Experiments and Flow Analysis of a Micropelletizing Die

M. R. THOMPSON[1]*, C. XI[1], E. TAKACS[1], M. TATE[2],
and J. VLACHOPOULOS[1]

[1]*Department of Chemical Engineering, McMaster University
Hamilton, Ontario L8S 4L7, Canada*

[2]*Gala Industries, Inc.
Eagle Rock, VA 24085*

A study has been performed to examine the process of micropelletization on four different polyethylenes with melt index values between 1 and 5 g/10 min. The experiments were done on a 50-mm 30:1 L/D extruder with an underwater micropelletizer attached. The average micropellet size that was produced ranged from 0.4 to 0.5 mm in diameter depending on whether a plastomer or high-density grade was selected. The dimensions of the pellets were influenced strongly by the occurrence of die-hole freeze-off. Minor sharkskin was observed on the surface of the micropellets, a result of the high stresses experienced in the pelletizer die. A non-isothermal, axisymmetric flow model was used to assist in the analysis by comparing the observed results to the predicted shear stresses in the die. The calculations revealed that extremely high shear rates were present in the die holes, resulting in a significant degree of wall slip. The measured rheological properties of the micropellets did not show any change in comparison to their virgin resins, likely because of the presence of wall slippage and the short residence time of the polymer in the die holes. Polym. Eng. Sci. 44:1391–1402, 2004. © 2004 Society of Plastics Engineers.

INTRODUCTION

Micropelletization is a relatively new technology for producing resin particulate that exhibits many of the advantages of a pellet yet possesses a size closer to that of a powder. The reason for manufacturing these "micropellets" is that they may better compete with powders in processes where the size of the solid is important. The advantages of conventional pellets (and micropellets) over powders include higher bulk density, the inclusion of additives for subsequent processing, and the consistency of shape throughout a feedstock batch and between batches. Consistency of feedstock shape ensures good dry flow properties within solids-handling equipment and into processing equipment like extruders and injection molding machines. Yet with the size of the micropellet (400−700 μm) being closer to that of a powder (75−500 μm) than a conventional pellet (~3 mm), it shows improved dispersion within a matrix of solids and offers a larger surface area-to-volume ratio over conventional pellets, which may translate to higher melting rates.

The combined advantages of powders and pellets exhibited by micropellets explain the interest of rotational molders, masterbatch compounders, and injection molding processors in the technology (1). While compounders and molders have contributed to the market growth of micropellets, it is in rotational molding that an explosion of use is anticipated. Rotational molding requires small-sized particulate for its feed material to ensure that the product is formed without entrapped bubbles and exhibits minimal variation in wall thickness (2). Till now, rotomolders have paid a premium for having conventional pellets ground (sometimes cryogenically) to obtain the proper particle size and still ensure adequate dispersion of stabilizers within their materials. With new evidence that micropellets may be used as a suitable alternative for ground powder in the production of quality plastic parts by rotational molding (2, 3), the economic attractiveness of micropelletization is anticipated to drive a more rapid adoption of this technology. For this to occur, more research on micropelletization is required to understand the impact of the process on the extruded resin, and to identify exactly which applications within rotational molding, injection molding, and extrusion are best suited for micropellets over powders or conventional pellets.

The manufacture of micropellets can be achieved by any type of pelletizer, with minor changes made to the

*To whom correspondence should be addressed.

Published online in Wiley InterScience (www.interscience.wiley.com).
DOI: 10.1002/pen.20134