

Institution: Queen's University Belfast		
Unit of Assessment: UoA12		
Title of case study: Blow moulding research leads to hi-tech spin out company		
Period when the underpinning research was undertaken: 2000 – 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Gary Menary	Professor	1996 – present
Period when the claimed impact occurred: 2014 – 2020		
Is this case study continued from a case study submitted in 2014? Yes		
1. Summary of the impact		
<p>Unique Stretch Blow Moulding technology developed by QUB has been implemented by leading brands and manufacturers, [text removed for publication], Pepsi and [text removed for publication], Procter and Gamble [text removed for publication], resulting in multi-million pound savings in materials and process costs, and ultimately in annual savings of greenhouse gas emissions measured in the thousands of tonnes. The research has led to the formation of a successful spin out-company, Blow Moulding Technologies (BMT), which supplies software, services and hardware globally across the packaging sector. This technology has been a key enabler in the introduction of new bio-based materials into the global plastics packaging market.</p>		
2. Underpinning research		
<p>This research activity was initiated in 1993 with EPSRC funding of GBP75,000 [GR/H18722/01] to model the Stretch Blow Moulding (SBM) process, which is primarily used to manufacture Polyethylene Terephthalate (PET) bottles for the carbonated soft drink (CSD) and water industries. In the early 2000's Prof G Menary's work on computer aided design of preforms in stretch blow moulding in collaboration with Coca Cola and Beverage Plastics Ltd resulted in a paper on modelling the nonlinear viscoelastic behaviour of PET at conditions appropriate to SBM [P1]. A breakthrough step was the development of a unique biaxial testing machine capable of duplicating the deformation behaviour of the SBM process; this significant contribution to the field received the Best Paper Award from the Institute of Materials [P2]. The research work was sustained through increased industrial interest and further funding from Invest NI and Boxmore Plastics to enhance simulation capability through extensive programme of industrial tests. The outcomes were recognised by the IMechE with the award of Best Paper [P3]. Subsequently, the French multinational, Danone directly funded [text removed for publication] SBM simulation research focused on PET characterisation enabling unique experimental data for modelling the behaviour of PET in the SBM process.</p> <p>Another transition step occurred through an EU FP6 project [STRP 505204-1] that developed wireless instrumentation capable of recording process conditions on industrial machines [P4]. Building on the success of the unique instrumentation capability from the EU FP6 project, Invest NI funded work to transform the measurement tool that had underpinned this research area into a commercial product named THERMOscan. This is a standalone, portable device which has revolutionised preform temperature measurement. A spin-out company, Blow Moulding Technologies, designs and manufactures this patented [P5] instrument to industry to optimise the SBM process setup, reduce energy usage and evaluate new materials. This provided the first measured data on the behaviour of the</p>		

preform inside the mould and was the foundation for subsequent **EPSRC funding** [EP/H020756/1] to use a new fluid structure interaction approach to better simulate the manufacturing process. The combination of novel instrumentation, unique data and a new modelling approach secured industry funding from **Procter & Gamble (P&G)** [text removed for publication] between 2008–2020. The work with P&G developed new approaches for measuring material data relevant to SBM and new models to accurately represent material behaviour in the process leading to a third **EPSRC grant in 2015 [EP/M020851/1] of GBP750,000** to develop a new instrument for characterising the behaviour of preforms. This research led to a new approach for characterising the behaviour of materials for the SBM process **[P6]**. In parallel, a collaboration with the multinational bottle manufacturer Alpla was initiated [text removed for publication] to support SBM simulation development to predict the mechanical properties of a bottle as a function of processing history.

3. References to the research

Key Outputs

- P1.** Menary G. H.; Armstrong C.G. ; Crawford R.J ; McEvoy J.P.; “Modelling of poly(ethylene terephthalate) in injection stretch-blow moulding”; *Plastics, Rubber And Composites: Macromolecular Engineering*, Vol. 29, no7, pp. 360-370, 2000. DOI: 10.1179/146580100101541166.
- P2.** Martin, P.J ; Tan, C.W.; Tshai, K.Y.; McCool, R. ; Menary, G.H. ; Armstrong, C.G. ; Harkin-Jones, E .M, “Biaxial Characterisation of Materials for Thermoforming and Blow Moulding.” *Plastics, Rubber And Composites: Macromolecular Engineering*, Vol. 34, no. 5, pp. 276-282, 2005 DOI: 10.1179/174328905X64803 [**won the James Walker award for the best paper in the field of Polymers from the Institute of Materials**].
- P3.** Yang, Z.J.; Harkin-Jones, E.M.; Menary, G.H; Armstrong, C.G.; “Finite Element modelling of stretch blow moulding of PET bottles using Buckley model: plant tests and effects of process conditions and material parameters.” *Proceedings of the Institution of Mechanical Engineers, Part E*, Vol. 218(4), pp.237-250, 2004 DOI: 10.1002/pen.20133 [**award winning paper from IMECHE for the best paper published in the volume**]
- P4.** Salomeia Y.M.; Menary, GH; Armstrong, CG, "Experimental investigation of stretch blow moulding Part II: Analysis of process variables, blowing kinematics and bottle properties." *Advances in Polymer Technology*, 2013, DOI: 10.1002/adv.21291.
- P5.** “Method and apparatus for providing an internal surface temperature profile of a thermoplastic preform during a stretch blow moulding process”. Inventors: Gary Menary, Cecil Armstrong, Yannis Mugurel Salomeia, Patent application number: 20110062611, Published March 2011.
- P6.** Yan, S., Menary, G. & Nixon, J. “A novel methodology to characterize the constitutive behaviour of polyethylene terephthalate for the stretch blow moulding process”, *Mechanics of Materials*, 104, p93-106, 2017 DOI: 10.1016/j.mechmat.2016.10.006.

4. Details of the impact

Spin Out Company - BMT

Blow Moulding Technologies ([BMT](#)) is a company spun out from the pioneering research on SBM at Queen’s University Belfast (QUB) in 2011. The company has established an international presence and supplies software, services and hardware to the packaging sector enabling global brands to minimise material and energy usage (**Figure 1**). Since 2014, BMT has collaborated with large multi-national companies such as **Danone, PepsiCo, P&G**, leading bottle manufacturers such as **Logoplaste, Alpla and Amcor** as well as the number

one SBM equipment manufacturer **Sidel** to develop innovative, lightweight bottle designs, and successfully introduce new bio-based materials into bottle packaging. The company has grown substantially, and **reached an annual turnover of GBP1,000,000 for the year 2020. Currently BMT employs 8 members of staff, 7 of whom are PhD graduates of the SBM research group within QUB.** BMT were awarded the best ‘New Start’ company in Northern Ireland in 2013 by Intertrade Ireland and in 2019 was awarded a GBP40,000 prize as a finalist in Shell Springboard competition – a UK competition for the most promising technology for reducing carbon footprint.

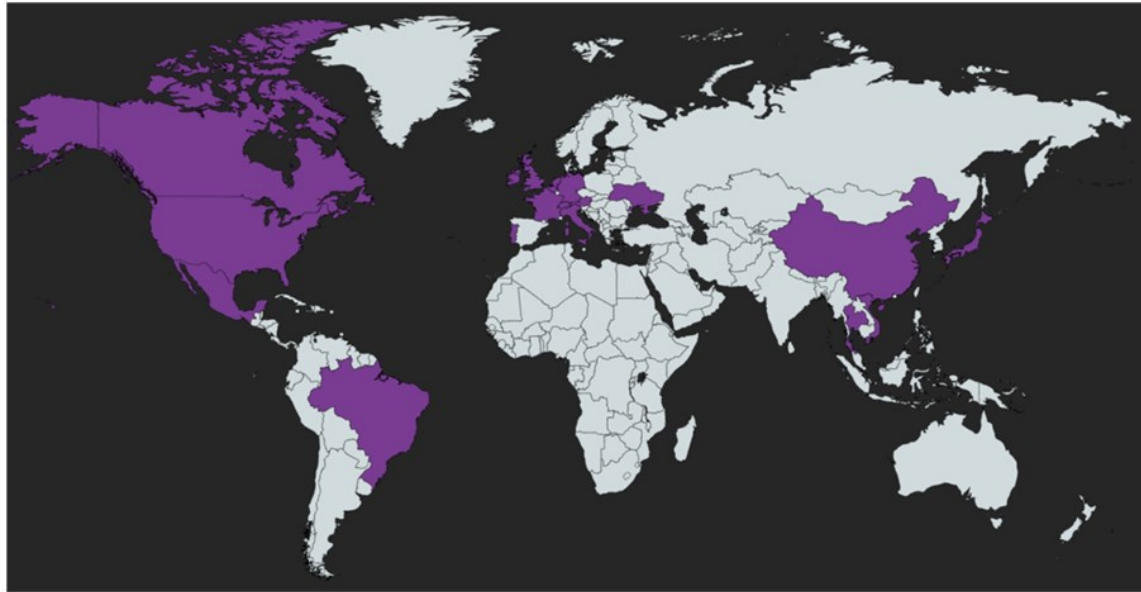


Figure 1: BMT Customer base (worldwide sales & services highlighted in purple)

BMT’s flagship product is THERMOscan, a patent [P5]-protected product used in the R&D centres of all of the major bottle manufacturers (**Figure 2**).



Figure 2: BMT THERMOscan system

It has become a de-facto standard tool used in the SBM industry for product and process development. The technology enables manufacturers to optimise their process setup, saving them time, energy and money and provides them with new information that enables a better understanding of their process, as well as more efficient production of bespoke products.

The Director of Logoplaste Innovation lab [S1], which serves Logoplaste’s 63 bottle manufacturing plants, highlights the impact: **“THERMOscan enables us to setup our processes easier and faster. With a new insight on how preform design and materials**

are influencing the heating process, we are now able to take upon even more ambitious projects. We now use the THERMOscan for all of our trials when developing new products”.

SOPLAR, a major Swiss machine manufacturer, states that *“THERMOscan has been an invaluable tool in helping us optimize and develop our IR-technology.”* [S2]

P&G use both the THERMOscan product and BMT’s software system across all new product development. As one example of the business benefits, **A principal engineer at P&G Brussels [S3]** used THERMOscan to successfully identify scale-up issues in new processes, saving product lead times of up to 12 months. On individual products, P&G estimate that routine use of THERMOscan saves USD10,000 – USD20,000 per week, per product.

P&G also employ the QUB developed simulation package in their virtual design process for their new and existing products; it is therefore used in the design of over 1 billion containers each year, and this has led to significant achievements in cost savings; as **principal engineer at P&G, Cincinnati explains [S4]:**

“The stretch blow molding model as an integral component of our virtual package system has the potential for saving [text removed for publication] through faster development and start up times as well as optimized material weights. The digital workflows are also a key element to designing for the future sustainable packaging requirements.”

The impact of BMT’s simulation services was further highlighted in the joint presentation with PepsiCo at the Society of Plastic Engineers Annual Blow Molding Conference held in Atlanta, Georgia, USA in Oct 2019. The Managing Director of BMT states [S5]:

“Through the use of our expertise which is has been developed based on knowledge developed from the SBM research group at QUB, we were able to design a new bottle that was 2g lighter, and reduce the design lead time by 50%. [text removed for publication] This is only one example of multiple projects that we conduct with PepsiCo and which we have replicated with companies from all over the world”.

Economic & environmental impact on the global plastics industry

Since 2014, the research in SBM has made a significant impact on multinational companies. The global position of these companies and the volume of their products ensure that the reach and significance of this impact is on a **global scale**.

Through collaboration with multinational companies, the **underpinning research has resulted in new technology, software and knowledge being integrated into the design and manufacturing process of billions of containers**. As well as commercial savings, there has been significant environmental impact through reduced use of petroleum based plastic and the transportation of lighter containers.

The technology provided by BMT has enabled Avantium renewable polymers to scale up from pilot plant to full industrial production for bio-based resins. The team leader of application development [S6] states *“Even though the performance benefits of Polyethylene Furanoate (PEF) are clear, customers such as brand owners and converters need confirmation that the material will also run on their industrial scale production lines”, “Being able to understand the interactions helps to inform the customers upfront about the differences they can expect”.*

Alpla is a multinational bottle manufacturer company with 178 locations in 46 countries. Since 2015, the technology developed by QUB is used for all of Alpla's new and existing products. This is key in enabling them to introduce new innovative materials and recycled content, all while ensuring a robust and reliable production process. As the head of modelling and simulation at Alpla states [S7]: ***“The research has enabled us to increase our knowledge of the process through the development of state of the art data acquisition equipment providing us with vital data for accurate measurement of input parameters and validation of the simulation”, “This research has had major impact on our simulation capability, and ultimately our business”.***

To highlight a specific example, with the aid of the simulation software developed at QUB, Alpla converted an existing, on the market shampoo bottle product from High Density Polyethylene to PET. [text removed for publication]. This is equivalent to [text removed for publication] savings of 320 tonnes of CO₂ output per year in raw material production. Importantly, the research enabled Alpla to develop a methodology for evaluating new materials for stretch blow moulding, including non-oil based and eco-friendly materials, which is a key challenge for them in the future. The QUB simulation technology is a key component in their ability to design new products and processes [text removed for publication].

5. Sources to corroborate the impact

- S1.** Letter from CTO, Logoplaste Innovation Lab, Cascais, Portugal
- S2.** Letter from Innovation Management, Head of Department, Soplar
- S3.** Principal Engineer, Procter & Gamble Technical Centre, Brussels
- S4.** Letter from Principal Engineer, Procter & Gamble Technical Centre, Cincinnati
- S5.** CEO, Blow Moulding Technologies
- S6.** Team Leader Application Development, Avantium Renewable Polymers
- S7.** Head of Modelling and Simulation, Alpla