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Trial report

Post-consumer film recycling – Protomax trial

Report of panel manufacturing trial at Protomax Plastics Limited

Project code: MDP041
Research date: January to March 2011 **Date:** September 2011

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Front cover photography: Finished panel product manufactured by Protomax

Executive summary

This trial report forms part of a suite of reports demonstrating the technical feasibility of using fully comingled post-consumer film packaging to manufacture products that the retail sector can adopt for use within their store networks and as part of their product ranges for customers. The overall project involves a number of upstream recyclers and downstream manufacturers manufacturing a number of different products from post-consumer films. There are a number of individual trial reports available, in addition to a summary report for the whole project:

- Film separation at Biffa Waste Services Limited;
- Processing of LDPE film at Ecoplast;
- CeDo manufacturing trial;
- Agglomeration trial at Hanbury Recycling;
- Centriforce manufacturing trial;
- Protomax manufacturing trial; and
- Post-consumer film recycling (overall summary report).

Trials were carried out by Protomax Plastics Limited, Penclawdd, Swansea, to determine the feasibility of producing 2,440 x 1,220 x 19mm panels from UK post-consumer and retail film waste.

Feed material for the trials was collected from three sources:

- Household waste film from comingled kerbside collections as segregated by Biffa Waste Services at its Trafford Park Materials Recovery Facility (MRF);
- Sainsbury's front of store and back of store collections; and
- Non-bottle rigid plastic post-consumer waste from Viridor's bottle recycling plant in Skelmersdale.

In addition Protomax supplied recycled wheelie bin material for the panel skins.

All the feed materials were handled satisfactorily by Protomax's P2 equipment; however the feed material from Sainsbury's and Viridor required a degree of hand sorting to remove contaminants; specifically metal packaging.

All the panels produced met Protomax's visual requirements for dimensional conformity, and were judged to be acceptable for use as display panels or hoarding boards.

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Acknowledgements

Axion Consulting and WRAP would like to thank the staff at Protomax Plastics for their time and cooperation with this trial.

1.0 Background

WRAP has commissioned Axion Consulting to demonstrate the technical feasibility of using fully comingled post-consumer film packaging in economically and environmentally viable products. The project involves Axion working with a number of manufacturing companies to trial the production of products using post-consumer films.

The manufacturing trial partners and products being trialled are:

- CeDo: refuse sacks;
- Centriforce: rigid panels for use in a variety of applications including hoardings; and
- Protomax: rigid panels for use in a variety of applications including hoardings.

There is a suite of individual trial reports available, in addition to a summary report for the whole project:

- Film separation at Biffa Waste Services Limited;
- Processing of LDPE film at Ecoplast;
- CeDo manufacturing trial;
- Agglomeration trial at Hanbury Recycling;
- Centriforce manufacturing trial;
- Protomax manufacturing trial; and
- Post-consumer film recycling (overall summary report).

The trials used two key feedstock materials; comingled films collected from domestic kerbside recycling schemes and plastic films collected through Sainsbury's front of store and back of store collection network. In addition the Protomax manufacturing trial used non-bottle rigid plastic packaging from Viridor.

2.0 Trial information

Trial host: Protomax Plastics Limited, Unit 14C Crofty Industrial Estate, Penclawdd, Gower, Swansea, SA4 3RS

Trial date: Equivalent of eight days during March 2011, with Axion attending the trial on 29th March 2011

2.1 Description of trial host/equipment

Protomax is a plastic engineering company based in London, and Swansea, with machine building facilities in Piesendorf, Austria. Protomax has produced a prototype machine P2 capable of processing comingled waste streams to manufacture a range of panels, which can be used in a number of applications including for example display panels, hoardings, shutterings and security panels.

The company's primary objective is to produce and sell P2 machines. An Eastern European customer has recently agreed to purchase a number of units and will be establishing production facilities within the next six months.

The P2 machine at Protomax's site in Swansea is a prototype and is not optimised for regular production runs. It is primarily used to produce demonstration panels for potential customers, typically using feedstock material sourced from its own operations. However in order to generate interest in the P2 machine and utilise its capacity Protomax can undertake limited production runs for customers.

By using different feed materials Protomax is able to produce application specific panels, for example ballastic and blast protective panels. Fire retardant, anti-bacterial and anti-fungal additives can also be incorporated in the panels if required by customers.

The prototype P2 machine produces a standard panel 2,440 x 1,220 x 19mm, which has a smooth polymer skin of 2mm and a rigid honeycomb core of 15mm, in 30 to 40 minutes. The density of the panels can be adjusted to suit a variety of applications from rigid panels through to fairly flexible panels that can be formed into a range of cylindrical applications.

The P2 system uses mixed plastic waste feed material which is typically sorted into two streams for the core and skin layers, with any contaminants being removed at this stage. The two feed streams are granulated and sieved through a 6mm screen. Depending on contamination levels the sieved material can be processed through a closed loop washing system, containing a disinfectant. The skin feed material, usually a rigid waste plastic of uniform colour, is pulverised and passed through a 500 micron mesh.

Depending on the nature of the feed stream a percentage of rigid material is added to ensure the panels have the required rigidity. At this stage a nitrogen blowing agent is added to the mix to produce the core feed material.

The material for the 2mm skin is fed to the P2 machine and heated. Once molten the formulated core layer is added to the mould which is closed and heated to produce a rigid panel with a honeycomb core.

2.2 Objectives of the trial

The main purpose of the manufacturing trial was to run three trials to produce ten in-specification (30 panels in total) standard 2,440 x 1,220 x 19mm panels each from two key feedstock sources:

- Biffa and Viridor material in a 70/30 blend;
- Sainsbury's and Viridor material in a 70/30 blend; and
- Biffa and Viridor material in a 50/50 blend.

A secondary objective was to visually evaluate the panels to determine if they were of sufficient quality to be used as display panels or in hoarding applications.

2.3 Trial feed material

The feed material used was:

- 'Grade C' film supplied by Biffa Waste Services from comingled dry recyclable household waste film, produced during normal production at Biffa's MRF facility at Trafford Park, Greater Manchester. The feed material contained paper, card, metalised film (crisp packets) and laminated film as contamination. **Figure 1** shows this feedstock material;

- Front of store material from Sainsbury's (primarrily carrier bags returned by customers to the store) and back of store (primarily shrink and stretch wrap and other larger films) collections, shown in **Figure 2**; and
- Non-bottle rigid plastic packaging waste from Viridor's bottle recycling plant in Skelmersdale, shown in **Figure 3**.

The feed materials were not weighed prior to the trials but it is estimated that approximately 350kg of each feed material was utilised for the trials.

Figure 1 Biffa comingled film feedstock

Figure 2 Sainsbury's film feedstock material

Figure 3 Viridor rigid feedstock material

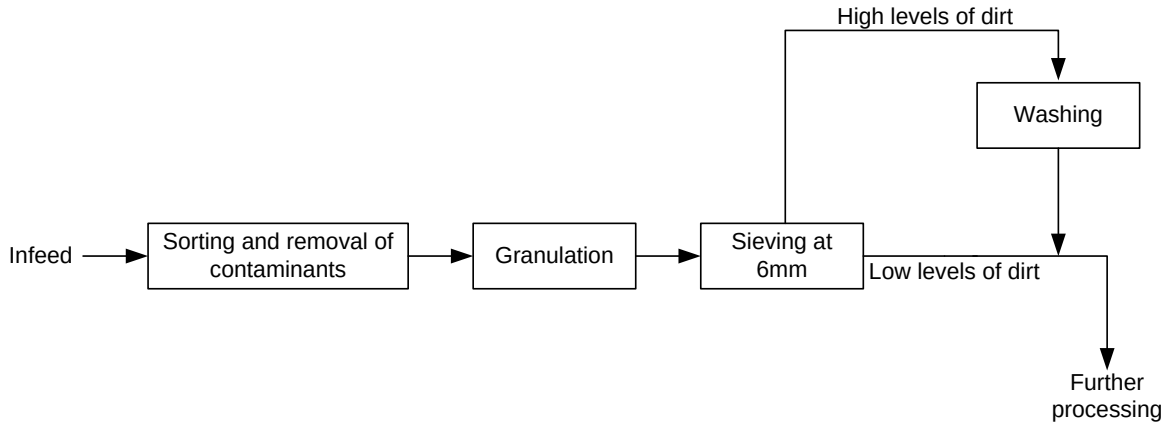
Protomax also supplied a quantity of pulverised recycled wheelie bins to be used for the panel skins. This material was predominantly high density polyethylene (HDPE) but there was likely to be small quantities of medium density polyethylene (MDPE) also in the material. For standard panels the company has found a recycled polyethylene is ideally suited for skin material. Black is the standard colour of the panels however other colours can be used for the skin material if required by customers. For panels requiring a harder surface recycled polypropylene is used for the skin material.

2.4 Trial methodology

2.4.1 Initial sample preparation

Prior to the manufacturing trial a number of activities were carried out by Protomax, as shown in **Figure 4**. Due to the presence of contamination the Sainsbury's and Viridor feedstock materials were hand sorted, after breaking open the bales, to remove large pieces of card from the Sainsbury's feed material and items of ferrous packaging from the Viridor feedstock. The level of contamination for both materials was approximately 1%. Visual inspection of the Biffa material by Protomax did not show any undesirable materials and therefore this feedstock did not require hand sorting.

Figure 4 Flow diagram of pre-processing stage



The three feedstock materials were granulated and sieved through a 6mm mesh screen in preparation for producing panels, as can be seen in **Figure 5**. The pulverised polyethylene skin material was passed through a 500 micron mesh screen in order to ensure a smooth surface for the panels.

Figure 5 Granulated feed material

Left: Biffa/Viridor 50/50; Centre: Sainsburys 100%; and Right: Biffa 100%

2.4.2 Trial procedure

For trials 1 and 2 (Biffa/Viridor 70/30 and Sainsbury's/Viridor 70/30) Protomax conducted a number of laboratory scale trials in order to determine the exact formulation for the panels. This showed that 30% of the Viridor material needed to be blended with the Biffa and Sainsbury's material in order to achieve the desired density/rigidity for the panels (0.5 kg/m^3). A small amount of nitrogen releasing blowing agent was also added to the mixture. The precise type and amount of blowing agent added is confidential to Protomax. Once the optimum blend ratio had been established approximately four full scale panels were produced to verify the formulation.

For the third trial there was a more equal mix of Biffa film material and Viridor rigid material. Again the nitrogen releasing blowing agent was added (the precise amount being confidential to Protomax). As with the first two trials, a number of trial panels were initially produced on the laboratory scale unit to determine the correct formulation. This was then followed by the full scale trial.

The trial was delivered over a number of days, with Axion attending one day of the trial. Prior to this date Protomax had produced nine in specification panels for each of the three trials.

Trial 1: Biffa/Viridor 70/30
The blend ratio for this first trial consisted of a 70/30 Biffa/Viridor blend plus a small quantity of the nitrogen blowing agent. As indicated the Viridor rigid material was added to achieve the desired rigidity for the panel.

The Protomax skin material was placed in the P2 mould and heated up until the polymer had melted. The precise quantity of the blended feed material for the core layer was added volumetrically to the mould, which was then heated and allowed to cool down before the completed panel was removed and allowed to cool down to ambient temperature. During the trial the cycle time per panel was around 40 minutes.

It should be noted that the usual set-up for this equipment is to have four units side by side with two operators controlling and feeding them. Using this configuration, Protomax claims to be able to produce approximately 50 panels per eight hour shift.

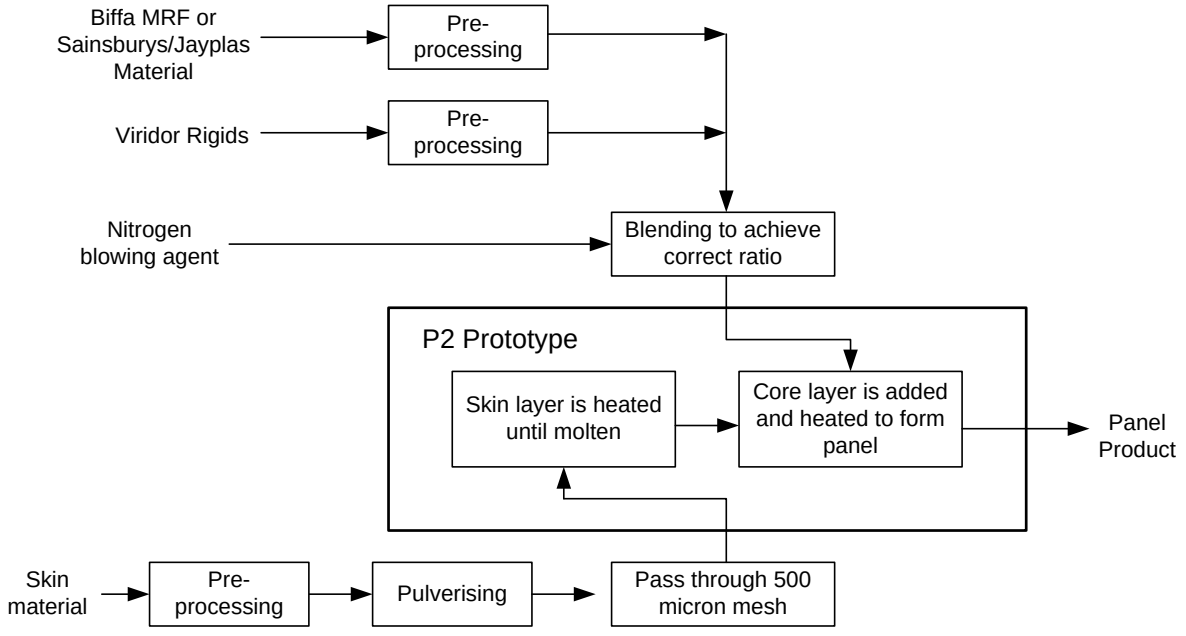
Trial 2: Sainsburys/Viridor 70/30
The blend ratio for the core layer consisted of a 70/30 Biffa film/Viridor rigids mix plus a small quantity of the nitrogen blowing agent.

Apart from the change to the Sainsbury's feed material the procedure for producing the panels was the same as that described for Trial 1.

Trial 3: Biffa/Viridor 50/50
The blend ratio for the core layer for this trial consisted of a 50/50 Biffa film/Viridor rigids mix plus a small quantity of the nitrogen blowing agent.

Apart from the change to the feed for the core layer the procedure for producing the panels was the same as that described for trial 1. **Figure 6** shows an overview of the production process followed for the manufacturing trial.

Figure 6 P2 panel production process



2.5 Product evaluation methodology

The panels produced by the P2 machine were evaluated as follows:

- Visual examination of the panels surface;
- Panel dimensions. The standard size is 2,440 x 1,220 x 19mm and a 2% shrinkage is expected, which is catered for in the design of the P2 machine;
- Visual assessment of the distribution of the skin layer; and
- Weight of the panels.

No further specific physical analysis or testing was undertaken on the panels. Protomax is able to vary its production to meet the specific needs of its customers and therefore testing and analysis is determined by the final application for the panel product.

3.0 Results and discussion

General observations

- The three trials all produced panels that met Protomax's usual standards for use as display panels or hoarding;
- Visual examination of the panels surface showed a similar smooth black appearance;
- All the panels met Protomax's standard size of 2,440 x 1,220 x 19mm;
- A cross section of the panels showed a consistent distribution of the skin layer at 2mm, which totally encapsulated the panel. A skin layer of 2mm is typical for the panels. **Figure 7** shows the cross section of a Biffa/Viridor 70/30 panel;
- The average weight of the panels was:
    - Trial 1: 29.9kg ranging from 29.3 to 30.1kg;
    - Trial 2: 30.2 kg ranging from 30.0 to 30.5kg;
    - Trial 3: 28.0kg ranging form 27.8 to 28.3kg;
- Protomax panel's can vary in weight from 17kg to 35kg, with an average of 23kg. The panels manufactured from this trial fall within this normal range of weights;
- Due to contamination of the Biffa feed material it gave off a rather foul smelling odour on heating. This disappeared once the panel had been removed from the mould and cooled down to ambient temperature. The odour was due to the material being unwashed and can be expected when material of this kind is used;
- The 50/50 Biffa/Viridor panels from Trial 3 had a less dense core compared those from Trial 1 and 2. This is due to the greater percentage of the less flexible rigid material from Viridor compared to the film material from Biffa; and
- On a mass balance basis no waste is generated from the core feed material (apart from the initial hand sorted card and metal removed from the feedstock materials) as it is added volumetrically to the mould. The only waste generated during the manufacturing process is a small amount of edge trim material of 400 to 450g, which is granulated, pulverised and returned for use as skin material.

An example panel can be seen in **Figure 8**.

Figure 7 Cross section of Biffa/Viridor 70/30 material panel

Figure 8 Example panel

4.0 Conclusions and recommendations

The key conclusions from the Protomax trial is that all three feed materials produced panels that met the company's visual dimensional standards.

The key recommendation is that the panels are suitable for use in applications such as display panels or hoarding. It is therefore recommended that products from the trials are put forward to prospective users for evaluation.

A secondary recommendation is that production throughput would be increased by arranging four P2 machines in sequence in a two by two array and improving/automating some of the operations. Using this configuration the two operatives could move in sequence from one machine to the other, whilst they were in the heating and cooling phases of the process.

Overall the trial demonstrated full dexterity, both of the feedstock that can be used to make the panels and the subsequent applications that the panels could be used for in a retail environment.

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