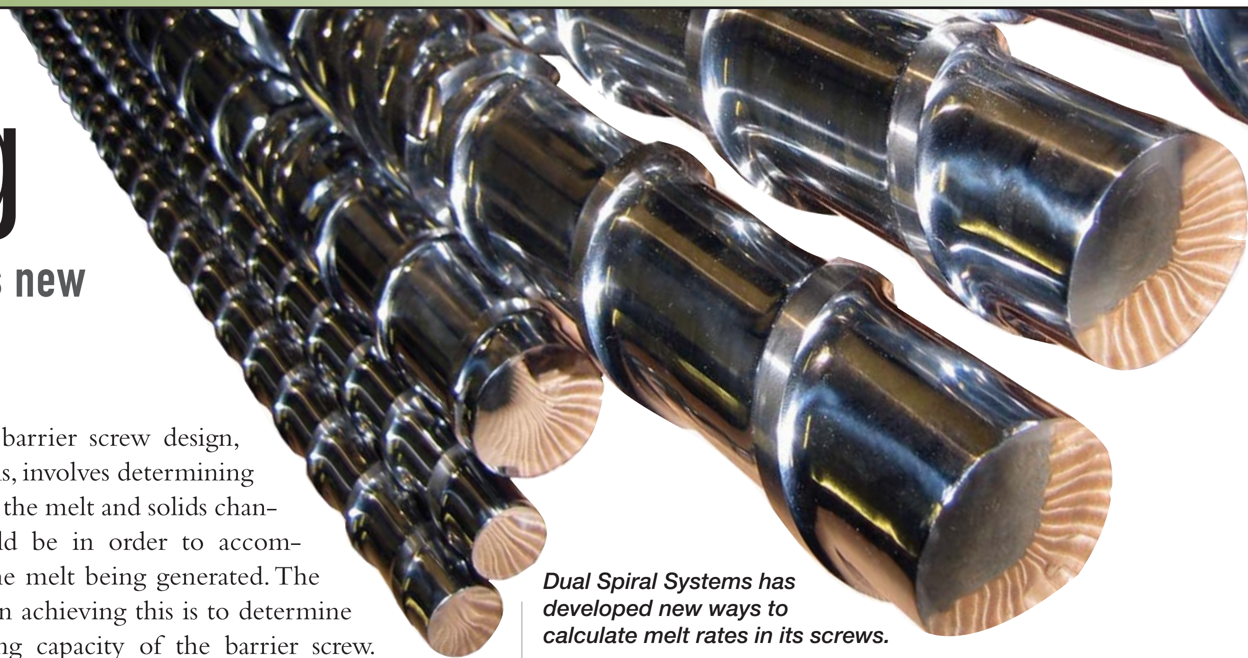

Dual Spiral Systems has developed new ways to calculate melt rates in its screws.

Front-end loading

Feedscrew quality is improving all round as new technologies are brought to bear on design

There was a time when feedscrews just melted resin, and people were happy with it. But over the years, the tasks they perform have become more complex, and so have the methods used to produce them.

There are, of course, two markets for feedscrews. One is the cheap-and-simple market, where moulders or extruders need a very simple design for a traditional material, and the other is all to do with sophisticated control of melt rates and monitoring of what's happening to a very exact degree.

"A lot of what people are looking for these days is simple rebuilding," says Jim Ley, regional sales manager with North American Feed Screw Ltd. (Mississauga, Ont.), which also designs new screws. "Service is the name of this game—we focus on fast turnaround, and we can rebuild a screw in seven to 10 days."

There are, he adds a large number of small, 50-mm screws in the field, used for small tonnage machines. Such an item can be shipped by Fed-Ex, which keeps costs down.

"Now, if you want quick service, you can't coat the screw, because it adds time," he cautions. "Carbide coating is not done in Canada, so the screw has to go to the US, and if you want a hard facing, which is usually chrome, it has to be brazed or welded on."

If the work to be done is largely straightforward remachining, then of course it's much simpler. Modern CNC systems, he points out, offer faster completion, and with better tolerances than were possible a dozen years ago.

As software for controlling the cutting process has been improved, so have programs for predicting melt behaviour.

"We've been able to improve what we offer in matching the resin with the actual feedscrew design," says Rafael Castillo, president of Dual Spiral Systems Inc. (Hamilton, Ont.) "We simulate the resin's behaviour, and we can calculate how much melt is being generated."

Proper barrier screw design, he explains, involves determining how large the melt and solids channels should be in order to accommodate the melt being generated. The first step in achieving this is to determine the melting capacity of the barrier screw. This can be estimated from the thermal and material properties of the polymer as well as process-related variables including screw speed, barrel temperature settings and the surface area where the solid bed is exposed to the barrel.

"By calculating the melting capacity along the axis of the screw it's possible to determine the volume of melt that is being generated at any point along the screw," he says. "We have successfully applied this concept for both grooved feed and smooth bore extruders."

Glycon's SmartBarrel concept helps track screw and barrel wear without the need for shutting down the machine and pulling the screw.

Dual Spiral Systems' barrier section design creates more melting, so output is higher. The geometry takes into account that there will be more liquid molten polymer and the volume of the channels is sized accordingly.

"This is what we refer to as a 'balanced' barrier section which basically means that the geometry of the screw is designed around the melting behaviour of the polymer," Castillo says. "The advantage of this is that the material is not subjected to additional shear as it is being conveyed. Other screw designs do not have this feature, and the additional shear results in a higher exiting melt temperature."

In film applications, this extra energy (measurable in BTUs) must be removed from the film as it exits the die so the film can solidify before reaching the nips. The extra heat means that the line will run slower because more cooling is required.

If the melt is already cooler when it exits the die, as it would be if it were sheared less, then there is less energy to take out of the film during cooling. As a result, film converters are able to run faster because less cooling is required. This applies with all screw sizes since melting is proportional to the inner surface area of the barrel.

One challenge screw designers are starting to face is designing for biopolymers. Resins produced from organic sources as opposed to natural gas, oil or other mineral feedstocks can show different rheological properties, and of course composite materials that use vegetable fibres can be subject to burning.

"We have started some very preliminary work on biopolymers," Castillo says, "but they are a specialty application. It's going to be in an R&D niche for a while."

One system with niche application is the Spirex Twinshot. This coinjection method handles two materials through one screw.

There are parts that can't be moulded using it, such as two-material moulding applications that require precise control of the B layer, hot-runner parts and parts with multiple gating. But where it can be used, Twinshot can cut costs significantly.

There about 30 Twinshot users at present.

Recent refinements to the system include a gearbox/motor driven auger screw instead of gear motor to give better torque carrying capability throughout the rpm range. Digital controls have been improved for process repeatability, and a new auger barrel design offers more consistent delivery and better venting.

Specific advantages of the Twinshot process include the ability to impart structural integrity without effecting surface finish, by utilising glass in the core. It can also reduce part weight and tonnage requirements by foaming the core.

Wear on screws is a constant concern, especially as more glass and mineral-filled materials come onto the market. A new approach from Glycon Corp. (Tecumseh, Mich.), which it calls Process Wear Management, is aimed at developing the tools and the discipline to make it easier to track wear and repair or replace critical components before they affect profitability. Glycon has teamed up with Dynisco, Inc. (Franklin, Mass.) , and RJG, Inc. (Traverse City, Mich.), to develop new sensor and data gathering technology.

"When it comes to wear, we like to make the analogy to automobile racing," says Jeff Kuhman, president of Glycon. "Racing professionals have made a science of tracking tire wear, measuring it and correlating it to the performance of the car. They can usually predict how many laps they can go without new tires and build the tire changes into their race plan.

"We're working to help plastics processors be just as smart about screw and barrel wear."

Melting and mixing characteristics of a typical plasticating unit are defined by the interaction of the rotating screw and the stationary barrel. As wear inevitably widens the radial clearance gap between screw and barrel, the process degrades.

Initially, a small amount of wear has very little effect and minor adjustments to screw speed and temperature settings are sufficient to maintain rates. Glycon refers to this as the "optimum performance window."

Tests show, however, that eventually the radial clearance gap between the screw and the barrel reaches a point outside the performance window. Energy costs soar and throughput declines dramatically.

"Processors have always known about this phenomenon," says Kuhman, "and, for years, we have recommended taking periodic screw and barrel measurements to track wear. But it is a time-consuming and often costly procedure, so processors usually don't implement such a program. Now, at last, we've been able to do something to help them."

Autoshut mechanism at the tip of a Spirex Twinshot screw, a key component in the design.

In 2005, Glycon introduced SmartBarrel, a system whereby a digital indicator is inserted through small ports in the extruder or injection-unit barrel to take accurate measurements of screw-flight dimensions. These manual measurements can be taken in a few minutes, while the machine remains near processing temperatures. A plug, which seals the port during normal processing, is designed to be measured to evaluate wear of the barrel liner.

At the same time, Glycon has been working with other suppliers on a continuous monitoring and data-gathering system called Flite-Scan. Eddy-current sensors take non-contact readings of the gap through the barrel wall, continuously, while the machine continues to operate.

Dynisco, a supplier of pressure sensors and related instrumentation, has worked with Glycon to develop new sensors specifically designed to stand up to the rugged, high-temperature conditions of a screw plasticating unit. RJG is contributing data-gathering and analysis systems to collect information on such factors as screw speed and energy consumption.

Correlating this information with run hours and pounds of material consumed, processors can begin to create a database to correlate gap measurements, with material throughput and operating costs.

Milacron has extended its ServTek line of injection end-products with a proprietary feedscrew encapsulation process it calls StarGuard. This, according to Mark Ruberg, Milacron's director of aftermarket services, can double the life of any screw manufactured from standard tool steels or high-wear powder metallurgy materials.

StarGuard is an extension of ServTek's existing Star product line of injection end products, and is available for injection moulding, extrusion and blow molding machines.

"StarGuard tungsten or chromium encapsulation provides crack and porosity-free protection," Ruberg says. "The entire length of the feedscrew is encapsulated, including the root, flight sides and flight lands."

There are several engineered encapsulations available, depending on the plasticising process.

Milacron's other major feedscrew product, its BarrV-BET screws, are available in a new version for LLDPE resins.

Currently, screws designed for even fractional melt index LLDPE's produce much higher melt temperatures than desired. This has dictated the use of very deep screw channels to reduce shear energy input.

In recent times, processors have been blending metallocene LLDPEs with other resins, notably fractional melt index LDPE. These lower viscosity resins result in unmelted or at least much colder domains of the mLLDPE, which in effect is lubricated by the molten LDPE.

A new patented VBET design significantly increases conductive melting such that much higher rates are seen before encountering melt fracture. Several Barr VBET screws are now in production resulting in increased film properties at higher production rates compared to other barrier screws.

This new-low shear design does not use a barrier section but uses almost half of its length as ET sections, which provide an increase in conduction melting by almost 30 per cent. In addition, processors have found the screw provides increased throughput rates, lower melt temperatures and a more uniform melt temperature distribution on all resins run in production.

Obviously, processors have to choose the screw that meets their cost objectives as well as their technical aims. But as understanding of screw design and behaviour widen, it's becoming far easier to buy exactly what you need, and to achieve precise results without just guessing what to do. **P**

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