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Technical Note

Improving the pellet quality with the optimization of process parameters in Xplore Pro-Pelletizer

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A pelletizer is a well-known type of rotating cutting device that is widely used in the plastic industry. In plastics processing, the polymer compound is melt-mixed in an extruder, and the extrudate is then chopped using a pelletizer to obtain pellets. These pellets are then processed in downstream processing operations such as injection molding, profile extrusion, film blowing, compounding, recycling, etc. The common goal of the pelletizing operation is to obtain dry, uniform (both in shape and size) pellets, which enable easy handling during transportation.

Several types of pelletizers are available in the market, which are specialized based on the particular process needs, material type, and quality requirements. Two outstanding pelletizer types are 1- Die-face cutter, which encompasses both underwater and water ring designs, and 2- Strand pelletizer.

The oldest and most straightforward method is conventional strand pelletizing, which can be used for various polymers, ranging from unfilled polyolefins to engineering plastics with up to 80% filler. The yield is uniform, and the pellets are cylindrical.

In this system, the strand exiting the extruder die is soaked into a water bath to cool below the polymer's melting point. Then, it passes through an air knife to remove water droplets before being introduced into the pelletizer. In this step, the strand is chopped into the desired required pellet size and then collected.

Some common defects encountered in pelletizing process can be listed as tail (depicted in Fig. 1), fine, twin, triplet, chain, dust formation, and poor strand control, which leads to jack straws, also known as angle cuts.

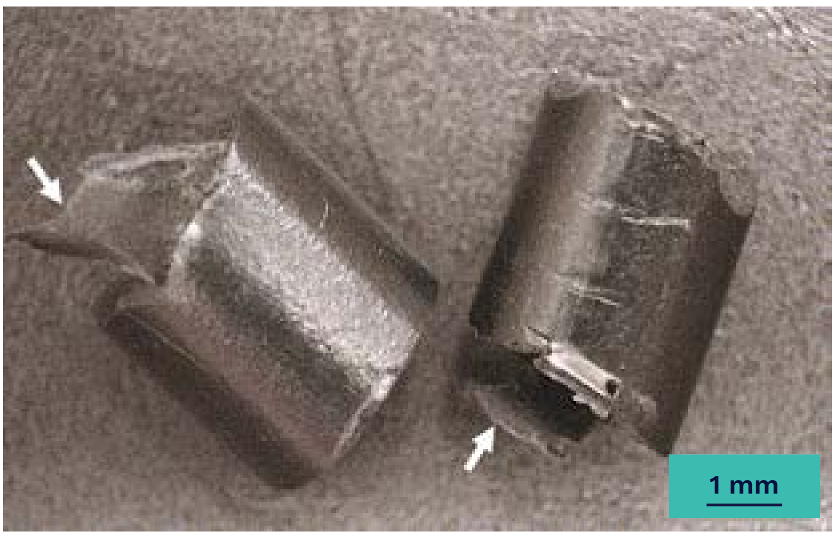


Figure 1. Tail on the pellets (designated with white arrows)

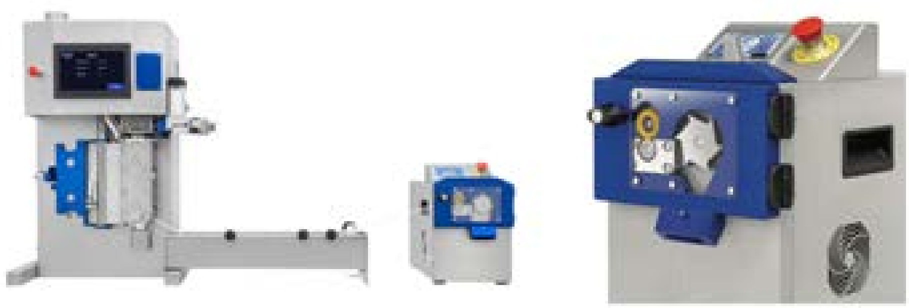
Xplore Instruments has developed Pro-Pelletizer (Fig. 2) to overcome the challenges of pelletizing with simple, adjustable parameters. The Xplore Pro-Pelletizer is intended to chop the solid polymer extrudate of Xplore MC15HT, MC5 and MC40 for small batches or to perform a micro-scale continuous production. In addition, pre-made strands using another type of processing equipment can also be pelletized using Pro-Pelletizer.

There are several troubleshooting techniques to yield more uniform pellets in size, shape, weight, and other desired characteristics for subsequent processing or aesthetics.

This study aims to demonstrate the performance of the Pro Pelletizer using various polymers and how to fine-tune the basic pelletizing parameters to obtain high-quality pellets. For this purpose, the polymers listed in Table 1 were pelletized under the following conditions:

- Pellet size: 0.1, 1.0, 3.0 and 8.0 mm
- Blade speed: 100 and 1000 rpm

The shape, size, and quality of the produced pellets were inspected visually, and pellet length was measured with a digital light microscope (LM, Bresser DST-1028).



(a) (b)

Figure 2. Xplore Pro-Pelletizer (a) demonstrated in combination with the micro-compounder and the water bath, (b) Closer view of the pelletizing chamber

Table 1: Polymers and their properties investigated in this study

Polymer Code	Polymer Identification	Hardness	Average Strand Diameter (mm)
SEBS-12	Styrene-Ethylene-Butylene-Styrene TPE (SEBS)	12 ShA	2.96
SEBS-70	Styrene-Ethylene-Butylene-Styrene TPE (SEBS)	70 ShA	3.54
TCP	Thermoplastic Co-polyester	45 ShD	2.86
PP-H	Talc filled (20%) PP homopolymer	60 ShD	2.56
PC	Polycarbonate	80 ShD	2.52
PLA	Poly(lactic acid)	83 ShD	2.84

In Pro-Pelletizer, pellet length can be adjusted between 0.1 - 8.0 mm, and strands of 0.5 - 6.0 mm diameter can be chopped. The results showed that high-quality and consistent pellet sizes are achievable with Pro-Pelletizer.

It is seen in Figure 3 that PC pellets can be chopped at different pellet sizes ranging from 0.1 to 8.0 mm successfully. With the pellet size measurements (Fig. 3c), both the consistency in pellet size as ± 0.08 mm and the accuracy of 3.0 mm in chopping the set pellet size have been ensured. It is known that, in dry blends of different ingredients such as pellets and powder fillers, it is almost impossible to have a homogeneous mixture of feed in the hopper due to the segregation of different particle sizes (known as de-mixing). For this reason, using solids of similar particle sizes is desired. With Pro-Pelletizer, it is possible to produce very thin pellets to be used in dry blends together with powder materials. As demonstrated in Fig. 3a, 0.1 mm thin slices of pellet can even be obtained with this pelletizer.

Another advantage is that the feed rate (line speed) of pelletizing and pellet size can be easily adjusted on the touch screen control of the machine, fully independent of one another. Line speed adjustment can be achieved with the slide bar until the strand does not stretch or sag, and the feed rate will be automatically arranged by the feeding rollers while simultaneously adjusting the blade speed to maintain the set value of pellet size.

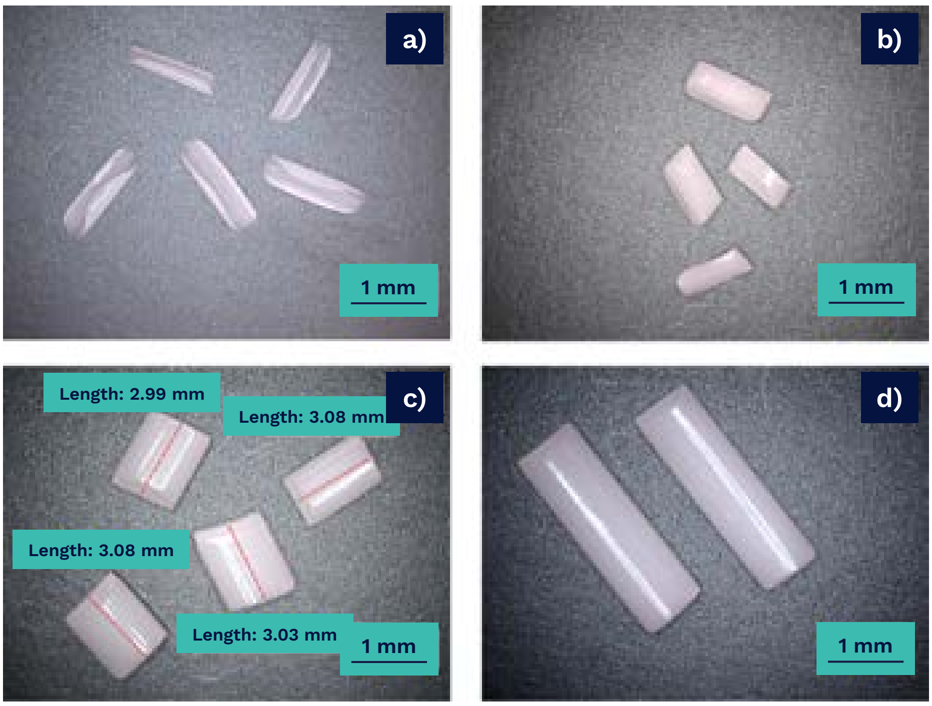


Figure 3. Pellets of PC with different pellet lengths a) 0.1 mm, b) 1 mm, c) 3 mm, d) 8 mm

Achieving smooth cutting surfaces is another critical parameter in pelletizing. Suppose the blade clearance (BC: distance between the stator and rotator knives) is not adjusted appropriately according to the polymer characteristics. In that case, this may lead to rough/rippled cross-sections and even tail formation. In Pro-Pelletizer, BC can be arranged at the lowest as 0.03 mm.

In this study, two polymer strands were chopped with BC of 0.1 mm: PLA, a brittle polymer, and TCP, a relatively ductile polymer. Eventually, with both polymers, smooth and flat surfaces could be obtained successfully without tail formation, as clearly seen in Figure 4 (PLA and TCP pellets at 1 mm pellet length).

Various polymer samples having different hardness or strand diameters can be chopped with Pro-Pelletizer at high accuracy, as shown in LM images of the pellets (Fig. 5). For polymer processors, the dust-free pellets ensure superb conveyance and high bulk density during storage as well as precise dosing during subsequent processing. In Fig 5, it is noteworthy that no dust, fine, or chains are observed. It is also apparent that various polymers can be chopped with a considerable consistency at 3.0 mm pellet length.

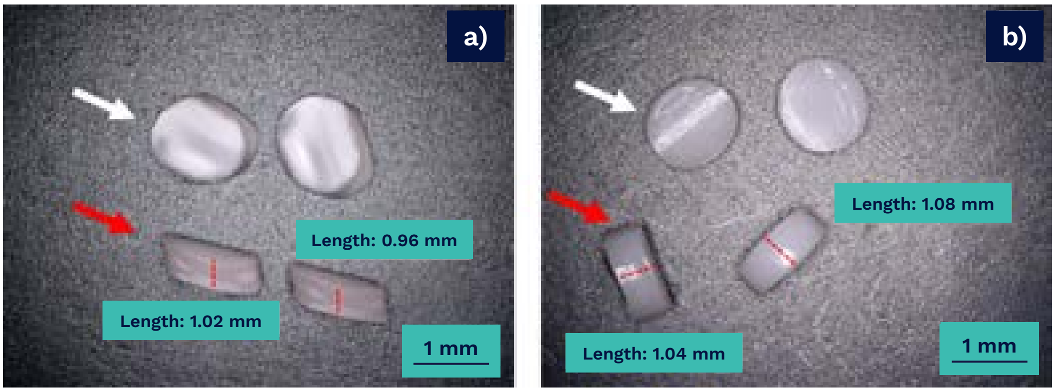


Figure 4. Cross section (designated with white arrow) and side view (designated with red arrow) images for pellet size of 1 mm a) PLA b) TCP

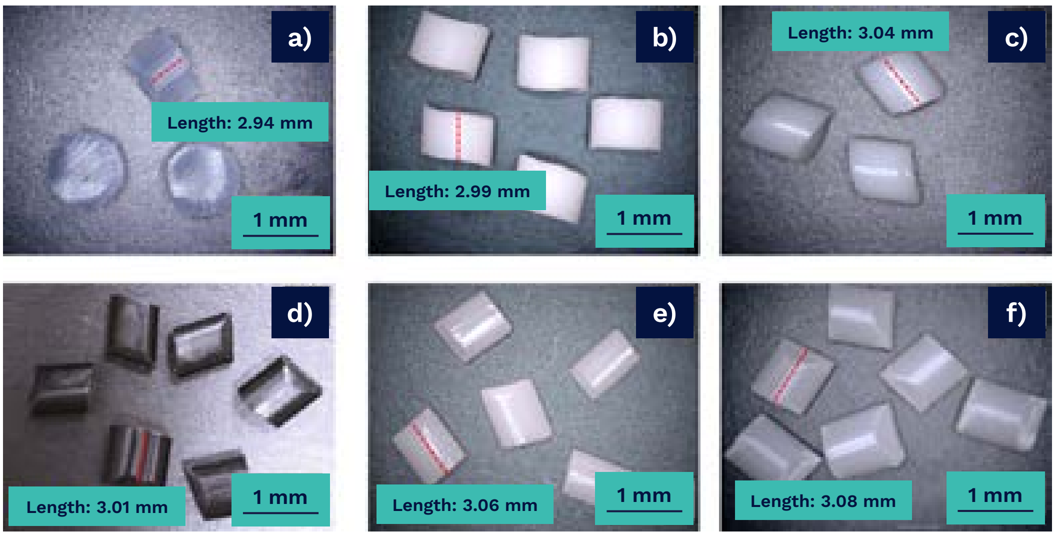


Figure 5. Pellets of 3 mm length with different materials a) SEBS-12 b) SEBS-70 c) TCP d) PP-H e) PC f) PLA (consistency in pellet size of ± 0.08 mm)

The blade speed is another crucial parameter that needs to be optimized during pelletizing. It is important to note that the intrinsic properties of the polymer and the blade speed should match each other to achieve optimum process conditions. For this reason, two polymers, SEBS-70 and PP-H were chopped at 100 and 1000 rpm blade speeds and were observed under the digital light microscope. The images in Figure 6 show that, while pelletizing SEBS-70, which is soft at room temperature and has high G" (shear loss modulus), smearing occurred at slow blade speed (100 rpm), whereas the problem was resolved at higher speed (1000 rpm). On the contrary, in the case of PP-H, which is hard at room temperature and has low G", high blade speed leads to dust formation, and lower speed yielded better quality pellets. This shows us that, by adjusting the blade speed according to the intrinsic properties of the polymer, it is straightforward to produce high-quality pellets.

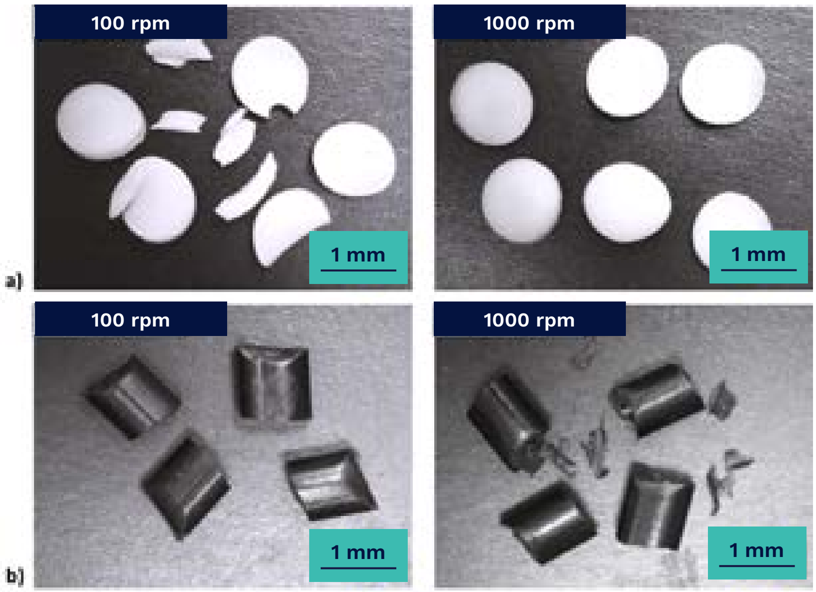


Figure 6. Pellets a) SEBS-70 at 1 mm pellet length b) PP-H at 3 mm pellet length

In summary, we demonstrated that Pro Pelletizer can be used to chop various polymers at different pellet sizes and blade speeds. The most important conclusion of this study is that the material properties and the pelletizing process parameters should correlate well. We also showed that pelletizing parameters could easily be adjusted to yield optimum pellet quality in Pro Pelletizer.
Although they are not investigated in this work, it is worth to mention that the Pro pelletizer is equipped with an air supply line to chop highly static polymers without any bridging and accumulation inside the chamber. Other advantages of the Pro Pelletizer can be listed as its long service life, specifically hardened sharp multi-tooth rotating blade, and a 'safety system' which protects the user from any hazard by rotating parts.

Pro Pelletizer is a system that easily fits a compounding system and makes the researcher's life easier since its parameters can easily be adjusted.

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