Volume Reduction

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With the increasing demands for more cost effective products, many companies are investigating the potential use of materials to reduce the volume of raw plastic used in their products. One of the current means is in the introduction of gas to replace plastic materials. One method is to mix into the polymer chemical blowing agents that generate the evolution of gas with in the process. The other method is by the direct injection of high pressure gas into the process.

Chemical Blowing Agents: There are two styles of chemical blowing agents. One is based upon the generation of nitrogen as the gas and the other is based upon the generation of carbon dioxide. With both materials the method is the same. The blowing agent, which can either be in powder form or in a pelletized carrier, is pre mixed and conveyed through the extrusion process. At the recommended melt temperature these blowing agents actually decompose and liberate gas as a byproduct. The gas will remain in the polymer solution as long as there is sufficient pressure to render it soluble. The actual expansion of the gas, therefore, is a result of a defined pressure drop in the system. Once the decomposition has taken place, it is this pressure drop that will cause the gas to form the bubbles in the polymer matrix and provide the volume reduction.

Chemical blowing agents can come in a variety of "decomposition" temperature ranges and are designed for specific polymers. Therefore, in setting up a system to produce gas or foamed materials, the choice of the correct grade of blowing agent is necessary to insure that the appropriate melt temperature can be reached to initiate the evolution of the gas, and equally as important, the extruder adaptors and dies must be carefully designed to produce the correct pressure drop. Ideally, one would want to have the foaming take place as the material exists the die. If the pressure drop is too low in the die, or the melt temperature is markedly exceeded in the extruder, premature foaming can take place in the extruder, producing an overblown structure which will evidence itself as large, random sized bubbles.

If the melt temperature is not achieved in the extruder, an under blowing effect can exist, producing few randomly scattered bubbles. Consequently, in designing a system for foamed extrusion, it is important to use the correct agent for the application and equally as important, a careful redesign of the dies need to be made to insure that the required pressure drop rate is achieved. In addition, the loading of the blowing agent is also important as this determines the extent of the foaming and affects the level of volume reduction once can achieve.

This pressure drop rate is most important, as it will control the size distribution and the number of bubbles formed. It should be kept in mind that as you replace plastic with gas bubbles, it is not uncommon to see a reduction in some of the physical properties. Burst, impacts, strength could be affected. Therefore the need to control the foaming, creating as small a bubble as possible and producing as uniform a bubble size distribution requires careful design criteria. One should be prepared for some development work as the currently used dies and other flow devices may not be useful to achieve a good uniform product.

In general the blowing agents based upon nitrogen are lower in cost but tend to produce larger, more random size bubbles. The blowing agents based on carbon dioxide are usually more expensive but tend to product smaller, more uniform size bubbles. Again, this generalization is merely that. Each system has to be evaluated on its own merits, but in starting a volume reduction program, one should evaluate the effectiveness of both types.

Gas Injection The other method is by the direct gas injection of high pressure nitrogen or carbon dioxide into the melt stream. This technique requires a substantial investment in equipment. The process for direct gas injection requires an injection section with the screw design established for high intensive mixing, sections designed for dispersive mix ing, and sections designed for the ade quate control of melt temperature to prevent premature foaming. In addi tion, a precise gas metering device is also needed to control the amount of gas per unit volume of plastic and needs to be slaved to the extrusion rate.

Consequently, the extruder L/D will need to be increased to accommodate these additional sections. One also needs to understand that the injection devices are open in the extruder and during the times when gas is not being introduced, such as startup and shut downs, material can be forced into the injectors. For most plastics that are not

thermally sensitive, the temperature of that section and the force of the gas pressure will generally help to purge the injectors of material. For thermally sensitive materials, the plastic could degrade and cause blockage of the gas injectors requiring frequent clean-outs.

Regardless of the path chosen, these factors are required:

- Understanding and adequate control of melt temperature
- Development of the correct amount of addition
- Proper design of the tooling to control the pressure drop rate
- Adequate dispersion of the agent used to create the foam
- Intensive testing of the finished part for physical property requirements

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See also:

- Effect of temperature
- Extrusion evaluation through pressure and melt temperature analysis
- Extrusion of thermoplastic foams

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