Best Practice Guide for the Use of Eddy Current Arrays

PUBLISHABLE SUMMARY

25701

Summary

Eddy current (EC) inspection is one of a number of NDT methods employing electromagnetism in conductive materials for tasks such as the detection of surface and near surface flaws and determining material properties. EC offers many advantages over other surface inspection methods such as magnetic particle or liquid penetrant inspection but is traditionally considered very dependent upon the skill of the operator and does not offer a permanent record of the inspection conducted.

The capability now exists through Eddy Current Array (ECA) technology to electronically drive multiple eddy current coils placed side by side in the same probe assembly. This project proposes to establish the essential variables that should be controlled when conducting an inspection and determine the performance of ECA systems relative to that of existing, recognised surface inspection methods: Dye Penetrant Testing (PT), conventional Eddy Current Inspection (EC) and Alternating Current Field Measurement (ACFM) as appropriate. Based upon the results of this study, a Best Practice Guide has been produced for the application of EC

Best Practice Guide for the Use of Eddy Current Arrays

Background

Eddy currents are created through a process called electromagnetic induction which begins with the application of an alternating current to a coiled conductor, such as copper wire within a probe, and leads eventually to the generation of eddy currents within the component under inspection. EC offers many advantages over other surface inspection methods such as magnetic particle or liquid penetrant inspection but is traditionally considered very dependent upon the skill of the operator and does not offer a permanent record of the inspection conducted.

Eddy Current Array technology makes use of coils multiplexed in a specific pattern to avoid interference between them, and each individual eddy current coil produces a signal based upon the structure of the material immediately below it. The data collected are referenced to a specific position and time and results are presented on a C-scan (plan view) image of the component. Relative to existing NDT methods, ECA technology is, in addition to allowing the generation of a permanent record of the inspection, reported to offer an improved probability of detection, a reduction in false calls, faster inspections and accurate length and depth sizing of flaws. For these reasons, ECA technology is now being considered as an alternative to other surface inspection techniques across a wide range of industries.

Objectives

- Determine the influence of varying inspection parameters upon the effectiveness of an ECA inspection and through this, determine the essential variables for such inspection;
- Assess the capabilities of EC arrays for crack detection and compare this with the performance of existing surface inspection methods and techniques;
- Establish a Best Practice guide for the implementation of an ECA inspection with a level of reliability equal to that achieved by existing methods.

Deliverables

- A capability statement for the inspection of austenitic welds using ECA and a comparison of the capabilities of the technique with those of other NDT methods and techniques employed for the detection of surface flaws;
- Best Practice Guide for the application of ECA to welded joints in austenitic materials

Benefits

- Facilitate the deployment of an inspection technique by sponsors which employs no chemicals, provides a permanent record of an inspection with length and depth sizing data and provides an equal or higher POD than existing surface inspection techniques;
- Participants acquire guidance through a Best Practice Guide on how to deploy the technique to achieve the required results.

Participants

The Sponsor Group comprised:

- Sellafield
- EDF
- Eddyfi

The project was also financially supported by TWI

Scope of Work

A set of welded specimens with known cracks were fabricated and/or provided by sponsors and inspection procedures developed for each of the techniques to be applied for their inspection. The samples were inspected by a number of operators certified and experienced in the application of the technique in question. The results from this testing will be used firstly to determine the essential parameters to be considered when applying ECA and subsequently to compare the capabilities of flaw detection and sizing achievable with ECA with those obtained using the other surface inspection techniques.

The concept of influential and essential parameters is discussed in ENIQ Recommended Practice 1 (ENIQ, 2005) and summarised here. Briefly, influential parameters are those parameters which can potentially influence the outcome of an inspection. Those influential parameters whose change in value would actually affect a particular inspection in such a way that the inspection could no longer meet its defined objectives are defined as the essential parameters and are the parameters (together with a tolerance where appropriate) which need to be considered for the qualification.

A case-by-case analysis had to be performed for each particular qualification in order to identify which of the influential parameters are essential for a specific inspection.

ENIQ divides influential parameters for any particular inspection into two distinct groups as shown below.

- Input Group: component characteristics, characteristics of defects to be detected and sized, environment;
- NDT Inspection System Group: procedure parameters (probe frequency, recording level, personnel requirements) and equipment parameters (digitisation rate, transmitter/receiver).

During the initial phase of the project, the sponsors were asked to agree upon an Input Group (component type, flaw type and material) and identify a range of NDT Inspection System Group parameters for an ECA inspection along with potential values and ranges for these. Identification of relevant NDT Inspection System Group parameters was based upon a combination of experience, a review of existing standards for EC and input from manufacturers of ECA equipment.

Based upon the agreed range of influential parameters, a design of experiments approach was employed to define a range of inspections to be conducted and the values for the Inspection System Group parameters to be used.

Test Piece Manufacture

Sponsors were requested at the project launch to provide their input in determining the Input System Group parameters. This involved identifying preferences for the materials and geometries to be used for the test specimens, and for the types of flaw they would contain. This was by necessity a limited selection with the recommendation being for the project to initially concentrate on cracks in austenitic stainless steel welds in plate to include a combination of welds with caps in place and ground. It was planned that a minimum of 20-30 flaws would need to be assessed.

Inspection

This involved 2 phases, the first being the experiments to determine the range of essential parameters for EC Arrays and the second being the inspections to determine the performance of ECA against that of other surface inspection methods.

Following the ECA inspections, the results of these were analysed to determine the essential variables, their ranges and to specify the optimum levels to be applied for the test pieces to be inspected. From this data, optimised procedures were produced and the inspection repeated employing a minimum of three operators.

For comparison of ECA performance against that of other surface inspection methods, inspection procedures were produced for PT, EC Weldscan and ACFM as appropriate based upon the requirements of relevant inspection standards (ASME V and ISO). The test specimens were inspected using these procedures, again employing a minimum of three inspectors.

All the inspections were conducted as ‘blind’ trials. For EC Weldscan and ACFM, the indication amplitude and the noise level (ie maximum indication produced in the uncracked as-welded area) were recorded. Alternating current potential drop (ACPD) was used to estimate the depth of the cracks.

Analysis

Defect detection and sizing capability were evaluated on a range of austenitic weld samples and a capability statement would be produced establishing the capabilities of the ECA technique.

The performance of ECA will be compared with that of other methods employed during the programme and against pre-existing data, where relevant, such as the published ACFM POD curve produced by Straub from UCL.

Price and Duration

The project had a duration of 1 year and a budget of £60,000. 3 Sponsors each made a contribution of £15,000 with additional support from TWI .

Further Information

For further information on how a Joint Industry Project (JIP) runs please visit:

http://www.twi-global.com/services/research-and-consultancy/joint-industry-projects/

JIP Co-ordinator: Tracey Stocks **Ref:** 25701/1/17v2

Email: jip@twi.co.uk

Project Leader: Shiva Majidnia

Email: shiva.majidnia@twi.co.uk