

# Queen's University Belfast contribution to the Polymer Industry

Celebrating 10 years of the  
Polymer Processing Research Centre  
at Queen's University Belfast





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## 4 Foreword by the Director

PPRC, an internationally recognised Centre of Excellence which carries out high quality, fundamental and applied research, was established at Queen's University Belfast in 1996 with assistance from the EU Technology Development Programme. Building on the success of over a quarter century of polymers research undertaken at the University, the creation of the Centre formalised the interdisciplinary relationship between the School of Chemistry and Chemical Engineering and the School of Mechanical and Aeronautical Engineering.

As well as achieving success in securing funding from Research Councils for fundamental research, PPRC continues to deliver one of its main aims in providing research and development support to the polymer industry: both locally and internationally. This support has been funded from a number of sources including direct funding from industry and government initiatives from the EU, DTI, InterTradeIreland and Invest NI.

As is evidenced by the forward looking aspirations of the academics and staff in the Centre, PPRC is continually striving to engage in even more sectors exploiting the technical advantages of polymers. One such example is in healthcare where, through collaboration with colleagues in the School of Pharmacy, PPRC successfully bid for funding to establish the Medical Polymers Research Institute in 2002 under the Research and Technological Development Programme administered by Invest NI. Other future initiatives include Environmental Polymer Recovery.



## 6 What do we do in PPRC?

PPRC services to industry range from the analysis and testing of raw materials and finished products to data searches, consultancy and technical advice. Companies also have opportunities to use PPRC to network with suppliers, converters and end-users and through knowledge transfer programmes.

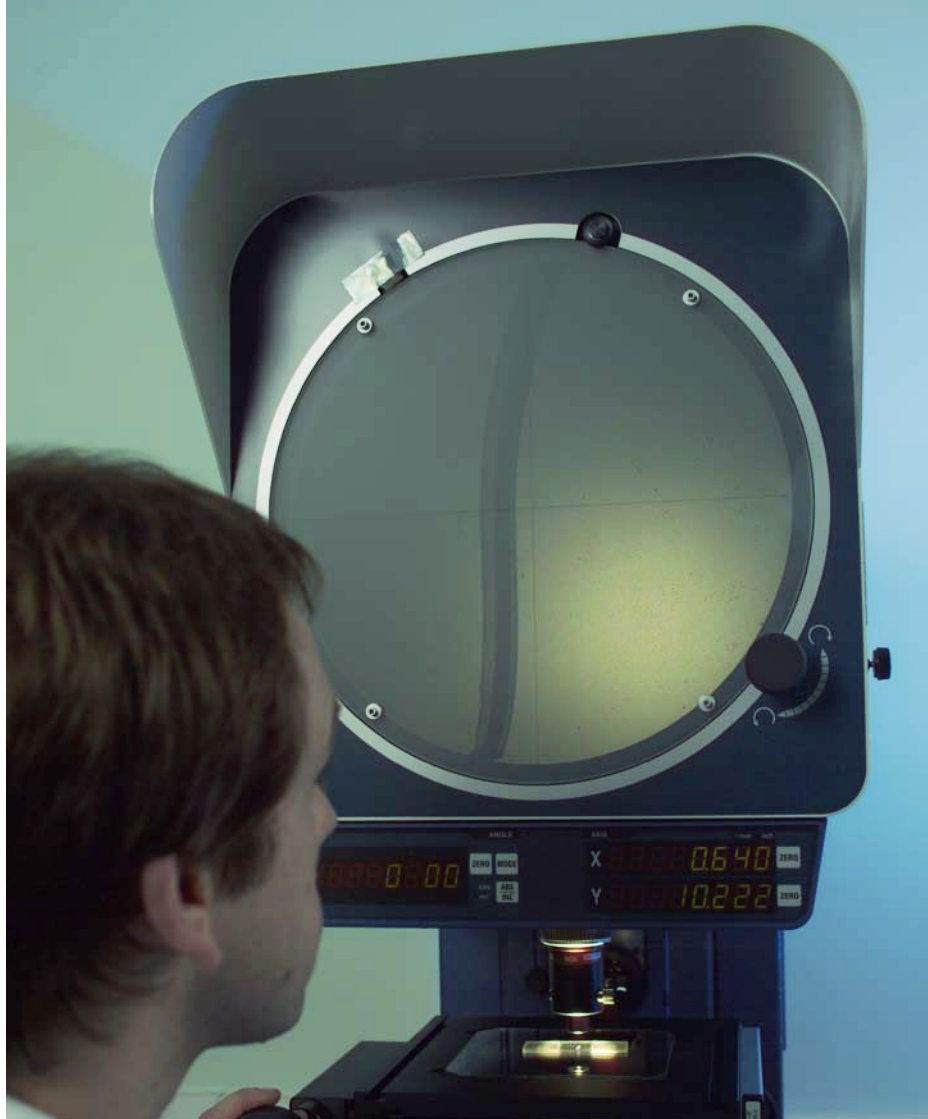
The Centre assists with product design, process analysis and development; mono and multi-layer extrusion of blown film, sheet and tubes



with gas vapour and vapour properties; and the analysis and testing of raw materials and finished products. Other areas of expertise include moulding techniques – rotational (single and multi-layer structures and one-shot foamed products), gas assisted injection and thermoforming as well as simulation of injection blow moulding using FEA and CFD.

The team also advises on the chemical, mechanical and processing properties of a wide range of materials and the diffusion behaviour of gases, vapours and liquids through mono and multi-layer polymers as well as providing training to industry.

The commercial focus of PPRC is also apparent in the services provided to companies to reduce costs such as recycling (on-site and off-site), increased energy efficiency and waste minimisation.





What are our  
resources?

The staff in PPRC has a wealth of experience gained in working with companies of all sizes and across a broad range of industries in developing products and processes using polymers and the team has a wide knowledge of a range of materials and a strong commercial focus on helping companies profit through technology.

This blend of experience and a “can do” ethos makes for a Centre which is both keen and comfortable

in working with companies and which fully appreciates the financial and time pressures faced by today’s industry. PPRC is ideally placed to meet industrial customers’ needs and delivers a broad range of services which include processing trials, material development, process optimisation and analytical services as well as the provision of short and long term training programmes.

Working with some 15 Academic Partners from the parent Schools of Chemical Engineering and Mechanical Engineering, the staff in PPRC is also involved in fundamental research. The Centre is instrumental in disseminating this knowledge for the benefit of industry through such technology transfer programmes as KTP and Fusion as well as presenting at conferences and technical meetings worldwide.

The Centre is equipped with state of the art, full scale, equipment employed in a number of processing disciplines and in particular extrusion and rotational moulding.

# 10 Extrusion



The extrusion facilities offered by PPRC include:

- One, two, three, four and five layer tube line;
- One, two, three, four and five layer sheet;
- One, two, three, four and five layer cast film line;
- One, two and three blown line;
- Compounding;
- Granulation.

These resources are used in a number of current research programmes including the following:

- Flexible films – consumer / agricultural / healthcare applications;
- Tubes – medical device / beverage dispense / automotive / telecoms applications;
- Sheet – construction / medical device . thermoforming / food packaging / military application

# Rotational moulding

Rotational moulding facilities in the PPRC include:

- Ferry RS 1600 carousel rotational moulding machine;
- Caccia 1400A shuttle rotational moulding machine;
- Wedco SE 12 UR grinding machine;
- Direct Electrical rotational moulding machine;
- Caccia High Speed blending machine;
- Rotolog temperature measurement system;
- Datapaq temperature monitoring system.

PPRC is particularly active in process development of multi-layer structures and development of new mPE grades as well as material sintering / densification studies and foaming technology.

The Centre also engages in research into different rotational moulding processes including:

- Cycle time reduction;
- Process monitoring and control;
- Novel mould tooling technology;
- Direct electrical heating;
- Ceramic coagulation Rotomoulding;
- In mould cooling;
- In mould pressurization;
- Material grinding;
- Computer simulation / Shrinkage modelling;



## Other processes

In addition to the wide range of industrial scale equipment used in extrusion and rotational moulding, PPRC's extensive list of equipment includes other items of processing and ancillary equipment available for use in research programmes.

These include the following:

- Arburg 320 50S injection moulder with gas assist unit;
- Vacuum former;
- Custom built plug assist pressure former.



# Analysis and testing

Augmenting the processing capabilities in PPRC is a modern analysis and testing facility offering a range of services to industrial partners.

As well as the usual Mechanical Testing techniques to establish tensile, flexural, and compressive and impact properties, the laboratory in PPRC boasts a suite of equipment enabling the following specialist investigative techniques to be undertaken.

DSC - Thermal technique used for the characterisation of properties such as percentage crystallinity and heat of reaction, transitions such as melting and crystallisation temperatures and identification of material components.

DMTA - Thermal-mechanical technique used for mechanical assessment of materials from  $-150$  to  $300^{\circ}\text{C}$  and for the identification of transitions such as glass transition temperature.

FTIR - Identification of material components, multilayer structures, blends and contaminants.

MFI & Dual Capillary Rheometer - Rheological techniques used for determination of material viscosity at different temperatures and shear rates. Can used to study melt fracture, degradation, die swell and multilayer component compatibility.

Permeation - O<sub>2</sub>, CO<sub>2</sub> and Water Vapour transmission rates through packaging films, pouches, closures and bottles.

The Centre also has facilities to determine the coefficient of friction of films and analyse the surface energy of polymeric materials.

# 16 Exemplar Project I

**Project Title:** Intelligent Process Control for Rotational Moulding  
**Start Date:** April 1999  
**End Date:** March 2001

## Project Partners

As well as the PPRC at QUB, the project partners included Rototek Ltd, Nottingham Trent University, a rotational moulding machinery manufacturer, a supplier of raw materials for rotational moulding, a polymer processor using rotational moulding and two companies designing and assembling products utilising rotational moulded parts.

## Aims of the Project

Due to its low start up costs, rotational moulding is dominant amongst small and medium sized enterprises (SMEs). In fact in Europe 87% of rotomoulding companies are SMEs. To meet technical challenges and to remain competitive these companies need constantly to innovate. Among other things, this means developing new technologies in-house or alternatively gaining access to them. Coupled with this, many SMEs both need and want to internationalise in search of new markets and business opportunities.

This CRAFT project enabled a group of industrial companies with a common industrial or technological research need to come together and to contract PPRC to carry out research on their behalf the results of which now belong to the SMEs involved.

The project aimed to further the capability of rotational moulding by developing both the process, and a superior, intelligent, online control capability.

## Results of the Project

The ultimate deliverable of the project was the development of new prototype machinery for the rotational moulding industry. The machinery incorporates (a) innovative heating / cooling, and (b), the intelligent monitoring and control of the dynamics, heating and pressure involved in the rotational moulding process. The results of the project have had a direct influence upon the core SMEs involved in the project, but also through its exploitation, an impact on SMEs who are not directly involved in the project.

It is estimated that the project has the potential to reduce cycle times in rotational moulding by 50% and increase turnover by 33%.

## Exemplar Project 2

**Project Title:** KTP with Steve Orr Ltd  
**Start Date:** July 1998  
**End Date:** June 2002

### Project Partner

Steve Orr Ltd (SOL) was established in 1977 and produces polyethylene netwrap and polypropylene baler twine for the agricultural industry. The company is based in Dromore Co. Down.

### Aims of the Project

The Project involved a two Associate partnership between Steve Orr Ltd and the PPRC and was instrumental in assisting the company to seek innovative solutions to a number of challenges and focus on new opportunities. It has also enabled them to reinforce the ethos of continual improvement in all aspects of the business.

The aim of the Project was to enable the company and its staff to improve their knowledge of the materials and technologies underpinning the business leading to increased output, lower unit costs and more consistent products which the company exports to 23 countries as well as servicing its established share of the domestic market.

## Results of the Project

Significant improvements to the following aspects of the business:

- health and safety;
- introducing new materials;
- in-house recycling;
- reduction in usage and costs;
- customer relations;
- successful application for funding and prizes.

The KTP raised the profile of the company locally and internationally and leading to increased confidence resulting on additional investment in equipment and personnel.

# 20 Exemplar Project 3

**Project Title:** KTP with The Burnden Group  
**Start Date:** July 2002  
**End Date:** September 2004

## Project Partner

The Burnden Group offers a wide range of products and services to the building, construction and plastics industries through three of its companies K2, Vital Energi and ASM producing conservatories, community power systems and stone cutting equipment respectively all of which operate which operate from two multi-million pound sites in Bolton, Lancashire.

## Aims of the Project

The aim of the partnership was to improve the technological knowledge base of the companies within the Burnden Group through a variety of key projects such as overcoming known product faults, improving product quality, and researching alternative materials and processes. PPRC worked together with the Northern Ireland Technology Centre at Queen's in delivering this Project.

An important aim of the Project was to design and build a test rig (in NITC) to study the effect of (simulated) solar gain on the distortion of woodgrain foil laminated PVC profiles. This laser precision equipment has since been patented with the potential to become the industry standard.

The Project also successfully provided support in the development and commissioning of a range of new tools with double the output and better product tolerance resulting in less raw material wastage.

## Results of the Project

As a result of the Project the Group has reduced labour and cleaning time of dies through the use of ultrasonic equipment which has resulted in an immediate saving in labour of £32k / year and due to longer tool life a saving of £200k / year. Successful trialing of a revolutionary extrusion process has been patented and could earn the company significant income from licensing fees which, in any case this process will save the company about £2.5M over the next two years in capital equipment costs.

Another important outcome is that the company is collaborating with British Plastics Federation on recycling of 20 year old post-consumer PVC windows.

Development of stone cutting equipment has changed completely from drawing board to computer based design resulting in ASM moving to new premises and now producing state-of-the-art CAD / CAM, CE-marked stone cutting equipment. Additional staff has been recruited to cope

with the increase in production / sales. Three dimensional CAD generated video clips were produced and are being used in marketing the new generation stone cutting machines

## 22 Exemplar Project 4

**Project Title:** Fusion with R A Pacaisti Teoranta  
**Start Date:** January 2002  
**End Date:** June 2003

### Project Partner

R A Pacaisti Teoranta, established in 1998, is based in Co. Donegal and is involved in the design and manufacture of packaging for the food sector. The company supplies innovative packaging for the take-away hot and cold food markets and holds the patent on many of its products. Due to the compact nature of the packaging it has the advantage of being more environmentally friendly.

### Aims of the Project

The aim of the Project was to design and optimize the process for the manufacture of a wide range of paper / board packaging products incorporating plastic film.

#### Results of the Project

As a result of the Project the company benefited from the following:

- Sealing head redesign leading to a 35% increase in production speed;
- New glue system saving 2 hours per change over;
- Increased efficiencies and cost savings resulting in new orders with world leading fast food chains.

# Exemplar Project 5

**Project Title:** Fusion with PPA Teo (Eirecomposites Teo)  
**Start Date:** September 2002  
**End Date:** February 2004

## Project Partner

Established in 2000, PPA Teo is a micro company in Co. Galway involved in the development of new moulding technology for the plastics industry. The company supplies electrical moulds and equipment for rotational moulding, vacuum consolidation of thermoplastic composites, monomer casting and resin transfer moulding.

## Aims of the Project

The objective of the Project was to optimise the design and processing capabilities of a novel rotational moulding machine originally developed by PPA for use with composites.

## Results of the Project

The Project objective was successfully achieved through completion and optimisation of the following:

- Significantly decreasing the cooling time by over 60% through the introduction of novel internal and external cooling methods and techniques;
- Increasing the heat transfer between the mould and the plastic;
- Examining the broad processing parameters to optimise material performance;
- Development of prototype machines / moulds to compare performances with conventional rotational moulding machines.

# 24 Exemplar Project 6

**Project Title:** Industrial Training Project Delivered on behalf of NIPA  
**Start Date:** February 2005  
**End Date:** March 2006

## Project Partner

The Northern Ireland Polymers Association is a local employer-led trade association for the polymer industry and represents approximately half of the some 75 companies in Northern Ireland.

## Aims of the Project

In performing the role of Sector Training Council in Northern Ireland NIPA plays a crucial role in forging links between employers, training providers and government in identifying and addressing skills issues and implementing strategic actions to address these issues. One such action was the Industrial Training Project funded by the Department for Employment and Learning through which NIPA engaged the services of PPRC to manage the Project and deliver a number of bespoke training courses to companies throughout Northern Ireland.

## Results of the Project

trouble shooting.

Drawing on their wealth of industrial experience, many of the engineers employed in PPRC visited the companies taking part in the project and carried out Training Needs Analyses to determine the skill level of the employees before developing detailed training programmes in conjunction with senior management in the companies.

Once the course content and level had been established, the PPRC engineers went on to deliver the courses either on site in the company premises or off site in the PPRC laboratories. In providing this bespoke service, PPRC took into account the shift pattern worked in many of the companies and the course were delivered at times agreed with the company to minimize disruption to production. Course delegates underwent an assessment process before being awarded certificates of attendance. The courses' contents covered a wide range of subjects including extrusion, rotation moulding, materials appreciation and

# 26 Exemplar Project 7

**Project Title:** Development of a new process for rotomoulding fibre reinforced and multi – layer plastic products.

**Start Date:** January 1999

**End Date:** December 2003

## Project Partner

Clarehill Plastics was established over twenty years ago and has pioneered the development of rotationally moulded environmental containers. The company is based in Moira, Co. Down and focusses primarily on rotationally moulded fuel storage products.

## Aims of the Project

The aim of the Project was to develop a process to rotationally mould fibre reinforced and multilayer products.

## Results of the Project

As a result of the success in developing and optimising the processing of fibre reinforced, multi-layer products Clarehill has filed a patent to protect the intellectual property derived from the Project and is planning to incorporate the new technologies in a number of exciting and innovative products which will be introduced to the market over the next few years

