Extrusion Foaming

Using Teledyne ISCO Syringe Pumps

TELEDYNE ISCO Everywhereyoulook™

Syringe Pump Application Note AN21

Overview

Extrusion foaming for the production of medium- and low-density thermoplastic foams has been carried out successfully for some time with physical blowing agents (PBAs). PBAs are inert gases, volatile hydrocarbons, or hydrofluorocarbons (HFCs) that are metered and dissolved in the polymer melt during processing. The extrusion foaming process can use a single extruder or two extruders operating in tandem. The tandem system can also use a twin extruder as the primary extruder.

The basic steps in the process involve:

- melting of the solid polymer
- injection and dissolution of the blowing agent into the polymer melt
- cooling of the blowing agent laden melt
- foaming through nucleation bubbling
- stabilization of the resultant cell structure[1]

The effectiveness of Teledyne ISCO Syringe Pumps for accurate and consistent control of the blowing agent content was demonstrated in the following experimental systems.

Experimental Setup

Figure 1 shows a schematic of a system for producing foamed sheets using an annular die and single screw.[2]

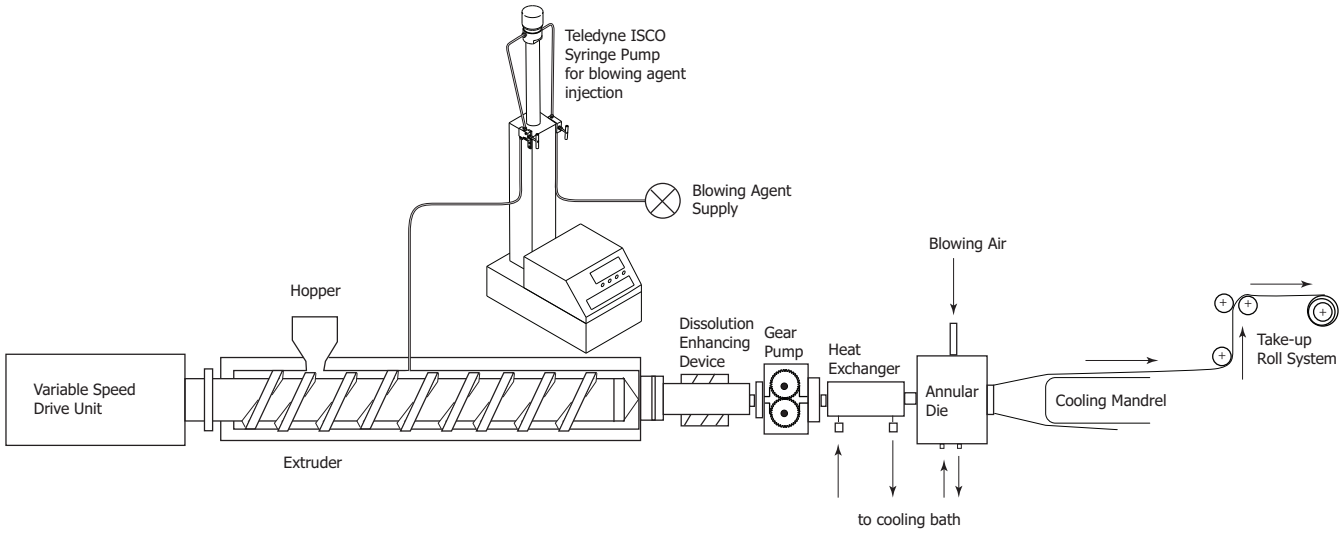

Figure 1: Single extrusion system With annular die[2]

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Figure 2 shows a tandem system for producing foamed filaments using a capillary die.[3, 4] The first extruder melts the plastic pellets and then mixes this melt with injected blowing agent (BA) supplied by an ISCO syringe pump. A mixing section at the end of the first extruder helps to quickly disperse the BA so that it forms a one-phase solution with the polymer melt. The second extruder helps homogenize the temperature and BA concentration.

A gear pump can be used to accurately control the mass flow rate. Downstream setups vary based on needs.

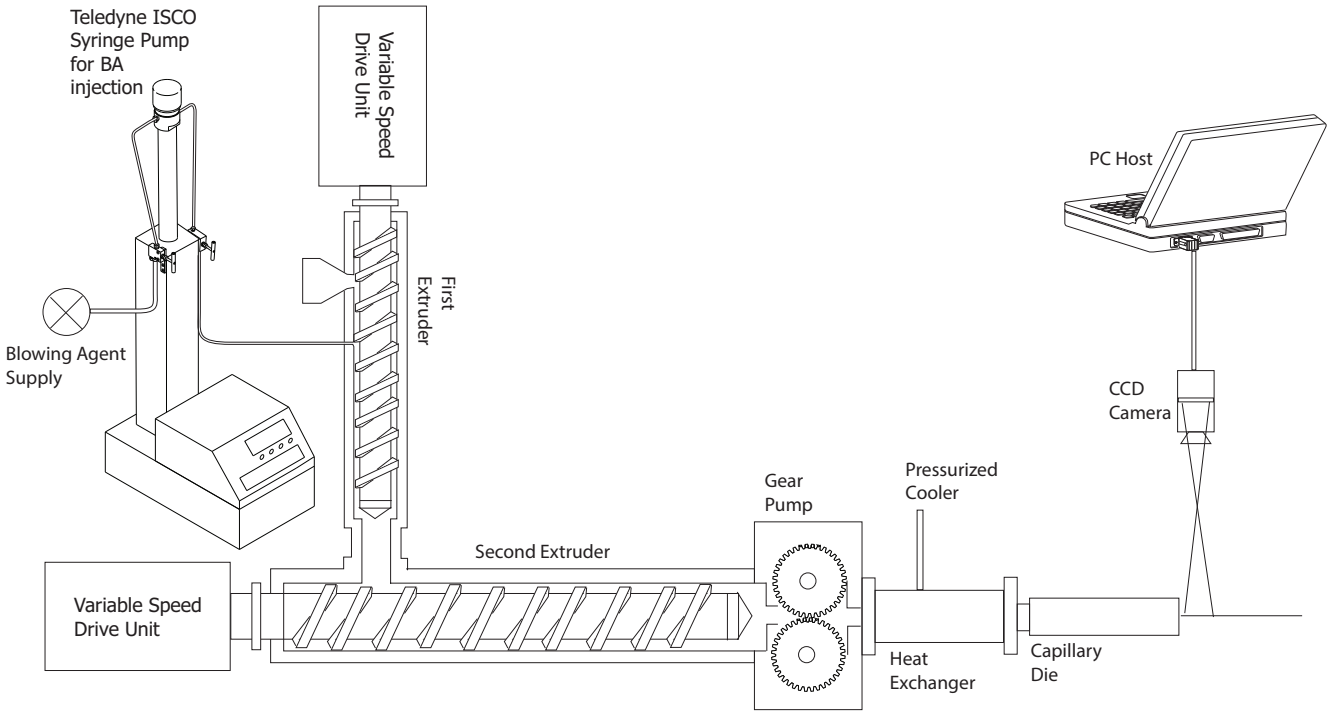

Figure 2: Tandem extrusion system With capillary die[4]

Results and Implications

In a typical experiment, gas injection begins with the syringe pump operating in “constant pressure” mode. As the polymers are melted and pumped forward by the extruder, the syringe pump is changed to “constant flow” mode, maintaining an accurate and consistent injection.

The amount of blowing agent can be varied by controlling the Teledyne ISCO pump flow rate, and the effect of gas content on cell morphology is investigated.

Figure 3 shows the cell density and expansion ratio of extruded low-density polystyrene (PS) blown with supercritical CO_2 ($scCO_2$) while varying the die geometry (e.g. diameter and length of a filament die) and temperature.

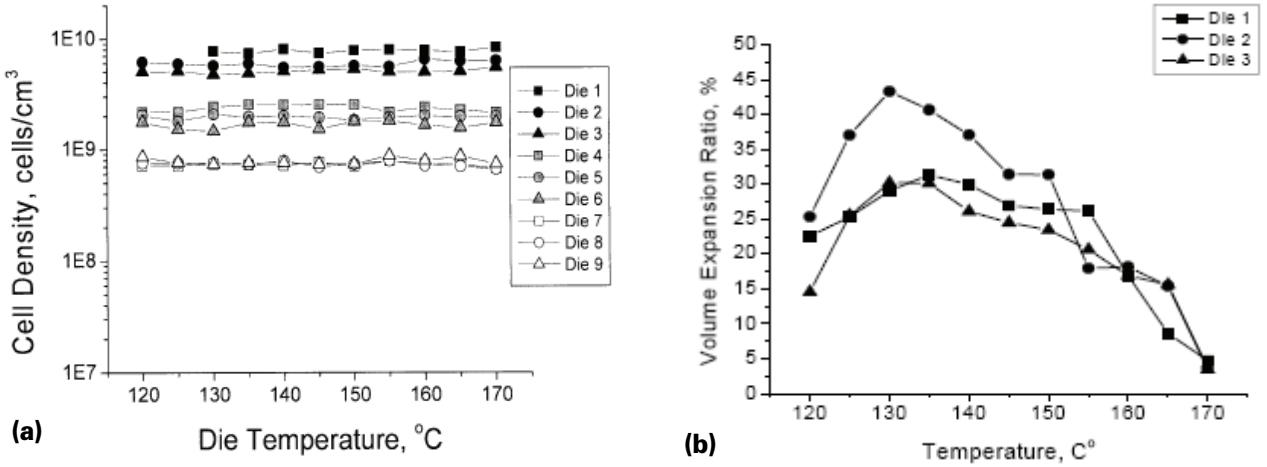

Figure 3: (a) Cell density and (b) expansion ratio of extruded low-density PS foams[3]

Figure 4 shows the cell density and expansion ratio of extruded low-density polypropylene (PP) blown with 5% $scCO_2$ by weight while varying the die geometry and temperature.

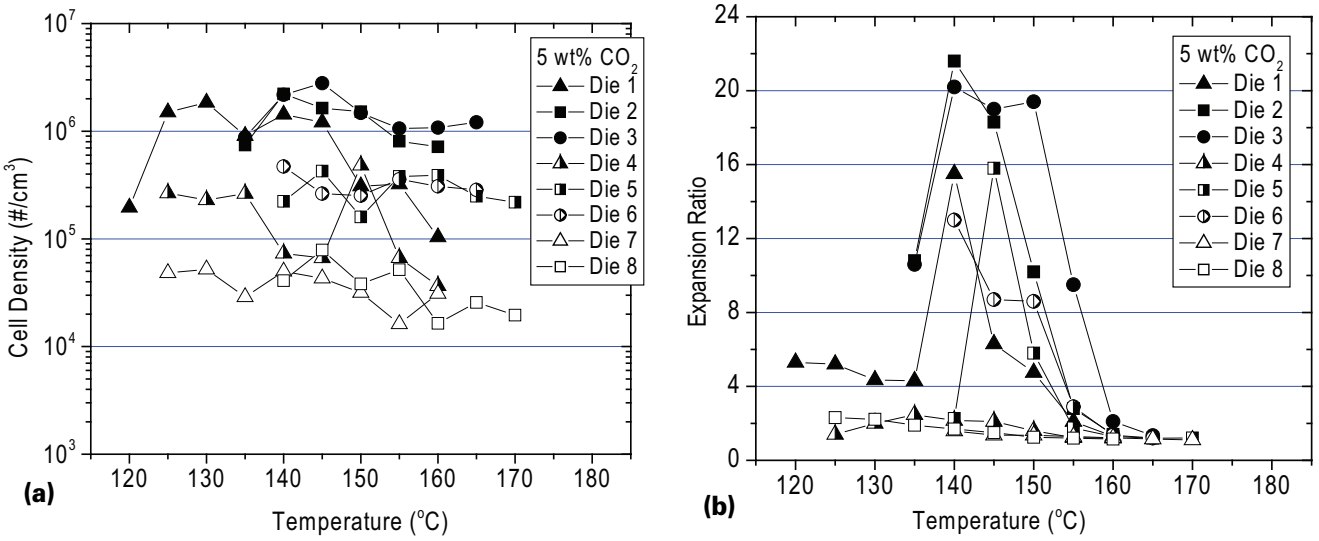

Figure 4: (a) Cell density and (b) expansion ratio of extruded low-density PP foams blown with CO_2[4]

Figure 5 shows the cell density and expansion ratio of extruded high-density PP blown with N_2 while varying the talc (nucleating agent) content and temperature.

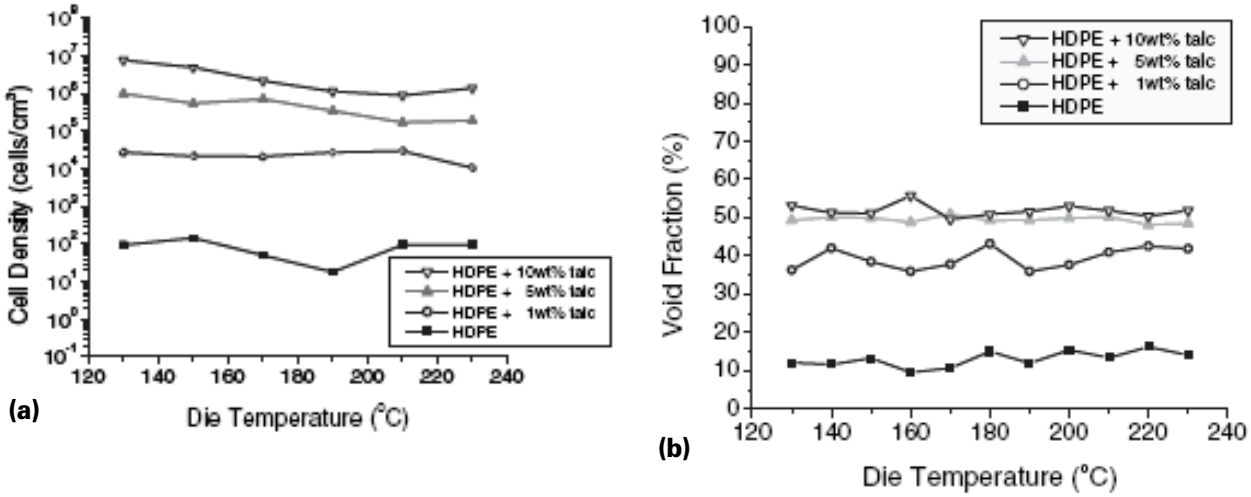

Figure 5: (a) Cell density and (b) expansion ratio of extruded high-density PP foams blown with N_2[5]

Figure 6 shows the cell morphology of extruded high-density PP blown with N_2 while varying the die pressure drop rate and the talc content. It is notable that temperature affects the expansion behavior of low-density foams significantly whereas the temperature does not affect the expansion behavior of the high-density foams. In both cases, gas content and die geometry affect the expansion behavior significantly, and the gas content affects the cell density.[2-5]

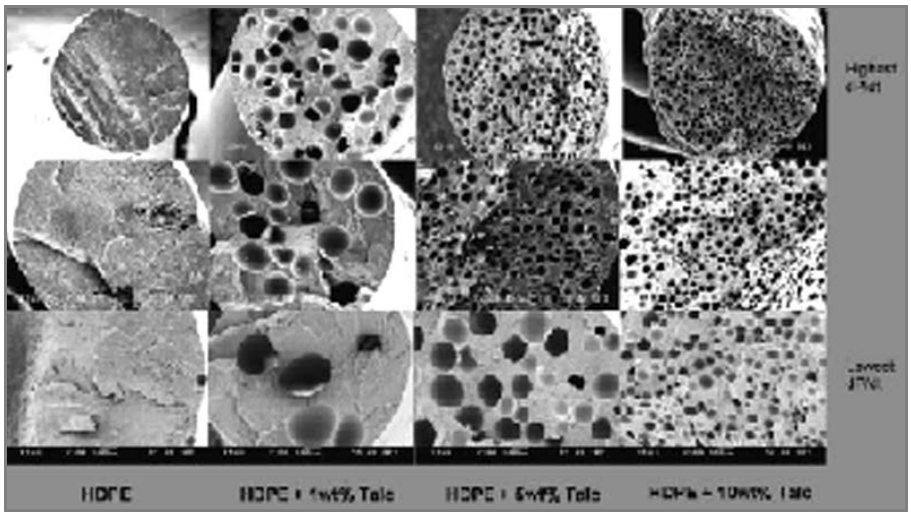

Figure 6: Cell morphology of extruded high-density PP foams blown with N_2[5]

Table 1: Commonly Recommended Pumps

	500x	260x
Flow Range (mL/min)	0.001 - 204	0.001 - 107
Pressure Range (psi)	0 - 5,000	0 - 9,500

REFERENCES

1) Lee, S.T.; Park,C.B.; Ramesh, N.S. "Polymeric Foams: Science and Technology." CRC. 2006.
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3. Xu, X.; Park, C.B.; Xu, D.; Pop-Iliev, R. Polym. Eng. Sci, 43: p. 1378, 2003.
4. Lee, P.C.; Kaewmesri, W.; Wang, J.; Park, C.B.; Pumchusak, J.; Foland, R.; Praller, A. SPE ANTEC Tech. Paper, 2115 (2007).
5. Lee, J.W.S.; Park, C.B. Macromolecular Materials & Engineering 291: p 1233, 2006.

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Product model names have been updated in this document to reflect current pump offerings.

Teledyne ISCO
P.O. Box 82531, Lincoln, Nebraska, 68501 USA
Toll-free: (800) 228-4373 • Phone: (402) 464-0231 • Fax: (402) 465-3091
www.teledyneisco.com

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