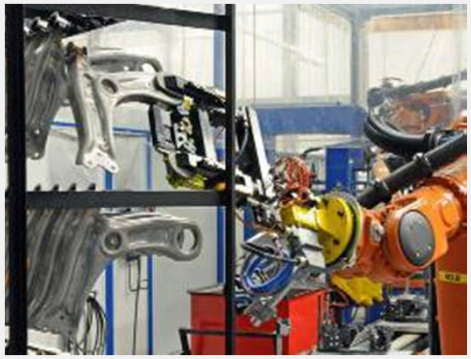
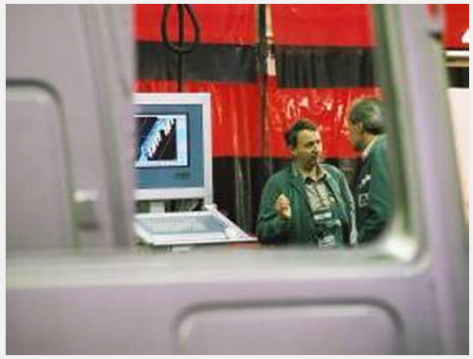


Remote Fibre Laser Welding benefits when applied to leading edge chassis structural and suspension products

Roger O'Brien
R&D Manager
ThyssenKrupp Tallent Ltd, UK

Richard Hewitt
Project Manager PVLT,
WMG, UK

LTS 2011 – WMG, 20th July, 2011

Remote Fibre Laser Welding benefits when applied to leading edge chassis structural and suspension products

1. ThyssenKrupp Tallent and WMG Introductions
2. Why Remote Laser Welding?
3. Remote Fibre Laser Welding (RFLW) Project
4. Future Project Work & Plans
5. Questions and Answers

ThyssenKrupp Tallent Ltd

ThyssenKrupp Metal Forming Overview

ThyssenKrupp Metal Forming

Turnover: € 991m • EBT: 3.128 Mio € • Employees: 5,389*

Metal Forming UK	Metal Forming Germany	Metal Forming France	Metal Forming RoW
TK Tallent, Ltd. Francis (CEO) Heyhurst (CFO)	TK Umformtechnik GmbH Dr. Egelkamp (CEO) Osburg (CSO) Dr. Plümpe (HR) Willenberg (CFO)	TK Sofedit, S.A.S. Espeel (CEO) Koll (CFO) Dr. Overrath (COO)	China (Wuhan) Turkey (Gebze)
Turnover 269,2 Mio € Employees *: 1,774	Turnover: 321,2 Mio € Employees *: 1,631	Turnover: 361,0 Mio € Employees *: 1,570	Turnover: 48,3 Mio € Employees *: 414
Aycliffe (UK) **Cannock (UK)** **Fareham (UK)** **Washington (UK)** **Bourn (UK)** **Llanelli (UK)**	**Brackwede (D)** **Ludwigsfelde (D)** **Pure (F)**	**Le Theil (F)** **Gouzeaucourt (F)** **Sermaises (F)** **Wroclaw (PL)** **St. Romain (F)** **Valladolid (E)**	**Wuhan (CN)** **Gebze (TR)**

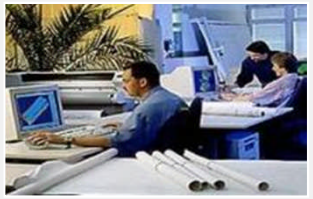
* Figures as of 30.09.2009

ThyssenKrupp Tallent Ltd

ThyssenKrupp Metal Forming European Overview

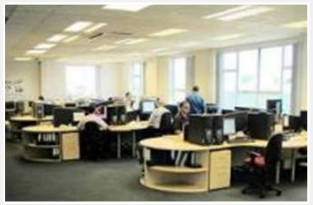
Capability

Design & Analysis



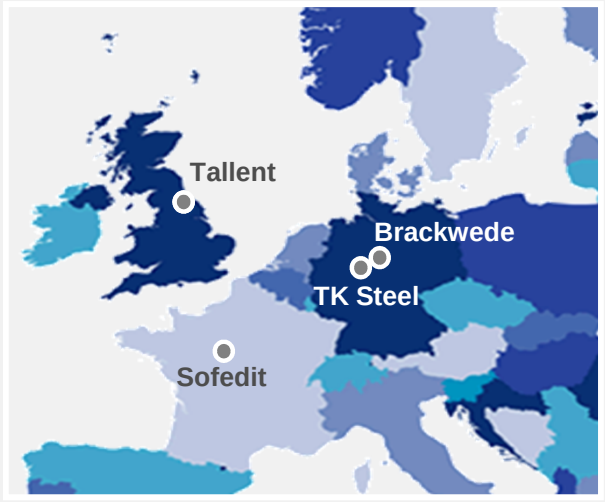
Test & Development

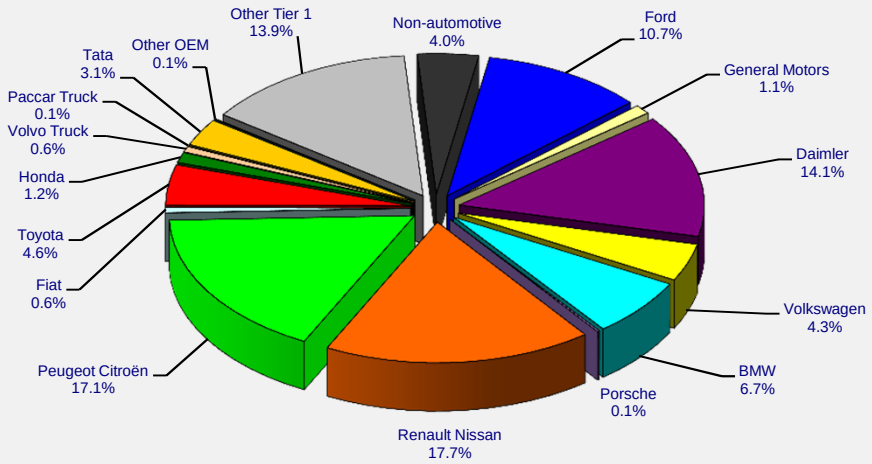
Program Management



Manufacturing

Locations





Chassis Products

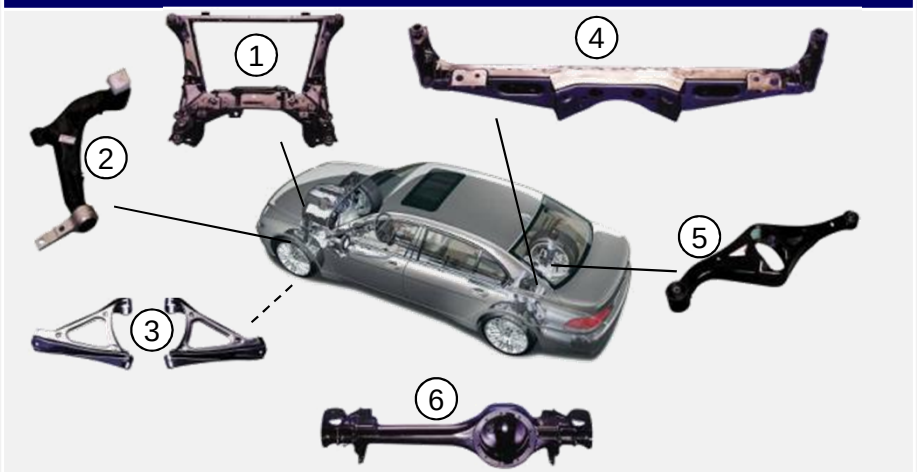
Remote Fibre Laser Welding benefits when applied to leading edge chassis structural and suspension products
Roger O'Brien – ThyssenKrupp Tallent
Richard Hewitt - WMG
Lightweight Technologies Showcase
Date: 20th July 2011

ThyssenKrupp Tallent Ltd

ThyssenKrupp Tallent Ltd

Typical Products and Customers from UK plants

Chassis



Typical Chassis products	Selected examples
1 Front subframe/assembly	Mini, Ford EUCD, new PSA/Fiat G9
2 Front transversal link	Ford Galaxy
3 Control arms	VW Touareg, Porsche Cayenne, Land Rover Discovery
4 Cross member	Mini, Ford Fiesta
5 Rear lateral link	Volvo S80
6 Axle cases	Land Rover Defender

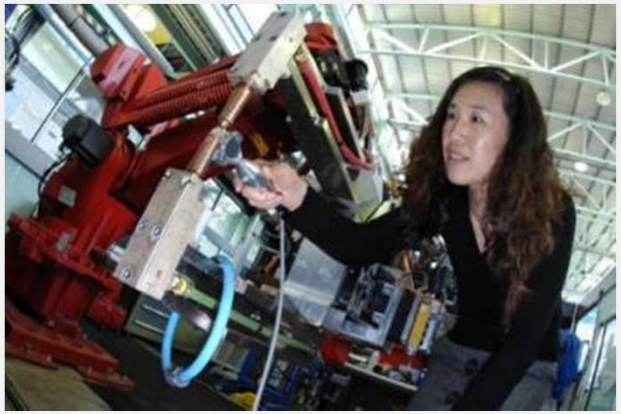
OEMs: Ford, GM, Jaguar, Mazda, SAIC, Saab, Porsche, BMW, Volvo, Land Rover, John Deere, Renault Nissan, DaimlerChrysler, Honda, PSA Peugeot Citroën, VW

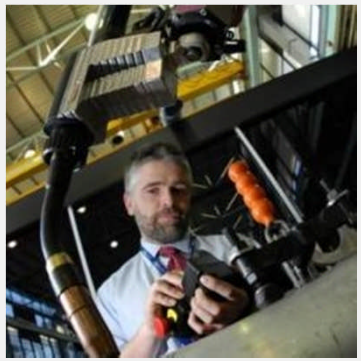
Body

Typical Body products	Selected examples
1 Side wall	Mercedes Sprinter
2 Cross car beam	Toyota Yaris
3 Side intrusion beams	Mercedes C-Class, various BMW models (1, 3, 5, 7 series)
4 Pillars/pillar reinforcements	Renault Laguna, Audi A3, Q7
5 Outer door panels	Renault Clio, Bentley Flying Spur
6 Door reinforcement	Mercedes Sprinter
7 Longitudinal	Renault Trafic/GM Vivaro

OEMs: BMW, Ford, GM, PSA Peugeot Citroën, Renault Nissan, DaimlerChrysler, Toyota, VW

WMG Overview





WMG Innovative Solutions — THE UNIVERSITY OF WARWICK

Mission Statement

"to improve competitiveness through the application of value adding innovation, new technologies and skills deployment"

Remote Fibre Laser Welding benefits when applied to leading edge chassis structural and suspension products

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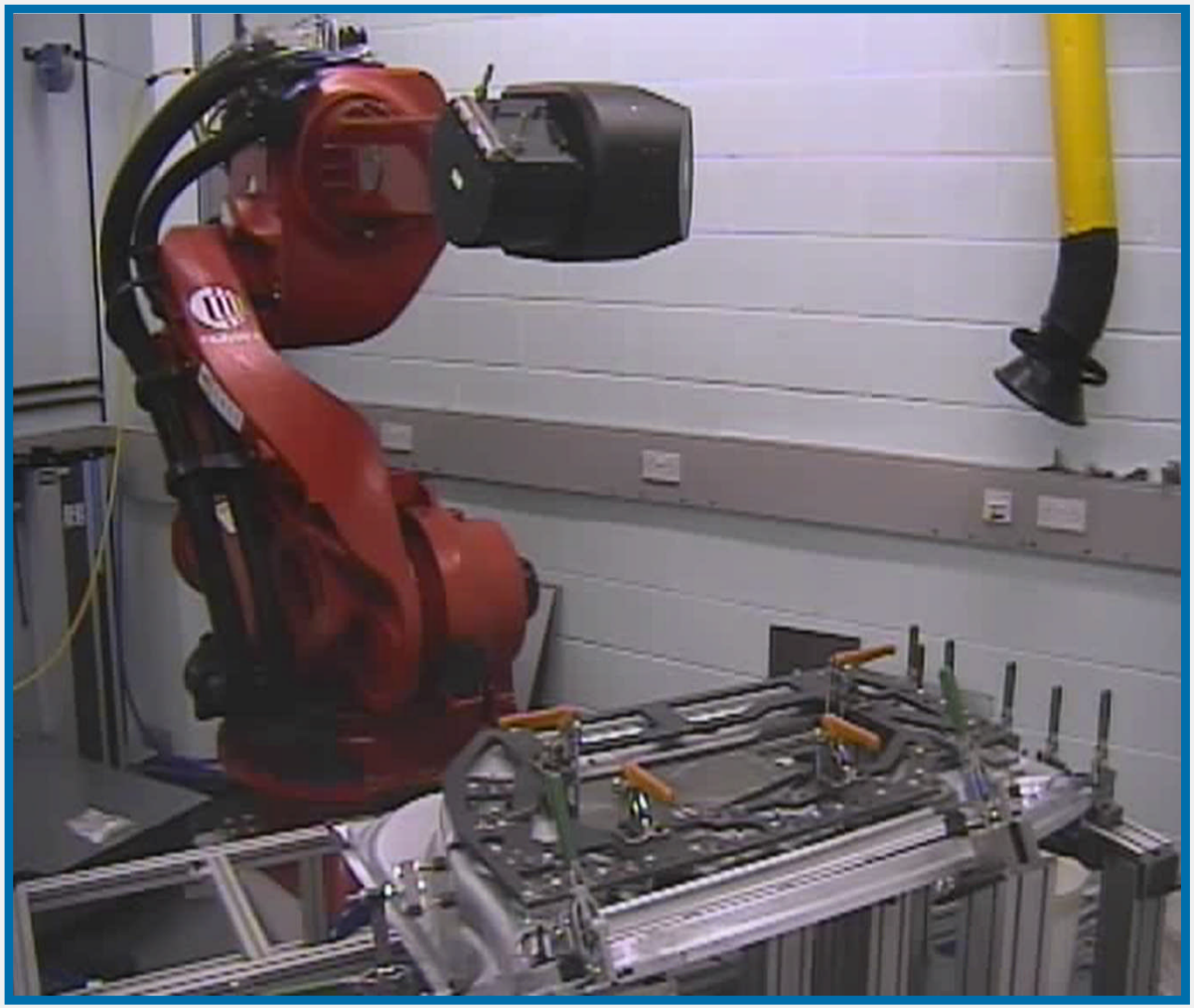
5. Questions and Answers

Why Remote Laser Welding?



Why Remote Laser Welding?

OPPORTUNITIES

- Faster Processing Speeds ?
  - Compared to MIG/MAG ?
  - Compared to Spot ?
  - Compared to others ?
- Single Sided Weld Access ?
- Access issues ?
- Flexible Manufacturing ?
- Reduced Floor Space ?
- Investment Costs ?
- Operating Costs ?
- Product Design ?
- Weight reduction ?
- Reduced distortion ?
- Customer perception ?

CHALLENGES

- Panel Fit Up Important ?
- Batch & material variation issues ?
- Thicker Materials ?
- Degassing of Weld Vapour ?
- Structural performance ?
- Tooling Specification ?
- Process Monitoring ?
- Laser Safety Requirements ?
- Few System Integrators ?
- Education & Training ?
- Customer lack of experience ?

Why Remote Laser Welding?

Range of opportunities and interest particularly for ThyssenKrupp Tallent:

- Relatively New and Emerging Technology
- Flexibility and reduced floor space requirements
- Operating and investment costs
- Speed of welding?
- Ability of process to overcome access issues?
- Improved consistency of welding?
- No consumables (No filler wire or shield gas)
- Weight Reduction
- Reduced Distortion
  - especially compared to MIG/MAG applications
- Durability and strength performance effects?
- Quality aspects?
- Physical plant considerations, including Health and Safety?

Why Remote Laser Welding?

How ThyssenKrupp Tallent may use RFLW?

- Technology Demonstration projects (like this project)
- Replacement or alternative to spot welding
- Replacement or alternative to MIG welding
- Solution to particular issues with access restrictions for conventional welding processes
- Flexible manufacturing cells for multiple product lines
  - Increased product lines
  - Increased flexibility
  - Lower volume or higher value niche products where traditionally we have not focused
- Improved capability for High Volume Products following multiple process routes
  - Use RFLW as fast setting/tacking cells to feed lines
  - Reduces process variability
  - More consistent product going into multiple parallel manufacturing lines

Remote Fibre Laser Welding benefits when applied to leading edge chassis structural and suspension products

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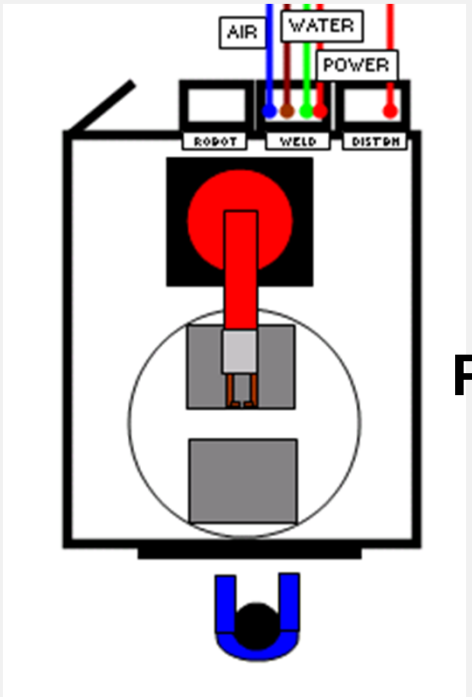
4. Future Project Work & Plans
5. Summary, Questions and Answers

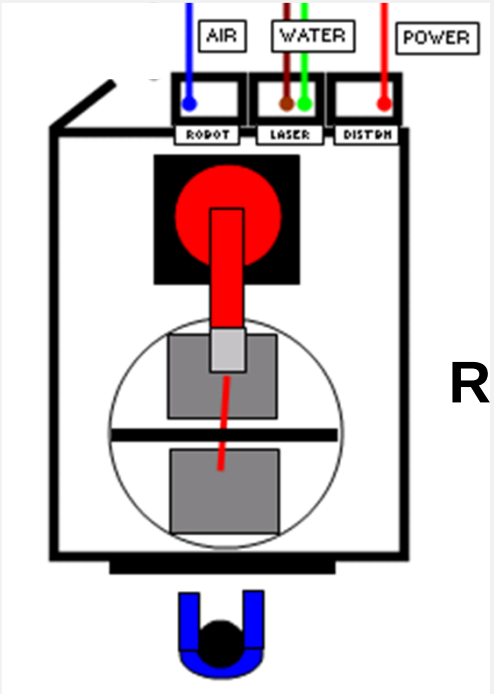
RFLW Project

Supporting the Business Case for RFLW versus welds

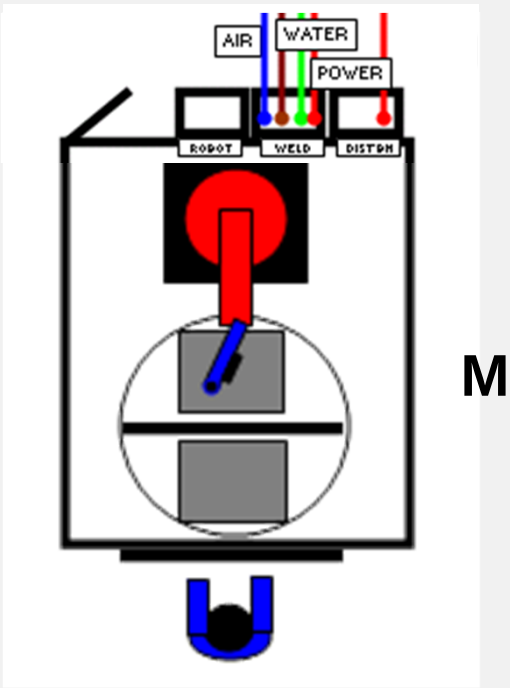
RSW v RLW v MIG Matrix



RSW



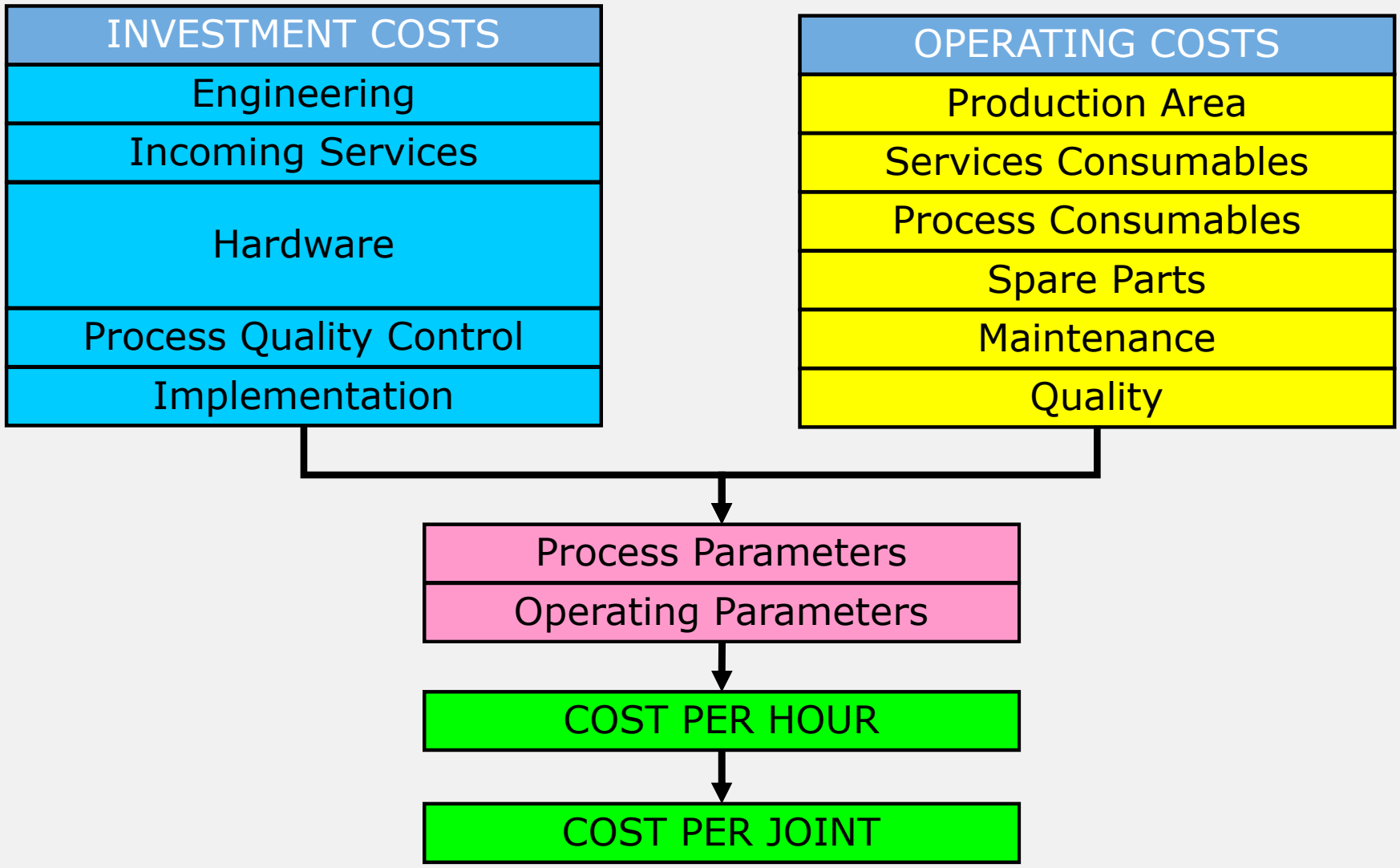
RLW



MIG

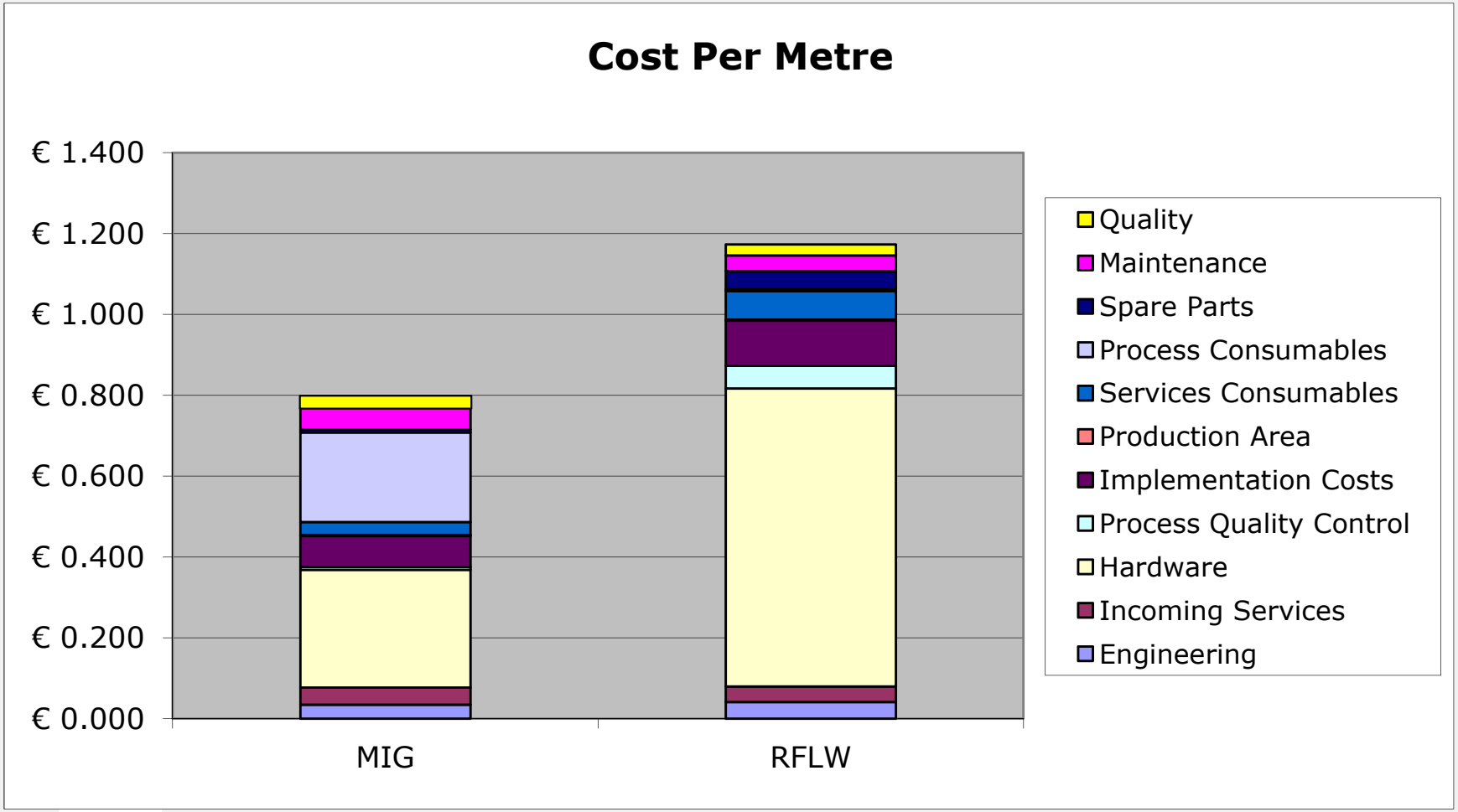
RFLW Project

Supporting the Business Case – Cost Model



RFLW Project

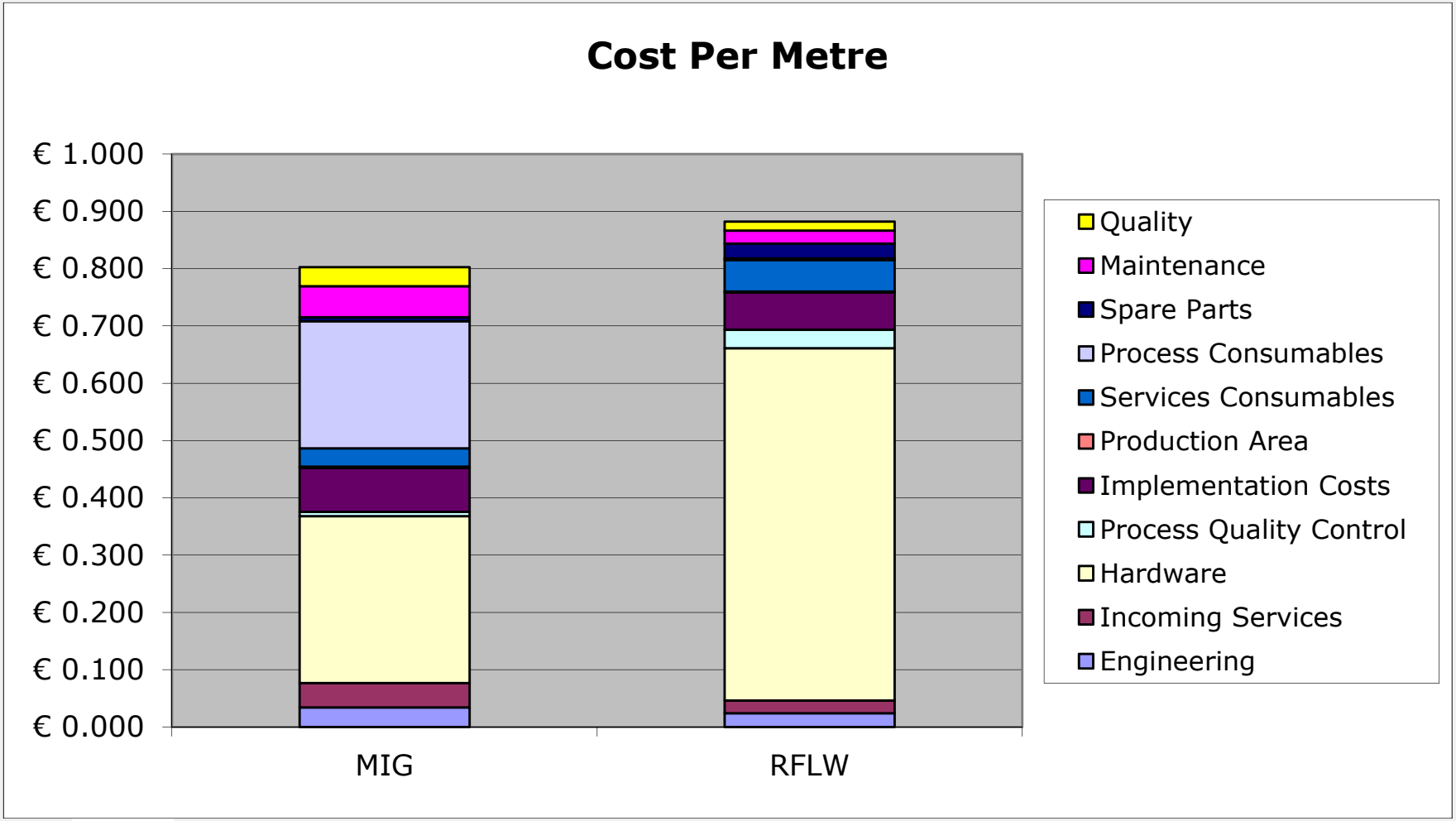
Supporting the Business Case: 4kW RFLW versus MIG



At present an equivalent 4kW remote fibre laser weld (RFLW) stitch seems to costs 35% more than a comparable MIG weld

RFLW Project

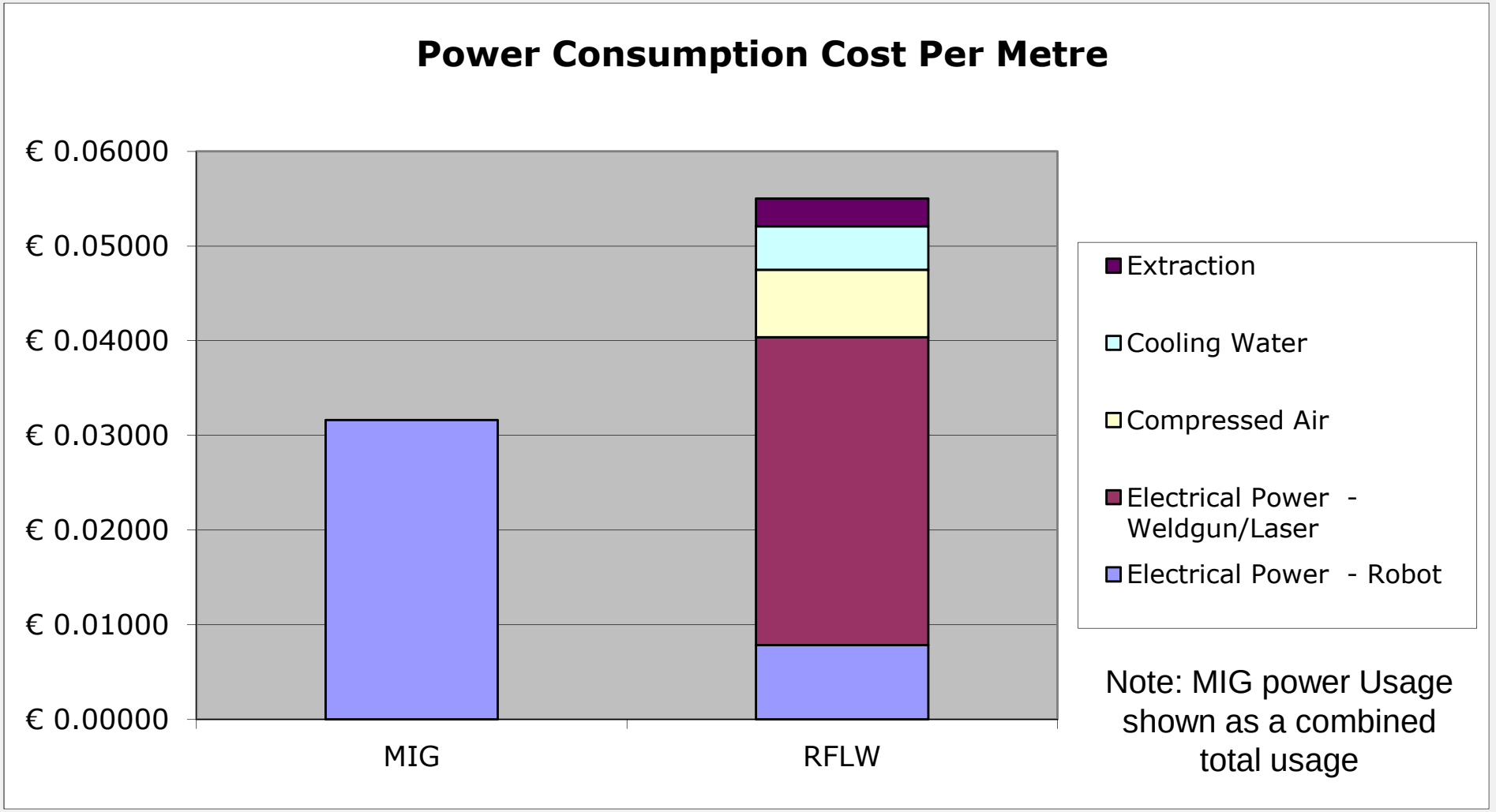
Supporting the Business Case: 8kW RFLW versus MIG



At present an equivalent 8kW remote fibre laser weld (RFLW) stitch seems to costs 10% more than a comparable MIG weld

RFLW Project

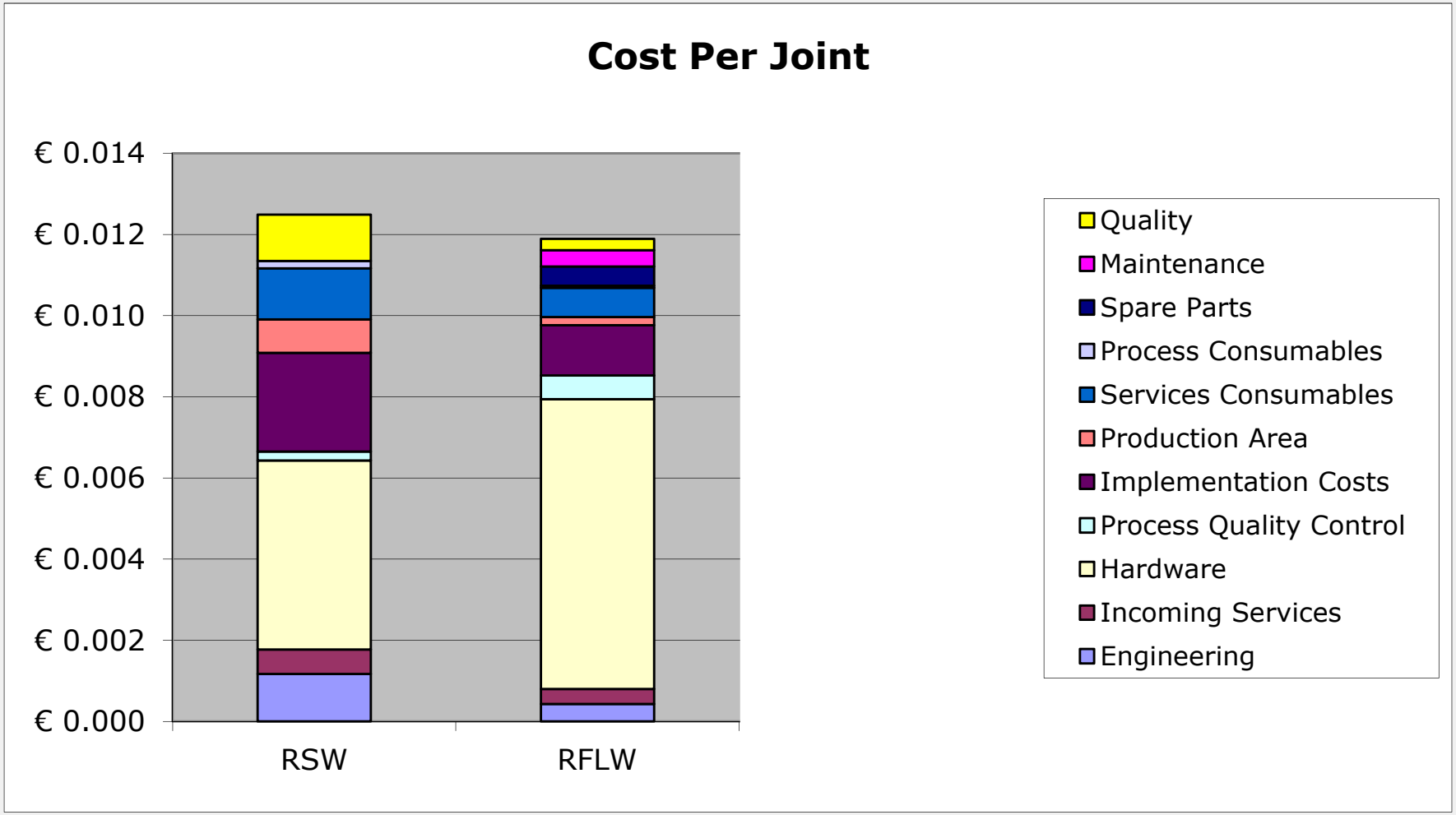
Supporting the Business Case: 8kW RFLW versus MIG



Full evaluation on-going

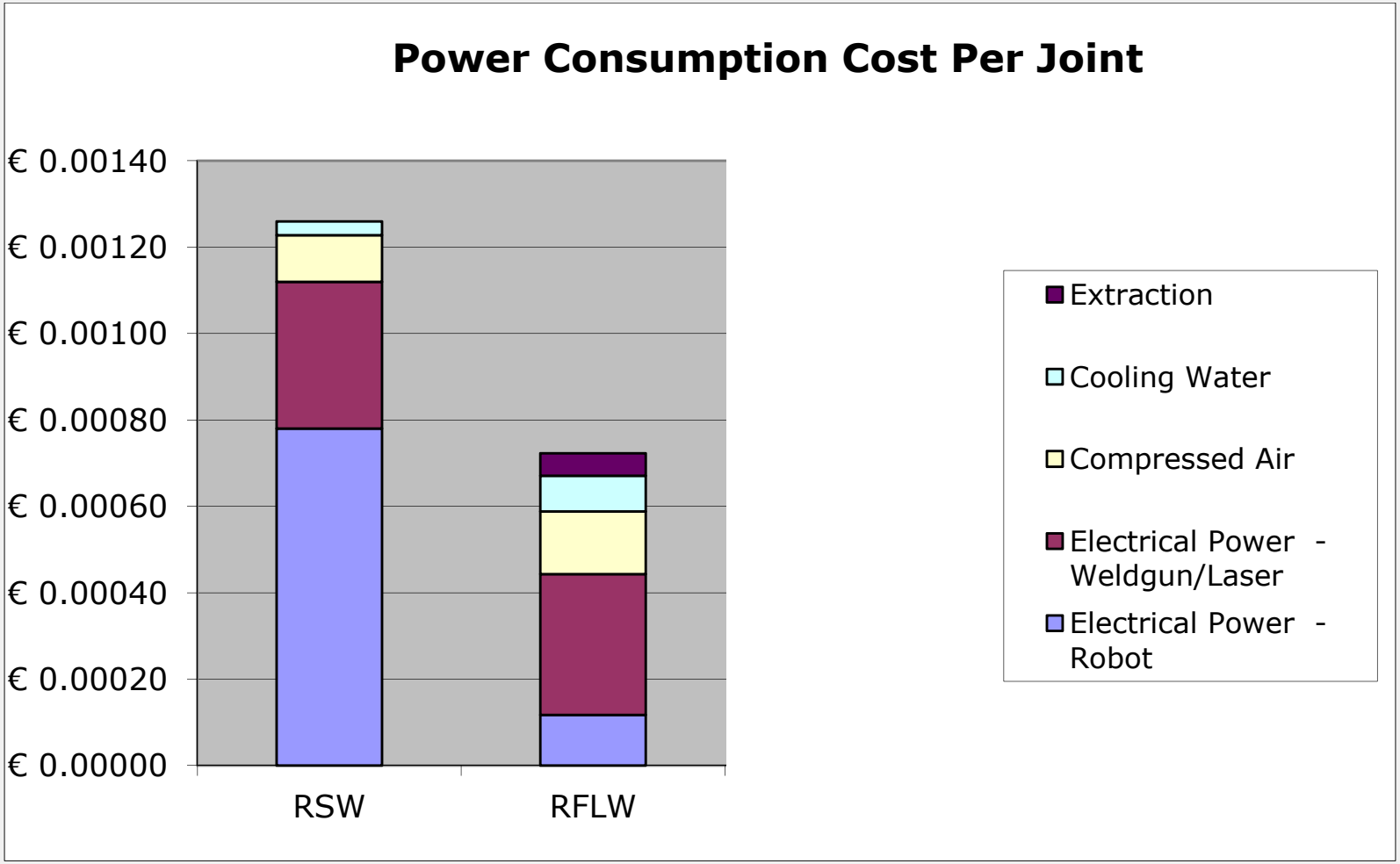
RFLW Project

Supporting the Business Case: 4kW RFLW versus Spot



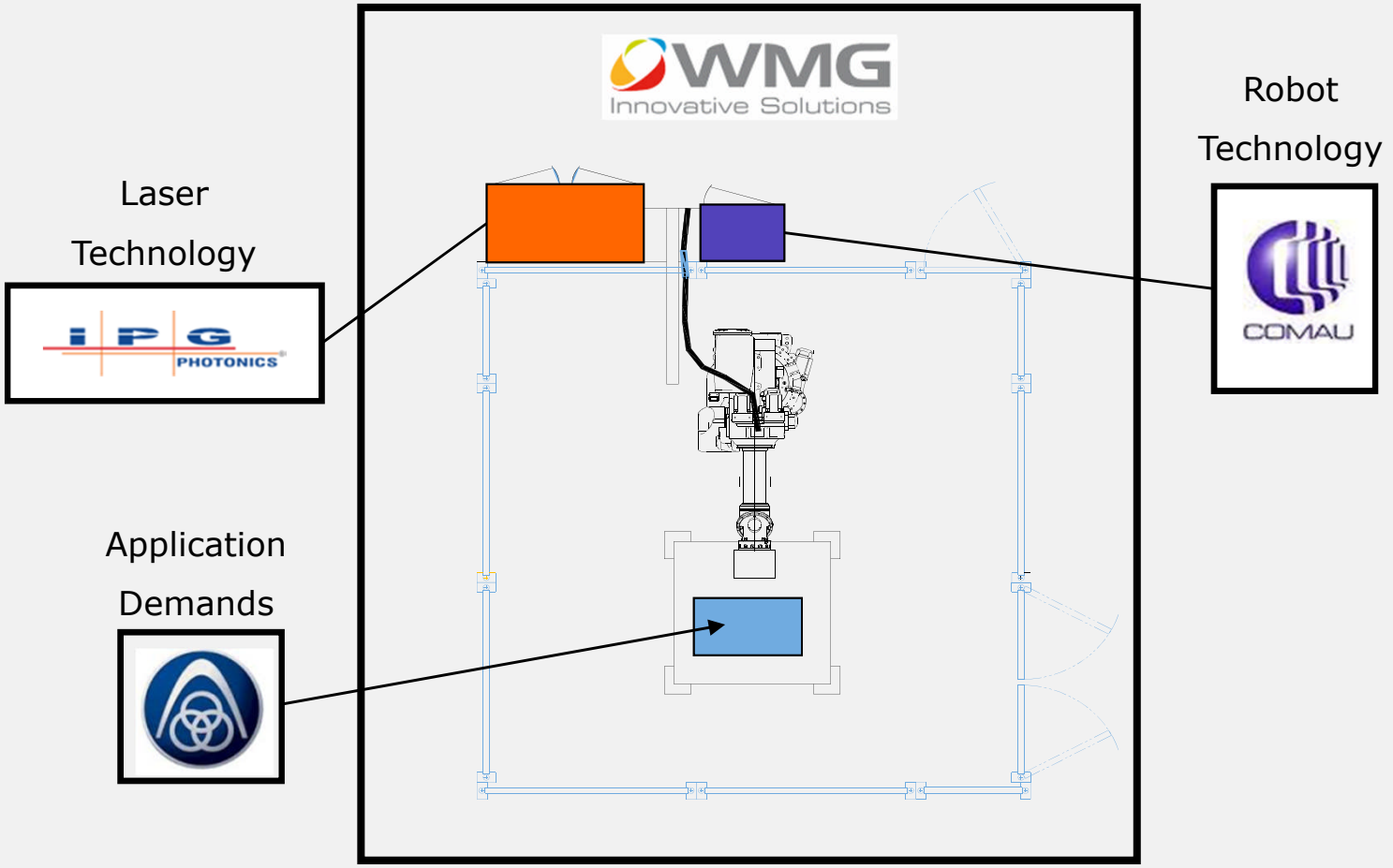
At present an equivalent 4kW remote fibre laser weld (RFLW) 'spot' seems to costs 5% less than a comparable Resistant Spot Weld (RSW)

Business Case – verses RSW



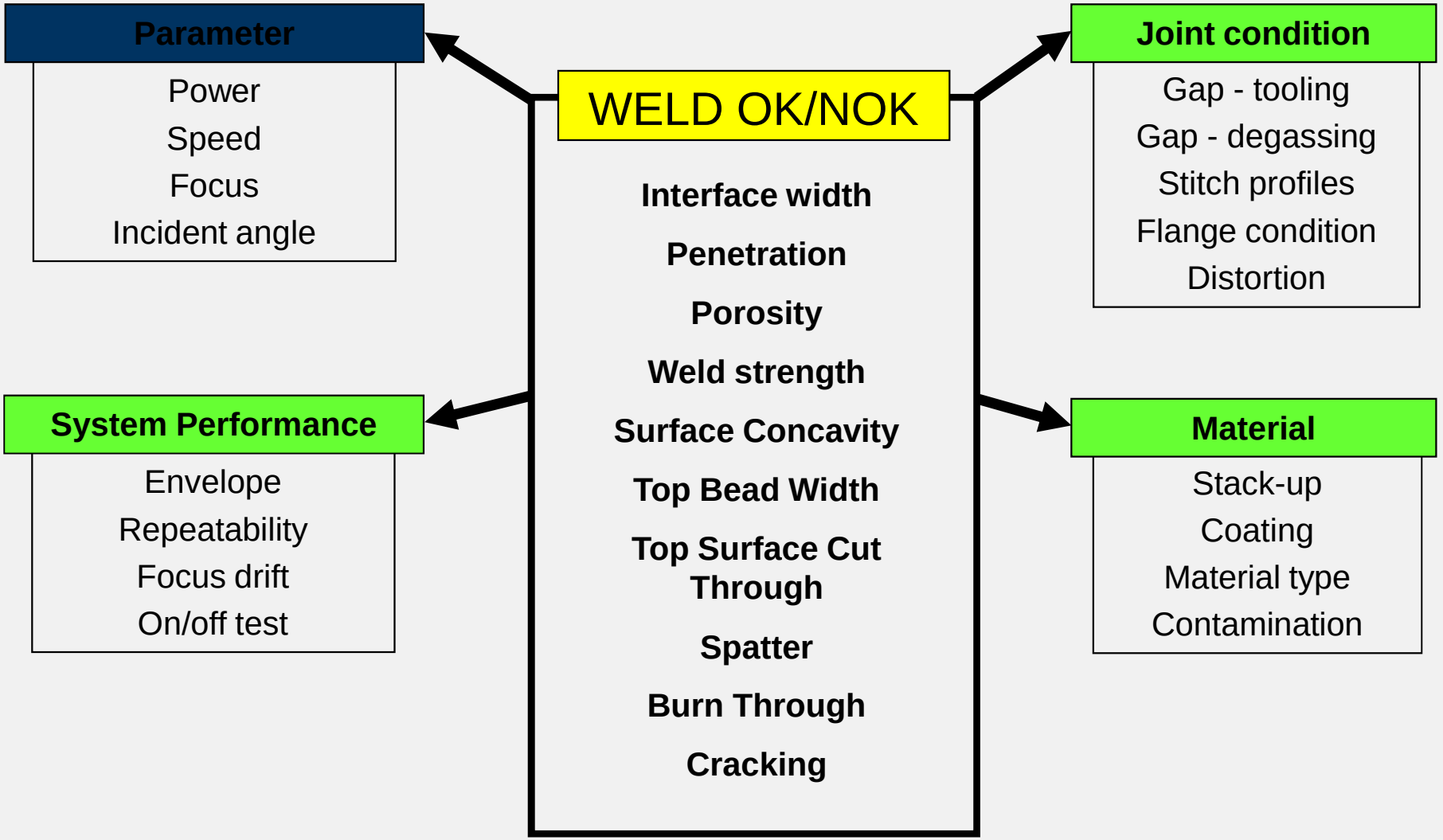
Full evaluation on-going

RFLW Project
Trial Facility



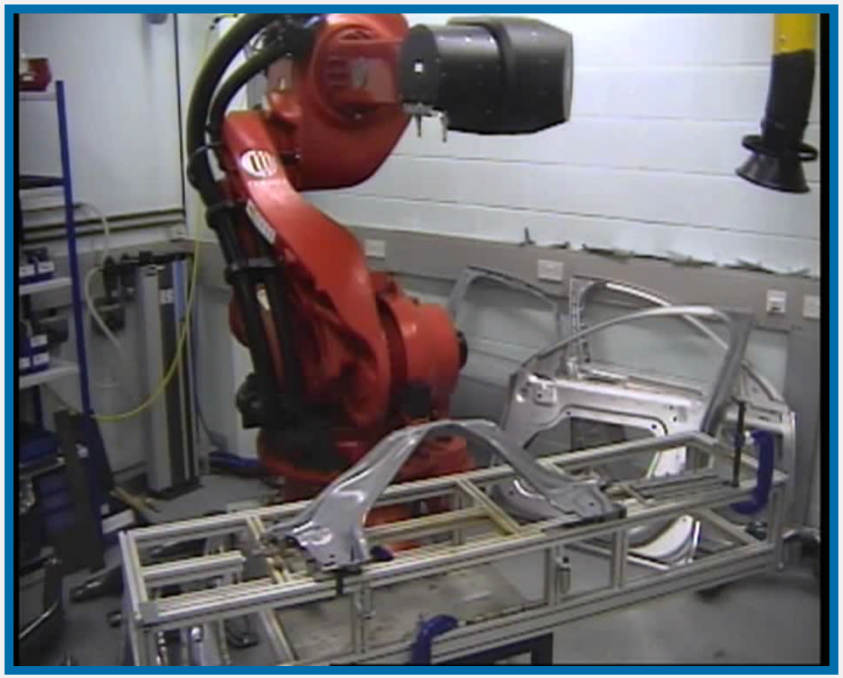
Trial Facility available within WMG

RFLW Project
Process Evaluation



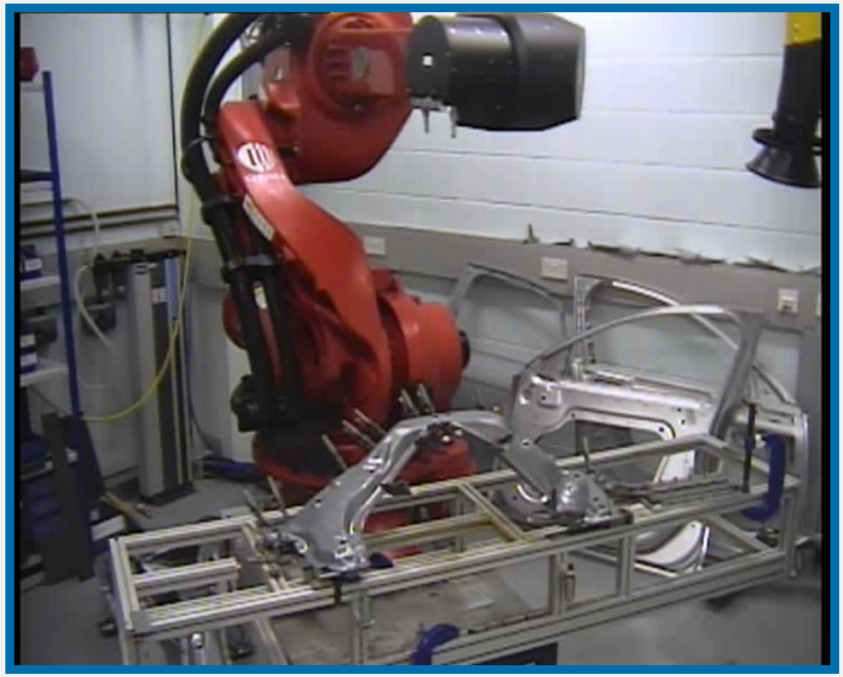
RFLW Project
Component Weld Trials
Rear Subframe – Current Production Part

Pre-process

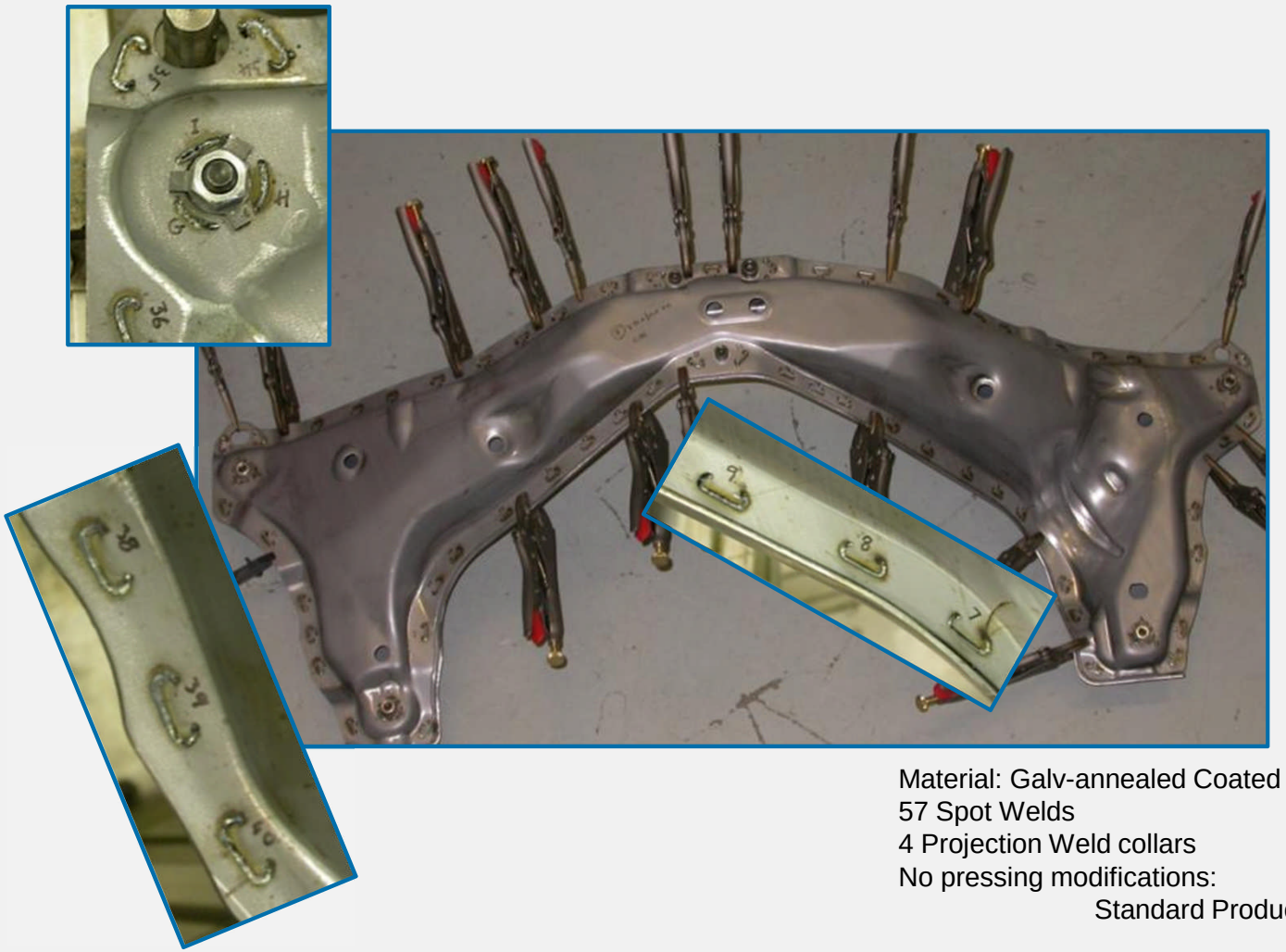


Material: Galv-annealed Coated HSLA Steel
57 Spot Welds
4 Projection Weld collars
No pressing modifications:
Standard Production Parts Used

RFLW

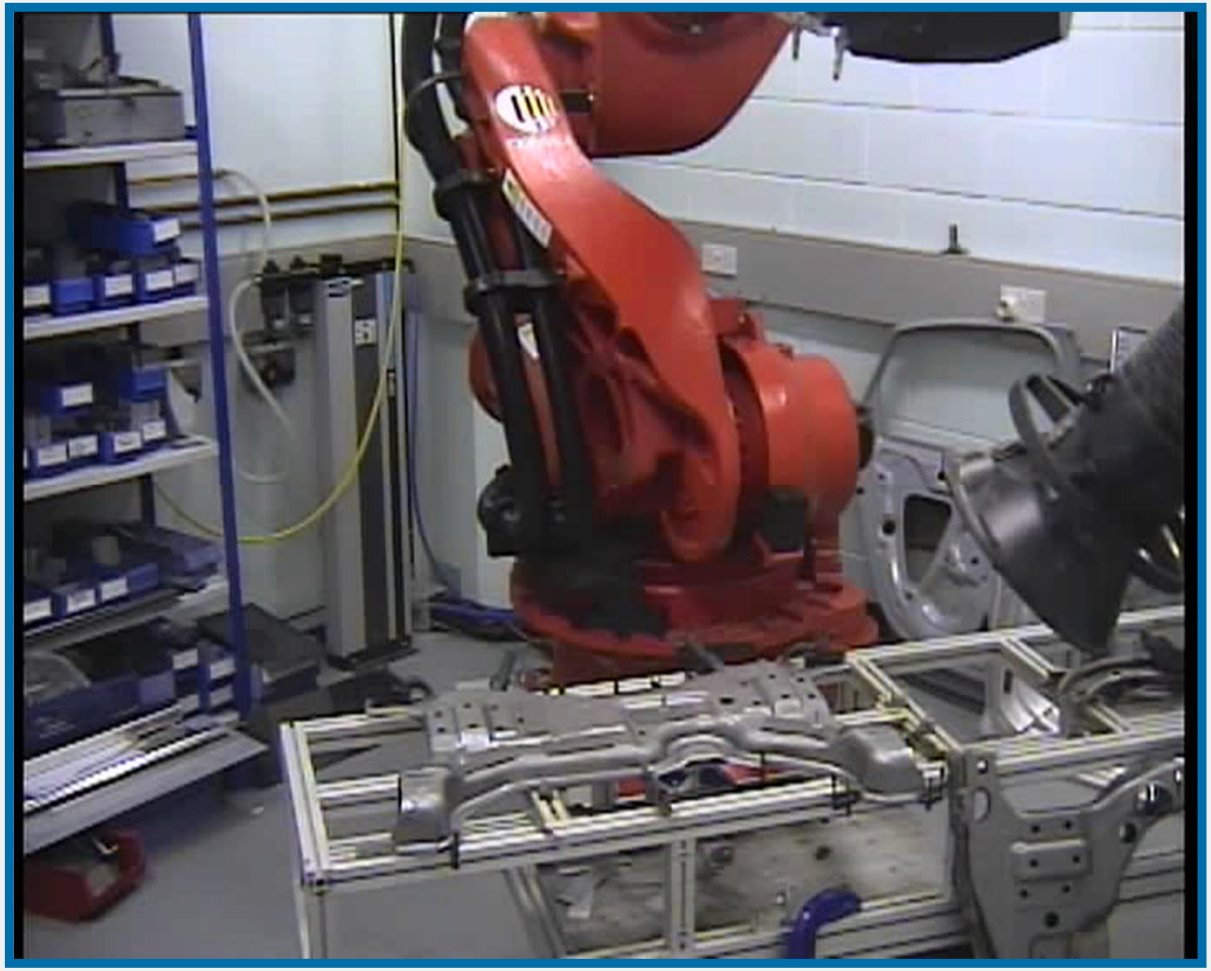


RFLW Project
Component Weld Trials
Rear Subframe – Current Production Part



Material: Galv-annealed Coated HSLA Steel
57 Spot Welds
4 Projection Weld collars
No pressing modifications:
Standard Production Parts Used

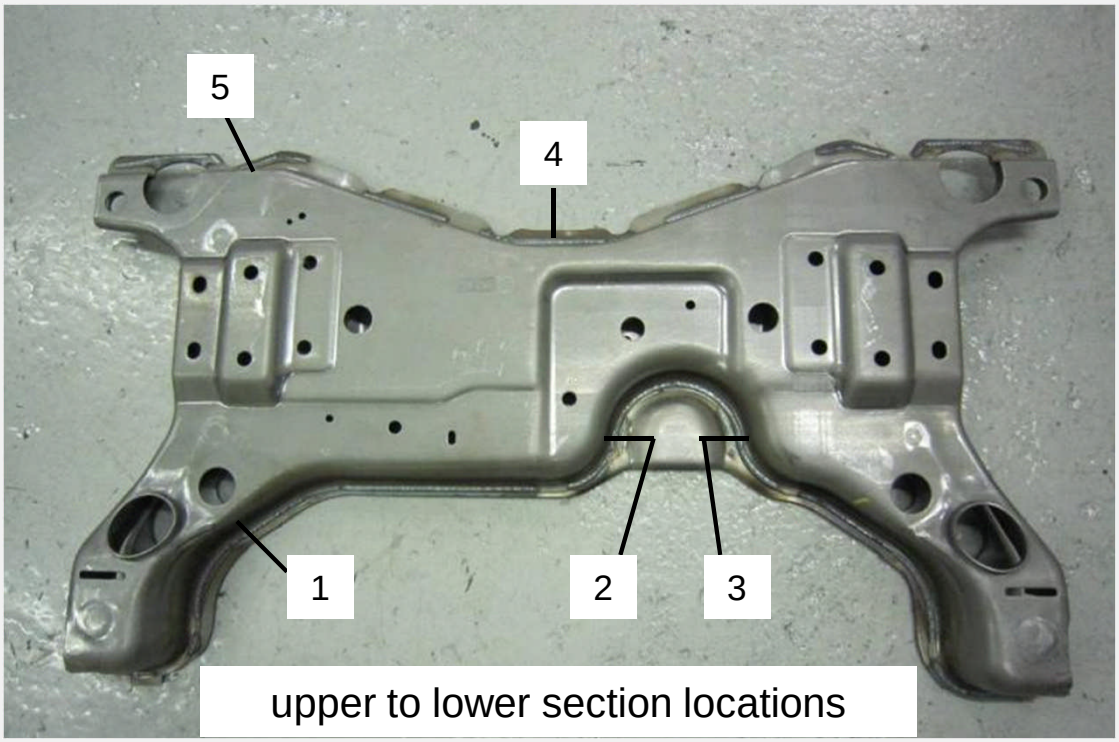
RFLW Project
Component Weld Trials
Front Subframe – Current Production Part



Material: HSLA Steel 2.5 & 3.0mm Thick
Standard Production Parts Used

RFLW Project
Weld Quality Evaluation – Front Subframe Model 1

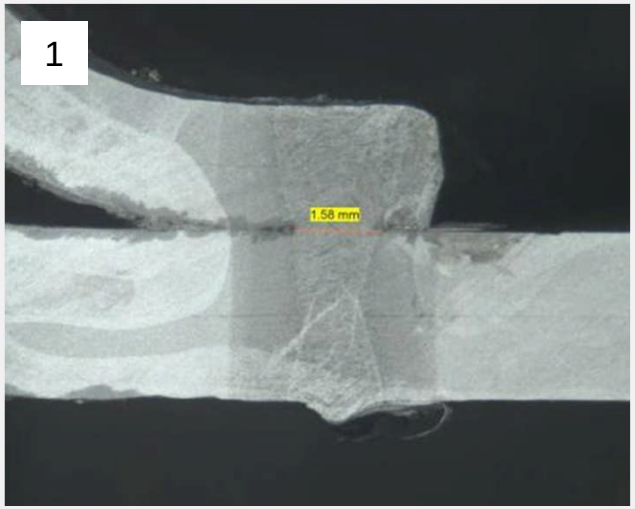
The welds examined below were not fully optimised and fit ups were not adjusted from the MAG weld condition.

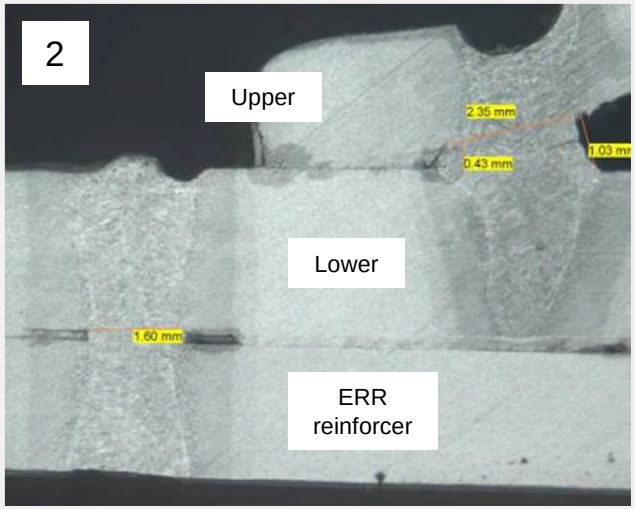


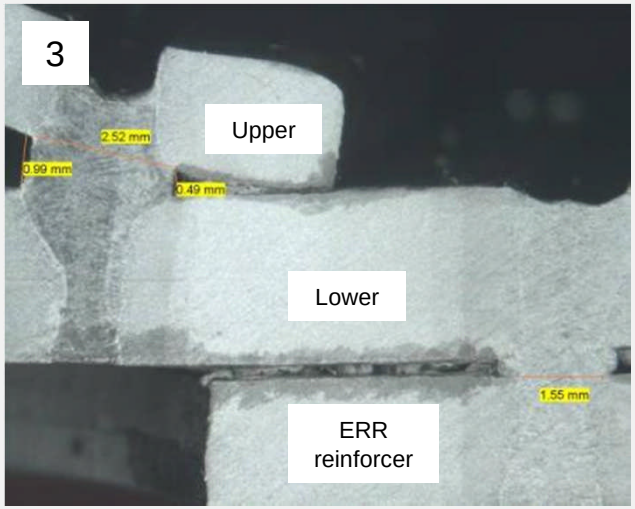
upper to lower section locations

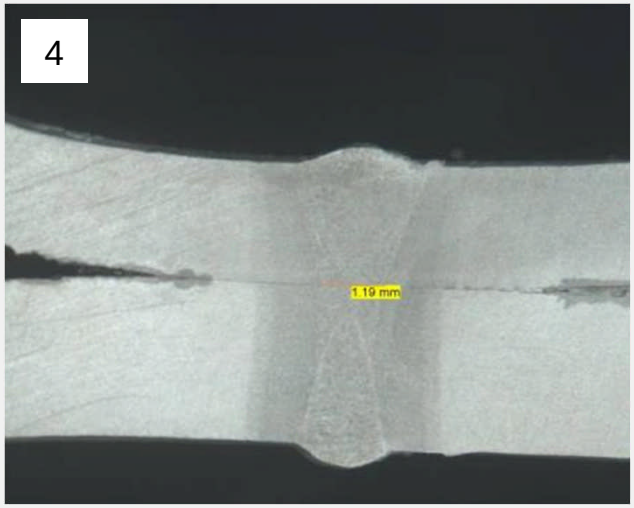
Laser seam appearance

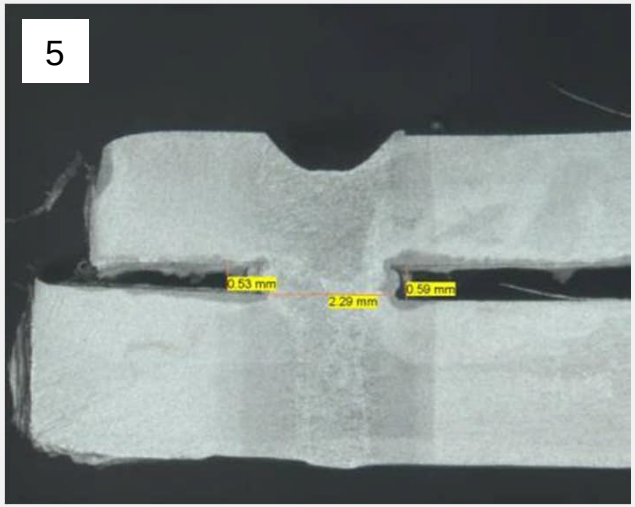
RFLW Project: Weld Quality Evaluation







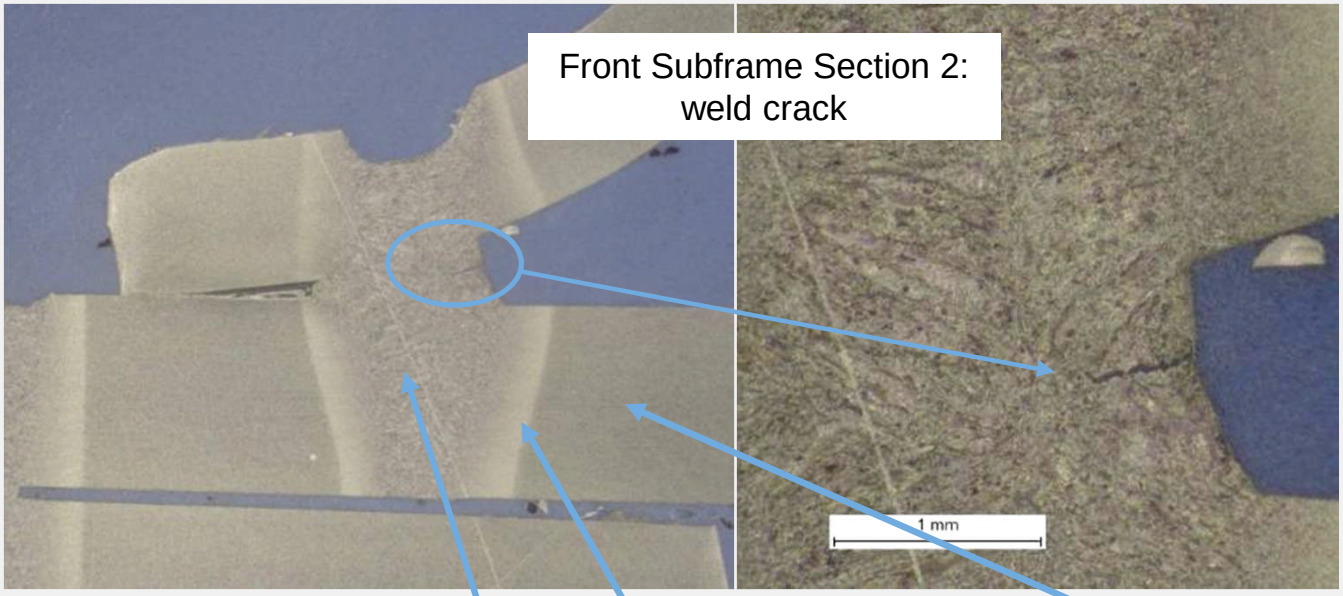




Seam Bend Test

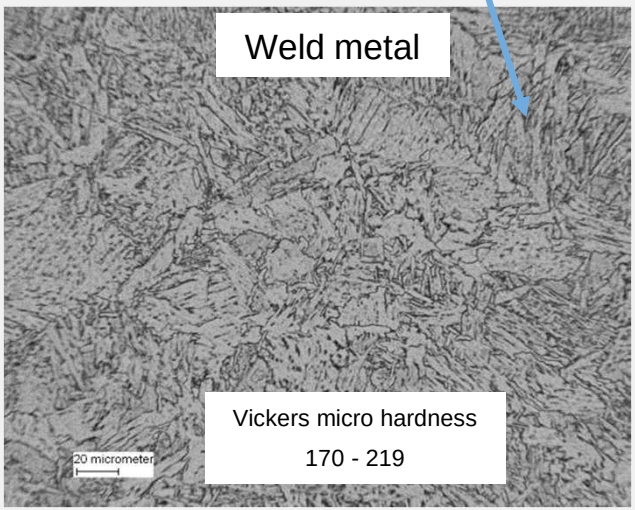
Front Subframe 1: Weld Macro Sections

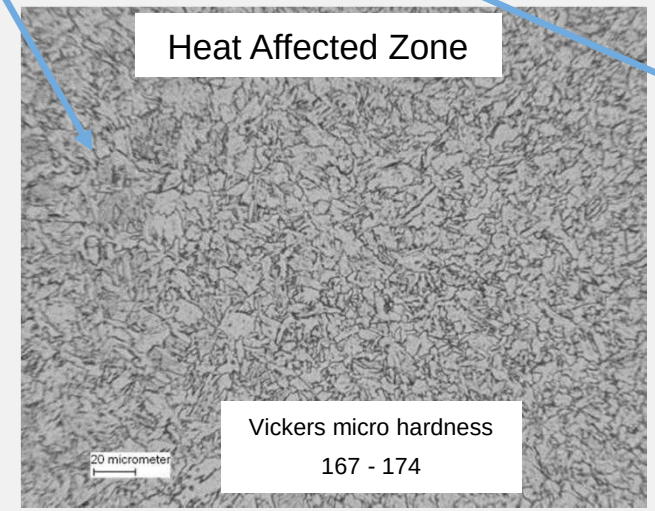
RFLW Project: Weld Quality Evaluation

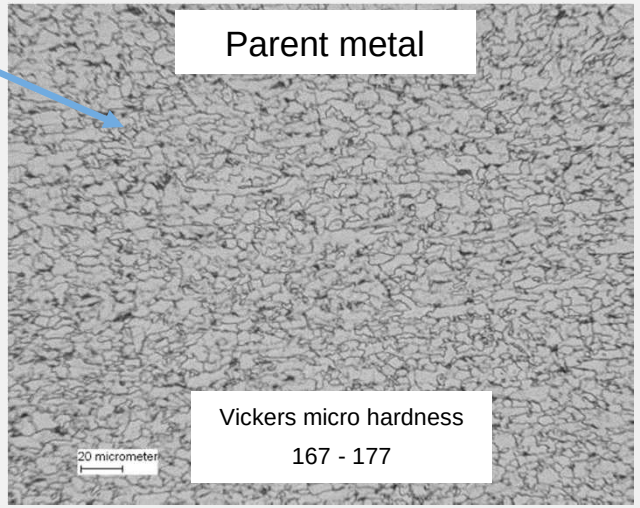


In this weld, the fit up gap has caused the weld metal in the upper panel to sag leaving a characteristic groove in the seam.

Weld metal in the widest part of the gap has cracked on solidification.







Peak hardness occurred in the weld metal. HAZ hardness was virtually identical to the parent metal value.

RFLW Project: Weld Quality Evaluation

Observations from Trials and Sectioning

The trials to date have succeeded in making functional welds on all chassis parts used

Sensitivity to fit up condition is evident

Small fit up gaps did not prevent a joint being made

- Characteristic of weld to sag creating a signature groove in the upper panel at gaps
- In some cases this resulted in small weld cracks
- Effect of such grooves on the strength & durability of the weld is being investigated

The effect of the narrower laser weld on fatigue durability is subject to further testing.

No evidence of porosity in the laser welds on the galv-annealed parts

Very little weld distortion

Potential benefit with regards to corrosion

- No silicon deposits (seen with MIG) which prevent and reduce local paint adhesion.
- Also less damage to the zinc coating compared to MAG on coated steels

RFLW Project: Weld Quality Evaluation

Recommendations from Trials and Sectioning

Design of part & fixtures optimised for laser welding should greatly improve the fit up

- Will help reduce / eliminate the weld sag / crack issue

Control and repeatability of pressed parts is essential

- Especially for panels above 2.0mm where it becomes harder to clamp out gaps

The welds usually penetrated through both panels, therefore:

- means that visual inspection could provide a reliable confirmation the weld is fully formed.
- presence of grooves in the upper weld bead could be used to:
  - indicate potential fit up
  - associated weld quality problems.

Possibility laser welds can be more reliably visually assessed than MAG or Spot welds

- Further investigation is required to gain confidence in this

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4. Future Project Work & Plans
5. Questions and Answers

Future Project Work & Plans

Current On-going and Future Planned Investigations:

Continue to develop and refine cost models based on increased experience

Carry out facility level comparison of RFLW versus MIG (not just single cell based)

Refine the area comparison and cost comparisons out of the above studies

Manufacture of further front sub-frame parts to fully finished level for rig test at TKT

- Part RFLW and part MIG due to current part design
- To assess strength & durability performance against existing parts & processes

Manufacture of further rear sub-frame parts to fully finished level for rig test at TKT

- Fully RFLW to replace all existing spot welds, some projection welds and most MIG
- To assess strength & durability performance against existing parts & processes
- Preliminary discussion underway with OEM about trying to put part on vehicle test

Investigations into clamping fixtures and panel control to minimise gap issues

Demonstrator Design project to re-engineering existing part to be suitable for RFLW and conduct full test, feasibility and cost comparison (longer term)

Future Project Work & Plans

OPPORTUNITIES

- Faster Processing Speeds
  - Compared to MIG/MAG ?
  - Compared to Spot
  - Compared to others ?
- Single Sided Weld Access
- Access issues
- Flexible Manufacturing ?
- Reduced Floor Space ?
- Investment Costs ?
  - Depends on speeds
- Operating Costs ?
- Product Design
- Weight reduction ?
- Reduced distortion
- Customer perception

CHALLENGES

- Panel Fit Up Important
- Batch & material variation issues ?
- Thicker Materials
- Degassing of Weld Vapour
- Structural performance ?
- Tooling Specification
- Process Monitoring
- Laser Safety Requirements
- Few System Integrators
- Education & Training
- Customer lack of experience

Successful implementation requires a new way of thinking!

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Thank you for your attention.
Any questions ?

Contact Details

For further information, please contact:

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