A Portable Solution to Enable Guided Ultrasonic Inspection

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Abstract:

This paper describes the development and application of an innovative ultrasonic (UT) inspection system which allows reliable and accurate non-destructive testing (NDT) of tubes, pipes, and other components and structures with the minimum of instrument-specific training. The system is 100% guided and menu-driven to reduce human error and ensure both inspection accuracy and productivity.

The new inspection solution can operate in phased array and or conventional UT. Set-up is menu-directed allowing the integral operating software to calculate all the ultrasonic parameters for each task according to the inspection procedure and create an easy-to-follow inspection plan. The operator can then scan the work piece, with an encoded scanner with complete confidence that the inspection procedure will be strictly followed. Inspection data is transmitted to a review station in the industry-accepted, non-proprietary DICONDE protocol, allowing advanced analysis tools, such as real time, volume corrected imaging, to allow easier and more reliable image interpretation. By using GE’s Rhythm software platform, inspection data can be reviewed and shared, reports generated and inspection results archived for traceability, tracking or further analysis.

1. The Evolution Of Portable Ultrasonic Flaw Detectors

1.1. Simple Probes and Simple Display

Early industrial ultrasonics was very much restricted to the application of compression probes, which were used to detect reducing wall thickness and hence corrosion, to check laminations and to identify simple internal flaws. Data display was also very simple, being in the form of an A-scan on a CRT. The introduction of shear or angle probes greatly expanded the functionality of ultrasonic inspection, as defects could now be positioned rather than merely being located. Twin crystal transducers were also developed, especially for applications involving coarse grain materials. By having a separate transmitter and receiver in the same element, it was found that it was possible to achieve a quasi-focusing effect where the beams cross, while at the same time enhancing the signal to noise ratio.

1.2 Advances in Electronics – From Analog to Digital

Advances in electronics from the 1990s onwards have given rise to great strides in the technology. Cathode ray tubes have been replaced by LED and LCD screens, which can be adjusted in brightness, contrast and even colour to aid viewing. Just as important, the implementation of these advances in electronics has greatly reduced the size and improved the portability and ergonomics of hand-held flaw meters. Moreover, computerisation and digitisation has meant that data is now processed, displayed, analysed and stored in the same instrument. It has also meant that datasets can be now saved, reducing the time needed to adjust
the instrument and reducing the number of accessories to be carried on site

1.3. Algorithm based diagnostics

One of the most significant advances made over the last few years has been the removal of much of the subjectivity from ultrasonic inspection. A typical example is in the area of spot weld inspection. Here the flaw detector will perform its measurements and then propose diagnostics, based on built-in algorithms. Instrument makes measurements and proposes diagnostics based on algorithms. Specifically, when the displayed real-time Ultrasonic image aligns with the weld specification, the image is frozen. An algorithm then analyzes it and proposes a diagnostic. The expert can accept or adjust the diagnostic before saving.
**1.4. From Conventional pulse echo to Phased array and TOFD**

Conventional PFD are requiring 20 to 30 parameters to be adjusted and Phased Array PFD are requiring up to several hundreds of parameters, some being inter-dependent. Even if some equipment’s have recently benefit from intuitive navigation (logic in the menu organization) and memorized datasets, advanced Phased Array Portable Flaw Detectors still require a highly skilled operator, an operator with up-to-date and recent experience of the technique.

The operator skills are not immediately achieved on training completion. Several years of experience are needed to get the necessary skills after the training and a newly qualified UT technician cannot be expected to immediately begin working on AUT systems.

**1.5. The Ever Increasing Complexity of Inspection Procedures and the Ever-Growing Shortage of skilled AUT operators**

As we have mentioned, PA and TOFD are complex techniques and as they require ever more parameters to be adjusted, they are becoming more complex. For example, an average PA procedure is about 20 pages long. Therefore, as the inspection procedure becomes more involved, the risk of human error increases.

This combination of increasing inspection complexity and a serious shortage in the availability of trained and experienced Automatic UT operators is very much the cause of the bottlenecks preventing qualified technicians to make a smooth transition from UT to AUT and from RT to AUT.

**2. Achieving an inspection solution, which is 100% guided and secured**

The transition of operator skills from UT to AUT or from RT to AUT can be speeded up if inspection is carried out within a controlled and authenticated environment, where the programmed inspection procedure is strictly followed.

This means that the operator is 100% guided, that the critical parameters are checked during the inspection and that the tasks requiring specific expertise levels are performed only by approved, certified skilled operators.

The solution is a workflow-based solution, which manages all the tasks required of all the stakeholders in the inspection.

**2.1 Ensure that the inspection procedure is strictly followed**

The inspection procedure can be programmed into the flaw detector. The Level III must specify the inspection technic, the probes frequencies, apertures and angles, as well as the method to define the probe position and the calibration method.
Then level II just has to define the pipe and weld geometry and to select the inspection procedure to apply. The instrument’s parameters are calculated accordingly. This will include the ultrasonic parameters for each weld, code, technique and pipe combination, according to the basic information keyed in by the operator. This information include, data such as operator name, and inspection location, weld number, weld preparation, pipe size and pipe material.

Only probes compatible with the inspection procedure will be presented to the user, and all parameters will be calculated according to these guidelines.

2.3. Ensure that the inspection procedure is always applied correctly and is relevant to the inspection:

Level II can visualize and validate or adjust and then validate critical parameters.

However, the level of adjustment is set by the Level III technician in the procedure.
2.4. Critical parameters must fulfill specified requirements to allow operator to move to next step

For example, the instrument initially indicates to the operator which accessories he will need to use in order to perform his inspection according to the approved procedure.

Probes, wedges and scanner accessories are clearly listed. The instrument also calculates the probe positions on the scanner to ensure the operator can easily adjust his probe so that it is set at the correct position. The user interface offers the benefits of contextual drawing, that the probe positions are clearly indicated to reduce the risk of error.

Once the operator has set all these parameters, the critical parameters (here for example the PCS) are checked.

On the left image, the operator’s adjustment was not correct according to the procedure set down by the Level III. The operator is prompted with a red message to adjust his PCS.

While he is dynamically adjusting the probe’s positions on the scanner, the PCS is calculated in real time and the message turns green when it satisfies the procedure’s requirement.

The operator cannot continue to move forward if this specific critical parameter does not satisfy the exact requirements stated in the inspection procedure.

2.5. Real time volume corrected images

Non-corrected image are difficult to understand; real time volume-corrected images show indications in their true position in the material. The geometrical overlay (here the weld
geometry) helps the user and the analyst to interpret and understand the flaw position and review and analyze the inspection data. Conventional digital tools offer features for image analysis, enhancement and measurement and, in addition, a variety of measurement and viewing tools is contained within the analysis software. Expert interpretation of inspection results can be provided immediately and reports can be printed off in real time.

2.6. Post-processing on a non-proprietary file format

The acquisition, reporting, review and archiving of inspection data is vital in all inspection activities. Rhythm is a powerful software platform which fulfils all these tasks.

Images can be enhanced digitally to maximise the benefits of digital inspection and the image data is created as a DICONDE file. As the software is totally DICONDE-based, you can be assured that inspection data will never become obsolete or inaccessible because of changes in image transfer protocols. DICONDE is the non-proprietary, universal standard and its first version was released by ASTM International in 2004.

Rhythm Report offers automated and rapid standardised reporting capability, incorporating DICONDE-tagged images and their contextual information.

Images can be manipulated off-line and analysis carried out using powerful application specific tools.

The data management features of Rhythm Review are also important in ultrasonic inspection. The ability to store ultrasonic imagery on local hard disc or on CD/DVD and the option of sharing data over a Review network with interested parties is important in ensuring both correct and qualified sentencing and traceability of inspection results.

Rhythm Archive is a comprehensive solution to the management and archiving of large volumes of inspection information. It is robust, secure and flexible. It features quick and easy input and retrieval of information, as its simple DICONDE-based tagging system eliminates the need for the complex image file naming conventions often associated with high volume, information storage.

2.7. Conclusions

This innovative ultrasonic inspection system offers significant benefits to asset owners, engineering contractors and inspection service companies. It will also help to address the very real problems faced by the inspection sector in terms of the ever-growing shortage of highly skilled inspection personnel.

It will allow companies to exploit and benefit from today’s high end inspection techniques to achieve improvements in productivity and quality of inspection by reducing human error.

In essence, the system rationalises the inspection process to ensure that the total inspection is carried out efficiently and accurately, with real time imaging to the standard industry protocol to allow rapid interpretation of results and effective, accessible storage.