INCREASE IN RELIABILITY IN ADVANCED ULTRASONIC INSPECTION METHODS

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ABSTRACT

The increase in the use of Automated methods has led to significant improvements in NDT in general and ultrasonic inspection in particular.

For instance, The Time of Flight Diffraction Technique (TOFD) sometimes allied to other methods such as Phased Array and Automated Pulse Echo is becoming increasingly used as an alternative to Radiography within both the construction industry and the in-service inspection of pressure vessels and pipe work. AUT, like any other inspection technique requires to be applied in a concise manner, in order to achieve the theoretical targets of high probability of detection (POD), a low false call rate, accurate sizing data and proof of coverage. In addition, the use of Corrosion Mapping is being more widely accepted and this paper will discuss how this increases reliability and gives greater confidence on results.

INTRODUCTION

The increasing demands by plant operators to obtain more accurate inspection data has increased the use of Automated Ultrasonic Inspection in order to both improve the data collected by plant operators as an aid to applying more reliable data to RBI programs. This alone would lead to the opportunity to increase inspection intervals and to effectively extend the life of plant assets.

It is now the aim of operators to obtain higher confidence levels in inspection by closely examining the coverage attained by a particular procedure and the probability of defect detection expected.

This paper will look at the existing data known about conventional inspection, highlight weaknesses and look at how AUT can increase reliability of inspection and therefore plant operator’s confidence.
EFFECTIVENESS OF CONVENTIONAL NDT

There have been many round robin tests and there is a significant amount of data available which demonstrates the effectiveness of both radiography and manual applied NDT methods.

Many of these exercises have similar conclusions. When these factors are used in Risk based inspection, and Plant Life Extension arguments. The following table shows the results of a typical round robin test which was carried out within the thickness range 6 to 25mm.

<table>
<thead>
<tr>
<th>Method</th>
<th>POD</th>
<th>FCR</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOFD</td>
<td>90%</td>
<td>10%</td>
<td>90%</td>
</tr>
<tr>
<td>MEAnder</td>
<td>80%</td>
<td>20%</td>
<td>80%</td>
</tr>
<tr>
<td>Lijscan</td>
<td>70%</td>
<td>30%</td>
<td>70%</td>
</tr>
<tr>
<td>X-Ray</td>
<td>60%</td>
<td>40%</td>
<td>60%</td>
</tr>
<tr>
<td>Gamma</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Manual PE</td>
<td>40%</td>
<td>60%</td>
<td>40%</td>
</tr>
</tbody>
</table>

FIGURE 1 POD, FCR, RELIABILITY

As can be seen by the results from the graph (FIGURE 1), there is a steady increase in reliability from the more conventional methods through to the automated techniques. One interesting factor in the calculation of reliability is the corresponding decrease in the “False Call Rate”, a very important factor as mis-representing a flaw can cause more problems than actually failing to detect one.

WELD INSPECTION COVERAGE

One of the more important aspects of Automated Inspection is the requirement to demonstrate inspection coverage.

Apart from proving AUT set ups on full scale specimens and reflectors, there was little known about actual coverage which could be attained by the procedure and there are particular reliability factors in the determination of actual coverage by AUT on different and sometimes complex geometries. Although for instance ASME specifically requires
documented evidence of coverage achieved, common practice is that at best a table and
drawing are included in the procedure indicating the setups for the different weld
geometries involved.

To produce a documented examination strategy showing component coverage is
cumbersome without software aids. Even with software tools such as professional
drawing packages, producing such scan plans is not a simple task if many different
geometries are involved. The procedure in formulating is fraught with sources of error,
Sonovation felt there was a need to assist industry in simplifying this requirement by
producing a simple to use software program that will assist in visualizing the coverage
achieved for any setup and giving a digital validation of the proposed procedure, in short,
a complete design package.

The logic behind such a software package and demonstrate how it can assist
regulatory Authorities, Design Organisations Operating Companies and the NDT industry
in not only increasing the reliability of AUT in preparing procedures but assuring
adequate coverage, the basis of a reporting format and acting as a validation tool, then on
to its use within QA and Data Base systems.

FIGURE 2 TOFD COVERAGE

The software system allows techniques to be demonstrated, either manually or
automatically via the codes that can be used and then gives a visual and digital evidence
of inspection coverage.

FIGURE 2 shows a typical Tofd solution for a pressure vessel with the actual coverage
shown. This would be the basis for the procedure.
CORROSION MAPPING

Ascertaining the remaining wall thicknesses of pressure vessels and pipework has always been problematical. Thickness testing is a method which has been viewed as a simple inspection solution but requires the same level of attention as any other method.

The introduction of corrosion mapping has led to significant improvements in this topic where proof of coverage, always the biggest issue with thickness testing, can be easily demonstrated.

The above data sets (FIGURE 3) are of a technician using a video tracking corrosion mapping system. In the case of the data set on the left, the technician was asked to scan the plate 100% with only the basic A-Scan to interrogate. The second scan shows a distinct improvement where the technician could see both the A-Scan and the C-Scan scan being constructed.

Clearly the proof of coverage is a significant advantage but many questions with this topic remained unanswered, especially calibration and transducer performance. There are two major points remaining which significantly affect the accuracy and coverage of corrosion mapping.

The first point is the control of beam coverage for a particular transducer. Each size of transducer, frequency and thickness to be examined, demands certain procedural controls which allows the technician to fully understand the performance criteria. The effective beam width (FIGURE 4) is the basis of the mechanical set up which controls the coverage. For example the engineer must know the actual effective beam width before he sets up parameters such as the actual raster to be employed during an inspection.
FIGURE 4  BEAM SPREAD IN SCANPLAN

FIGURE 5 shows the effect of the actual signal as it breaks a predetermined threshold level. Factors such as poor surface, the wrong sensitivity and a poor choice of transducer can seriously affect the accuracy of the inspection.

FIGURE 5  BREAKING THRESHOLD LEVEL

There are now novel methods available which can cater for the variables prevalent in both automated corrosion mapping methods.
FAST SCREENING TOFD

One of these methods is Fast Screening Tofd (FSTofd) which gives coverage versus inspection sensitivity. This utilises the longitudinal and shear wave modes (FIGURE 6) of a particular Tofd set up and demonstrates the footprint of the inspection and the minimum thickness achievable.

This allows rapid scanning of areas of around 150mm per sec and scan widths of up to 150mm dependant on thickness and minimum detectability requirements.

Data can be quickly assessed and displayed via D-Scan through the ScanPlan format system in C-Scan and there are no issues such as signal shape and beam characteristics which affect the reliability of the inspection.
AUTOMATED WELD INSPECTION

With the knowledge of procedural coverage (FIGURE 8), tight transducer performance controls it is there are now significant advantages to be gained in applying AUT in the inspection of new construction and maintenance programs.

Automated inspection with the numerous advantages of data digitisation, proof of coverage and near finite sizing ability can offer plant operators more reliable data which they can confidently apply to their Risk Based Inspection and Plant Life Extension programs.

FIGURE 8 MODELLING OF WELD COVERAGE IN PE MODE

ECONOMIC FACTORS

The use of AUT in plant inspection can be more expensive than conventional NDT. The reason for this is the increased level of training and the more expensive capital equipment required for these exercises.

However, when other items are factored in such as the ability to have other activities around the inspection area, instant and more accurate data, the advantages, both technical and financial become clear.
TRAINING AND QUALIFICATION

Training and Qualification, as always, is an extremely important factor to be considered for all NDT and recent incentives by ASNT and the European Community have gone a long way to improving this.

However, training is heavily biased towards new construction weld inspection and unfortunately little attention is paid to in-service problems and their particular needs. Often problems encountered during in-service inspection are not catered for during the Training and Qualification courses.

The use of job specific training, bespoke validation and competency testing would be advantageous.

CONCLUSIONS

The following points can significantly assist in increasing the reliability of Automated Ultrasonic Inspection.

- A comprehensive knowledge of inspection coverage and what is achievable
- Good comprehensive specifications for in-service inspection
- The use of the latest technologies such as FSTofd
- Effective job-specific training
- The use of validation exercises for bespoke applications
- The use of agreed procedures between client and Inspection Company.