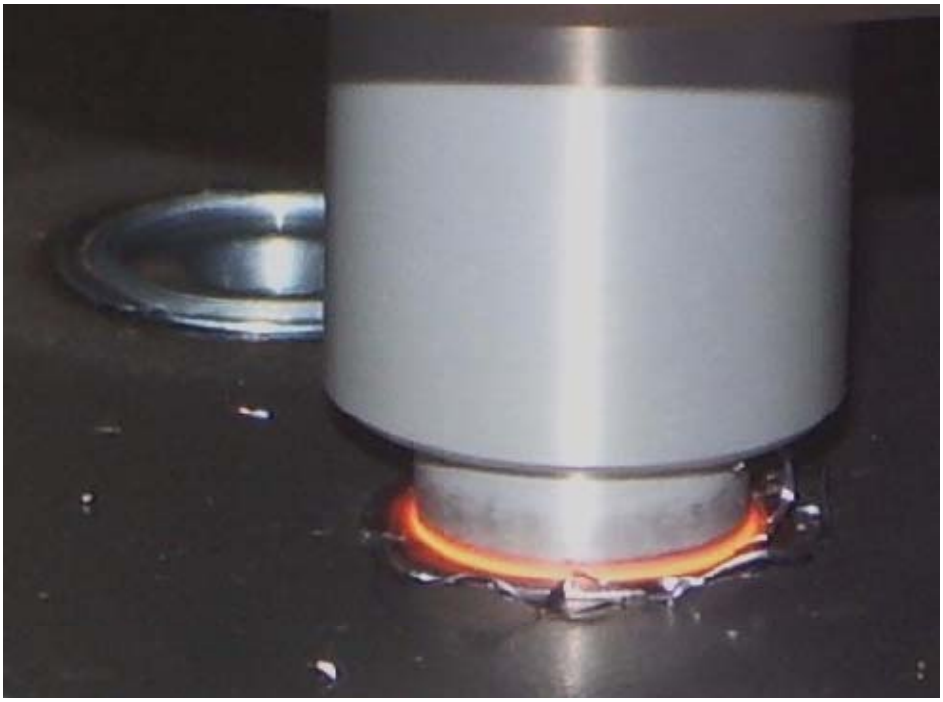
PROJECT OUTLINE

TWI

PR10199 **MARCH 2006**

FRICTION STIR SPOT WELDING OF HIGH STRENGTH STEELS FOR TRANSPORT INDUSTRIES

For: A Group of Sponsors



Friction stir spot welding (FSSW) has the potential to be a valuable high productivity manufacturing technique for high strength steels of interest to the automotive and transport industries, offering high quality, highly repeatable welds at a competitive cost. The FSW process was itself originally developed and industrialised via a TWI GSP, the Sponsors of which were amongst the first to benefit from this new technology. A similar opportunity now exists for TWI member companies to support and direct the development of FSSW and gain competitive advantage from the early adoption of this technology.

BACKGROUND

Friction Stir Welding (FSW) has become established as a method of making high quality joints in a number of materials in both butt and overlap configurations. A range of materials and thicknesses has

been successfully welded under experimental conditions and in production, but to date almost all work has focussed on longitudinal welds in one, two or three dimensions.

Recently the increasing use of high strength steels and dissimilar material combinations in high productivity manufacture has encouraged the development and adoption of new joining techniques capable of meeting the quality, reliability and cost requirements in the automotive and other industry sectors, including rail and other transport structures. Friction Stir Spot Welding (FSSW) has already seen limited production use for joining aluminium in the automotive sector and has great potential in high productivity manufacture. So far, little has been published on FSSW of high strength steels, but the data available is encouraging. Recent internal studies at TWI have independently shown promising results with several tool materials, and it is now appropriate to develop the process further to enable industry to consider this process for adoption. This Group Sponsored Project aims to study the characteristics and performance of the FSSW process for appropriate high strength steels, and to further develop it to achieve the quality and reliability required for large scale industrial application. This work will enable industrial companies to reach an informed decision on the merits of the process, and its potential for commercial use.

OBJECTIVES OF THE PROJECT

- To develop high quality and economically viable friction stir spot welding in high strength automotive steels by applying TWI's knowledge and expertise to:
  (i) the selection of new tool materials
  (ii) development of tool designs
  (iii) development of process parameters and tolerances
  (iv) investigation of alternative weld paths to improve properties.
- To explore the capability of the FSSW process to weld through material coatings, adhesives and sealants.
- To gather data for specification and evaluation of robotic application of the process in a production environment, as well as preliminary data on process economics.
- To examine quality control and non-destructive testing requirements.
- To enable Sponsors to make an informed comparison of the friction stir spot welding process with competing processes, based on technical and commercial issues.

BENEFITS

- Cost savings due to the low energy consumption of the FSSW process, reduction of pre-weld preparation and the elimination of consumables such as self-piercing rivets, filler material and shielding gas.
- New design and high productivity manufacturing possibilities are offered through freedom of material selection and predictable/reliable weld quality.
- Reduction of environmental hazards such as arc radiation, fume and spatter.
- Potentially reliable method for welding through coatings and/or sealants.

PROJECT APPROACH

Materials

It is proposed to study the following materials in the thickness range 0.5-2mm, with a hot-dip or electroplated zinc coating where appropriate:

- High and ultra-high strength steels; up to 1500MPa tensile strength, e.g. HSLA, Dual Phase, TRIP and martensitic boron treated steels.
- Other steels, (e.g. appropriate stainless grades) can also be considered if requested by the Sponsor Group.
- The Project Sponsors will make the final choice of materials thickness and joint configurations to be investigated. This could include dissimilar materials.

Equipment

Initial work will be performed using the latest FSW equipment, adapted for FSSW. TWI's TTI machine is a state of the art CNC FSW machine, instrumented to collect data on all major welding parameters including forces acting on the tool and spindle torque, which will be essential in specifying production

equipment. It is ideally suited to high temperature tool materials such as ceramics and refractory alloys. In addition, robotic FSSW trials will be undertaken using industry standard equipment designed for FSSW.

Tools: Materials and Design
The friction stir tool is an essential component of the process. New materials, capable of withstanding high temperatures and stresses are becoming available. Preliminary trials have shown real potential for some of the tool materials and those showing most promise will be investigated in the Project. In addition, tool design will be developed in order to minimise forces and weld cycle time.

Process Variables
Trials will be undertaken to optimise the quality of the weld in terms of performance, but also with productivity issues in mind. Parameters such as forces, torque, rotation speed etc will be monitored and recorded, and the data analysed to allow a full understanding of the process mechanics to be developed. The use of complex weld paths has been shown to improve weld strength in aluminium spot welds, although the weld time is increased. It is planned to assess whether the same benefits are achievable in welds in steel, and if so to determine the best combination of weld path, weld properties and productivity.

Welding Through Adhesives and Sealants
It is suggested that some welds are also made through adhesives and/or sealants. Since this can be achieved with resistance spot welding of steels, it is expected that this should also be possible with friction stir spot welding.

Weld Assessment
Mechanical properties of welds will be assessed using shear, cross-tension and chisel or peel tests to ISO standards. Selected welds will also be examined metallographically to determine microstructures and hardness distributions. A brief preliminary suitability study will be made of established NDT techniques for assessment of FSSW quality and reproducibility.

Weld Performance
A number of tests will be carried out to assess the performance of the welds. These will include drop weight tests, fatigue tests and salt spray corrosion tests. The specimen configurations and the test protocols will be agreed with the Sponsor Group. Further weld samples will be made available to Sponsors for their own additional trials.

Process Economics
There is very little information available on the process economics of friction stir spot welding. It is expected that there will be significant power savings over resistance spot welding, but this may be offset by slightly lower productivity. The cost of welding tools, and the potential for regrinding worn tools will be assessed. Data gathered will help establish whole life costs, and will help Sponsors make informed decisions on cost and quality issues.

PROJECT DELIVERABLES

- Detailed tool designs suited to the production of friction stir spot welds in a range of high strength steels chosen by the Sponsor Group.
- Welding parameter information and process tolerances for welding a range of materials.
- Preliminary data to enable a comparison to be made between the costs and productivity of resistance and friction stir spot welding.
- Design information detailing the mechanical properties and performance of friction stir spot welds made using tools and parameters developed during the project.
- An outline specification for robotic application of the FSSW process to a production environment.
- An understanding of the reliability and quality issues affecting the process, including NDT recommendations.

PRICE AND DURATION

This programme of research and development work is estimated to cost £240,000 (pounds sterling). Six sponsors are sought, each providing a contribution of £20,000 per annum. This Project will take two years to complete.

TWI will initiate the project when four Sponsors have agreed to support the project,

although the scope of work will be reduced if the planned number of Sponsors are not found.

During the project, progress updates will be issued monthly by e-mail and at six monthly intervals the Sponsors will meet to review the work and guide its progress. A detailed progress report will be prepared for each six month meeting. A Project Leader from the Friction and Forge Processes Group at TWI who has experience of both FSSW and industrial manufacturing methods will manage the project.

LAUNCH INFORMATION

Date:	**Wednesday, 1 March 2006**
Time:	**10.30**
Venue:	**TWI Ltd, Granta Park, Great Abington, Cambridge**

FURTHER INFORMATION

Interested parties are requested to contact TWI staff as listed below:

Will Kyffin
Tel: +44 (0) 0114 254 2918
Email: william.kyffin@twi.co.uk

John Kell
Tel: +44 (0) 01223 891162
Email: john.kell@twi.co.uk

Philip Threadgill
Tel: +44 (0) 01223 891162
Email: philip.threadgill@twi.co.uk