Welding of Plastics Components
Best Practice and
Assessment of Joint Integrity
Profile

Joined TWI: April 2006 as a Senior Project Leader
Expertise: Chartered Polymer and Adhesive Engineer with Material Science background.

CEng. The Welding Institute
PhD: Joining Technology
MSc: Advanced Manufacturing Systems
BSc: Polymer Engineering

- Joint Fabrication
- Analytical and Mechanical testing
- Polymer Processing
- Plastic Welding
- Adhesive bonding
- Surface Modification, Analysis & Pre-treatment
- Product development
- Failure Investigation

Dr. Farshad Salamat-Zadeh
Content

- Introduction to TWI
- Use of Plastics in Automotive Sector
  - Assembly of Plastics
  - Case Studies
  - Standards on Thermoplastics Welding
  - The Need
  - Available support
- Short summary of TWI automotive technology & services
- TWI automotive technologies taster
• Membership based Research and Technology Organisation since 1946
• Expertise in manufacturing, engineering, materials and joining

• Non profit distributing
• 850+ staff
• £75M turnover
• >4500 company members in 70 countries
National Network
Industry sectors

- Technology group supporting many industry sectors
- Cross sector technology transfer
Annual Support for Industry

- More than 8,000 hours of free technical support
- More than 800 Single Client and Group Sponsored Projects
- 70 Core Research Projects
- 85 European Collaborative Programmes
- Representation on over 100 standards committees
- Over 18,000 training and examination students per year
TWI Technology Services

- Joining and welding processes
- Structural performance
- Quality and safety advice
- Training and certification
- Materials engineering
- Surface engineering
- Manufacturing implementation
- Non-destructive testing
Use of Plastics in Automotive Sector
During the oil crisis of the '70s, automakers realised that plastics could make cars more energy efficient by reducing weight.

Applications include:
- Cabin console, door assemblies, headlight and sideview mirror housings, air intake manifold, fuel tanks, fluid reservoirs such as; windscreen washer, power steering, brake and clutch fluid.

Advantages:
- Light weight
- Durable
- Corrosion resistance
- Tough
- Ease of colouring and finishing
- Resilience
Plastics in Automotive

- Steering Fluid Reservoir
- Engine Manifold
- Fuel Tank - Internals
- Engine Coolant Expansion Tank
- Throttle Manifold
- Key Fob

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Plastics reduced the weight of the average passenger car built in 1988 by 66 kg

- Saves millions of gallons of petrol each year
- Will save the energy equivalent of 21 million barrels of oil over the average lifetime of those cars

- By the 1993 model year, over 114 kg of plastics were used in the average vehicle
- By 2020 plastic will account for 18% of average vehicle weight
Automakers face challenging new fuel-economy and greenhouse-gas emissions regulations

In North America passenger cars must meet corporate-average fuel economy (CAFE) standards of 54.5 m/g (4.32 l/100 km) by 2025

In EU, light-duty vehicles will be required to reduce CO₂ emissions on new cars to 95 g/km by 2021

Lightweighting in part, requires replacing conventional metals with polymers and hybrid materials
Plastics in Automotive

- In North America passenger cars must meet corporate-average fuel economy (CAFE) standards of 54.5 m/g (4.32 l/100 km) by 2025
- In EU, light-duty vehicles will be required to reduce CO₂ emissions on new cars to 95 g/km by 2021
- Global trends pushing automakers to reinvent their products and manufacturing processes
- Lightweighting in part, requires replacing conventional metals with polymers and hybrid materials
Replacement of engine components such as the engine manifold requires advanced engineering thermoplastic materials, which need to be moulded into a complex 3D structure.

Due to moulding limitations, such structures will often be designed and moulded in two halves.

Consequently, a suitable joining process needs to be selected to join such parts together.

Advanced new-materials with complex designs demand suitable joining solutions.
Assembly of Plastic Components
There are currently 16 different welding techniques available for assembly of plastic parts.

<table>
<thead>
<tr>
<th>Friction</th>
<th>Direct Heat Source</th>
<th>Electromagnetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasonic</td>
<td>Heated tool</td>
<td>Infrared</td>
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<tr>
<td>Spin</td>
<td>Hot gas</td>
<td>Laser</td>
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<tr>
<td>Vibration</td>
<td>Extrusion</td>
<td>Induction</td>
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<tr>
<td>Orbital</td>
<td>Resistive implant</td>
<td>Radio frequency</td>
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<td>Friction stir</td>
<td>Heat sealing</td>
<td>Microwave</td>
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<td>Flash-free</td>
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</tbody>
</table>
Weld quality of plastics is very much dependent on both the material and the joint design for the specific welding process.

Verification of weld quality has been a challenging task:
- Visual inspection
- Pressure / burst test
- Microtoming

Companies have their own internal specifications for *Welding of Plastic Parts* which dictates both design and welding/joining aspects of plastic components.
Case Studies

Materials Joining and Engineering Technologies
Welded component - 1 (POM)

Uneven weld gaps
Computed Tomography
Welded Component - 2 (PP)
Standards on Thermoplastics Welding
Available Standards

- Many national and international standards on the welding and testing of plastics pipes and geomembranes
- Some European standards on manual plastics welding techniques
  - Hot gas, extrusion, etc.
- No international standards on the welding and testing of moulded plastics components
  - DVS guidelines for hot plate, ultrasonic, vibration and spin welding
- Need to determine and promote best practice for the welding and testing of moulded plastics components
Overcoming Barriers

Standard Bodies

BSI CEN ISO

OEMs

TWI and others

Tier-1
Approach

- TWI was invited to review the internal welding guides and procedures of a major automotive company.
- TWI helped to set up a new Working Group within BSI committee PRI/80 “Welding of Thermoplastic Moulded Components”.
- Aim is to assist Design engineers and Tier-1 suppliers to design correct joints for welding of injection moulded components.
Subject: Materials

Sector: Manufacturing & Services

Scope

Under the direction of PRI/80 is responsible for the preparation of British Standards specifically in the welding of thermoplastics materials using the following processes: laser, linear vibration, spin, hot plate, infrared, hot ‘convection’ gas and ultrasonic welding. The group also provides the UK input into CEN/TC249/WG16

Who is currently involved

- BSI Secretary - PRI/-1
- TWI Ltd
- Jaguar Cars
- Ford Motor Company
- Emerson
- JCB Research
- Ultrasonics
- Telsonic UK Ltd
- Rofin-Baasel UK
- Mergon International
- Manufacturing Process
- British Plastics Federation
Available Supports

Materials Joining and Engineering Technologies
The understanding of welding is essential for those involved in the material selection, design and fabrication of plastic moulded components

- On request TWI has developed a bespoke course: **Welding of Moulded Plastic Components**

- The course provides an appreciation of polymers, welding techniques and factors affecting weld quality
Three-day training course and assessment, including practical demonstrations, to improve understanding of material selection, design and fabrication of moulded plastic components.
Plastic Welding Training

Day - 1
• General introduction to Polymers and welding principles
• Mechanical and non-destructive testing of plastics welds
• Design guidelines for plastics welding
• Hot plate welding
• Spin welding
• Infrared welding
• Hot gas convection welding

Day - 2
• Ultrasonic welding & hot air stacking
• Vibration welding
• Laser welding
• Adhesive bonding

Day - 3
• Welding demonstrations
  • Ultrasonic welding
  • Hot air staking
  • Hot plate welding
  • Vibration welding
  • Spin welding
  • Laser welding
• Multiple-choice examination
• Feedback and discussion
### Joining processes
- Vibration welding
- Spin welding
- Hot plate welding
- Ultrasonic welding
- Infrared welding
- Laser welding
- Hot air and ultrasonic staking
- Adhesive bonding

### Inspection techniques
- Visual
- Microtoming
- SEM/EDX
- Ultrasonic
- X-ray radiography
- Thermography
- Optical microscopy

### Mechanical testing
- Tensile
- Flexural
- Flower test
- Compressive
- Creep
- Peel
- Fatigue
- Impact
- Pressure/burst test
- Nano-indentation

### Analytical testing
- DSC
- TGA
- DMTA
- FTIR
- GC-MS
- Rheometry
- Permeation

### Services offered
- Process selection and optimisation
- Mechanical testing
- Failure investigation
- Joint design
- Materials analysis
- Training and assessment
- Standards development
- Non-destructive inspection
- Materials selection
- Prototype equipment and part development
- Pre-production welding
- Welding
Short summary
TWI automotive technology & services
Welding Facilities at TWI

- Yb fibre lasers, Powers up to 10kW
- Arges 3D beam scanner (1kW Yb-fibre laser)
- Automotive resistance welding capabilities - Matuschek ServoSpatz control
- Arc welding processes; MIG, MAG, TIG, CMT
- Welding of Plastics
  - Vibration, laser, US, RF, IR, Heated-Tool, etc.
- Adhesive bonding
- Mechanical joining
Friction welding and brazing

Friction Stir Welding
- Continuous FSW
- Friction Stir Spot Welding
- Linear / Rotary friction

Brazing
- Vacuum and controlled atmosphere brazing
- Related corrosion testing
- Metal – ceramic joining
Materials Joining Experience

- Steels, coated steels, AHSS & UHSS
- Stainless steels, Austenitic, Martensitic, Duplex
- Aluminium alloys, sheet, extruded and cast
- Copper alloys
- Nickel super alloys
- Titanium
- Composite and sandwich materials
- Thermoplastic and thermoset polymers
- Dissimilar materials joining
- Metallic and ceramic coatings
- Nano-materials
- Additive manufacture

Metal fibre sandwich panel
Thank you for your attention ...

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Materials Business Group

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