A UL Thermoplastics Testing Center White Paper

"COMPETITIVE ADVANTAGES & COST SAVINGS BY CONDUCTING A MORE THOROUGH ANALYSIS OF DEMOLDING PROPERTIES"

Measuring Friction Coefficient versus Sleeve Mold Release Force in Assessing Demolding Performance

On first examination, injection molding of thermoplastics seems straightforward enough. Materials are fed into the heated barrel of an injection molding machine, melted, and then injected under high pressure into a mold cavity. After this melt cools, a plastic component is realized: CDs, DVDs, or housings for computers or flat screen televisions, for example. The process of cooling shrinks the melt on the mold core, necessitating an ejection force to demold the component from the mold of the machine.

This force is critical: if it is too high, because of the strength with which the plastic sticks to the mold core, the machine's ejector pins may punch through and damage the plastic component. Ideally, the molded part should slip down easily from the mold core. The friction coefficient refers to the sticking or adhesive force that exists between the plastic part and the metal surface of the mold. Reduce this force, and demolding will be more efficient.

The Importance of Demolding

Demolding is key because of its impact on cycle time. Consider, for example, the above examples of CDs and DVDs. In a typical high-production setting, these discs have a cycle time of, say, 1.3 seconds; every 1.3 seconds, one has to demold a new CD or DVD. If the component can be removed from the mold with a lower ejection force, then the cooling time of the injection molding cycle can be reduced, allowing the cycle time to be cut to, say, 1.2 seconds.

This tenth of a second can save the injection molder a great deal of money by improving throughput and perhaps reducing capital needs to meet production capacity. If a facility can operate with nine injection molding machines instead of 10, significant savings are realized through lower equipment costs, energy usage, labor, and so on. A good demolding process accrues to the bottom line.

One of the means manufacturers and materials providers use to facilitate efficient demolding is the use of a release agent, typically a wax that is added to the thermoplastic resin before the melt. The type and cost of such agents is critical.

For example, with CDs and DVDs, the cooling process results in a very fine structure (i.e., the bit structure of the surface) that precludes the use of many common release agents, because after demolding, the components have to have their surfaces coated to resist scratching. Therefore, a release agent is needed that not only allows the component to slip from the mold easily, but also allows the post mold coating to fix on the surface of the plastic.

Three principal areas impact demolding:

1) Raw materials
   - Component recipes
   - Crystallization and strength
   - Release agents

2) Mold design
   - Mold coatings
   - Surface structure
   - Metal grade

3) Injection molding process
   - Mold temperature
   - Melt temperature
   - Holding pressure

These areas can align with three functional areas within an organization: Research & Development for raw materials, Design Engineering for mold design, and Process Engineering for the injection mold process. Testing of the demolding process supports the efforts of these groups in making improvements in their respective areas of responsibility.

Expanding the Focus of Testing

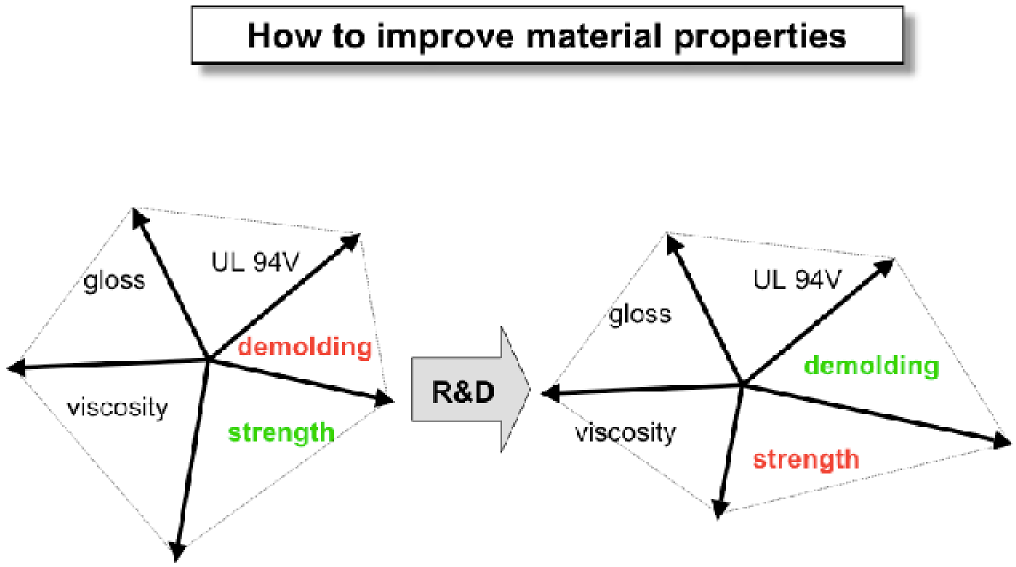
The testing of demolding, particularly for those developing raw materials, has focused on speeding up cycle times and reducing the amount of release agents used in the thermoplastic. The typical percentage of a release agent in the melt is 0.5 percent. If this can be reduced to, say, 0.2 percent, dramatic cost savings will be realized as well as a reduction of problems observed in the molding process.

Having completed this detailed analysis of demolding properties with the UL-TTC, in 2009, a large materials manufacturer saved more than $14 million with an average of $14,000 per metric ton of material production.

Cost savings come principally through lower consumption of release agents, but also through more efficient, quicker operations enabled by that reduction. "If you have too much release agent in the melt, the agent comes out of the plastic and may create a mold deficit," says Klaus Salewski, head of processing at Underwriters Laboratories Thermoplastics Testing Center (UL-TTC). This happens when the release agent condenses on the polished surface of the mold, and it results in a very bad surface of the component part.

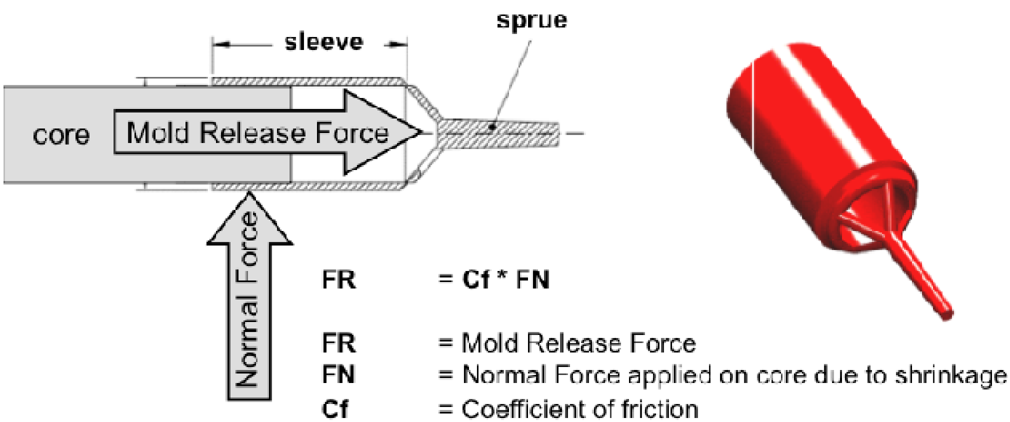
Release agent wax will improve the "flowability" of the melt. Viscosity will be reduced, but the solidification process will take longer. So not only do the demolding properties and friction coefficient need to be examined closely, but also the viscosity, as it will affect cycle time.

Release agents also affect other factors. For example, they are likely to decrease the flame retardant properties of the material. "A matrix of material properties are involved, not just demolding," says Salewski. "Sometimes you improve one property, but in doing so you may diminish another. You have to look at a host of properties, all together."



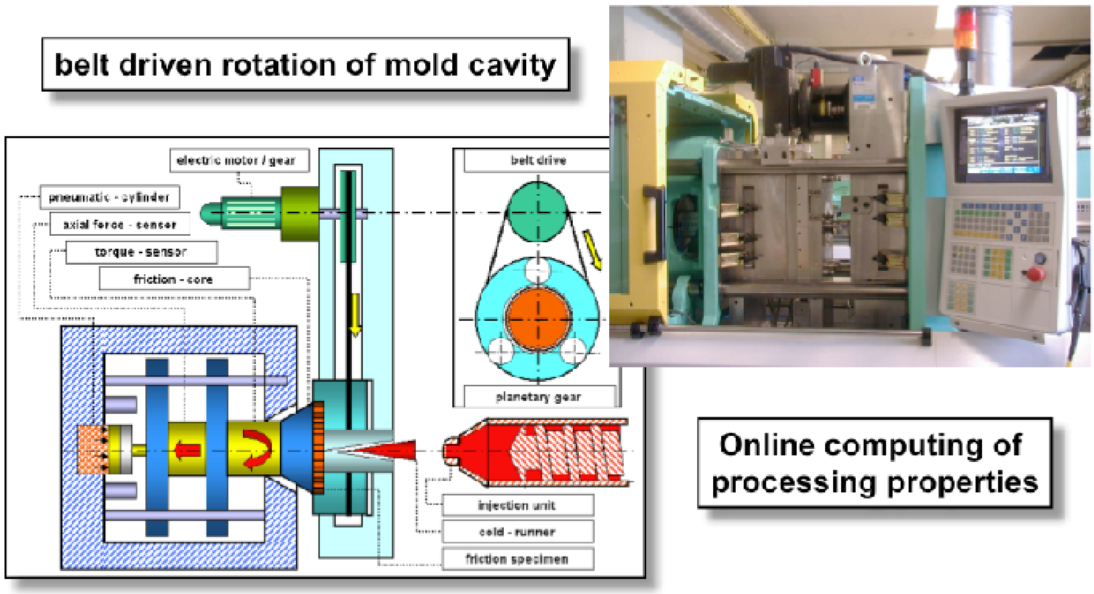
Friction Coefficient versus Sleeve Mold Release Force Testing

Most raw materials producers have test methods to characterize demolding properties. The most common one is to do injection molding of sleeves, then measure the ejection force necessary to remove the sleeve from the core. At the opening of the mold, the part remains on the core due to the material contraction. At the end of the opening stroke, the ejector pins detach the part from the core. The force applied to the part for demolding is called the Mold Release Force (FR).



There are advantages and serious disadvantages to this method. The advantages are its simplicity, convenience, low cost, and viability for virtually everyone. The disadvantages include its inability to control normal force. As such, results are impacted by shrinkage, Young's Modulus (the ratio between axial stress and strain, describing the elastic nature of a given substance), and the pressure of injection. The test can only yield a comparative performance rating. "The Sleeve Mold Release Force Test is not precise and sometimes gives wrong information," says Salewski. "That is not a good prescription for materials or process improvement, which is what demolding testing should support."

A newer, quicker, and more convenient method of testing patented by UL-TTC is measuring the friction coefficient through UL-TTC's patented online measuring method, which uses a belt-driven rotation of the mold cavity and online computer processing. This process measures complex variables, uses expensive tooling, and is protected by the UL-TTC patent.



There are compelling reasons to use the Friction Coefficient test. Unlike Sleeve Mold Release Force testing, it controls normal force, and has no impact from shrinkage, Young's Modulus, or injection pressure. This test yields clear demolding properties, an absolute performance rating, and can be used in conjunction with Computer Aided Engineering.

A more precise understanding of the demolding properties, and the ability to relate demolding to other properties that must be considered for a global understanding of injection molding of thermoplastics, is much more likely to realize the initial goals of testing: improved materials with lower concentrations of release agents, and faster cycle times for competitive advantage.

Materials Testing and the UL Thermoplastics Testing Center

The UL Thermoplastics Testing Center (TTC) carries out tests for all major plastics applications, ranging from polyethylene to high-performance thermoplastics. The TTC works with companies involved in compounding, extrusion, and injection molding, as well as raw materials producers and automotive manufacturers and their suppliers. The Center uses robots and state-of-the-art machinery to offer one-stop service for customers and can manage approximately 200 tests for thermoplastics, as well as the production of granules and test pieces. The production of test pieces is carried out using fully automated injection molding machines. The center uses approximately 100 different injection molds for use in tests under UL, ISO and CAMPUS standards and also has complete production lines that enable the compounding of ABS and its blends, polycarbonates and industrial thermoplastics, in quantities ranging from 1.3 to 100 kilograms.

For more information on the UL-TTC and a virtual tour of the Center, please go to: www.ul.com/global/eng/pages/offerings/industries/chemicals/plastics/ttc.

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