Predicting distortion in vehicle body assemblies

Iain Masters & Xinmin Fan

EuroPAM
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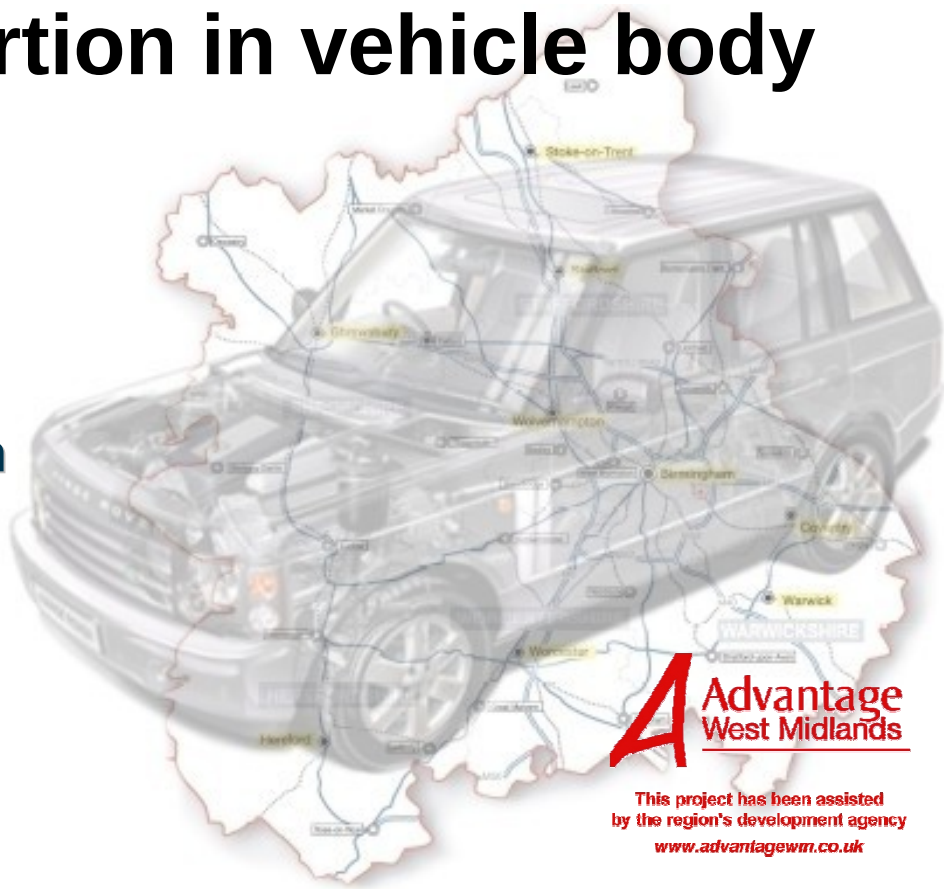


This project has been assisted
by the region's development agency
www.advantagewm.co.uk

Outline

- PARD Programme
- Background
- Causes of Deformation
- Software Requirements
- Initial results with Steel assemblies
- Future work

PARD Programme

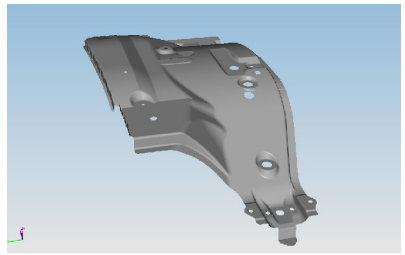
- **Collaboration between Advantage West Midlands, Jaguar Land Rover, Warwick Manufacturing Group and the automotive supplier base**

- **Objective is to improve competitiveness of OEM's and their suppliers, through partnership in the programme, to develop leading edge technologies and best practices**

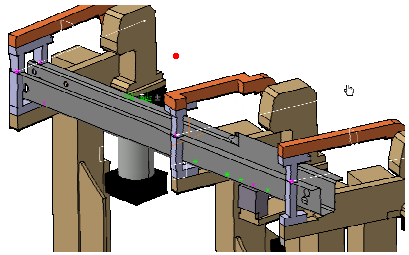
Background

Dimensional Variation in body assemblies associated with:-

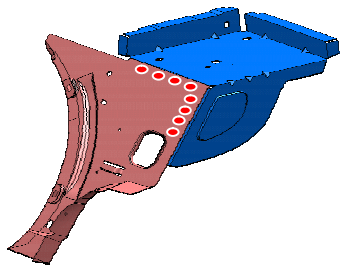
- Component variation
  - DVA type software assumes rigid parts



- Fixture / Jig
  - Wear addressed by regular maintenance



- Joining method
  - Mechanical, thermal distortions not addressed

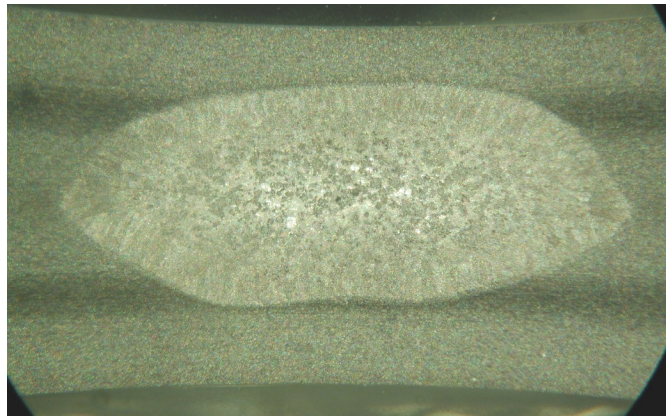


Need for Simulation tool

- More accurate control of BiW assembly variation
- Optimising manufacturing cycle times and quality
- Reduced jig/fixture development time
- Introduction of ‘new’ materials
- Aid to decision making

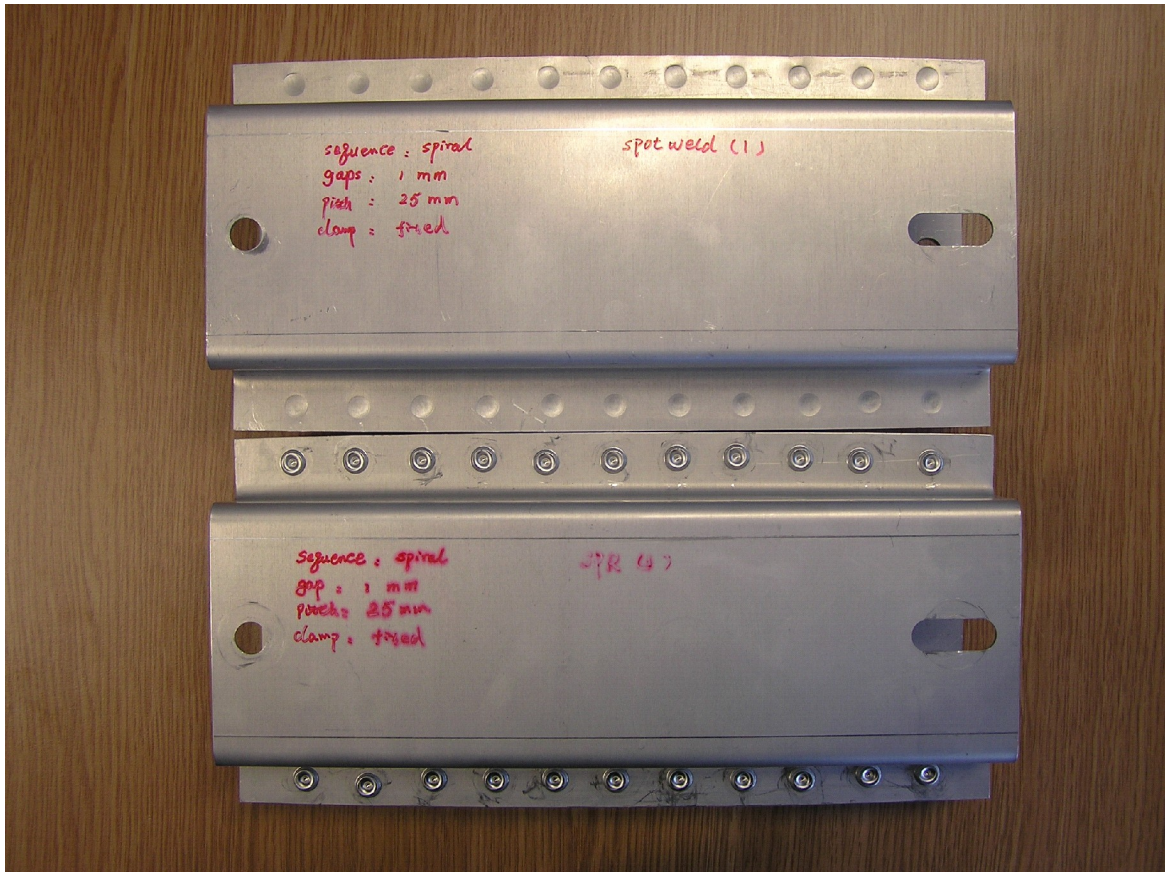
Joining Methods

- Resistance Spot Weld (RSW)



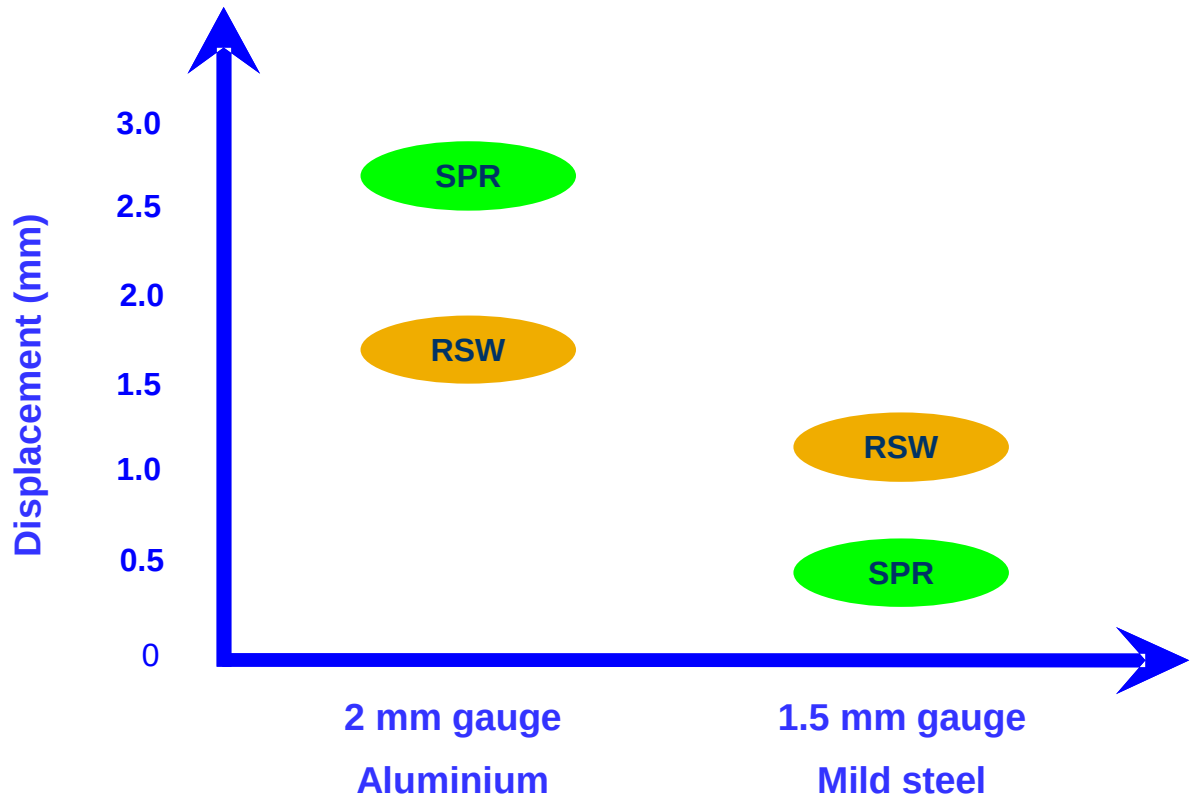
- Self Piercing Rivet

Observed Distortions with RSW and SPR in Al Top-Hat Assemblies



Aluminium Top-hat / Top-hat assemblies showing deformation caused by Resistance Spot Welding and Self Pierce Riveting

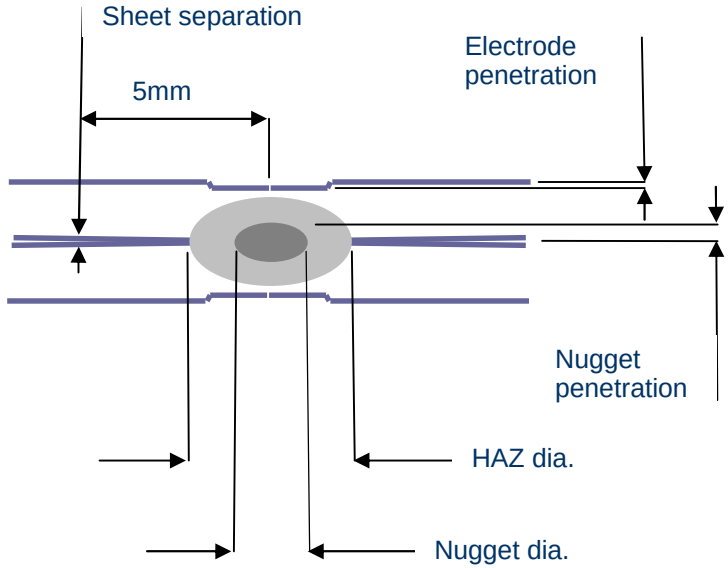
Observed Distortions with RSW and SPR in Top-Hat Assemblies



Maximum distortion across the flanges of two top hats joined flange to flange

Resistance Spot Welding

- **Distortion around RSW caused by sheet separation**
- **Sheet separation arises from expansion and contraction in the fusion zone**



New Automotive materials

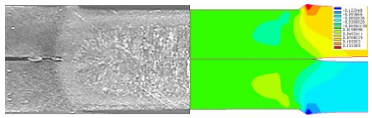
- **Reduce environmental impact of vehicles**
- **Issues for RSW Joining**
  - **High Strength Low Alloy steels**
    - **higher energy input than conventional steels**
    - **short hold time to avoid quenching**
  - **Aluminium**
    - **High welding currents**
    - **High electrode forces**
    - **Short weld times**

Software requirements

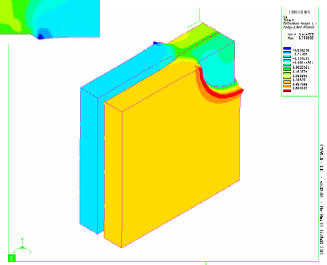
- **Ability to model local distortions around a spot weld**
  - Electro / Thermal / Mechanical interactions
- **Modelling of assembly process**
  - Welding sequence
  - Clamping conditions

Local - Global Modelling Technique

LOCAL MODEL

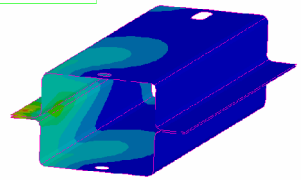


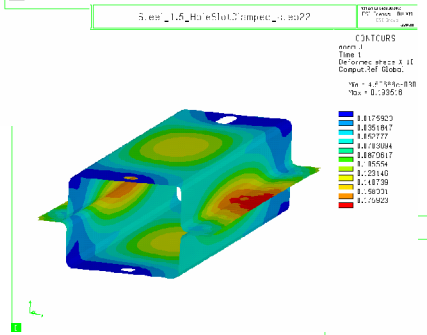
2d model of individual weld



3d model of individual weld

Application of 1st weld

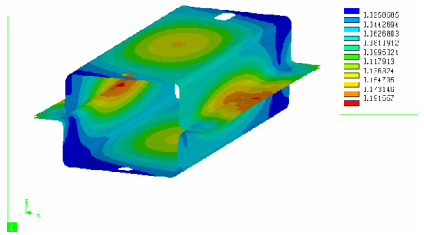




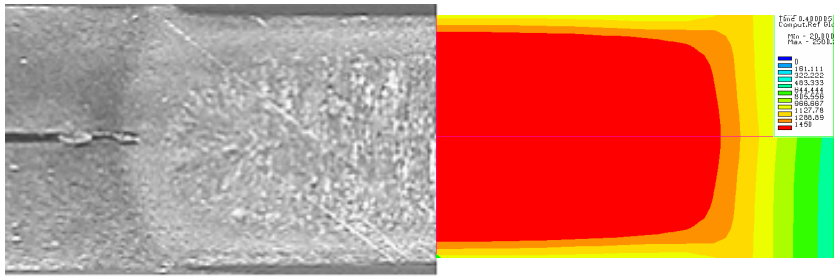
Application of final weld

GLOBAL MODEL

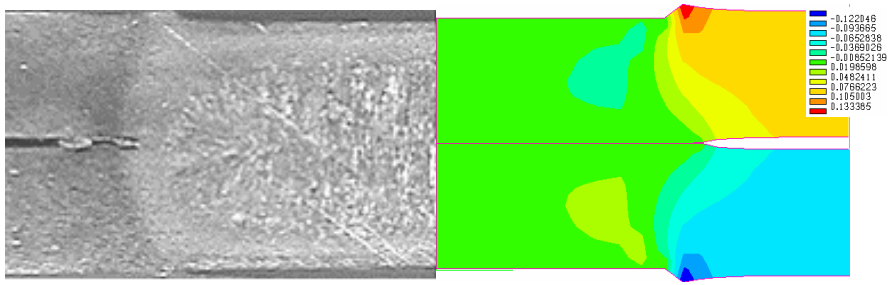
Release from fixture



Validation of Local Weld Model



(a) Nugget size



(b) Sheet separation

(Welding current=10.5 KA, Electrode force = 2.5 KN, Welding time = 15 cycles)

Nugget size and Sheet separation

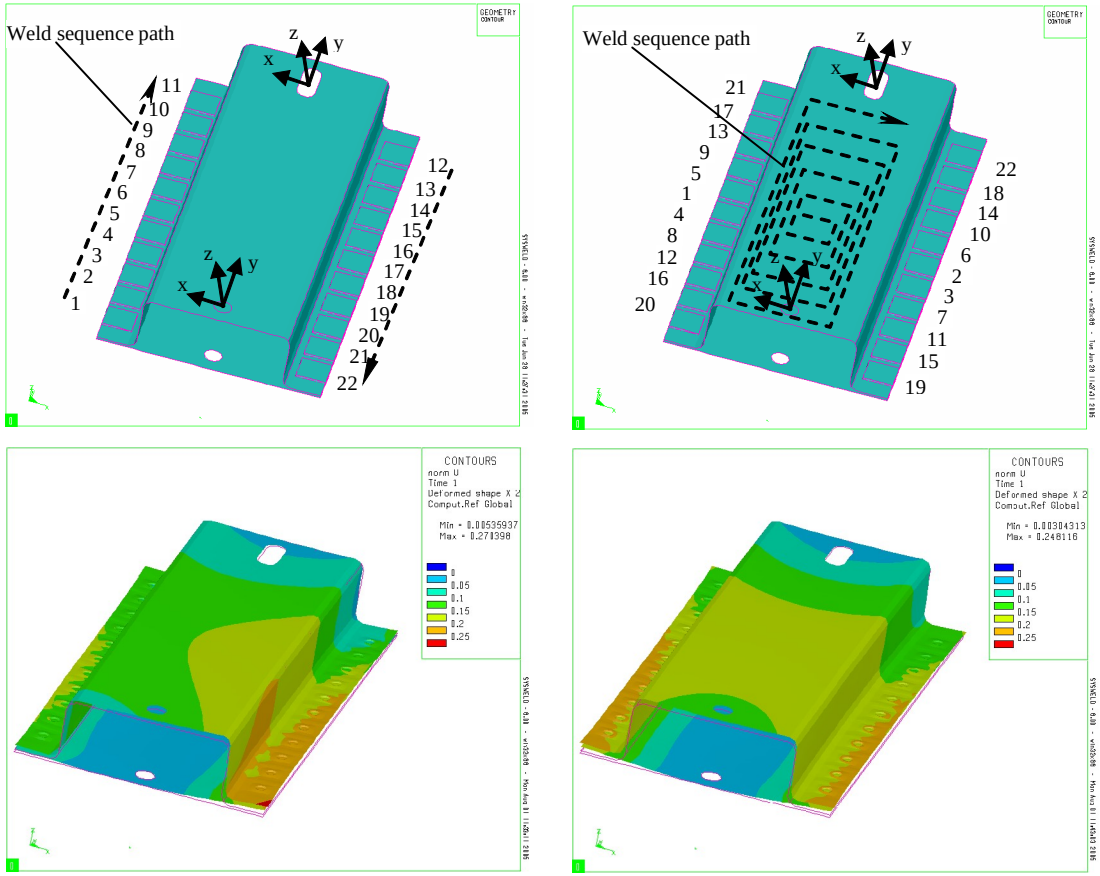
Validation of local weld model

	Target	Actual	Simulation
Nugget dia. (mm)	>4.9	6.0	6.1
Nugget penetration (mm)	-	1.1	1.3
HAZ dia. (mm)	-	7.2	7.6
Sheet separation 5mm from centre (mm)	<0.15	0.1	0.12
Electrode penetration (mm)	<0.15	0.006	0.16

Distortion Prediction – Effect of Weld Sequence

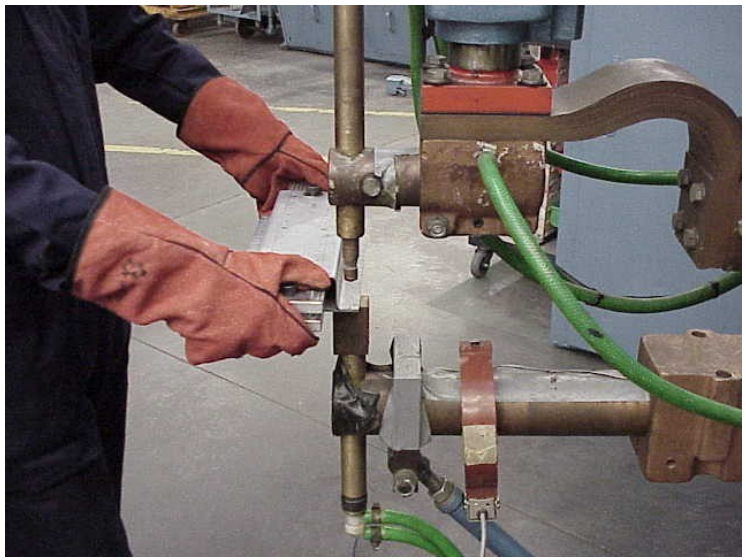
(a) Inline joining sequence

(b) Spiral joining sequence

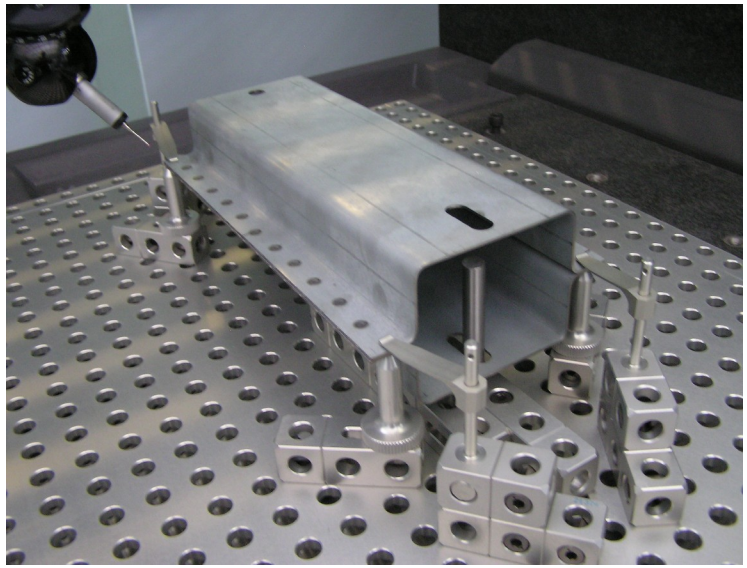


Steel Top-hat / Flat plate assembly

Physical Validation

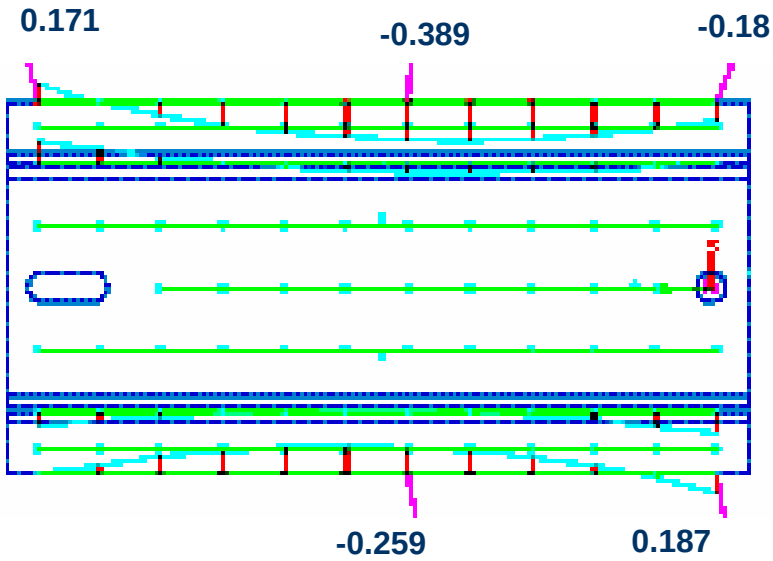


Welding Top Hat assembly

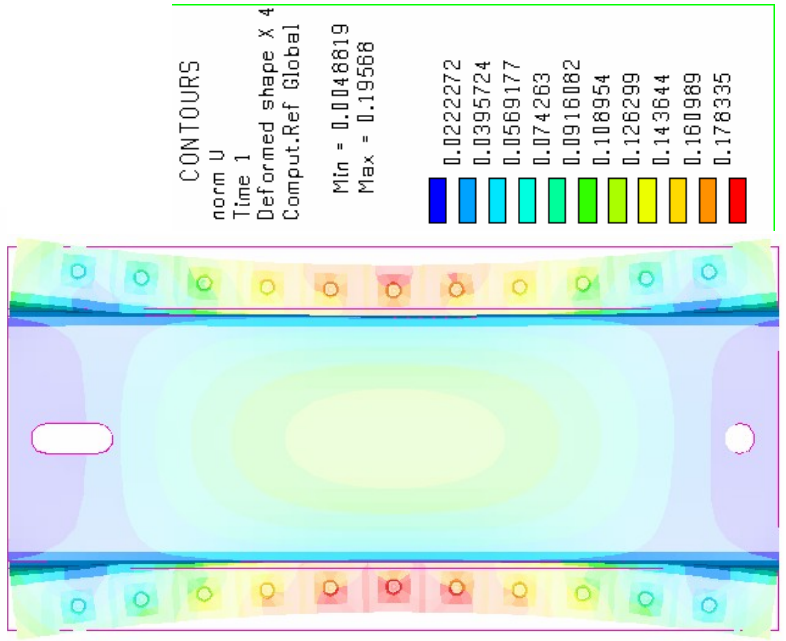


CMM measurement of assembly

Comparison of Test and Simulation



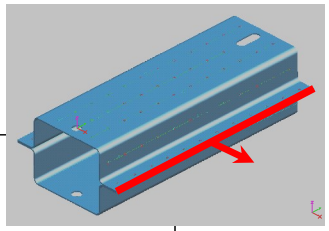
CMM measurement

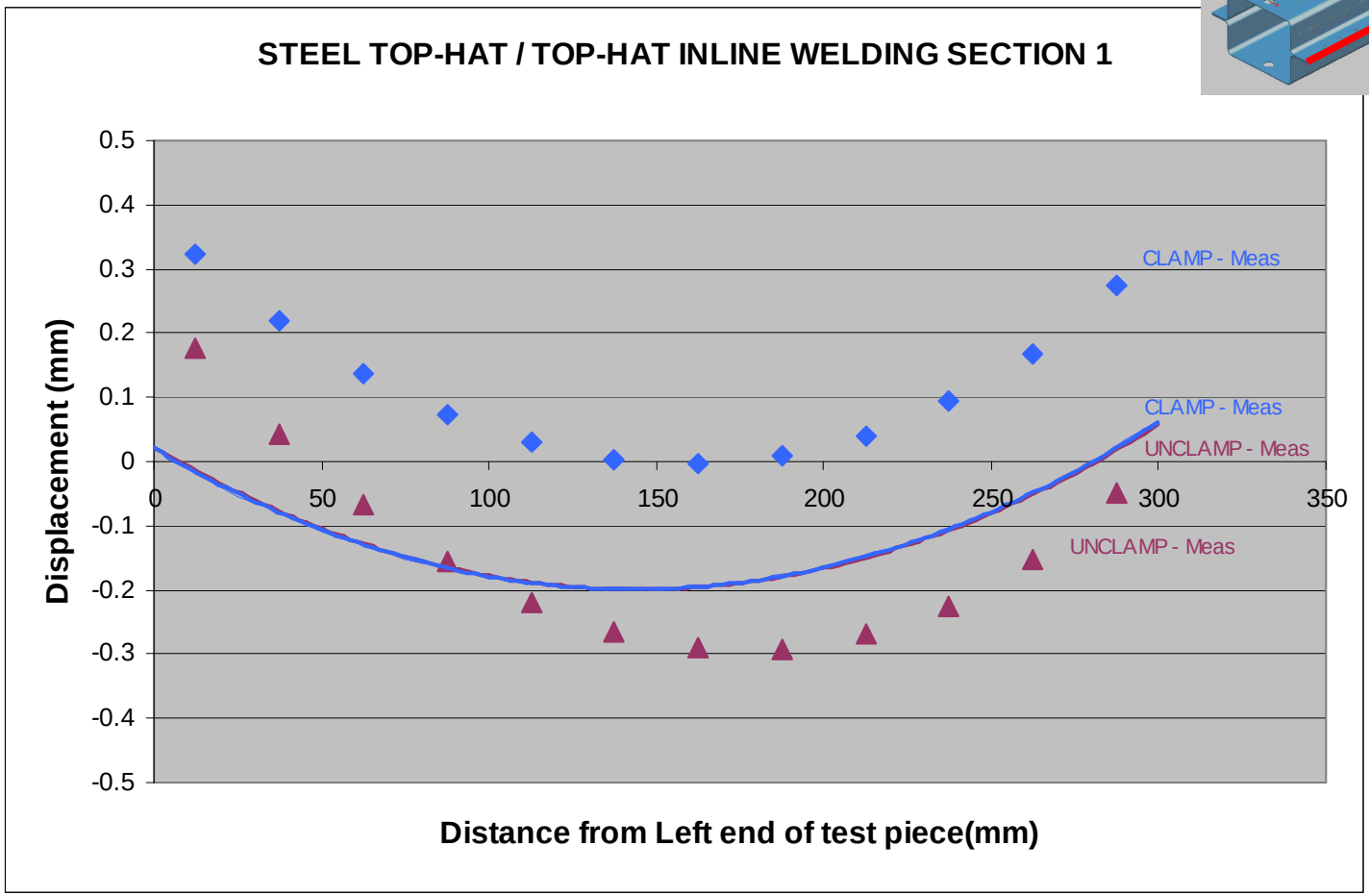


Simulation result

DC01 + Zintec Top-hat / Top-hat assembly – in-line welding sequence

Comparison of Test and Simulation





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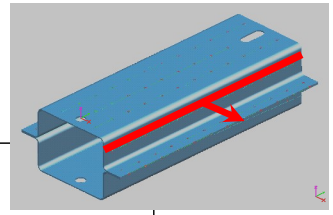

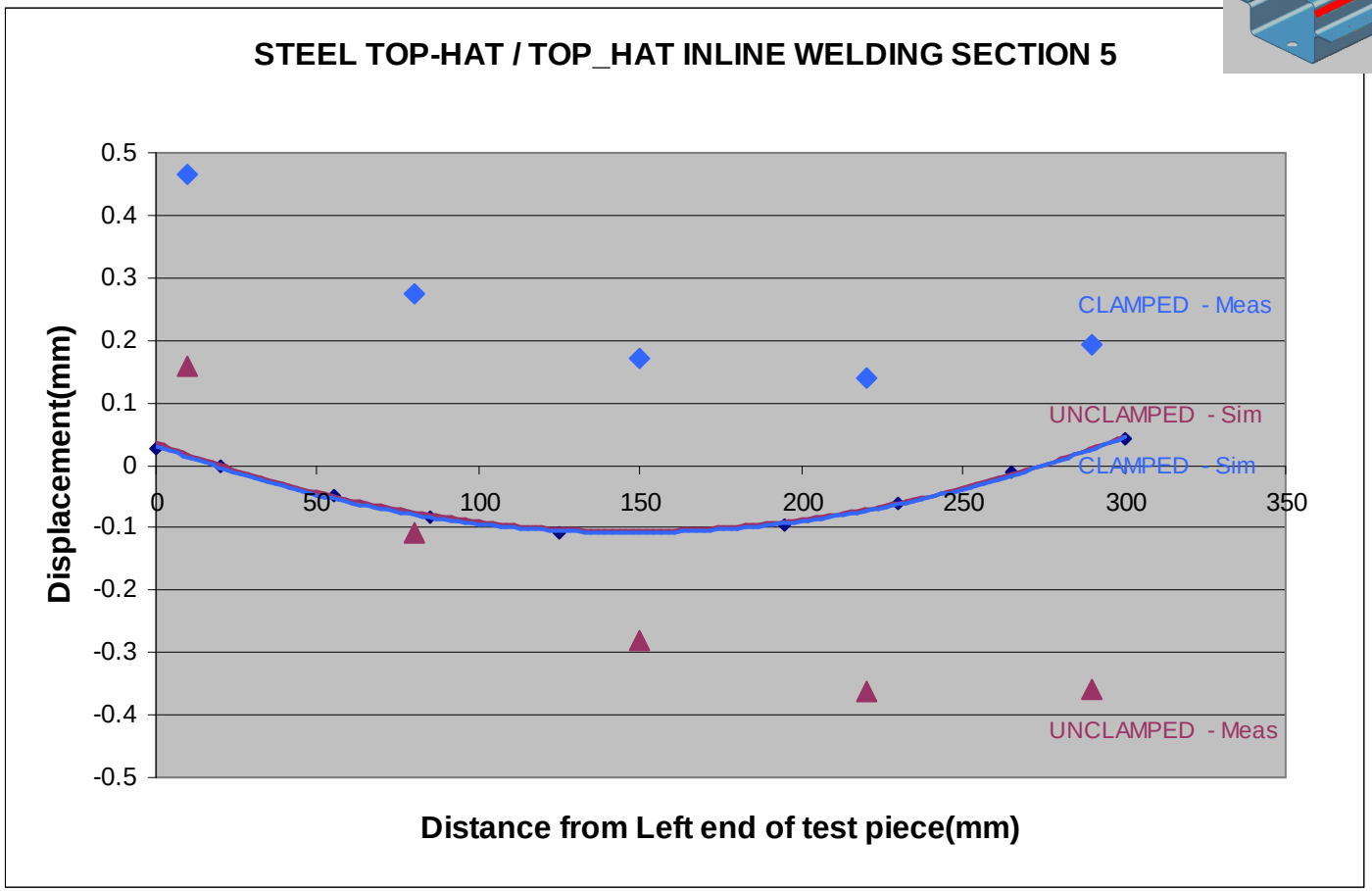

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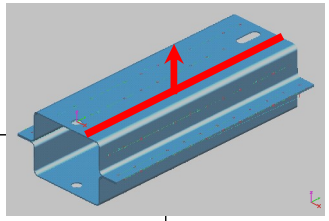

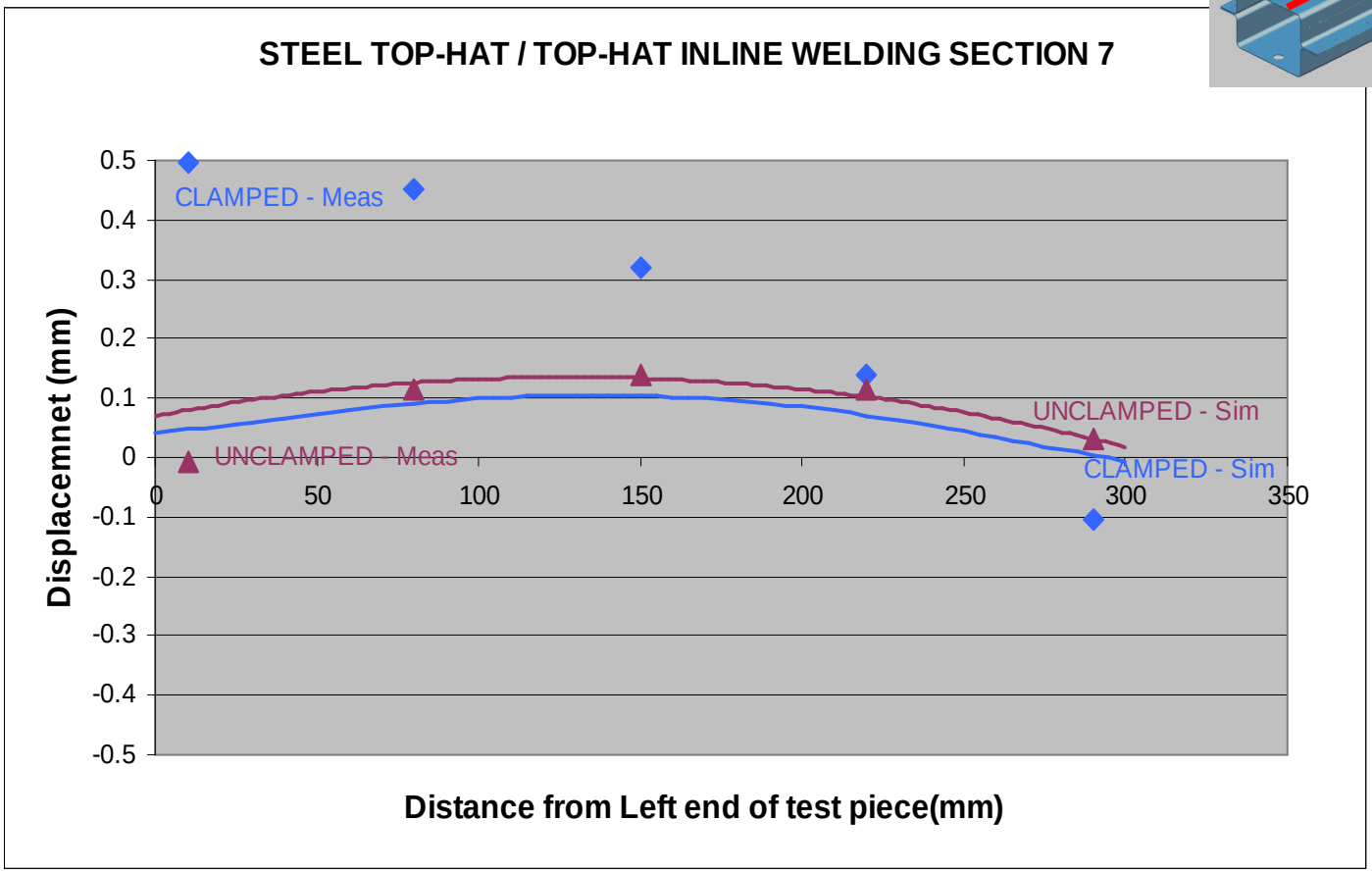

Conclusions

- Successful prediction of direction of deformation
- Underestimate of magnitude of distortion
  - Component & Fixture accuracy?
  - Mesh size?
- Projection of welds on to global model and model size could be extremely large
- Extensive material data is required

Future Work

- Case study with actual part
- Validate model for RSW of aluminium
- Use Pam Stamp Simulations as the starting point to incorporate distortion and residual stress information into SYSWELD

Acknowledgements

Advantage West Midlands

JAGUAR

LAND ROVER

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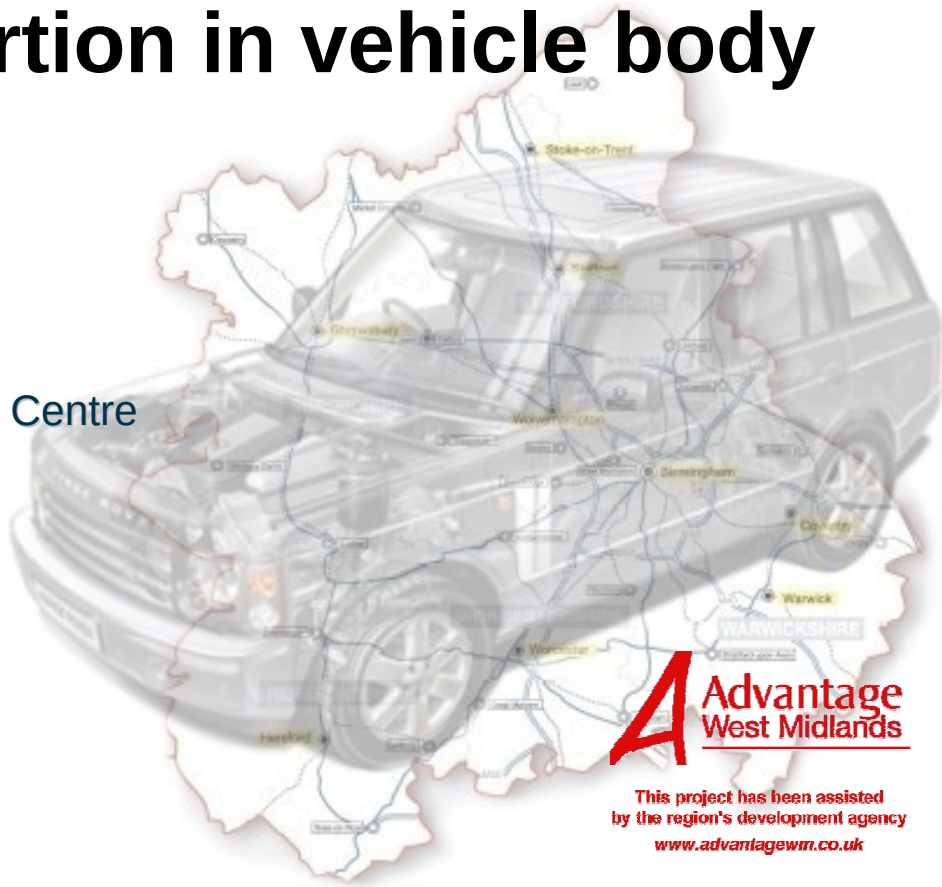
THE VIRTUAL TRY-OUT SPACE® COMPANY

Predicting distortion in vehicle body assemblies

Iain Masters & Xinmin Fan
Warwick manufacturing Group
International Automotive Research Centre
The University of Warwick
Coventry
CV4 7AL
UNITED KINGDOM
+44 (0)24 7657 5380/5408



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