taken a longer time in comparison with others in few situations although analyzing defects, as well as identifying parameters attributing to defects, is highly accurate. For example, time examination for the same specimen decreased from 6 min to 8 min by changing step displacement form 5mm to 7 mm. However, it is able to process the data offline.

4. CONCLUSION

A methodology based on the development of an expert system is proposed which helps in realizing the most flaws that may be created during manufacturing (especially welding) of components. The designed module introduces new system that can automate evaluating of the results of A-scan method according to EN standard. It can simultaneously recognize the number and type of serious defects, then determine location of them in the component. Another advantage of this expert system is that user does not require having any in-depth technological knowledge regarding the applicability of the ultrasound testing method. Moreover, it relieves the user from committing any error while taking the decision regarding the evaluating result of ultrasonic examination. Therefore, it would increase productivity.

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TABLE 1. The Results of defect recognize using expert system (examination time:5min, first scan type)

Number of Flaws	Location	Type of Flaws	Parameters value
5	X(0,0,20,20,30) Y(14.332,16.277,13.275,16.683,14.537) Z(5.221,6.781,3.288,4.672,2.629)	Non-accepted	initial position of probe=10mm
2	X(20,30) Y(16.683,14.537) Z(4.672,2.629)	Point or Smooth Crack	origin location= at the end of weld edge
1	X(20) Y(13.275) Z(3.288)	Rough Surface Cracks Vertical to Sound Beam	step displacement=5mm
0	-	Rough Surface Cracks Oblique to Sound Beam	Angle=45 deg
3	X(0,0,20) Y(14.332,16.277,16.683) Z(5.221,4.672,6.781)	Multi-reflectors Flaws	-
3	X(0,20,30) Y(16.277,13.275,14.537) Z(6.781,3.288,2.629)	Planner Flaws	-
2	X(0,20) Y(14.332,16.683) Z(5.221,4.672)	Non-planner Flaws	-
6	X(0,10,10,20,30,30) Y(15.334,12.365,14.237,14.328,13.233,16.344) Z(4.226,4.263,6.385,5.238,3.148,6.284)	Recording Flaws	-

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