Blown Film - Cooling Air Parameters

The following question was asked by W. E. Segal of Exxon:

How do the variable of velocity, air volume, flow direction, and air temperature affect the quality and rate of blown film production?

This question is critical to the production of blown film. Cheng[1] in a paper on this subject at the 1978 ANTEC rightly stated in his introduction that "despite the recent advances in the science of polymer processing, our understanding of the extrusion of tubular blown film remains in the stage of art. The bottleneck in blown film extrusion lies in the cooling of the fast moving thin melt film."

It is important to understand that three elements of the blown film process are of first order importance to be able to produce near uniform gauge blown film. The extruder must produce a uniform temperature melt of polymer feeding to the die at a constant rate. The die must convert the melt to a uniform thickness tube at a constant melt temperature. Finally, the air ring must uniformly cool the cylindrical tube of melt which exits the die and is drawn down in gauge in both the machine and transverse direction.

If perfection were obtainable from both an extruder and die, adverse air ring performance caused by non uniform air velocity, direction or temperature would result in uneven melt cooling followed by uneven stretching of the plastic causing gauge variations in the film.

While the mathematics and physics of heat transfer in blown film are complicated, Cheng[1] and others have illustrated that the air velocity from an air ring may be the singular most important variable con trolling the time rate of cooling of the film. Flow instability placed on the air velocity by a high Reynolds number (i.e. turbulent flow) obviously caps the velocity usable from an air ring.

For uniform gauge control, the air temperature at the film surface, used to remove latent heat from the plastic, must be uniform. Can it be anything but uniform? The conversion of blower motor power to velocity energy with the resulting frictional heating of air molecules need not provide an absolute uniform temperature rise. It is not unusual to measure an average temperature rise of air through an air ring of 15 to 30 degrees F.

From personal experience, I have measured variations of air temperature circumferentially of 10 or more degrees F. Equally important, I have measured time dependent variations of air velocity of up to 15% caused in part by the blower design, system resonance, and inlet air parameter variations.

‘The direction of air flow from an air ring in respect to the bubble is too important a factor to ignore. A circumferential component to the air velocity exiting the air ring lips is usually bad. It may twist the bubble and produce an intolerable bubble instability at a rather low axial velocity.

An air velocity profile which exits the air ring with a component directed either towards or away from the bubble center line will alter the air pressure and velocity uniformity at the film surface. Is this good or bad? The answer seems to be, "it depends." While beyond the scope of this article to attempt to define the best direction of discharge for any blown film process, it may help to recognize the existence of this variable.

Mr. Segl asked about air volume related to air ring performance. The volume normally supplied related to the volume required to provide the required cooling are two different quantities. Remember, velocity, not volume, is the more important parameter affecting blown film cooling. Nevertheless, air flow rates of 50 to 150 CFM per inch of die diameter are not uncommon for an air ring. Keep in mind that a high volume may be required to reach the desired velocities used in current air rings. Velocities of 3000 to 8000 feet per minute are common. The air ring lip de sign will govern the volume velocity ratio.

Hopefully this non-technical article will serve as a catalyst to those interested in the blown film process to relate their experience, knowledge, or theory of air ring performance to the newsletter. The floor is open for your comments.

Bibliography:

1. Cheng, C. V.: "Studies on Blown Film Cooling," 36th Annual Technical Conference S.P.E., Volume XXIV, page 476 (1978).

- Robert B. Gregory

See also

- Blown film
- Blown film vs the cast film process
- Blown film air cooling
- Centrifugal fans
- Internal bubble cooling
- The effects of molecular structure, rheology, morphology and orientation on polyethylene blown film properties

Return to Consultants Corner