

Optimize Cycle Time and Quality with Turbulent Flow

By Tim Miller, Heat Transfer Product Manager

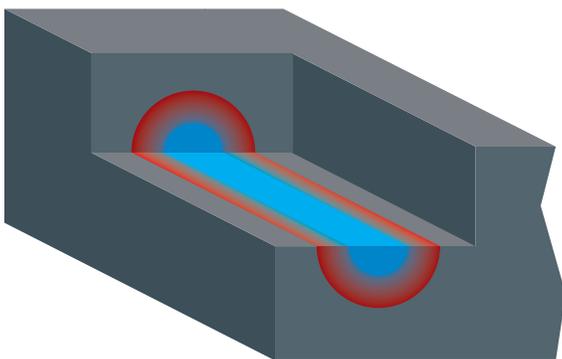
If you are like most processors, you search for anything you can do to reduce cycle time and increase productivity. One simple solution is to shorten the cooling portion of the injection molding cycle. Mold cooling can account for as much as 75% or 80% of the total cycle time. It just makes sense that anything you do to cut cooling time will have a huge impact on cycle time and increase productivity dramatically. As an added benefit, enhanced cooling may also reduce warping and shrinkage of molded parts.

As an example, take a hypothetical molding machine running on a 16 second cycle. If 75% of the cycle time is for cooling, that would account for 12 seconds. If you can reduce the cooling portion of the cycle by just 2 seconds, you will increase your productivity from 225 cycles per hour to 257 cycles per hour – an increase in productivity of almost 15%. Reduce cooling time by 4 seconds and you would run 300 cycles per hour and increase output by 33%.

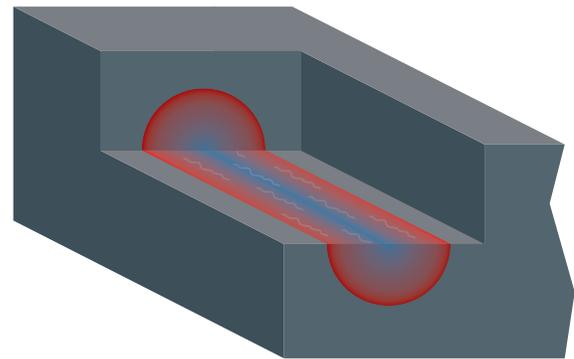
Obviously the payoff potential is significant, but what's the secret? As you probably already know, simply cranking down

the temperature or increasing chiller size does not necessarily increase productivity or decrease cycle time. The key is not increased cooling capacity but rather more effective removal of heat; and the key to efficient heat removal is turbulent flow.

Reynolds numbers can be helpful to help determine requirements for turbulent flow. The Reynolds number is a dimensionless number used to characterize different types of flow, such as laminar, turbulent, or transitional (between laminar and turbulent) flows. Laminar flow occurs at low Reynolds numbers, where the fluid flows in mostly neat straight paths (think of layers of laminate flooring), and is characterized by smooth, constant fluid motion. Turbulent flow occurs at high Reynolds numbers and tends to produce random eddies, vortices and other flow instabilities. Laminar flow is desirable in piping to and from the chiller and mold, but inside the chiller heat exchangers and mold passages, turbulent flow is desirable because it enhances the heat exchange between the fluid and the surfaces. Reynolds numbers can vary greatly depending on the cooling fluid characteristics including density, viscosity, velocity, passage size, and also the



Laminar Flow



Turbulent Flow

elevation at which the process takes place. There are a few online calculators available to calculate the Reynolds number of a particular process or mold.

As cooling fluid (usually water) flows through the passages of a mold, only the fluid in contact with the mold will readily absorb heat. If the fluid heated on the perimeter of the passage is flowing too slowly (laminar flow), it can insulate the cooler fluid at the center of the flow and prevent it from absorbing more heat. In other words, you are not using the total heat absorption capacity of the cooling fluid. The best way increase cooling efficiency is to increase turbulence in the cooling passages and prevent laminar flow. Turbulent flow ensures that the maximum amount of fluid comes in contact with the walls of the cooling passages and helps to provide more even temperatures throughout the mold.

As an example, a 20 ton chiller would have about 48 gpm (182 L/min) of flow available under nominal operating conditions. Turbulent flow is best achieved through a typical mold by providing flow rates of nearly double that amount. However, a chiller's effectiveness is compromised at that doubled flow rate. For this reason, in process applications when only a portable chiller is required, Conair recommends using a chiller with dual pumps to ensure consistently higher flow to the mold. One pump is dedicated to recirculating fluid through

the chiller evaporator, while the other provides the increased process flow to the mold. This configuration can deliver enough fluid to achieve turbulent flow in the mold and increase heat transfer efficiency. Dual pumps are also recommended in applications where process flow requirements can fluctuate. The additional pumping capability, along with separation of process and recirculation functions, ensures optimum chiller performance even as process cooling demands change.

For plants that have central cooling systems, Thermolator® mold-temperature control units can provide important advantages. First, they allow processors to fine-tune the temperature of the cooling fluid to the individual process allowing them to optimize cooling for different materials. A second important function is that the mold-temperature controls units also act as booster pumps, ensuring adequate pressure and water volume to create turbulent flow through the mold regardless of the load on the overall central chilling system.

A system of properly configured chillers and mold-temperature control units can help processors achieve turbulent flow and increase process efficiency and productivity. For assistance in specifying and sizing the most efficient cooling system for your plant – or for ways to get more cooling out of your existing equipment – contact the heat-transfer experts at Conair.

