Market Sector:

MULTIPLE SECTORS

Technology Theme:

ADDITIVE MANUFACTURING / TRANSFORMATION / MODELLING & SIMULATION

NATIONAL CENTRE ADDITIVE MANUFACTURING

mtc Manufacturing Technology Centre

ENVIRONMENTAL IMPACT OF METAL ADDITIVE MANUFACTURING (AM)
A DISCOVERY PROCESS FOR SUSTAINABLE MANUFACTURING

IDENTIFICATION OF ENVIRONMENTAL IMPROVEMENTS FOR AM

Using the NCAM's Metal Powder Bed Fusion facility, the MTC conducted a discovery project focussed on identifying and assessing opportunities to reduce the carbon footprint of the metal AM process chain.

> This discovery into the environmental impact of additive manufacturing has created an assessment process and a rich data set which can support industry in understanding and reducing the carbon footprint of additive manufacturing.
>
> **Steve Smith, Associate Director, Transformation Team, MTC**

THE CHALLENGE

Additive manufacturing presents a unique opportunity to create novel products that would be infeasible, if not impossible, to make using conventional approaches. AM has been heralded as a significant tool in the transition to sustainable manufacturing by enabling new products and business models. From an environmental perspective, AM is already reducing the lifetime impact of components for specific applications.

Despite these benefits, during the manufacturing phase, current metal additive processes such as Laser Powder Bed Fusion (LPBF) are energy intensive and generally have higher associated carbon footprints per kg of final part than conventional manufacturing.

MTC'S SOLUTION

- Through a combination of direct measurement and literature review, a carbon emissions estimation model was generated to better understand the current impact of a typical LPBF process chain, including post-build operations, heat treatment and surface finishing.
- Workshops were held with process experts to identify development opportunities that could improve the environmental impact of the AM process chain.
- Sustainable improvement concepts were collated and evaluated in terms of viability.

THE OUTCOME

- The largest contributors to carbon emissions for the LPBF process chain were identified as:
  - Embodied carbon associated with consumables;
  - Electricity from process chain equipment and ancillaries;
  - Embodied carbon from primary production of metal powder.
- Concepts for improving the environmental performance of the AM process and AM facilities have been collated and assessed to guide future research efforts.

BENEFITS TO THE CLIENT

- A better understanding of the environmental impact of the LPBF process chain.
- Capability to quantify the effect on carbon emissions before implementing changes to the AM process.
- A clear roadmap for research and development to support more sustainable AM production in the future.
- A transferable approach for conducting discovery projects with an environmental focus.

> Additive manufacturing is a technology area that has huge potential to create more sustainable products. Through deeper understanding and demonstration, the MTC can drive the journey to sustainable adoption of AM technologies.
>
> **Dr Justyna Rybicka, Technical Lead in Sustainable Manufacturing, MTC**

TOWARDS SUSTAINABLE ADDITIVE MANUFACTURING:

Opportunities to improve the environmental performance of the Laser Powder Bed Fusion process chain

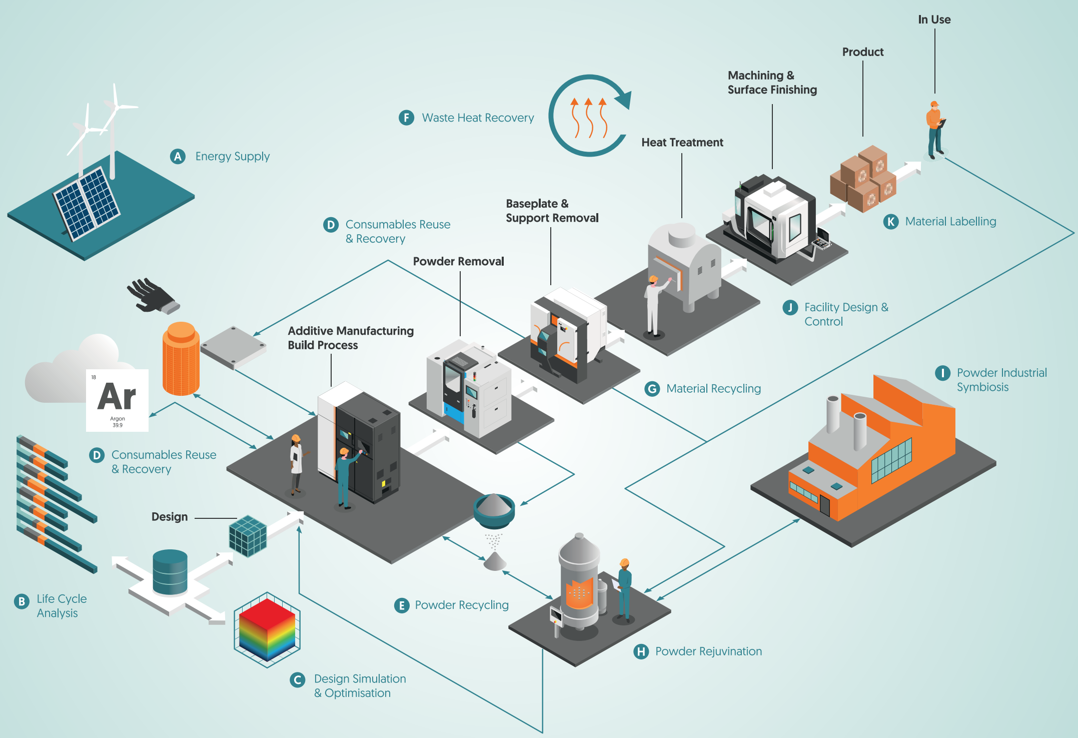
A Energy Supply: Electricity supplied by zero carbon sources and generated electrically locally where possible

B Life Cycle Analysis: Careful product design and process selection of the most appropriate route for manufacturing parts with consideration of impact across the entire product lifecycle

C Design Simulation & Optimisation: Use of advanced design tools and simulation to optimise components for efficient manufacturing and minimal material use as well as for functionality. Applying data and learning for previous builds to improve and de-risk future designs

D Consumables Recovery:
- Point-of-use equipment to harvest and recirculate exhaust industrial gases such as argon from AM machines and furnaces
- Transition to reusable consumables and personal protective equipment (e.g. gloves)
- Development of longer lasting filters for AM machines and ancillaries

E Powder Recycling: Efficient strategies for managing the reuse of powder, enabled by digital powder traceability solutions



F Waste Heat Recovery: Harvest residual heat from chillers and higher temperature processes such as heat treatment

G Material Recycling: Conversion of consolidated material from supports, scrap and end-of-life components into powder to enable a circular economy for metal powder

H Powder Rejuvenation: Novel approaches such as Plasma Spheroidisation to preserve and restore the quality of powders thereby extending their useful life

I Powder Industrial Symbiosis: Industrial ecosystem for metal powders to better utilise recycled powder across different sectors and applications

J Facility Design & Control: Facility designed to maintain temperatures with lower energy requirements, built using sustainable materials and intelligent energy management throughout operation

K Material Labelling: Standardised labelling of AM products to ensure that material is identifiable at end-of-life to enable recycling

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AMGTA – Additive Manufacturer Green Trade Association

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