psi, as seen in added feed section and barrel wear as well as higher power usage from the drive motor. Most grooved feed sections thus are desirably produced from highly wear-resistant materials such as tungsten carbide lined cylinders.

Whether the feed section is smooth bore or grooved, the amount of wear definitely can affect feeding effectiveness and hence output rate and output stability. Worn smooth bore feed sections can be repaired with a sleeved section that will bring the bore back to original tolerances. Repair of grooved feed sections involves more effort because of the complexity of the machining.

Material Effects on Feed Section Design. The form of the material entering the feed hopper or feed section has an effect on the processing success of the extruder. Powders and fluffy regrinds, for instance, generally lead to more feed and processing difficulties than pellets, cubes, and heavier regrinds. The bulk density of the feed material determines how effectively the screw's feed flights are filled and how well the extrusion process can then commence. Most low-bulk-density regrinds and some powders (especially filled powders) will not readily flow down the hopper and through the feed throat to fill the feed flights adequately. When hopper flow problems are evident, special material forcing devices, such as compacting screws in the hopper/feed throat, sometimes are used to ensure a filled screw feed flight. Alternately, the materials that cause feeding difficulties can be pelletized or otherwise densified on other equipment to alleviate feed difficulties and hence processing inefficiencies on the production extruder.

Feeding melt to an extruder introduces the difficulty of obtaining a free-flowing situation through the feed throat area and may require a pressure-building source to push the material into the feed flights. Some processes drop a melted ribbon of material into the extruder's feed section, which makes a filled feed flight difficult to ensure. The screw feed flight design can help the feeding efficiency, but extrusion stability is not usually optimum.

Feed throat opening designs can vary, depending on the manufacturer and the process being performed. Today's typical, efficient throat design is a large rectangular opening directly above the screw. Through the years, feed openings have evolved from round shapes to oval to "obround" (lengthened oval-shaped) to rectangular. Today's rectangular throat design has an opening length of 1.5 to 2.5 times the barrel inner diameter dimension. The larger feed openings allow a free flow of material even with moderately high regrind percentages to ensure properly filled screw feed flights. The only uses of small feed openings in this era involve hoppers with force feeding screws (compactors) or force-fed melt conveying extruders.

Tangential feed throats enter the screw area from one side and have added clearance around part of the screw's diameter. They are used for feeding rubber strips to allow partial wrapping around the screw.

Most extrusion processes perform with best product uniformity when the screw is operated with full feed flights. Sometimes a metered feeder is used to run the process with starved feed flights for some processing reason; the extruder's stability must be acceptable or added processing devices must be used, such as melt pumps (see discussion of melt pumping later in this section). Twin screw extruders appear generally less sensitive than single screw machines to the starve feeding mode as far as output stability is concerned; but as the starving level is increased, even their output stability deteriorates.

Material Lubrication Effects. Some plastics formulations call for additives that create feeding and/or melting problems. The easiest place on the extruder to introduce additives is in the feed throat where the material is at atmospheric pressure. Should the material still feed and melt acceptably, the application of additives in the feed area is the most economical approach. When additives create feeding or melting difficulties, the possibility of injecting the additives somewhere along the barrel length is considered. Introducing liquid additives away from the feed area will help avoid solids conveying deterioration and, if far enough down the barrel, will avoid disrupting the melting perfor-