

Cycletime Tips - General

Volume 42: Grooved-Feed Extruders

The extruder (barrel and screw) is the heart of the process used to melt, mix, and convey polymers for shaping and sizing into usable products. Many years of research and millions of dollars have been expended in pursuing the “perfect” system for extruding products with the highest output and best quality. The standard extruder design for the extrusion industry has been one that utilizes a smooth-bore barrel with a screw that provides some degree of compression while melting, mixing, and conveying the plastic. Polymer scientists have provided various resins to the industry that can be challenging to process on this conventional equipment thus providing the impetus to develop new extrusion technologies. One of these “new” developments is the grooved-feed extruder.

While not really new at all, grooved-feed extruders have been around for decades and yet are still widely unknown in an industry that has been dominated by conventional, smooth-bore extrusion technology. It was discovered that machining axial grooves into the feed section of an extruder could significantly increase the frictional forces needed for efficient solids conveyance. This increase in the frictional force on the barrel substantially increases the throughput capability of the extruder. The shape, number, size, and length of these grooves can be variable based on resin used, the screw size and design employed, and also on the manufacturer of the equipment.

As a result of the improved feeding performance, the standard design of compression screws found in the “conventional” smooth-bore extruder was found to be lacking. This stimulated research into new, no- or lower-compression screw designs that could intensively melt and mix the higher volume feed rates. It was also found that the feed throat, or feed-section area, required intensive (water) cooling due to the high heat generated by the increased frictional forces. This in turn necessitated improvements in the metallurgy used in both the barrel in the grooved-feed section but also in the screw to reduce the wear resulting from the solids conveyance at high pressures. The design of the grooves, thermal separation of the heated barrel and the grooved-feed section, and screw design are the vital components of any grooved-feed extruder.

Just like the incredible number of choices we have today at the automobile dealership, extruder manufacturers that make grooved-feed extruders have developed their own special technology. It is not the purpose of this article to suggest that one design is better than the other. This Tech Tip is instead provided to hopefully inform the reader that technology exists that may be able to positively affect your productivity while extruding challenging materials.

High Molecular Weight High Density Polyethylene (HMW-HDPE) has been around in the United States since the very late 70’s and proved to be one of these challenging materials to extrude in conventional smooth-bore extruders. Some of the problems

encountered when this resin was first introduced were high extruder pressure and melt temperature, low output (compared to LDPE), and physical properties that were low compared to published data. Output on smooth-bore extruders was significantly lower than the results obtained in Europe using grooved-feed extruders. This was (and still is) mostly due to the very high viscosity of the resin and its resistance to flow and compress along the length of a screw in smooth-bore extruders. Consequently, this low flow (and partial backflow in the compression zone) resulted in increased residence time and greater shear and heat history thus degrading the resin to the point of being weak – again in comparison to data generated in Europe on grooved-feed extruders.

With the desire to provide to consumers lighter, thinner products using this new HMW-HDPE resin, the race was on to introduce to the U.S. market the new grooved-feed technology needed to run this resin successfully. While this technology was widely known at the time in Europe, it was a challenge to the extruder manufacturers to introduce a process that was more costly even though it could potentially provide from 30 to 100% improvement in output rates above those obtained using HMW-HDPE on smooth-bore extruders. Concurrent with this 1980's and 90's challenge to the extruder manufacturers, resin manufacturers were (and still are) working on new process developments that could make stronger, easier to process resins with broader and, in some cases bi-modal, molecular weight distributions.

As the grooved-feed extruder proved its ability to enhance output rates and provide greater retention of the properties inherent in the resins, processors began to ask whether this technology could be used with other resins. Again, much research has gone into determining what resins can be extruded most efficiently on the grooved-feed extruder and here again, the reader must determine the suitability of this process for their own purposes. An outstanding article in *Modern Plastics Magazine* (December, 1998), by William A. Kaplan, outlines the work of Johannes Wortberg and Rober Michels entitled: "Single-screw extruders run a diverse range of resins". Their work investigates the effectiveness of barrier screw with grooved-feed extruders for both commodity (LDPE, LLDPE, EVA, HDPE, PP, PS) and engineering resins (PA6, PC, TPU, TPE) and is a good read for those interested in this subject. Other articles have been written on this subject over the years and before expending the capital on this "new" technology, one should completely investigate whether the grooved-feed extruder truly meets their requirements.

Advancements in technology are the force that drives our industry and there are a number of reliable sources available. The Technical Service Representatives at General Polymers can work with you to target your resin and equipment needs and then help with process optimization.

Just call us at General Polymers – we really try to be the “who in how things work” for you.