Tooling up for multiple layers

The latest multi-layer pipe dies can make products more efficiently and flexibly – while future designs may even allow the incorporation of 'layer multiplication' principles. Lou Reade reports

Main image: Muna Noor's Omanplast pipe has multiple layers to protect it from damage in stony soil

One critical element of making multi-layer pipe is tooling – and a number of research teams (both academic and commercial) are leading the charge to develop tools that could be used to make enhanced pipe designs.

Researchers at **Case Western Reserve University** in the USA recently developed a new type of extrusion die to create pipe and tubing with multiple layers.

Tyler Schneider, a postgraduate researcher in the department of macromolecular science and engineering, told delegates at this year's Antec conference: "It is capable of producing layer structures of tens to thousands of layers, achieving layer thicknesses from millimetres to tens of nanometres."

Layer multiplication co-extrusion can produce melt structures of high layer numbers with low layer thicknesses. This can boost properties such as barrier and impact strength. To date, the process has largely been limited to the production of multi-layer films.

"If the output could be that of an annular shape, the technology could be used to improve barriers properties in tubing and piping, or produce film-foam tubing and piping, for insulation applications," said Schneider.

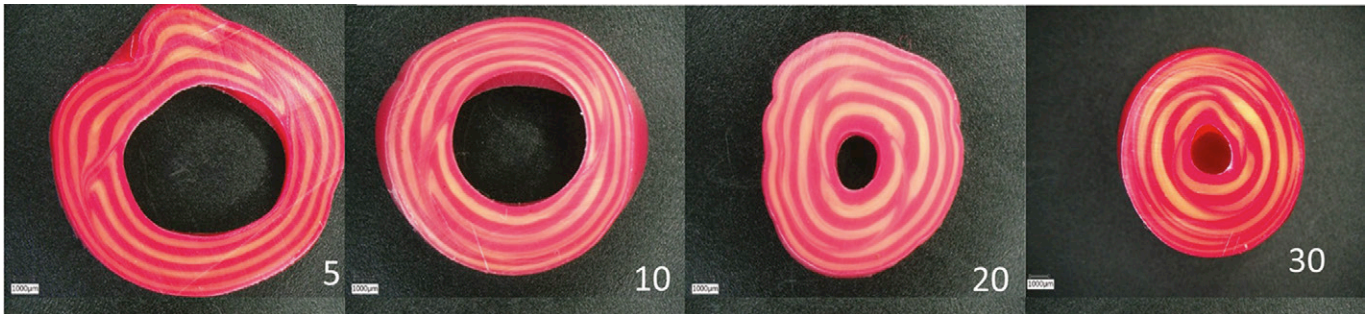
The researchers have now produced and validated a die to produce annular structures.

Multi-layer pipes are typically made using crosshead dies to apply layers to an already formed – and partially solidified – annular structure in a downstream process.

"Imagine the drastic process length increase that would be needed to produce a tube with 1,000 plus layers," said Schneider.

The researchers used a multilayer co-extrusion line – comprising two Killion single screw extruders, a 9-layer feed block, high aspect ratio multiplying dies and a custom-designed tubing die. Extruded samples were sheared off the die face with a brass bar and allowed to cool in a water bath prior to cutting for imaging. In runs incorporating angular rotation, a custom-designed annular die land was used, along with an electric motor for rotation control.

The die design was validated by extruding a layered Dow 5004I LDPE system (in two different colours) into 9-, 33-, and 129-layer structures. The die was attached to a high aspect ratio multiplier – functioning as an adapter – and the 9-layer feed block. The two different materials enter the feed block flow paths and split into sub-flow paths of



Above: Case Western has developed a die that could apply 'layer multiplication' to pipes

either four or five layers. These layers then intermesh and contract to the correct size, before being combined into a single multi-layered melt structure.

Increasing the number of layers was achieved by incorporating more multipliers between the feed block and tubing die. In the case of 33 layers, three multipliers were used. In the case of 129 layers, five multipliers were used.

The extruded product – which was not round due to a lack of post-processing equipment – was viewed using optical microscopy. Results confirmed that layer multiplication co-extrusion could be applied to pipe co-extrusion.

There were two main issues of the layered tubing: one was the presence of weld lines where the layered flows meet to form the annular shape; the other was the slightly irregular nature of the layering near the weld lines. These were solved to some extent by building a new angular land that could rotate.

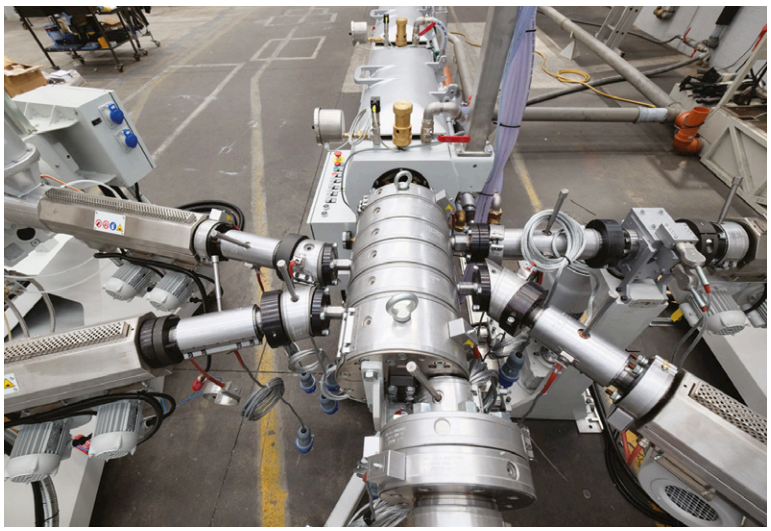
"Future work will study the weld line strength within different material systems extruded with this technology," said Schneider.

Radial design

Below: Tecnomatic recently supplied an extrusion line to make five-layer polybutene and PEX pipe

Tecnomatic of Italy recently delivered a multi-purpose extrusion line to make five-layer polybutene and PEX pipe to a leading European producer.

A key component of the line was an optimised version of its Athena die-head. Based on a radial distributor design, the product has been modified to enhance the flexibility and accuracy of its distribution – which is especially important to shape the EVOH and adhesive into a very thin and uniform layers, says the company.



The radial distributors do not have any dead zones, which allows for easy cleaning and fast assembly and disassembly. Radial spirals allow low pressure losses and high flexibility in terms of layers structure (thick or thin layers) and number of layers, while their short flow path leads to reduced residence time and rapid material and colour changes, says Tecnomatic.

The line produces pipe in sizes from 8 to 32mm. It has an output of up to 50 m/min for the five-layer PEX or PE-RT pipe (for diameters of 16mm), and up to 40 m/min for most polybutene pipe diameters.

The line configuration includes an Atlas 60.30 as the main extruder – in a gearless version, to reduce maintenance and optimise energy consumption – while Mizar and Atlas 30 co-extruders are used for adhesive, EVOH and external layers. All extruders work in synchronisation mode and are integrated and fed by multi-component gravimetric systems. Ultrasonic wall thickness and eccentricity scanners continuously control all pipe parameters during the production.

Advantages of the Athena die-head include:

- Short flow paths and low melt volume, for a short residence time;
- Rapid material colour changes;
- Optimal melt flow and layer uniformity; and,
- High flexibility in terms of layer structure (thick or thin layers and materials).

By using a co-rotating twin-screw extruder, a second downstream production process can be eliminated, saving on energy costs and handling. Two single-screw extruders are used for the thin internal and external layers, while the die-head can process up to 1200 kg/h in diameters of 200mm.

It is based on three-spiral geometry, with the inner one modified for a filled PP material, to ensure high melt flow. The die-head, despite the high output to be managed, is compact and has a contained