New Technology Spotlight…

Major Advance in Extrusion Die Temperature Control

The main purpose of a light metal extrusion container is to physically contain the taper-heated billet as the ram pushes it through the die. A second, and considerably more difficult task is to maintain a uniform temperature in the die throughout the extrusion stroke. This is done by correcting any changes in the temperature of the container liner whenever and wherever they occur. This is subsequently reflected in the temperature of the die. There are just now two principal methods of managing container temperature. They can be differentiated by the location of their heating units.

Container Housing Method: This method heats the container by placing heating elements outside the mantle, in the container housing. The container is surrounded by elements that have a sheath temperature of about 1,300-1,400°F, and controlled by thermocouples located near the liner. Liner temperature is usually controlled in two or more axial zones. With this type of blanket heater, since the sensors are some distance from the heat source, the response time is unavoidably slow. In addition, it is impossible to achieve fast and effective zone control to compensate for the variations in the rate of heat loss from different parts of the container.

Container Mantle Method: This method for heating containers positions the heat source inside the mantle itself, usually near its center of mass. It's an improvement over the housing method, and with a thermal control system that again monitors temperatures in two or more axial zones, the possibility of overheating the mantle is considerably reduced.

By strategically placing specially designed electrical resistance heating elements within the body of the container in only the areas where heat is needed, and with thermocouples on the liner, control over the changing temperatures during the extrusion process is much enhanced. Although this method is certainly an improvement on having the heat source outside the actual body of the container, heat is still being applied to the core of the mantle, with the controlling sensors on the liner. Depending on the location of the heating elements in the mantle, the time taken for the temperature of the mantle to react effectively to temperature changes in the liner can be far from immediate.

The objective of any container thermal control system is not to maintain a uniform temperature throughout the container, it is to maintain a uniform temperature at all points in the liner. The further the source of heat is from the liner, the more difficult this task becomes.

A conventional container usually becomes hotter at the top than the bottom. Heat lost from the bottom of the container rises inside the container housing, and increases the temperature at the top. The higher temperature at the top of the liner then reduces the viscosity of the alloy at that point, and it flows through the die slightly more rapidly at the top than at the bottom. In a large multi-hole die, the runout from the top holes will be longer than from the bottom. With a conventional container, the vertical temperature difference at the end of the liner is usually 150-200°F. Experience has shown that unless the die is corrected, for every 10°F variance, the difference in runout length will be about 1%. This will, of course, cause problems both with pullers and with cutting to length. This vertical difference in rate of flow also makes the production of absolutely round tubes extremely difficult.

Virtually all of the added value on which the extruder depends is generated at the moment the softened alloy passes through the die. The extrusion die designer must assume that the die will remain completely and uniformly at operating temperature at all times during extrusion. He also assumes that the rate of flow of alloy through all parts of the die will remain uniform. For this to happen, the temperature of the container liner must remain uniform, vertically as well as horizontally, during the extrusion process. The die may have been uniformly preheated, but the thermal mass of the container is much greater than that of the die stack. The die forms a tight seal with the face of the container, and therefore by conductivity thermal transfer begins between them the moment the die is installed. Measurements have shown that during extrusion, the die has about the same vertical temperature difference as the top and bottom of the exit of the liner.

Quick Response Container

CASTOOL in Ontario, Canada has finally successfully solved this difficult problem with its patent pending Quick Response (QR) Container which employs at least four temperature control zones, vertical as well as axial. Cartridge heaters with multiple zones are positioned close to the liner, rather than in the middle of the container mass. Their purpose is to heat the liner, not the mantle. Specially designed double thermocouples are used which monitor temperatures of both liner and heaters simultaneously. The time taken to respond to a demand for heat is in direct proportion to the distance between the temperature sensor and the heat source. The heating elements are therefore positioned close to the thermocouples. The quick response that results ensures that the liner temperature will remain fairly constant from the beginning to the end of the push.

The QR Container has now been in the field for more than a year, and the results have exceeded expectations. In a recent carefully monitored study conducted at a plant of a major multi-national extruder, the following results were recorded: Before vertical temperature control, the temperature difference between the top and bottom of the liner at the die end was 150-230°F. With top and bottom zone control, as well as axial, the vertical temperature variance in the liner was completely eliminated. This was achieved by only replacing the heat lost at the bottom of the liner near the exit. A vertical temperature difference of about 20-50°F still remained in the die. This was then corrected by increasing the temperature at the bottom of the liner exit to 30°F more than the top. The vertical difference in die temperature was then reduced to zero. Dies that had to previously be shimmed off-center in order to make them run properly no longer needed this adjustment. Large multi-hole dies that previously would have had the upper holes choked no longer needed any correction. Bars that previously ran convex now run flat.

Justification

For any extruder, reducing the cost of energy consumed by the container is a major priority. Actual results prove that a container designed to primarily control the temperature of the liner rather than the mantle often shows a 75% reduction in the amount energy used and sometimes more.

Additionaly, long-term savings come from extended mantle life. By eliminating the possibility of overheating, mantles retain their hardness. Extreme internal thermal stresses that can result in cracking no longer occur. By vertical temperature control as well as axial, the scrap caused by the vertical temperature variance in large dies is eliminated, and large extrusions can now be produced to tolerances that were never before possible.

Conclusion

The QR Container represents a major step forward in the technology of extrusion die temperature control. By positioning the heating elements close to both the liner and the thermocouples that control them, and using at least four temperature control zones, vertical as well as axial, the QR Container ensures that during extrusion the die temperature will remain more consistently uniform than ever before.