



**QUEEN'S
UNIVERSITY
BELFAST**



Rotational Moulding: Towards a Sustainable Future



Mark Kearns
Moulding Research Manager

Queen's University of Belfast
Polymer Processing Research Centre
School of Mechanical and Aerospace Engineering

Presentation

- Background to PPRC at QUB
- Current Rotomoulding R&D Projects
- Innovate UK: Towards Zero Waste Rotocycle Project
- EPSRC: ACCEPT Project

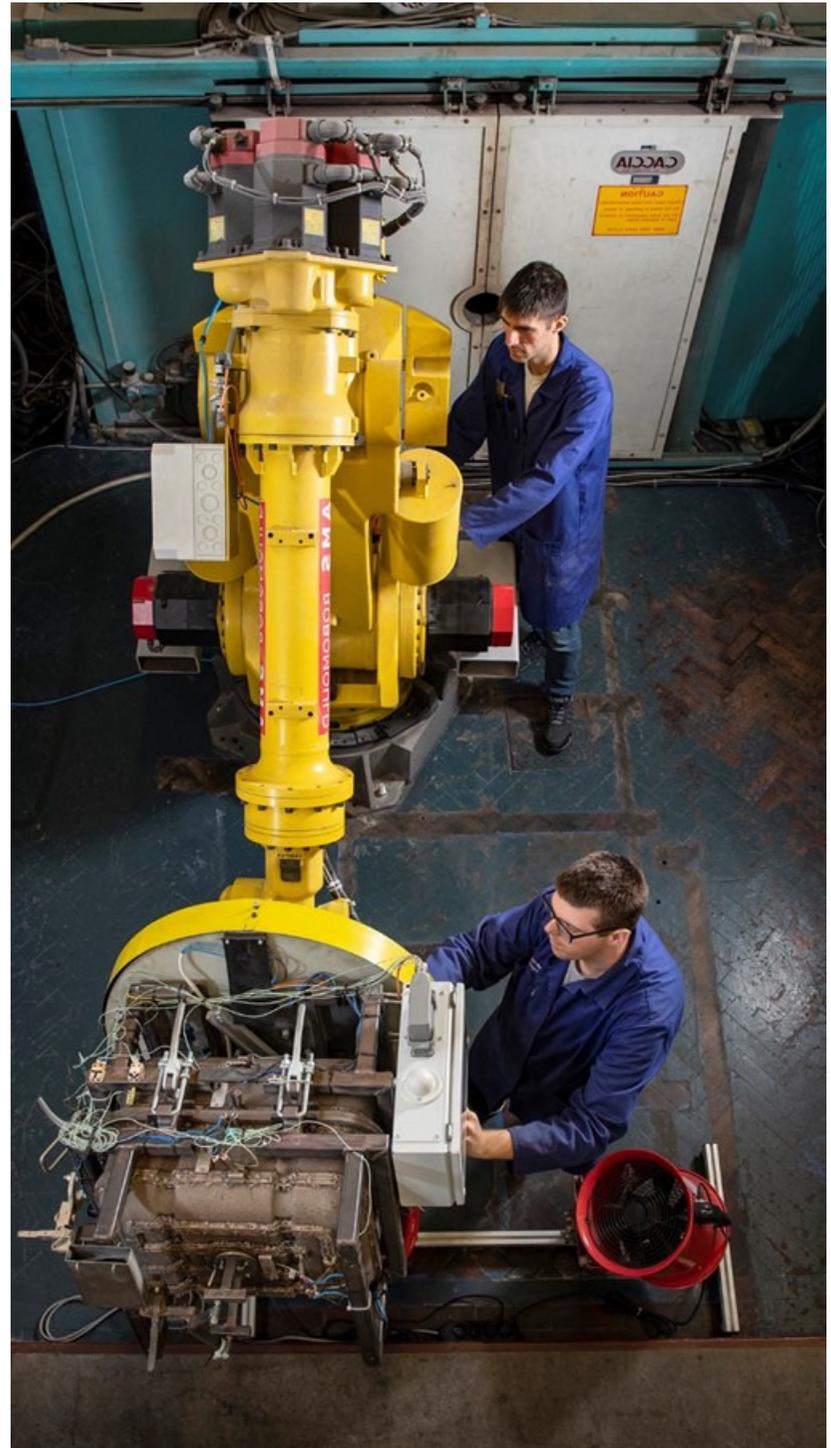


Innovate UK



Expertise & Capability

- Permanent, core staff of 7 experienced engineers and researchers
- Offering Industrial Training Programmes, Consultancy and Technology Transfer
- Undertaking Research & Development including desk top studies, industrial scale processing trials and material characterisation
- ~ £2 million worth of equipment
- ~ 400 m² of modern laboratories

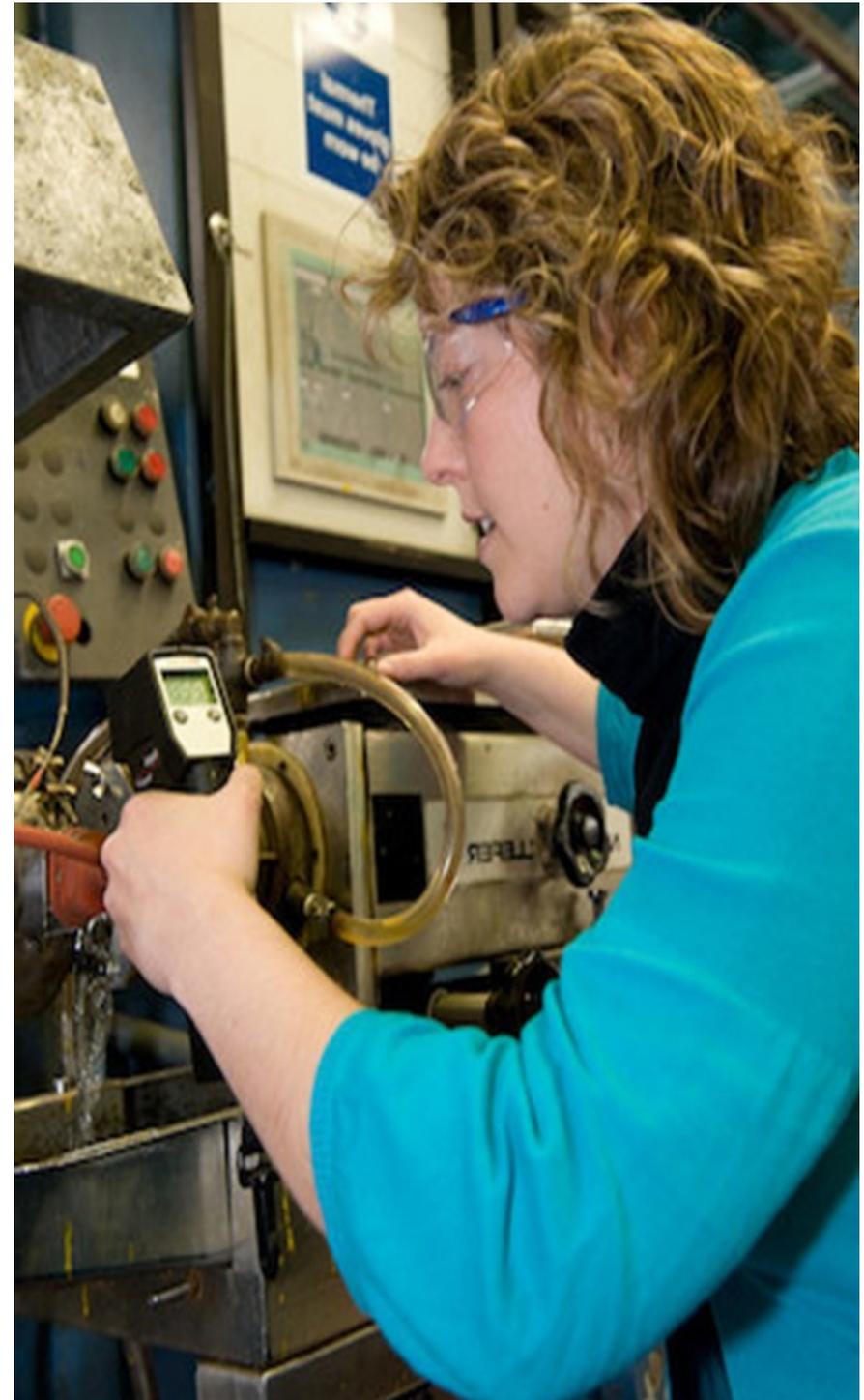


Industrial Engagement

- Industrial Training Programmes
- Consultancy
- Technology Transfer
- Collaborative Research & Development

Sources of Funding include:

- Direct funding from companies / trade organisations
- EPSRC
- Innovate UK including KTP
- EU including Horizon 2020 and Interreg
- InterTradeIreland including Fusion
- Invest NI including Innovation Vouchers

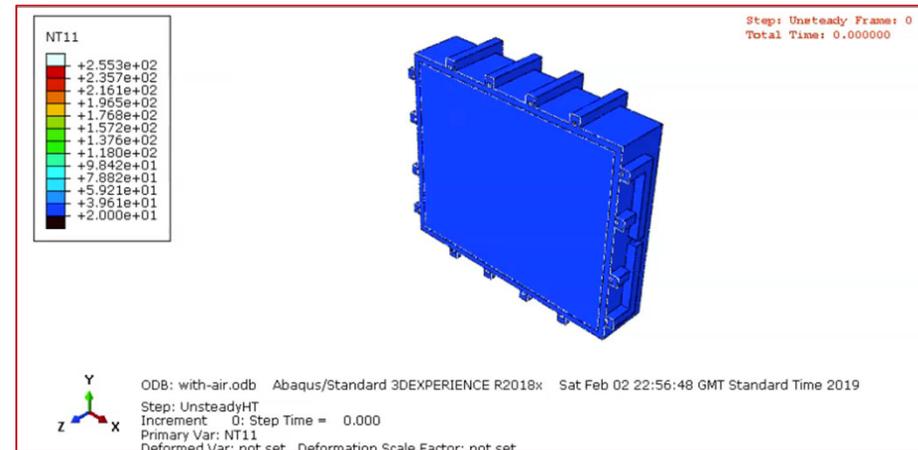
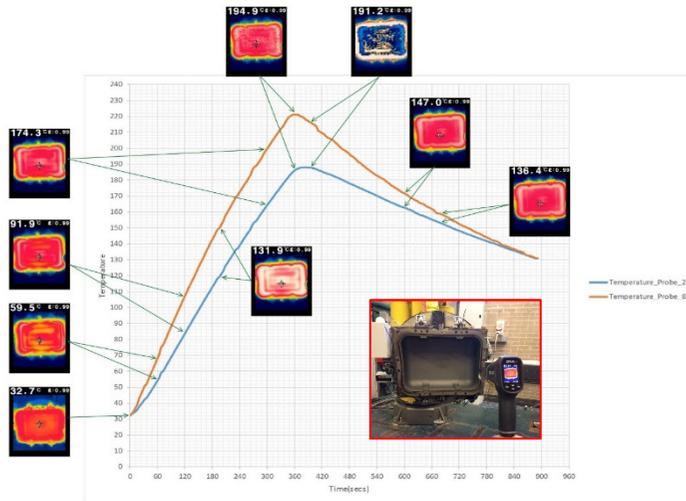
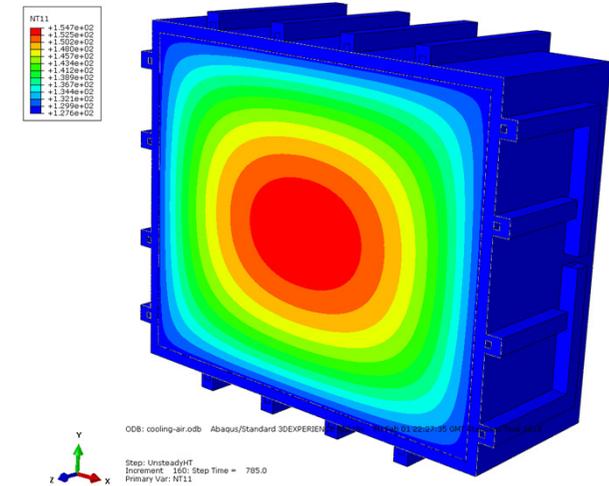
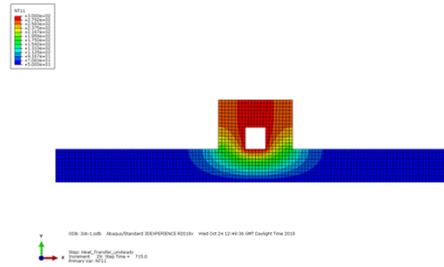
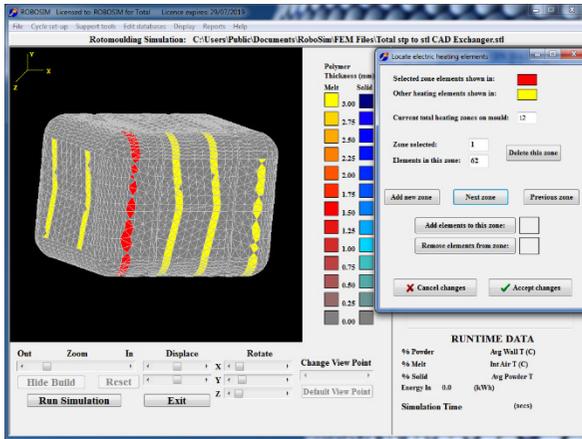


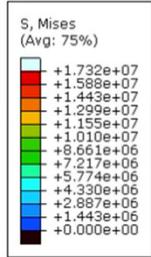


- Development of **Thermoplastic Fibre Reinforced** Rotomoulding – High performance PE/PP fibre
- **Thermal / Optical Imaging** of the rotomoulding process – sintering / densification
- Development of in-process **Ultrasonics** for rotomoulding
- **In-mould Water Spray cooling** of multi-layer structures – foam
- Development of rotomoulded structures for **Off-shore energy industry**
- Development of rotomoulded structures for **Solar energy industry**
- **Powder flow analysis**, modelling & simulation - DEM
- **Shrinkage & Warpage** analysis, modelling & simulation

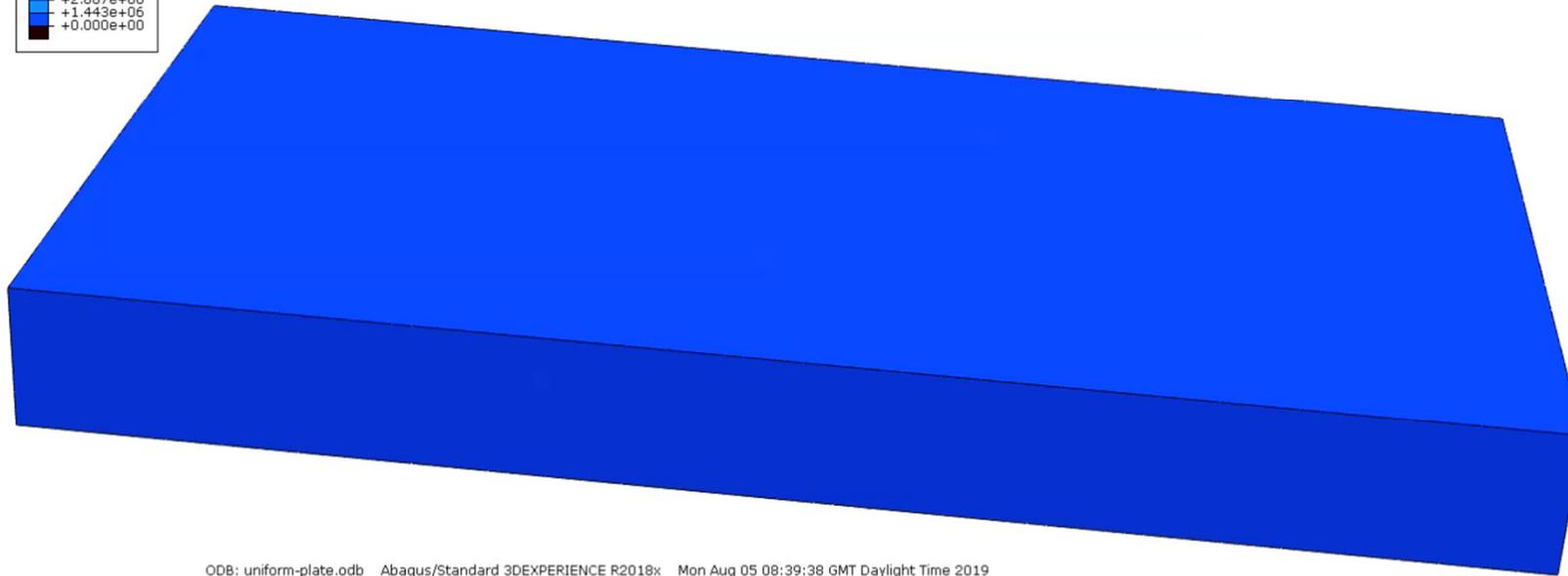


- Robot Controlled rotomoulding – AMS Robomould®
- Electrically heated moulds for rotomoulding – efficiency analysis
- Materials - modelling and analysis (Big Data)
- Roto-Composite rotomoulding research – carbon fibre
- Process Modelling & Simulation – Rotosim development / Robosim development
- Collaborative Technology Transfer
- Industry 4.0 for Rotomoulding
- Recycling & Rotomoulding – Roto PE / PCW PE





Step: cooling Frame: 0
Total Time: 0.000000



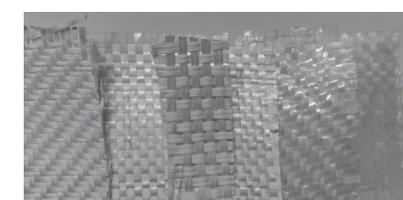
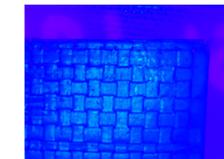
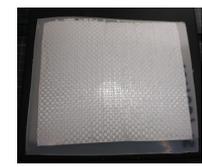
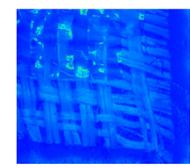
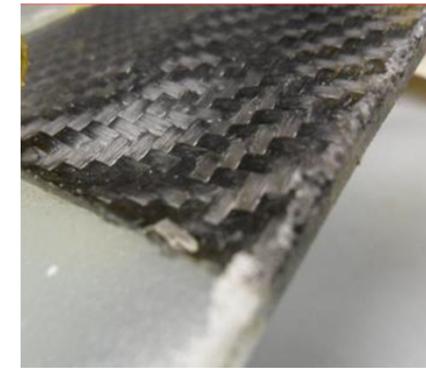
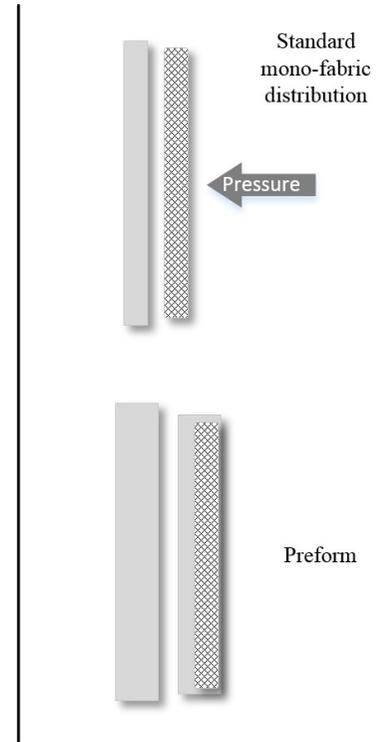
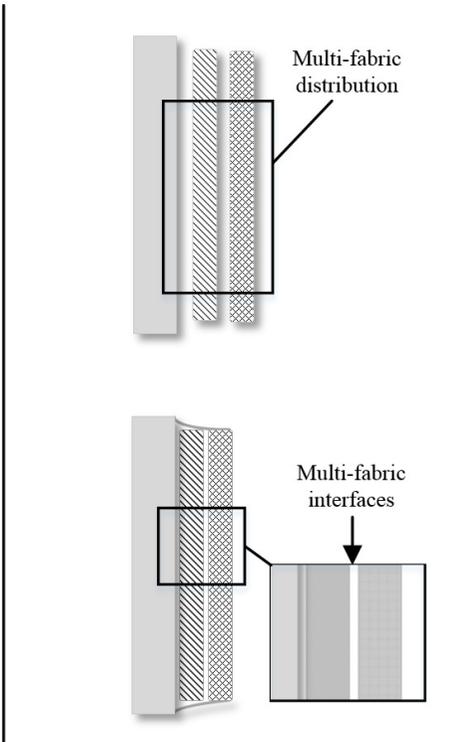
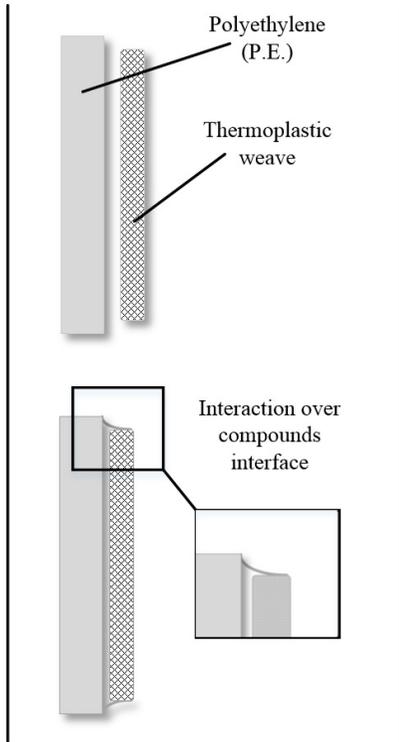
ODB: uniform-plate.odb Abaqus/Standard 3DEXPERIENCE R2018x Mon Aug 05 08:39:38 GMT Daylight Time 2019

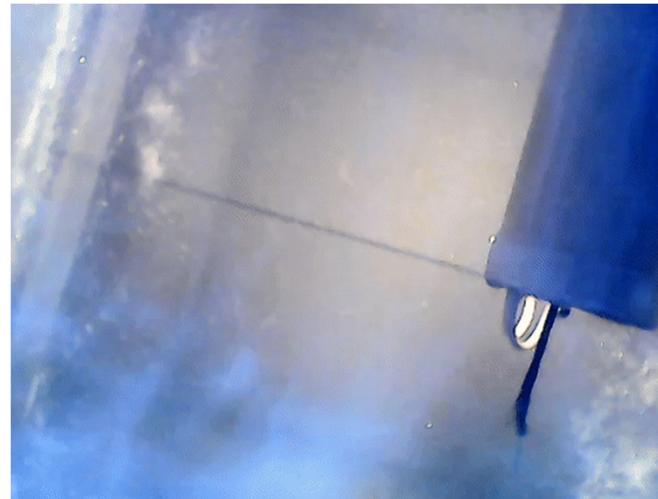
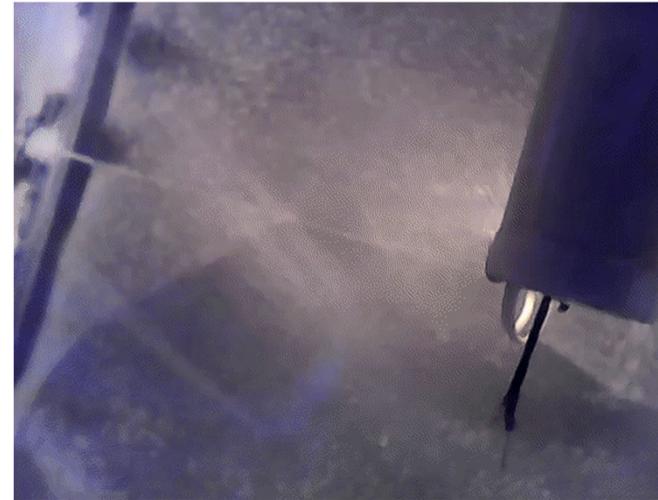


Step: cooling
Increment: 0: Step Time = 0.000
Primary Var: S, Mises
Deformed Var: U Deformation Scale Factor: +1.229e+01



Carbon Fibre Pre-preg + Rotomoulding

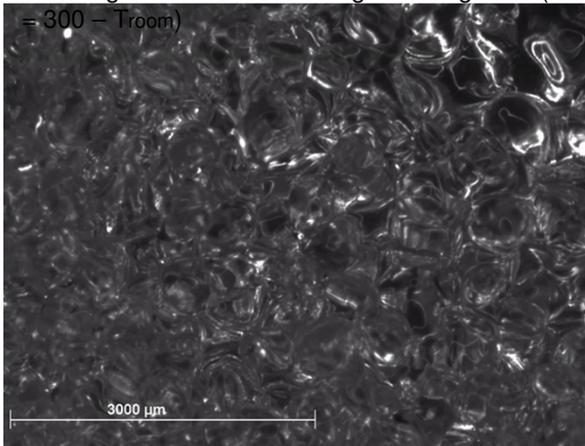




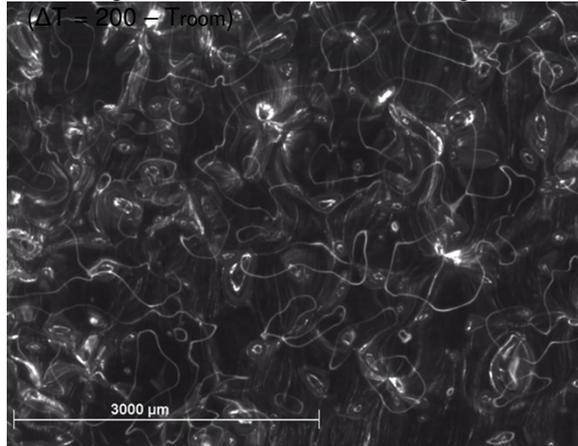


Visual investigation of the processing parameters on sintering and densification of rotational moulding grade of polyethylene

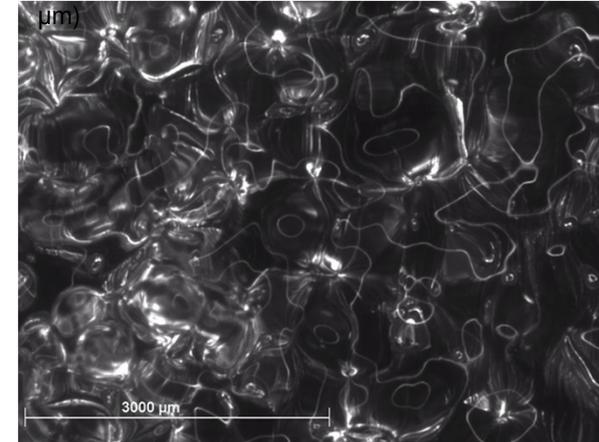
Sintering of mPE 3583 UV: High Heating Rate ($\Delta T = 300 - T_{room}$)



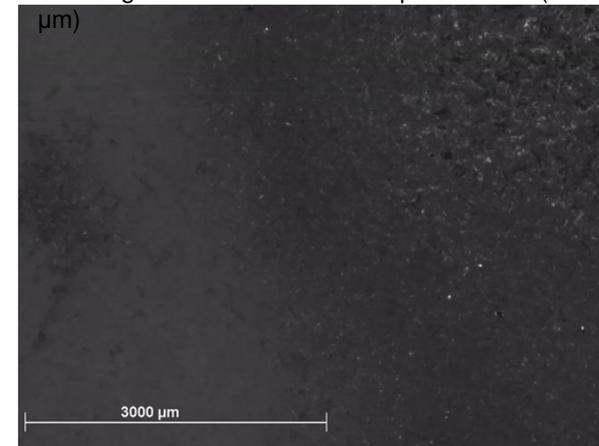
Sintering of mPE 3583 UV: Low Heating Rate ($\Delta T = 200 - T_{room}$)



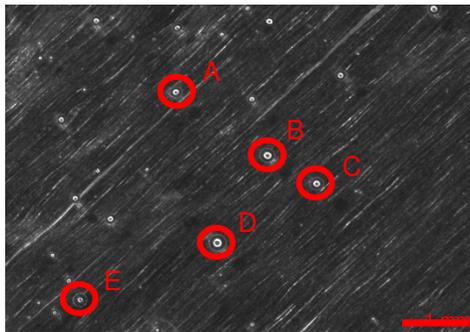
Sintering of mPE 3583 UV: Coarse particle size (500-600 μm)



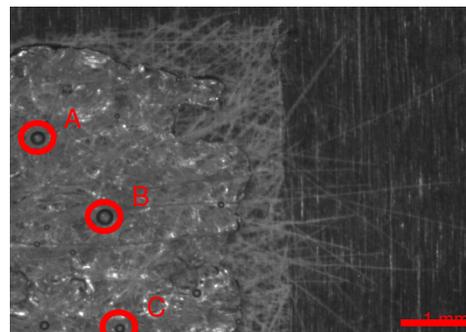
Sintering of mPE 3583 UV: Fine particle size (90-105 μm)



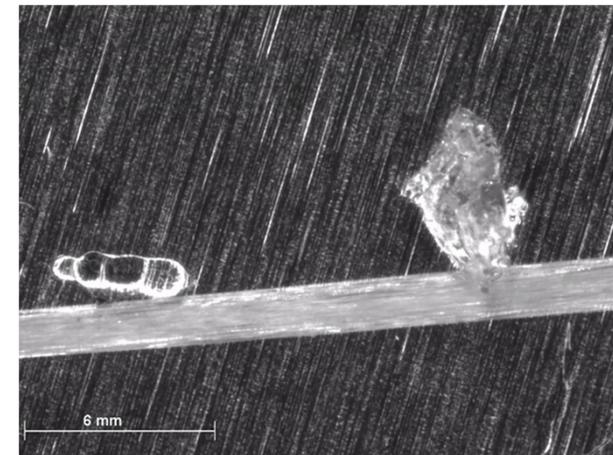
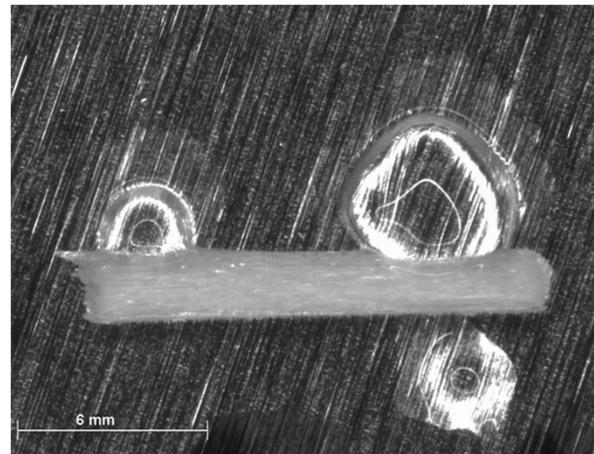
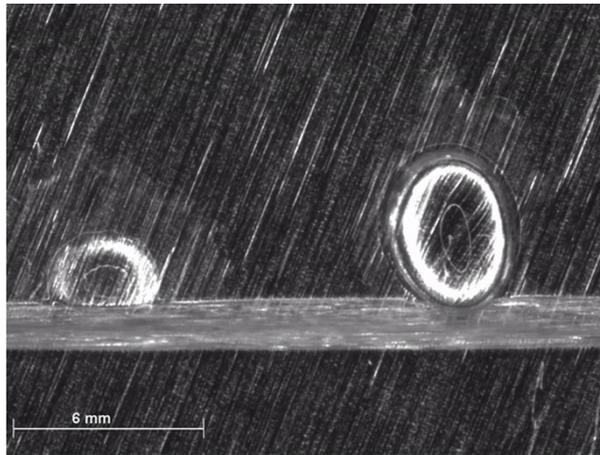
Both heating rate experiments use a medium particle size of (~300 μm)



Visualisation of the melting process of rotational moulding grades of PE using an TP-Picture

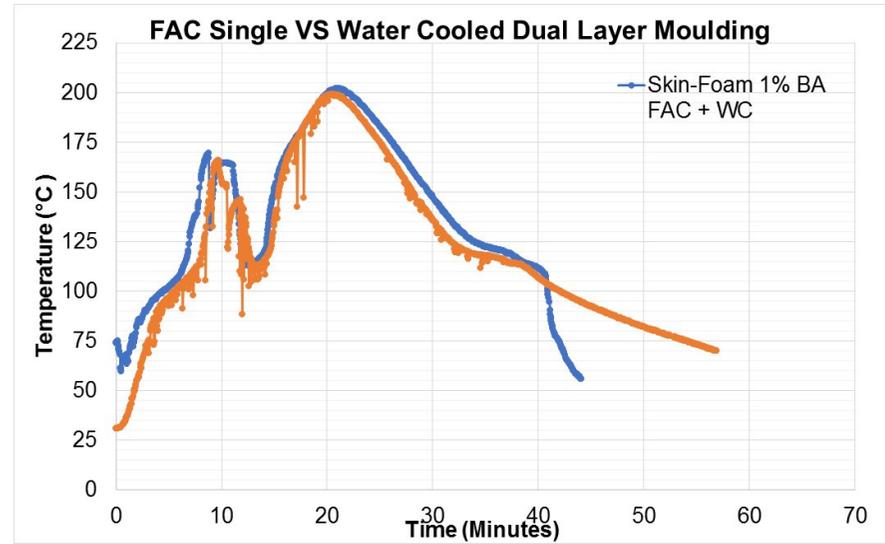
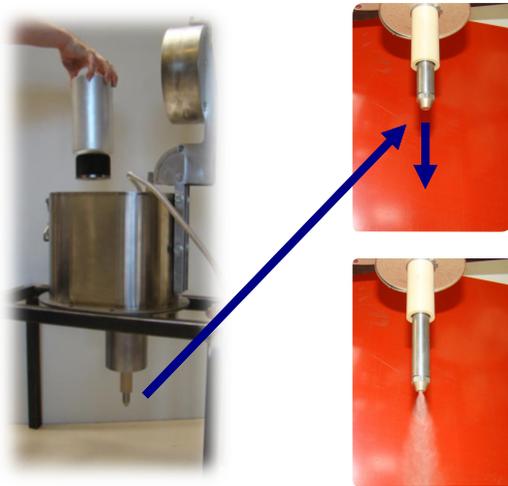


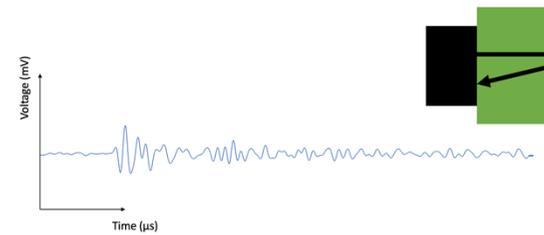
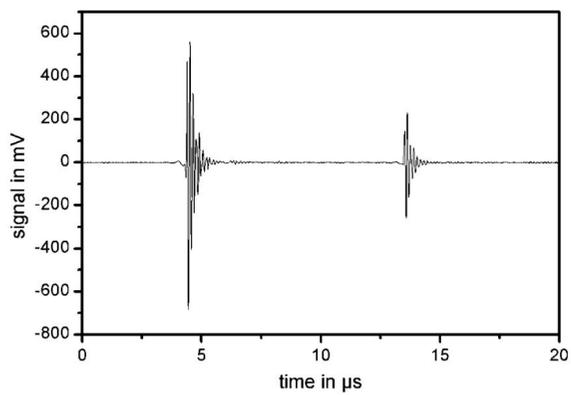
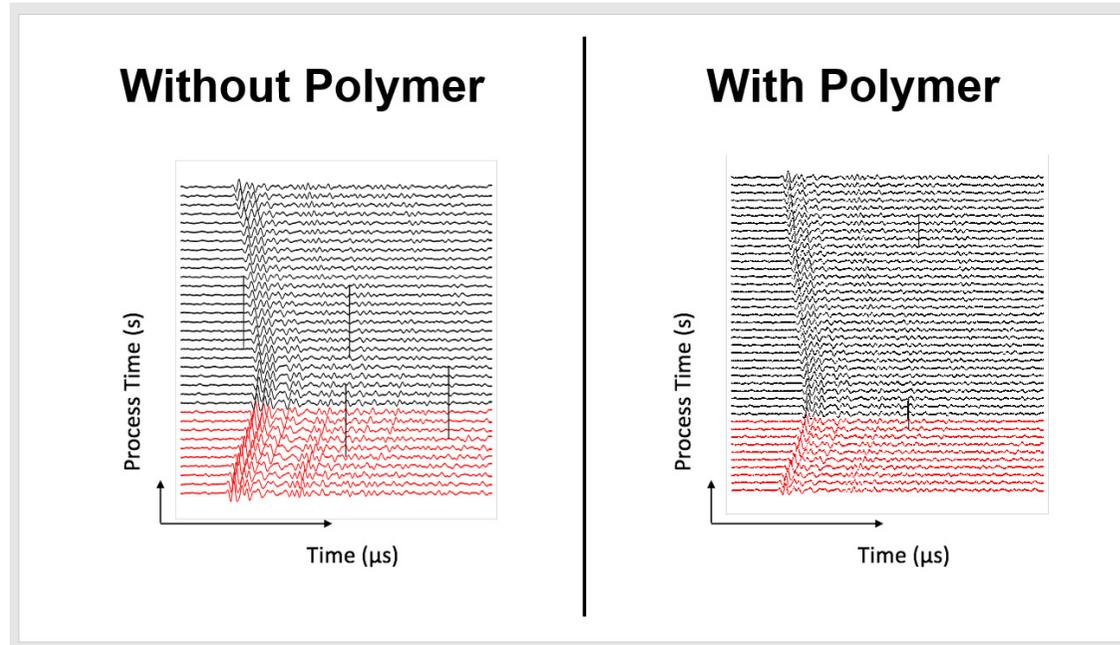
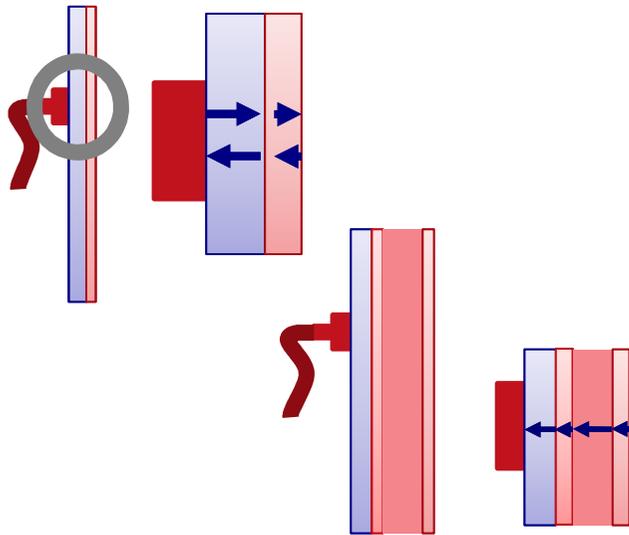
Visualisation of the melting process of rotational moulding grades of PE reinforced with E-glass fibre mats





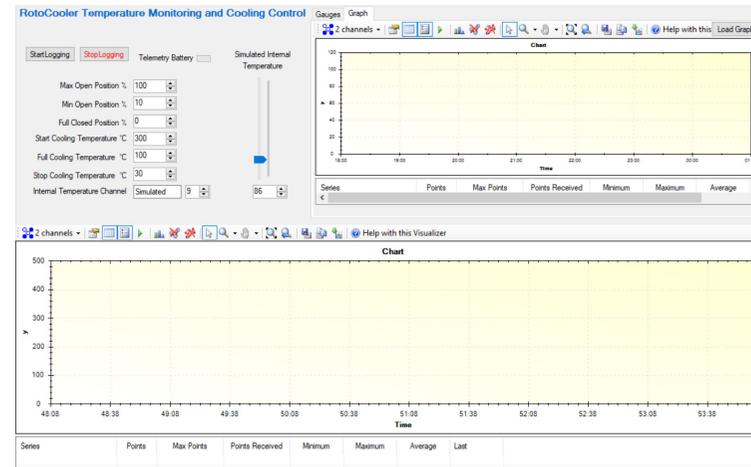
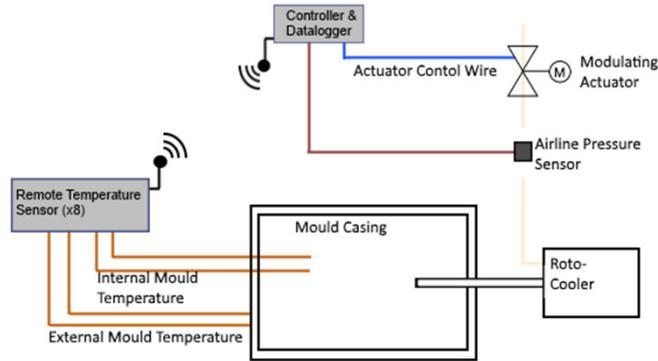
Reducing the Cycle times of Multi-layer Foam Rotomoulding using Rotocooler







The Fourth Industrial Revolution





QUEEN'S
UNIVERSITY
BELFAST

Innovate UK



Plastics Innovation: Towards Zero Waste

(Plastics Research and Innovation Fund
June 2018)

- £4 million for innovation projects that reduce the harm that plastics do to our environment and increase productivity and growth of the UK economy.
- The aim of this competition is to support innovative activities that result in less persistent plastic waste in our environment.
- The competition has been designed to support innovation with the potential to deliver circular economy approaches to plastic use.



UK Research
and Innovation



QUEEN'S
UNIVERSITY
BELFAST

Innovate UK



ROTOCYCLE - Novel use of hard to recycle plastics in rotomoulded applications

Project Value: ~ £500k

Timeline: 18 Months – Jan 2019 to Jun 2020

The Rotocycle project involves:

- Harlequin Plastics Limited, NI (<http://www.harlequinplastics.co.uk/>)
- Impact Laboratories, Scotland (<http://www.impact-solutions.co.uk/>)
- Impact Recycling, Newcastle (<http://www.impact-recycling.com/>)





- By delivering this project successfully, a new **lower cost material** will be introduced into the rotomoulding market
- A unique '**full supply chain**' assessment will determine whether recyclate can be used reliably at an industrial scale
- By developing a **new recyclate based rotomoulding grade** of plastic and developing a processing method to use it, we will:
 1. **Reduce the amount of virgin plastics** used in the economy and its environmental impact
 2. Provide a **new market** for post-consumer waste plastics
 3. Drastically **reduce the costs** to manufacture rotomoulded products.



QUEEN'S
UNIVERSITY
BELFAST

Harlequin Products





Consortium Exploitation and Commercialisation Plan

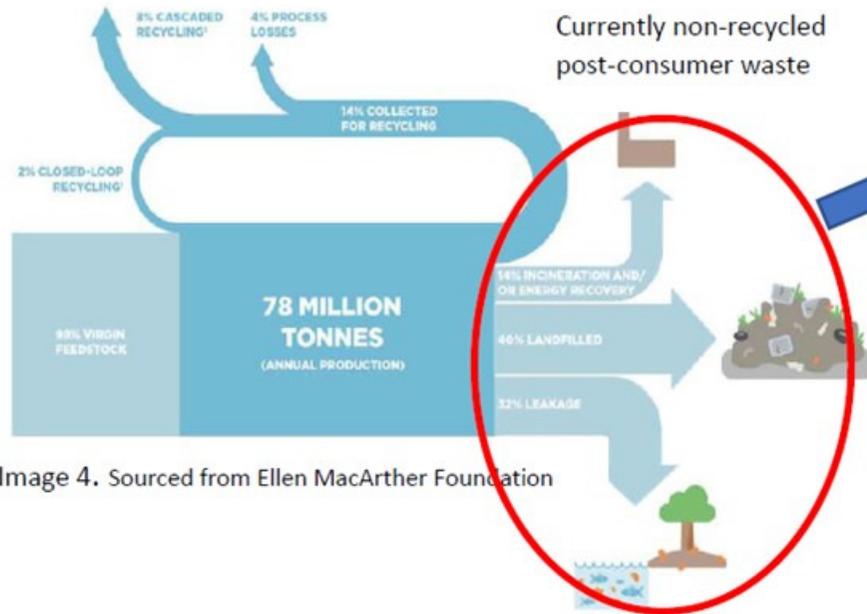


Image 4. Sourced from Ellen MacArther Foundation



Produces a rotomoulding grade blend from waste



Manufactures Products



Certify product ready for market

disseminating results to industry



New Products sold into market





- (a) To investigate and research **extrusion compounding** to optimise the processing of modified post-consumer waste PE and PP
- (b) To investigate and research **grinding and powder analysis techniques** to develop rotomouldable powdered recycled PE and PP
- (c) To investigate and determine **optimum rotomoulding conditions** and the associated **mechanical and thermal properties** characteristics of recycled polymer in **mono-layer and multi-layer applications** and with the addition of chemical blowing agents.
- (d) To develop and manufacture a **commercial rotomoulding product** at the Lead Company site produced with postconsumer waste PE and PP
- (e) To advance the **fundamental understanding** of extruding and rotomoulding chemically modified post-consumer waste PE and PP
- (f) Showcase the results of the project through a **dissemination** event hosted at QUB



Pellets compounded at Impact
Laboratories and ground at
QUB cryogenically

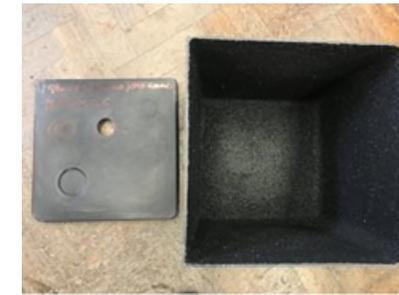


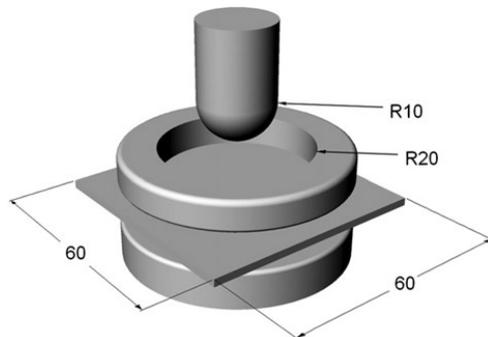


Initial Rotational Moulding Trials - Baseline Virgin Material

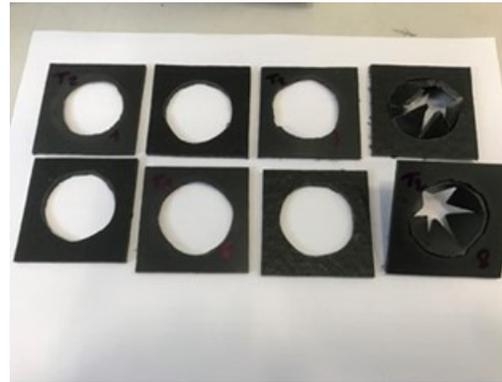


- Ferry Rotospeed RS160 rotational moulding machine
- QUB cube test mould – 300mm x 300mm x 300mm
- Internal mould air temperature monitoring used
- Various mixes with virgin polyethylene

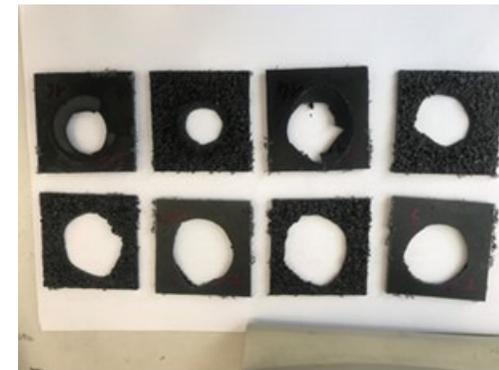




RT



-40°C



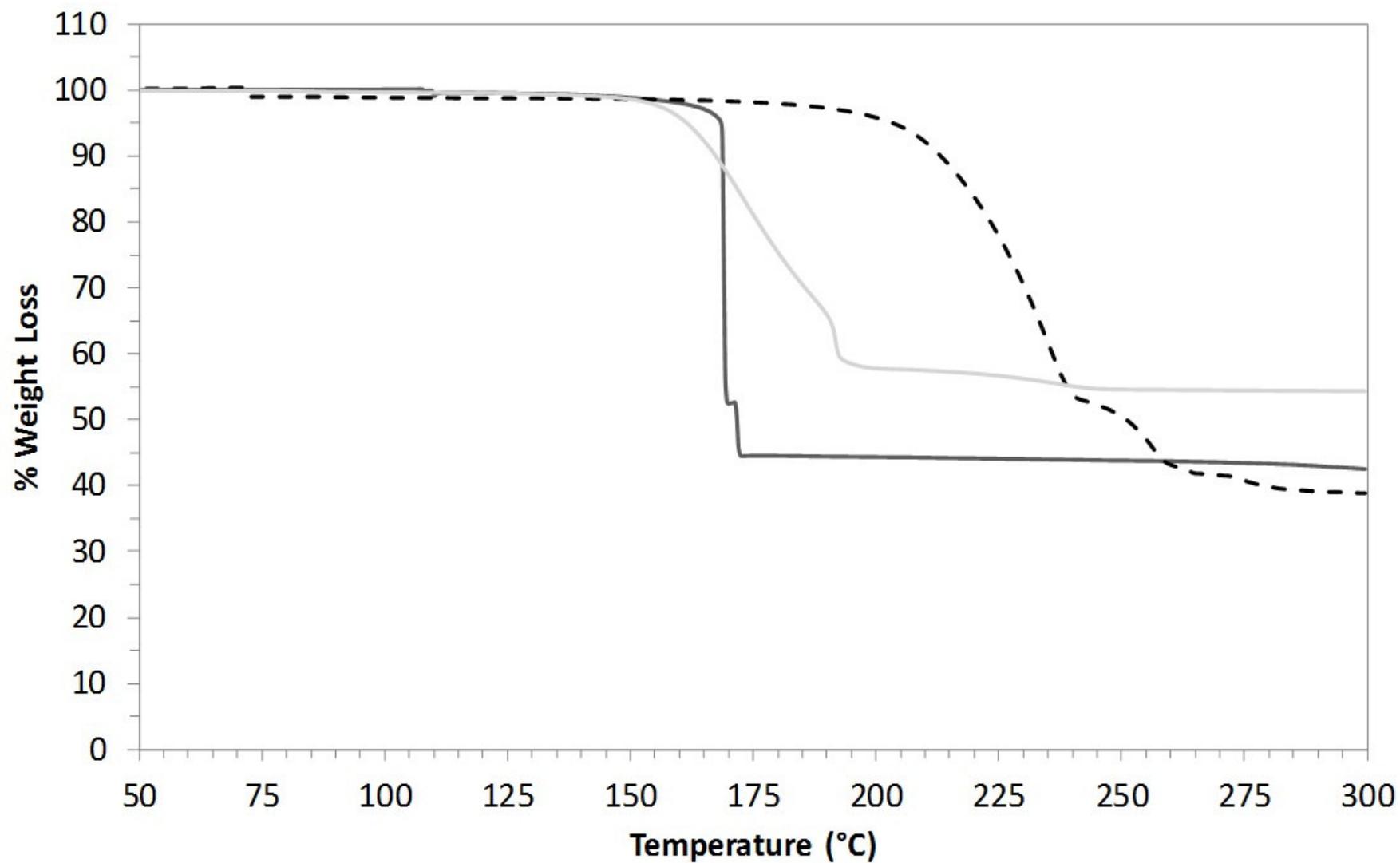


- QUB Work continuing – Foam processing / optimised formulations / mechanical testing
- Industrial Trials - Feb / March
- Project Finishes June 2020

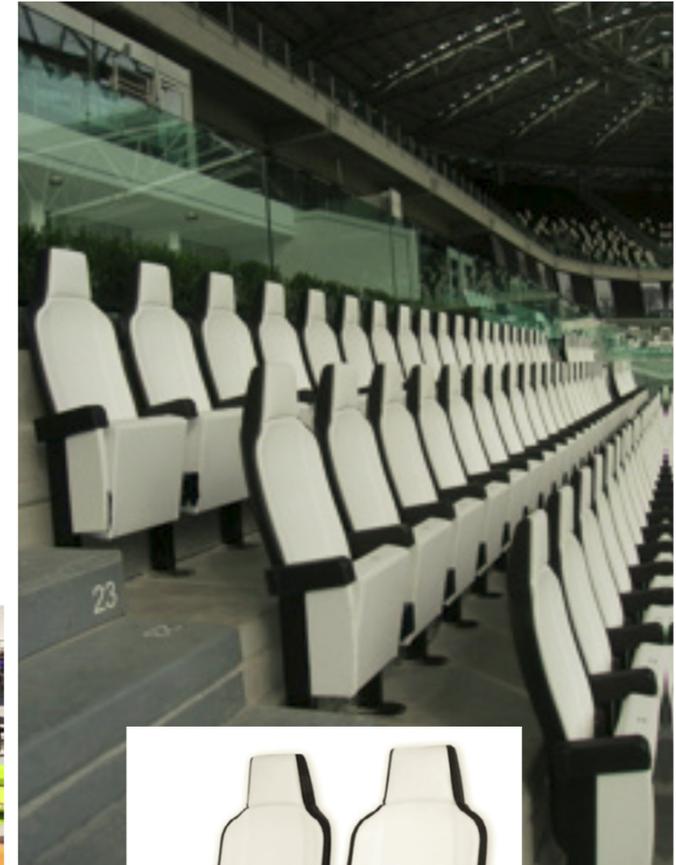




TGA profiles of chemical foaming agents









QUEEN'S
UNIVERSITY
BELFAST

EPSRC 'Circular Economy' Project



UK Research
and Innovation



Plastics Research and Innovation Fund
(~ £1m) 1/4/19 to 30/10/20

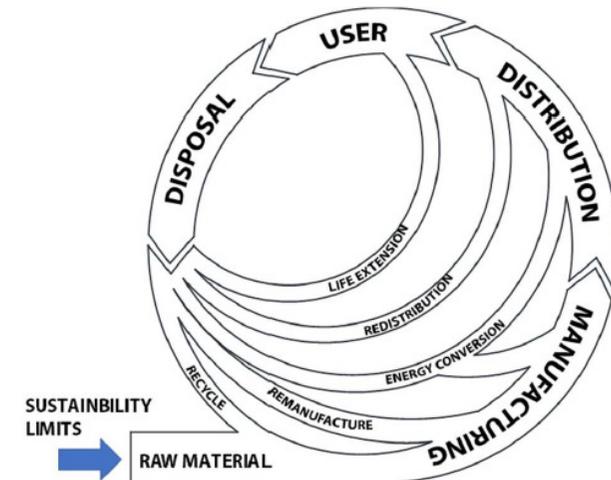
Advancing Creative Circular Economies for Plastics via
Technological-Social Transitions
(ACCEPT Transitions)

'By integrating **innovation and creative thinking** across **technological, policy, consumer behaviour and supply chain management** domains on a focused region of the UK we can develop '**socio-technological transitions**' that will facilitate a just transition to a **circular economy** for existing and future plastics, conserving and creating **sustainable energy and materials, developing new products and green jobs**, and supporting **economic growth in NI and the wider UK.**'



Project Objectives:

- Identifying the factors that facilitate or impede **recycling behaviour**;
- Exploring **perceptions** of plastic use and social/technical innovations to reduce plastic use;
- Eliciting **views and policy interventions** for a 'just transition' of the plastics system;
- Identification of supply chain **hotspots** to maximise added value and decarbonisation;
- Overcoming barriers to the **remanufacture and incorporation** of plastics;
- Demonstration of **creative approaches** to design of products and structures;
- Providing **assurances on quality and emissions** to support growth in the pyrolysis sector





QUEEN'S
UNIVERSITY
BELFAST

EPSRC 'Circular Economy' Project



- Projects integrates **innovation and creative design** thinking across technological, policy, consumer behaviour and supply chain management domains.
- Combined **network of key stakeholders** in government, industry, society and academia to achieve its aims.
 - School of Psychology
 - School of Chemistry & Chemical Engineering
 - School History, Anthropology, Philosophy and Politics
 - **School of Natural & Built Environment (Architecture)**
 - **School of Mechanical & Aerospace Engineering**
 - Belfast City Council
 - Cherry Pipes Ltd
 - Greiner Packaging
 - Northern Ireland Polymers Association
 - Polyfuel Ltd



- To date waste plastic is generally used in very **pragmatic** and often relatively **low cost** solutions.
- In this project we want to find its inherent **'beauty'**, especially celebrating the **fluid forms made possible through rotational moulding**, helping to create better designed products.
- The concept of the **Block** comes from a cross-disciplinary design process to create a **'beautiful' 3D interlocking block**;
 - A **beacon** of what might be possible
 - To open up **new possibilities**
 - To push the **design** of the block as far as possible
 - To show how waste recyclates can be revalued into something not just practical but also **socially/culturally acceptable**



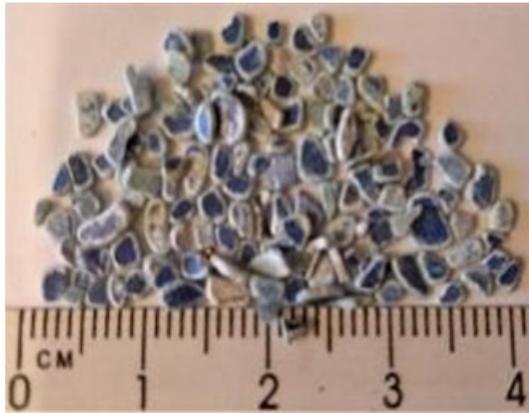


- This project demonstrates the power of bringing designers into the process of *material development* as early as possible.
- **Collaboration:** manufacturers, plastic specialists, mould makers and end users, to draw out and develop the best aesthetic possible.





Recycled materials:





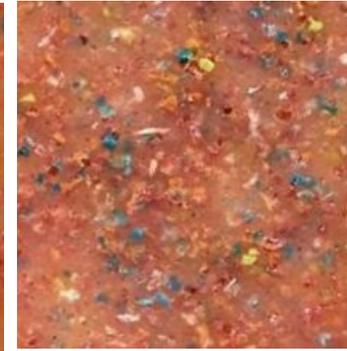
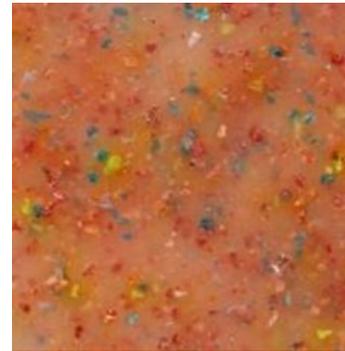
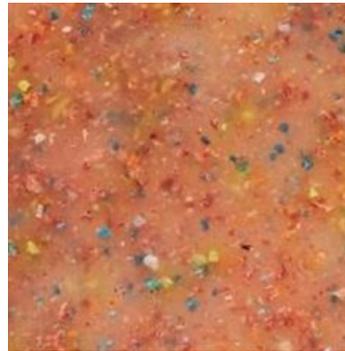
10%

20%

30%

50%

Material
Blend A



Material
Blend B





- PPRC, QUB Work continuing:
 - Designs being finalised
 - Industry Feedback
 - Mould manufacture
 - Full Scale rotomoulding
 - Demonstrator

- Project Finishes 2021



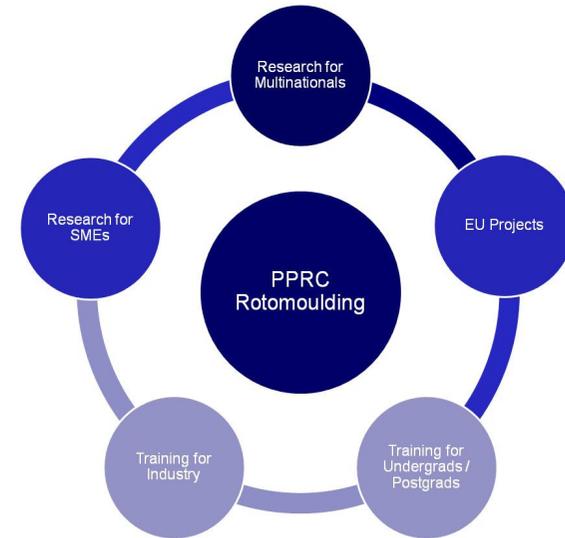


**QUEEN'S
UNIVERSITY
BELFAST**

Many Thanks



***Two-day Hands-On Rotomoulding Training
Course at Queen's University, Belfast
May 20-21, 2020
Further Details: m.kearns@qub.ac.uk**



Mark P. Kearns B.Eng, M.Phil, C.Eng, FIChemE

**Moulding Research Manager
School of Mechanical & Aerospace
Engineering
Polymer Processing Research Centre
Ashby Building
Stranmillis Road
Belfast
N. Ireland
BT9 5AH
T: +44 2890 974711
F: +44 2890 660631
M.Kearns@qub.ac.uk**