FACULTY OF ENGINEERING AND ARCHITECTURE

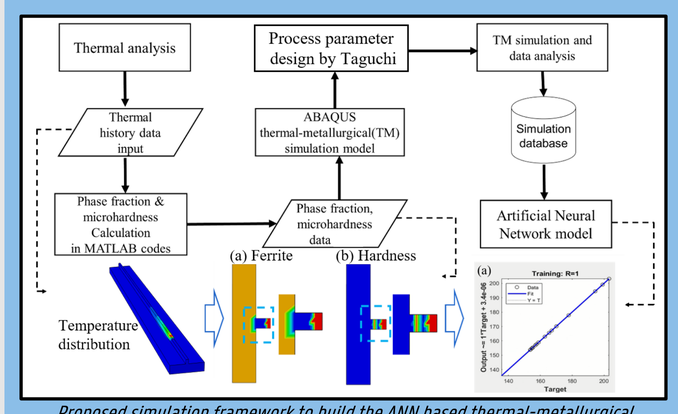
SOETE LABORATORY – EMSME (EA08)

Robin Motte, Jun Cheng, Rafael Nunes, Wim De Waele

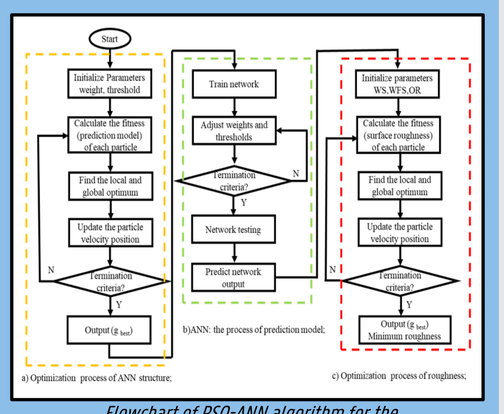
RESEARCH ON WIRE+ARC ADDITIVE MANUFACTURING (WAAM) AT SOETE LABORATORY

PhD: Modelling and prediction tools for WAAM based on machine learning

- A thermal-metallurgical model for mild steel produced by WAAM
  - Thermal analysis using different heat source models
  - Phase transformation theory for phase fraction and hardness calculation
- Prediction / optimization of microstructural and mechanical properties of mild steel produced by WAAM
  - Machine learning prediction model for microhardness, phase fraction, etcetera
  - Intelligent optimization algorithm for microhardness, phase fraction, etcetera



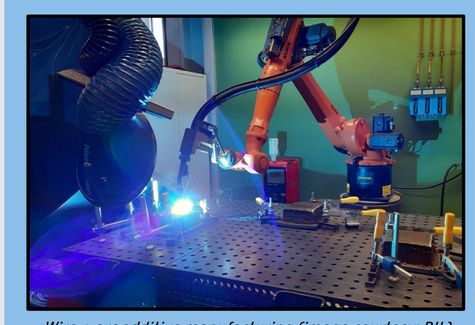
Proposed simulation framework to build the ANN based thermal-metallurgical model.



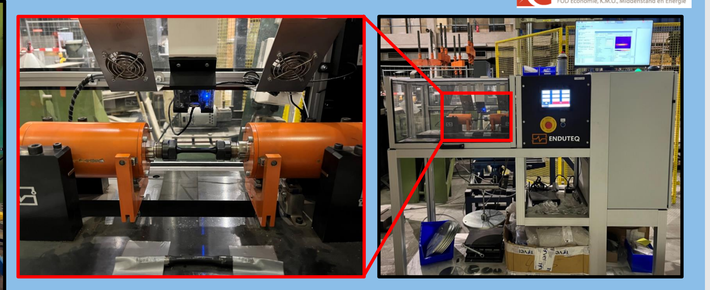
Flowchart of PSO-ANN algorithm for the prediction/optimization model

WAAMMEC: Mechanical properties of WAAM structural components

- Fatigue characterisation of 2 WAAM materials
  - Rotating bending fatigue tests
  - Specimens extracted in deposition (X) and build (Z) directions
- Compared to design curves in standards for steel construction and pressure equipment

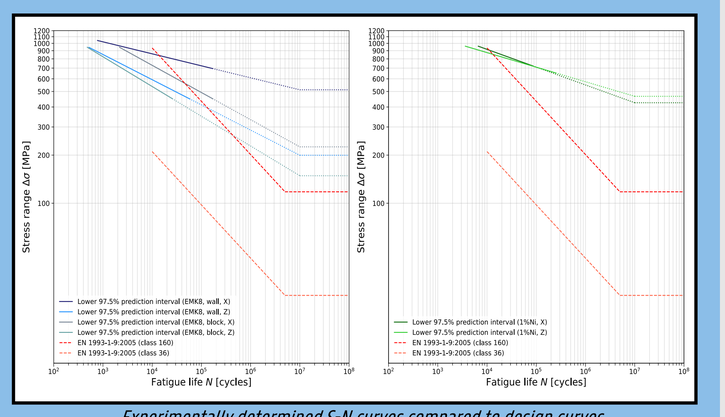


Wire + arc additive manufacturing (image courtesy: BIL)



Rotating bending fatigue test setup

Walls printed for specimen extraction



Experimentally determined S-N curves compared to design curves

Polished fatigue specimen

PhD: WAAM of Al Alloy and the Joining Between Additively to Conventionally Manufactured Al Parts

WAAM manufacturing of aluminium plates (image courtesy: BIL)

Evaluation of the printability of 2xxx, 5xxx, and 7xxx aluminium alloys
Influence of process parameters and printing conditions:

- Heat input
- Filler metal quality (surface roughness and contaminants)
- Shielding gas and shielding gas flow
- Deposition path
- Interpass cleaning and interpass temperature

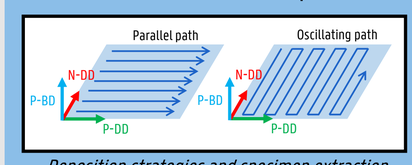
Evaluation of the joining between AM to conventionally manufactured aluminium parts

- Fusion welding processes (GMAW, GTAW, LBW, and PAW) and solid-state welding processes (FSW, and RFW)
- Correlation of the manufacturing process with the weldability of the aluminium parts
- Evaluation based on mechanical and metallurgical aspects

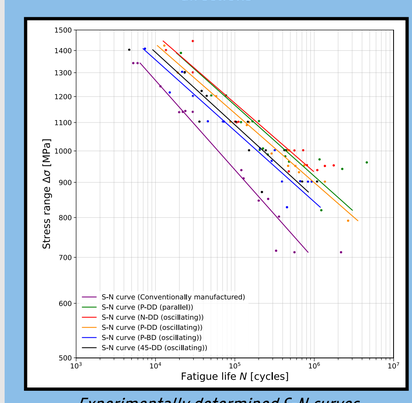
Cross-section of typical welds between AM to conventional Al plates by fusion welding processes (image courtesy: BIL)

Print-AM: Integrity of WAAM components through intelligent printing

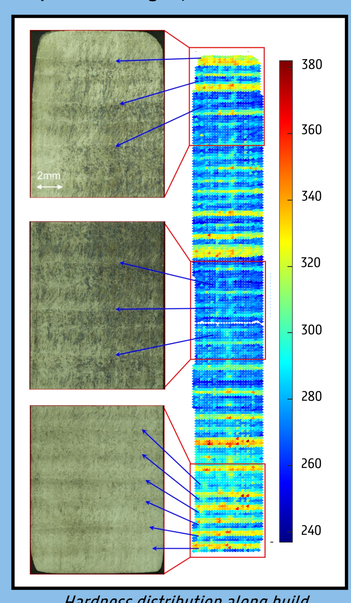
- Effect of deposition pattern + anisotropy
  - Hardness mapping, tensile, Charpy and fatigue tests
  - Fatigue performance comparable to conventionally manufactured material
- Development of machine learning based models
  - Incomplete data → data imputation and augmentation
  - Process parameters → yield strength, ultimate tensile strength, elongation and hardness



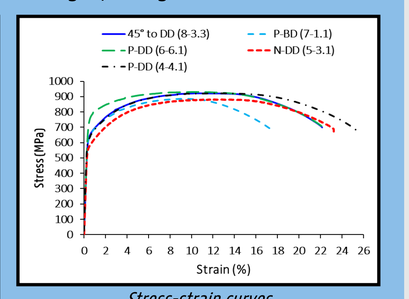
Deposition strategies and specimen extraction directions



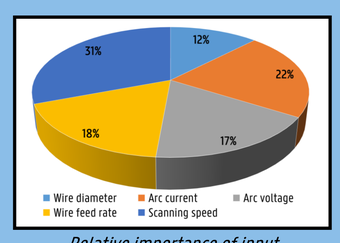
Experimentally determined S-N curves



Hardness distribution along build direction



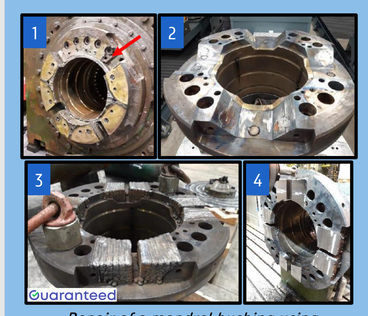
Stress-strain curves



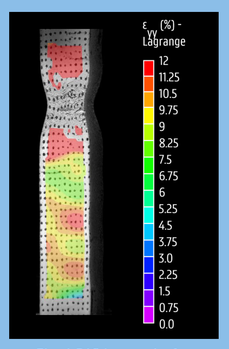
Relative importance of input parameters for machine learning model

PhD: Structural integrity of steel WAAM components

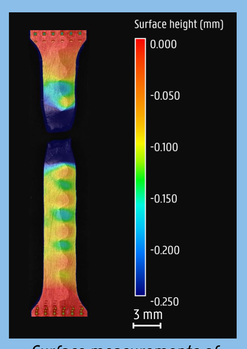
- WAAM in remanufacturing applications
- Characterisation of residual stresses
- Characterisation of interface between WAAM deposit and substrate
  - Digital Image Correlation (DIC)-aided tensile tests: specimens extracted at interface
  - Deformation is related to waviness of interface (due to adjacent weld beads)
- Feasibility and influence of pneumatic impact treatment
- MSc thesis '23-'24: influence of surface waviness on fatigue performance



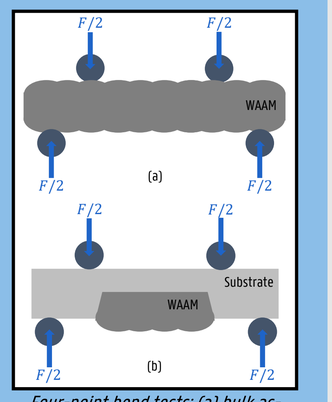
Repair of a mandrel bushing using WAAM (image courtesy: Guaranteed)



Final DIC image before failure (deposit on left side)



Surface measurements of failed specimen (deposit on left side)



Four-point bend tests: (a) bulk as-printed WAAM material; (b) machined groove filled by WAAM

Contact

wim.dewaele@ugent.be
jun.cheng@ugent.be
rafaelnunes.gomesnunessilva@ugent.be
robin.motte@ugent.be

www.ugent.be/ea/emsme/en/research/soete

Universiteit Gent
@ugent
Soete Laboratory - Ghent University

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