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Why (& How to) Do a Gate Seal Experiment?

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Part of optimizing any molding process is determining the 2nd stage or pack and hold parameters. Most processors deal with two: time and pressure. I would like to add a critical third: Should you "Hold" until the gate freezes or not? There are some more subtle issues as: Is there a difference between pack and hold for your machine? Is there a velocity associated with pack? However, for this article we are going to focus on figuring out the 2nd stage time. Following the strategy of Scientific Molding, we take the plastics point of view and we find or develop an experiment to figure out what is needed. No guessing or playing darts to figure out the number of seconds to set for 2nd stage time. Anybody want to guess what percentage of processes has any data to back up the current hold time setting selected. My guess would be less than 50% and it is a critical plastic variable.

A critical plastic variable? You betcha! My experience dates back a couple of decades when working at Dow Plastics, as Technical Representative solving customer problems. From automotive, to pipe fittings to electronics to medical issues would develop and the customer would sometimes blame the resin. Some parts were fine others failed prematurely. The process was claimed to be the same but there were good and bad parts produced by the same process. The salesperson would call in, a big name, large volume customer and the they needed answers fast. The answer, a good percentage of the time, had to do with how long it took the gate to seal. It took more years than I like to admit before I caught on to the importance of gate seal or unseal relative to part performance. Could be impact, elongation, dimensions, stress cracking, cold vs. warm properties, dimensions and the shocker to me was chemical resistance variations. Hard to believe that one section of a part has a different chemical resistance than another but it happens. Bottom line is that before anybody can determine 2nd stage time you must know which way the molecules in the part are happier, run with the gate frozen or unfrozen/unsealed. It can make a vast of difference in part performance. Before we discuss the experiment and testing, and because most of us were trained to run with gate seal, let us look at a case history.

A personal case history: The strategy is to take the plastics perspective. Ask the molecules which way are they happier. Sounds crazy but a lot of money is lost by not to doing the appropriate testing. Take for example a common leaf rake, $10 to $20 at your favorite hardware store or home center. Last year it was time for me to buy a new rake for the fall leaves. I mosey down to the home center and buy a rake that was warranteed for five years. I kept the receipt. OK, first time out no problem, warm day rake does its job. Next week a bit cooler, near freezing, I live in Michigan, and after five minutes of raking, my wife is laughing at her husband having a temper tantrum in the back yard. Look at the picture in Figure 1, find the gate.

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Figure 1：My broken Rake!

Guess where the crack started. You got it, at the gate! Why? Start with the plastics point of view. First, how much pressure does it take to fill the solid area? Not that much, it is polypropylene and the nominal wall is not thin wall. Next, how much pressure does it take to fill the tines? Different story here, a fair amount of pressure, the tines are harder fill, plus shorts at the end of the tines will not sell. So, 2nd stage pressure better make sure there are no shorts. Hold pressure might be relatively high to make sure there is enough pressure to fill the tines completely. Factor in the possibility that the processor wants to make sure there are no shorts and goes for a long 2nd stage hold time. Therefore, molecules near the gate are frozen close together, gate-sealed process. Pressure at the ends of tines is lower due to the pressure drop. At warmer temperatures, the molecules are not happy but they do their job, but lower the temperature and guess what; a bit of shrinkage occurs. Now you have crossed the line and the molecules are fighting one another, no place to go. Stress is higher in the gate area and when I add the stress of raking, they give up and crack. Note there is no stress whitening near the crack it is a brittle break, not the way polypropylene should fail. The part fails when the combination of the internal stress plus external stress exceeds the strength of the plastic. In this case, a lot internal stress and I added a little more and it broke. Moreover, I am having a fit that this is one more molder that did not do the testing. Yes, the cause could have been due to other factors like the wrong resin grade, too much regrind etc but my bet would be they ran with gate sealed and all of this lot will break if used at lower temperatures. This thought process also applies to applications as varied from large trashcans to 5-gallon pails that have a crack across the bottom to living hinge and thin wall parts. There are a number of issues the influence the resin properties near the gate and the only way to find out what is best for performance is to test parts with and without gate seal. Oh yea, did I take the rake back and get another? Fuming for a wasted trip, it was returned, and when asked if I wanted replacement my answer was NO. Why? I did ask the clerk if they had many returns, “A few” Try to imagine the conversation, one more person that thinks Bozzelli is a nut case. I wonder how much it cost the rake manufacturer for me to return that rake, a significant chunck of his profit margin. OK, if there is a difference in part quality between parts run with or without the gate frozen, how do you find out?

Find what the part, resin, mold and process demand. Run a gate seal experiment and find out the approximate gate seal time. It does not have to be exact. The gate seal experiment is easy. First find a pressure the makes the part look OK. Then change 2nd stage time; add or subtract it from the cooling or mold closed timer to keep cycle time the same, then weigh parts to four significant figures. Make sure

you go long enough on time that the part weight stops increasing. Then plot the data. For cold runners it will look like Figure 2. For hot runners the slope will change and for valve gates anything can happen.

Figure 2; Typical Gate Seal Data for a Cold Runner

Shot #	
1	
2	
3	
4	
5	

Once you know how long it takes the gate to freeze, you have some testing to do. Make an appropriate number of parts with a hold time known to provide parts with gate seal and a second set with a known 2nd stage time to provide parts with gate unsealed or unfrozen. Take these to quality control and put them through the performance testing spanning the full range of use temperatures, do not worry about dimensions. You will be surprised at how many times you see all the parts fail on one side and pass on the other side of gate seal. Even if there is no difference between parts with gate sealed or unsealed, you can save money on resin, as the parts made gate unsealed will be lighter than those with the gate sealed.

Knowing which way the part or resin is happier, you can now objectively determine 2nd stage time. If gate sealed is best, and you found the gate seal time to be 5.5 seconds then set the higher say 6.5 or more to ensure gate sealed parts. This is providing you can get the screw back with in the cooling time so as not to extend the cycle. Even if you have to extend cycle time, your costs goes up that is bad, but what is the cost of failed parts in the field? If gate unseal is best, I start at the halfway point, in this case set 2.75 seconds on the hold timer, run parts at a range of pressures to see if I can minimize sinks, and provide dimensions to specifications. Once data is in on these parts I increase or decrease the hold time and/or pressure to center the part to specification.

If this makes any sense to you, factor this gate seal or unseal influence on properties to other aspects of processing and the mold design. How critical is consistent cycle time if the process is run with gate sealed or unsealed? Does gate seal vs. unsealed influence the decision to use a cold, hot runner, or type of hot runner? What kind of part performance consistency will you have it you picked the exact gate seal time? Bottom line, do the testing, get the data before the part goes into production. Let me know if I am all wet on this or missed anything. We are all in this together.