What's the best for you in pipe dies: helix or spiral?

An emerging technology that is increasingly penetrating applications such as pipes and tubes, blown films, and blowmolded containers is spiral mandrel distributor extrusion dies.

For multilayer products this design principle offers outstanding advantages, and in many cases provides the only solution. Extrusion dies with up to nine concentric spiral mandrel manifolds have been produced.

In addition to spiral distributors of cylindrical or conical shape, die systems were introduced for blown-film extrusion in the early 1990s with the melt distribution on a plane-so-called flat spiral, stack, or pancake dies. Such a design principle has also been adapted for pipe dies and is increasingly used for small pipe and tube extrusion. Since not only spirals but also pre-distribution channels are located in the same flat disk, we propose using the term Circular Distribution or in German: Circular-Verteilung (CV).

Spiral mandrels

Conventional spiral mandrels are widely used for small multilayer pipes and tubes, such as automotive lines, medical tubing, and hydraulic and pneumatic ducts, as well as underfloor heating and hot and cold water plumbing.

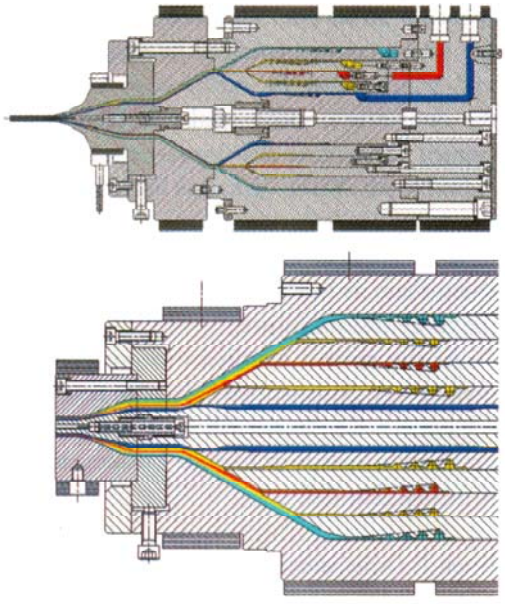

Figure 1: Five-layer die with concentric spiral mandrel manifolds.

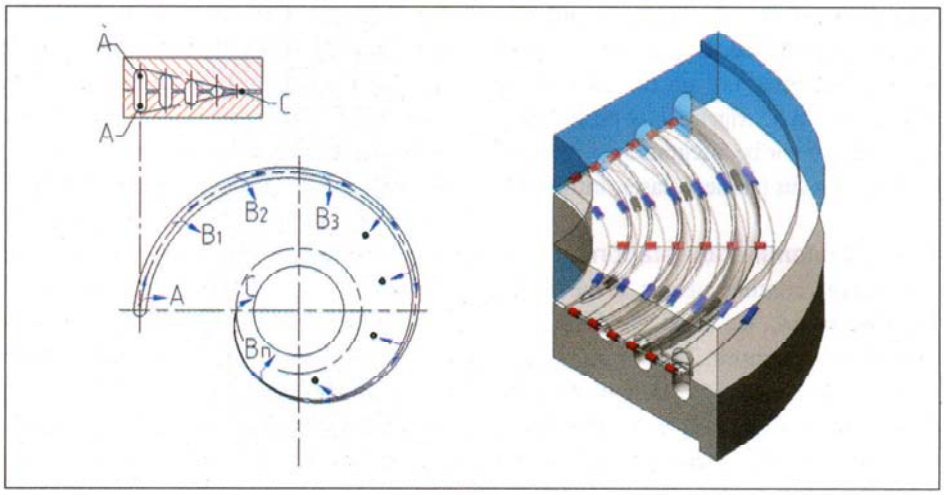

Figure 2: Working principle and layout basics of circular distributors.

Figure 1 is an example for three-, four-, or five-layer automotive tubes based on nylon with various functional layers such as barriers, adhesives, or conductive inner layer. Formation of the layer structure depends on the rheological flow behavior of the merging melt streams: symmetrically, at a single point, or sequentially one after the other.

Circular distributors

Layout and design are supported by computer simulations, similar to the conventional spiral mandrel systems. Two-dimensional network models are common design tools.

The working principle and layout basics are shown in Figure 2. Computer-aided design tries to optimize uniform volume flow and low pressure drop with shear velocities, ensuring short material and color change times (lower limit) and, on the other hand, avoiding excessive

Figure 3: Open block (module) with circular melt distribution channels and central mandrel.

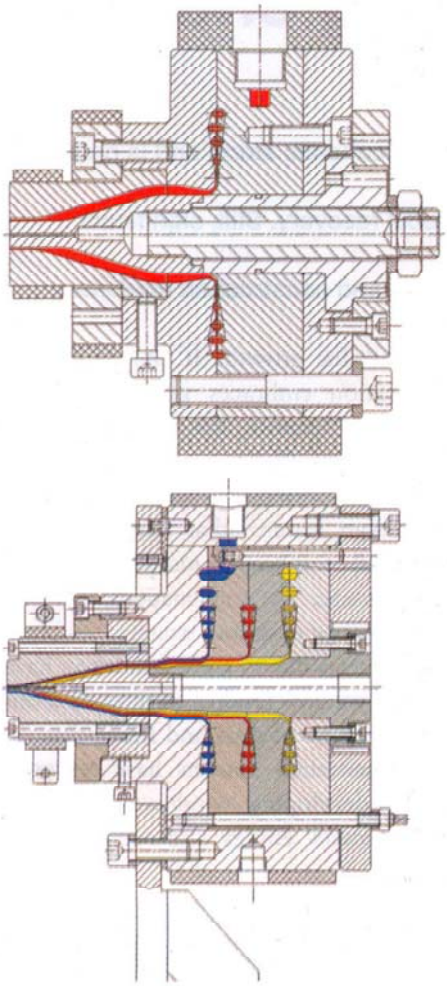

Figure 4: Mono- and three-layer dies for micro-ducts (medical tubing).

heat generation and/or excessive pressure buildup (upper limit).

Circular melt-distribution technology offers ideal prerequisites for modular design. Melt feeding, predistribution, and radial distribution take place in one block (module). For multilayer products a multiple of modules can be stacked together. Components of the individual blocks are of the same or similar design. A central mandrel with passages for air flow or other fluids locates the flow channel assemblies using the inner holes of the disk blocks (Figure 3).

Besides compact size and economy in manufacturing, the system has many more advantages:

- Short flow passages and small melt volume (equaling short residence time)
- Low shear rate at walls (thus low heat dissipation and temperature increase)
- Low pressure drop (equals high throughput potential)
- Great flexibility regarding layer structure (thick/thin, materials, throughput) and number of layers
- Thermal insulation and individual temperature control for each block
- Special design of individual modules (e.g. incorporation of corrosion resistance)
- Ease of handling for cleaning and assembling

There are, however, a few disadvantages:

- Merging of layers is only possible sequentially, thus there are limitations with polymers having wide viscosity differences
- Numerous contact (sealing) surfaces, thus specific requirements for manufacturing

In the end, the advantages predominate, especially in smaller dimensions.

Single- or multilayer

Some of the stated advantages have major importance when extruding very small medical tubes, specifically small melt volumes and quick purging. Also important is easy access to the die insert from the rear. Circular die systems have been built for mono- and multilayer medical tubes (Figure 4).

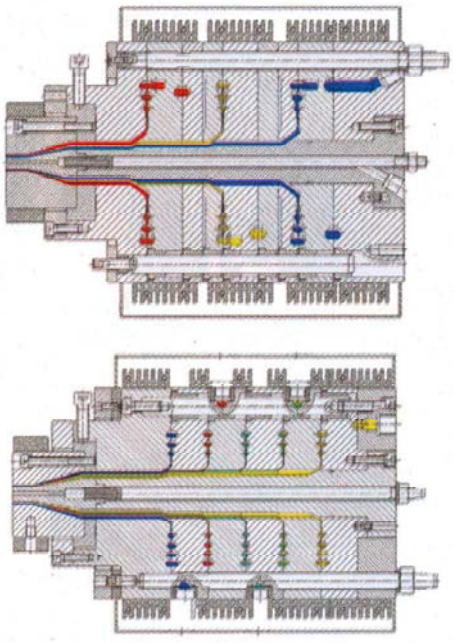

Figure 5: Coextrusion dies for multilayer nylon pipes with functional layers.

Figure 6: Modular die with circular melt distribution for barrier films.

Modular design and all the related advantages have also introduced CV systems for automotive fuel lines. In Figure 5 one can find special features like thermal insulation between modules and a heater/cooler unit for better temperature control, avoiding degradation and ensuring shorter purging time.

CV die systems for small blown film, e.g. multilayer structures for long-shelf-life food packaging, are similar to the pipe systems. In principle, unlimited numbers of modules can be stacked one above the other with limitless possibilities for introducing specific product properties: for example, meat casings based on nylon (Figure 6).

Future trends

Since blown-film dies with flat spiral disks have gained market acceptance, the initial question "helix or spiral?' must now also be asked in other extrusion fields. The flat spiral distributor is now a viable option, especially for smaller dies and coextrusion systems. It now points the way forward.

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