BCAST: Industrial Capability Highlights

Brunel University London

BCAST

LiME
Liquid Metal Engineering Hub


BCAST

Introduction

BCAST (Brunel Centre for Advanced Solidification Technology) is one of the world's largest and best equipped solidification and casting research groups, focussing on both fundamental and applied research within the solidification field. Established in 2002, and led by Professor Zhongyun Fan, BCAST has grown to become one of the most successful light metals research centres in the world.

BCAST's unique combination of fundamental research with the development of new technologies and industrial demonstration and implementation is working towards creating a transformational impact on industry, in ways that make a vital and distinctive contribution to the planet's sustainability.

BCAST undertakes applied R&D with industrial partners to exploit fundamental research and technological development to support the metal casting industry in implementing innovative processing technologies and new products. BCAST is located on Brunel University London's campus in over 10,000 m^2 of space, housing over £20M of investment in large-scale metal processing facilities and over £10M investment in state of-the-art analytical and testing equipment. These, together with our extensive metallurgical expertise, constitute a unique national asset allowing us to address the full innovation value chain spanning discovery, understanding, adaption/integration, validation and deployment.

Our scale-up facilities, the Advanced Metal Casting Centre (AMCC) and Advanced Metal Processing Centre (AMPC), provide industry with the opportunity to work towards bridging the gap between fundamental, laboratory-scale research and full-scale industrial trials, providing outputs that can result in significant time and cost reduction towards commercialisation and development of state-of-the-art alloys, processing technologies and cast components.


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6082

The Advanced Metal Casting Centre (AMCC)

The first of the purpose-built scale-up buildings is the Advanced Metal Casting Centre (AMCC). The AMCC was opened in April 2016 with the investment of £14M from the Engineering and Physical Sciences Research Council (EPSRC) for metal processing equipment, Brunel University London for a dedicated building, and industrial partners and government funding for research projects.

The capabilities of the AMCC include:

Low Pressure Die Casting

A commercial low pressure die casting machine with a 240 kN press, and a retractable 600 kg batch melting furnace. Die cooling achieved with water, compressed air, or an air/water mist.

High Pressure Die Casting

A commercial 1600 tonne clamping force, cold chamber high pressure die casting machine, including automated die spraying and robotic component extraction. Batch melting of up to 600 kg of either aluminium or magnesium alloys with conventional dosing, and vacuum assisted dosing.

Melt Conditioned – Twin Roll Casting

A twin roll casting machine with 100 mm diameter water-cooled rolls for casting magnesium alloy strip of up to 400 mm wide. The system includes a 200 kg tilt-furnace, in-line edge trimming and guillotine; and BCAST's patented high shear melt conditioning technology.

Direct Chill Casting

A pilot-scale single strand direct chill casting table capable of casting 204 mm diameter billets up to 2.3 m in length. The system includes a heated launder and a 200 kg electric tilt furnace for melting aluminium alloys.

Extrusion

A 16.5 MN long-stroke direct extrusion press capable of extruding 204 mm diameter billets up to 800 mm in length. The line includes gas fired billet heating, an air/water quench, and a 14 m handling table with puller, stretcher and finishing saw.

The Advanced Metal Processing Centre (AMPC)

The Advanced Metal Processing Centre (AMPC) is the second of the purpose-built scale-up buildings. It houses industrial and pilot scale metal processing equipment, complementary to that of the AMCC, in a second bespoke building. The processing equipment is supported by machining, joining, mechanical testing and 3D inspection facilities. Together with the AMCC, the AMPC demonstrates technologies developed in the laboratory at a recognisable industrial scale, and allows BCAST's industrial partners to carry out their R&D activities bridging the gap between discovery and full implementation. Funding for the AMPC has been provided through a £15M award from the Higher Education Funding Council for England (HEFCE) UKRPIF programme (now managed by Research England) and over £60M of support for R&D from the private sector over ten years.

The capabilities of the AMPC include:

Sand Casting

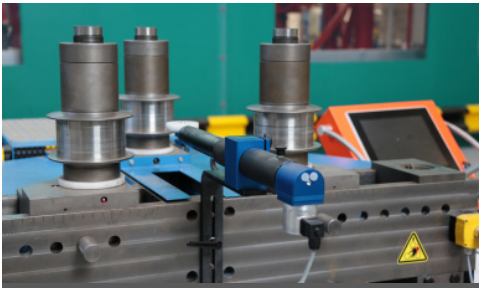
Commercial foundry equipment forming a no-bake (air-set) sand casting line, for moulds up to 1 m x 1 m in size, comprising hopper, sand mixer, vibratory compaction, roll-over, 300 kg furnace for melting aluminium, heated ladle and de-coring oven.

Gravity Die Casting

A commercial 90° tilting gravity die casting machine, with 800 x 500 mm platens and four double die cooling channels for air and water, capable of casting components up to 20 kg in weight.

Free-form Bending

A commercial 6-axis servohydraulic computer numerical control (CNC) free-form bending machine to allow continuously fed extruded profiles of up to 4 m in length to be bent into complex geometries.



Roll Bending

A commercial 35 tonne roll bending machine, with three individually servomotor-driven rolls, computer control, automatic radius correction, and positioning resolution of 1/100 mm.

Electromagnetic Pulse Forming & Welding

An innovative method of shaping and joining that uses the force generated by short, energetic electromagnetic pulses in combination with field shapers, mandrels and dies. It can be used for many applications including shaping hollow sections and joining dissimilar metals.

Heat Treatment

A range of large heat treatment ovens for homogenisation, solution and ageing treatments of billets, extruded profiles, fabricated components and cast components. The facilities include a water/polymer quench bath.

Machining

Machining facilities include a CNC machining centre, CNC lathe, electro-discharge wire cutting, and other workshop equipment. The equipment is used for fabricating prototype components and machining test specimens.

Joining

A cold metal transfer (CMT) welding set with a universal robot, for welding at very low heat input to minimise distortion and for welding thin gauges. A Flow Drill Screwdriving system, which forms holes, threads and inserts a screw in a single step: ideal for joining to hollow sections and where access is difficult.

Mechanical Testing

A 100 kN servohydraulic fatigue test frame and a 100 kN electromehcanical universal test frame, both with environment chambers for testing at up to 600°C. Strain measurement by contact extensometry and a dual-camera optical strain measurement system. Supported by hardness testing and inspection microscopes.

X-ray CT Scanning

Two x-ray computed tomography systems for 3D inspection: a 450 kV system for inspection of large sized components capable of imaging defects of 100 µm; and a 150 kV system with micron scale resolution in small samples.

Optical 3D Scanning

Precise measurement of components by stereo-camera optical 3D scanning with triple scan functionality, additional photogrammetry, touch probes for out of sight measurement, and inspection turntable.

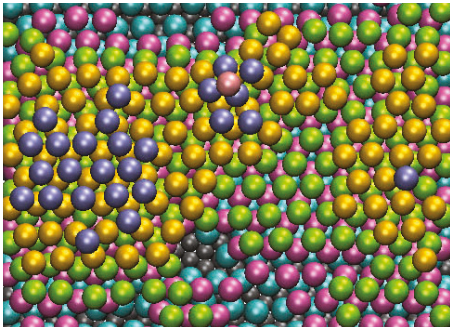
The Future Liquid Metal Engineering Hub

BCAST leads the £10M EPSRC funded Future Liquid Metal Engineering Hub (Future LiME Hub), which focusses on fundamental science and early stage development of alloys and technologies, using lab scale experimental techniques and advanced analytical instruments, that may be scaled-up in the AMCC and AMPC facilities.

The long-term vision of BCAST and the Future LiME Hub is full metal circulation, in which the global demand for metallic materials is met by a full circulation of secondary metals (with only limited addition of primary metals each year) through reduced usage, reuse, remanufacture, closed-loop recycling and effective recovery and refining of secondary metals, as illustrated.

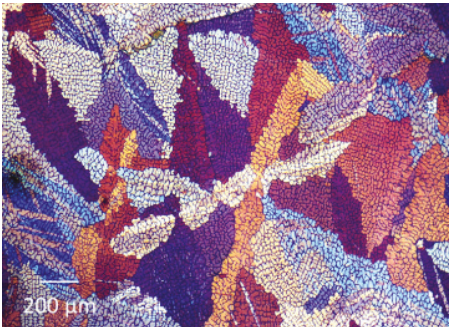
The core Future LiME Hub activities are based within BCAST, and are supported by the complementary expertise of our academic spokes at Oxford, Leeds and Manchester universities and Imperial College London, and significant new financial investment from funding bodies and our industrial partners.

Research Themes



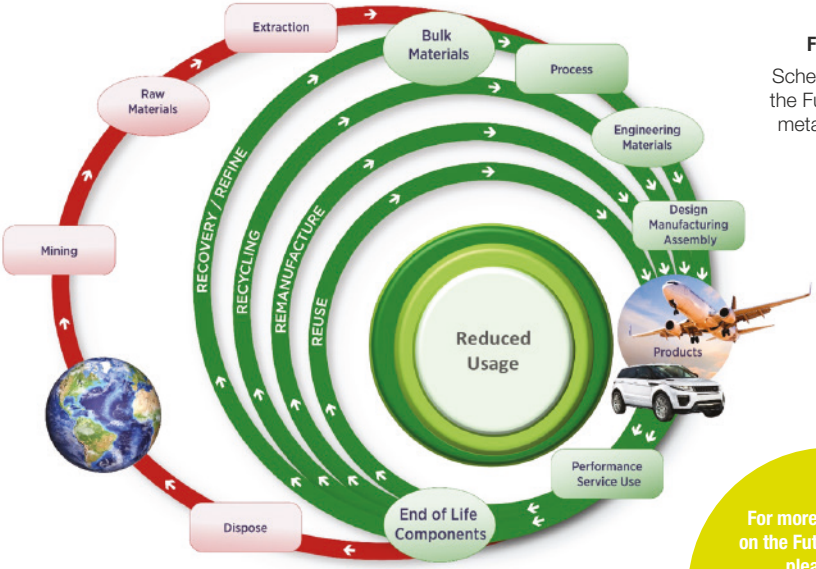
Fundamental

The fundamental research theme focusses on three main areas of solidification science. These are: heterogeneous nucleation, the solid/liquid interface during crystal growth and microstructure formation.



Alloy Development

Alloy development research concentrates on the design of optimum microstructure in lightweight aluminium and magnesium based alloys to deliver maximum performance, by using a combination of experimental and theoretical approaches. These are used to achieve the required physical properties including strength, ductility and conductivity.

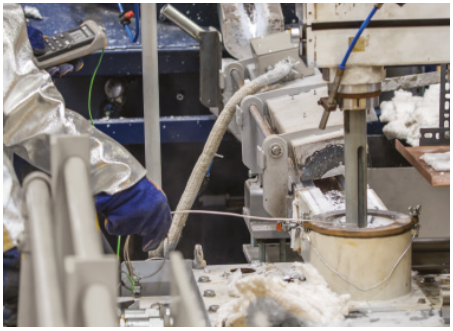


Full Metal Circulation

Schematic illustration of the Future LiME Hub full metal circulation vision.

For more information on the Future LiME Hub please visit

@liquidmetaleng
www.lime.ac.uk
www.brunel.ac.uk/BCAST



Technological Innovation

Technological innovation research primarily focusses on novel solidification processing technologies. One of our significant technological achievements is the development of the high shear technology for melt conditioning and its implementation in many casting processes to produce high quality products, capable of closed-loop recycling.

Industrial Applications

The industrial application research theme provides an industrial steer for all research activities within the Hub. We work with many partners ranging from OEMs to Tier 1, 2 and 3 suppliers within the light metal supply chains. The scope of projects includes new alloy development for OEMs, to the advancement of Tier 1 cast products using our high shear technology for melt conditioning.

Carbon Aluminium Automotive Hybrid Structures – CAAHS

Case Study

- **Carbon Aluminium Automotive Hybrid Structures (CAAHS), a 24-month Innovate UK-sponsored, lightweight, high strength vehicle chassis research programme with £2.9 million project costs**
- **Expertise from five collaborating partners including BCAST at Brunel University London, Bentley Motors Ltd, Constellium, Gordon Murray Design (Lead Partner) and Innoval Technology**
- **Focused on the generation of a new automotive structure that was 40% lighter than the steel equivalent using Gordon Murray Design's iSTREAM® technology**
- **Utilised a variety of forming and joining techniques in the AMCC and AMPC facilities at BCAST**
- **Featured Constellium HSA6™ high strength aluminium alloys and recycled carbon fibre**

The programme aimed to further develop the next generation of aluminium alloy materials and processes for application in automotive body structures. This resulted in a new generation of the iStream® lightweight automotive structure that offered 40% weight savings over the original steel based system.

During the first year, the team worked on designing the new frame using aluminium and recycled carbon fibre panels. Aluminium alloys, extrusion shapes, cutting edge joining and manufacturing techniques were trialled at scale in BCAST's Advanced Metal Casting Centre (AMCC) and at Gordon Murray Design (GMD). Information collected throughout the first year allowed for the development of a new advanced frame that was manufactured to full scale in the second year within BCAST's AMCC and at GMD. In total, two new frames were completed and manufactured; one to undergo crash tests to assess performance and the second kept intact for showcasing at public events.

The new iStream® structure that resulted was inherently recyclable and provided a development path for future weight reduction in body, chassis and power train systems through the development of higher strength recyclable aluminium alloys and enabling joining technologies.

Forming and Joining Techniques used at the AMCC and AMPC

- **Direct chill (DC) casting** and **Extrusion (1:1 scale)** to cast and extrude billets to their net shape at full scale.
- **Free-form (3D) bending** for more design flexibility in comparison with traditional bending techniques for lightweighting solutions. Combining several parts into one single part resulting in fewer welds and other joint types and dramatically reducing the lead-time for full scale prototype assemblies.
- **Electromagnetic pulse technology (EMPT)** for high speed joining, forming and cutting of extrusions using a non-contact welding process or mechanical fastening process, with no heat input.
- **Structural adhesive bonding** of the automotive frame materials to replace welded sections with bonded joints. No heat affected zone, therefore no strength loss and no heat treatment required.
- **Fusion welding with Cold Metal Transfer (CMT)** of the extruded sections in order to minimise energy and heat input and maximise weld strength in the metallic part of the body in white structure.

If you are interested in collaborating with us or for further enquiries regarding our facilities, please contact:

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