Demagnetisation of Thick-Section Ferritic Steel Components for Electron Beam Fabrication

PUBLISHABLE SUMMARY

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Background

There is a resurgence of interest in welding thick section steels within the renewable energy, nuclear and fossil fuelled power industries. Although Electron Beam (EB) and narrow gap (NG) arc welding processes provide a cost effective and high integrity joining solution, the presence of residual magnetism in the materials can impede the effective application of these processes. This project will investigate how such fields arise and what practical steps can be taken to eliminate their effect during fabrication of heavy section low alloy steels. Experience with these materials is that they are easily magnetised and difficult to fully demagnetise. This is problematic in EB welding as the process is less tolerant to residual magnetism than conventional arc welding processes, and as section thicknesses increase the possibility of the occurrence of lack of fusion flaws, due to deflection of the beam resulting in a missed joint, is increased. In addition it has been noted that some arc welding processes, particularly in thick steel with NG joint details, are also sensitive to residual magnetism. As a consequence, there is a need to measure and mitigate residual magnetic fields in ferromagnetic materials. The project has examined the origins of residual magnetic fields in large structures, and developed techniques for demagnetising large components using numerical and experimental methods.

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Objectives

The aim of the project was to ensure that the application of EB welding is not inhibited by problems with residual magnetic fields in components in thick section steel forgings, rolled plate and castings. The specific objectives of the programme were:

1. To review knowledge of the best methods used to avoid or reduce residual magnetic fields in steel parts
2. To identify materials, processing routes, handling techniques and configurations of components that are problematic
3. To develop a better understanding of how magnetic fields arise
4. To define methods for assessment and measurement of residual magnetic fields in joints for EB welding
5. To develop new techniques to demagnetise components that are currently problematic or to accommodate magnetic fields during EB welding.

Project Outcome

- Review report on the origins of magnetic fields in low alloy steels.
- Procedures for assessment of residual magnetic field strength.
- Procedures for effective demagnetising of low alloy steel.
- Recommendations for alternative methodologies to demagnetising to accommodate residual magnetism during EB welding.

Progress statements were issued every two months by e-mail and the Sponsors met to review the work and guide its progress at six monthly intervals. A progress report was prepared and issued prior to each six-month meeting, and a final report on project completion.

Benefits

- Improved EB weld quality and reliability;
- Reduced cost of EB welding thick sections.

Participants

The Sponsor Group consisted of:

- Rolls- Royce plc;
- Areva;
- Pro-Beam.

Scope of Work

The project examined the mechanisms involved in magnetisation of alloy steels and investigated the relative severity of influence of the factors that can cause residual magnetism. This allowed the logical development of corrective measures taking account of the differences in magnetic properties of base materials and welds. Materials and components for the project were selected in consultation with the Sponsor Group. The manufacturing process routes were studied for the various materials of interest and the instances when the material could become magnetised were identified and assessed. This involved liaison with specific materials producers and a series of measurements of magnetic properties at various stages of manufacture following the initial melting process. Welded samples of structural and low alloy steels with deliberately varying levels of residual magnetism were produced. The work examined the most successful bulk and local demagnetisation techniques in the Sponsor Group's collective experience, which were investigated and understood by means of theoretical analysis and modelling.

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As an alternative strategy to either local or bulk demagnetisation, methods for accommodating existing residual field and fields developed during welding were examined. The work included:

- Design optimisation of magnetic screening tubes based on EB welding experience, FE models, measurements and experiments
- Development of a method based on detection of magnetic fields and application of corrective compensation during welding.

Project Budget

The project had a duration of two years and a budget of £133,500. It was funded by three Sponsors each making a contribution of £44,500. The fee for additional companies buying-back into the project results is £44,500.

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

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