4 variables, 7 Questions

How to determine what changed in your process

By Chris Nomura, Consultant/Trainer

Anyone who has been through RJG training is familiar with the concept of the Four Plastics Variables. The Four Plastics Variables (4PVs) are a way of breaking the process down into four components in order to help us understand what is actually affecting part quality, *separate* from machine settings.

Our natural inclination is to look at the process from the perspective of *machine settings*. If you look at most setup sheets, you will see things like barrel temperature, injection speed, or mold heater temperature. Looking below you will see that our setup sheet is very different.

Decoupled #2, 2-Stage Decoupled Molding

Process Sheet

Mold #: A672 Material: Lexan 104 Cycle Time: 34

Template Name: none

Plastic Temperature

30/30: 514 Back ppsi: 825

Plastic Flow Rate

Fill Time 0.95 Part(s) weight: 29.27

Peak plastic pressure/mold: 7425 Air: 3135

Plastic Pressure

Pack Time: 3 Pack Plastic ppsi: 8250

Hold Time: 6 Hold Plastic ppsi:

Gate Seal: 5 Final part weight: 32.3

Plastic Cooling

Cooling timer: 15

Coolant: water

Temp(in) 110 Temp(out) 117 Flow: 2.5 g

Steel Temp 113

Clamp

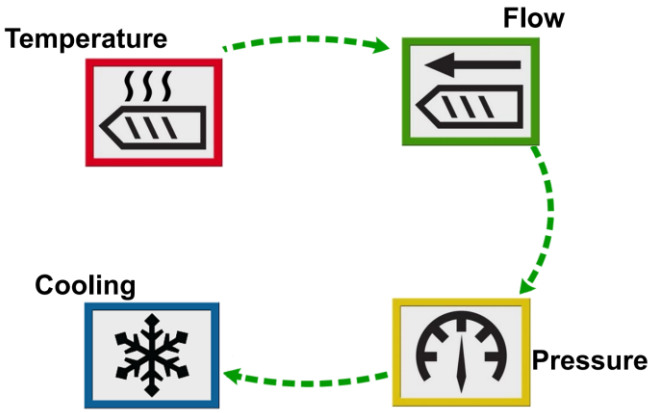
Force: 85.6t

Type: toggle

What we want to focus on is the variables that actually affect the part. If we do that, we should be able to replicate that process on any machine on any day.

Making one good part is relatively easy, but making thousands or millions is a bit more challenging. When things go wrong, we need to ask ourselves, "What changed?"

In order to determine what's changed in our process we are going to look at each of the 4PVs.



Our first plastic variable is perhaps the simplest to understand; temperature. The *question* we are going to ask ourselves is, "How hot is it?" with "it" being the plastic. If it's too hot, we will cool it down, if it's too cold, we will heat it up. There are several *machine* variables that we can use to create that change, but as long as we get the temperature back to where it should be without changing the other three variables, we should be alright.

Next comes Flow. Flow is a bit trickier than temperature in that we have *two* questions we must answer;

How much plastic are we moving?
...and
How fast are we moving it?

To determine how much we are moving, first we will remove pack and hold, and then weigh a short shot. This tells us how much plastic we are injecting into the mold during the flow portion of the process. If we are moving too much or too little, we can adjust the amount by changing our shot size and/or transfer position.

Our actual speed is indicated by the fill time. Much like how a police officer doesn't care what you read

on your speedometer, we don't focus on the injection speed setting, rather we want to see how long it actually took to get from point A to point B. That's the fill time.

Once flow is over, the plastic begins to enter the packing or pressure part of the process. Notice a trend? The 4PVs are in the order that the plastic itself undergoes in the process. It is essential that we check the variables in this order so that we do not affect earlier parts of the process as we go down the list of questions.

Our two questions regarding pressure are:

How hard are we packing and holding?
...and
For how long?

Answering how long we are packing and holding is just a function of the pack and/or hold timer, but in order to determine how hard we are actually packing we need to know the intensification ratio of the machine, or the ratio between the hydraulic pressure setting on the machine, and the pressure the plastic actually experiences. Intensification ratios vary dramatically, and without knowing our particular machine's intensification ratio we have no idea how "hard" we are actually packing it out.

There are other variables that may affect actual plastic pressure like mold deflection or check ring leakage. Without an instrumented mold we are not able to confirm with absolute certainty that the pressure in the mold is the same. Helping to verify these kinds of questions is one of the major advantages of instrumented molding.

Lastly we come to cooling - ironically often the most overlooked plastic variable. It is ironic because cooling typically makes up at least 60% of our total cycle time.

Again we have two questions to answer;

How fast are we cooling it?
...and
For how long?

As with pressure, "For how long?" is relatively straightforward to answer; we just look at actual cooling, take out, and cycle times and verify that they haven't changed. Remember that from the plastic's point of view, cooling continues until the entire part has reached room temperature. This may take *hours* for thick wall parts collected in a gaylord.

The two variables that we have at our disposal to affect cooling rate are plastic temperature and mold temperature; the greater the distance between the two of them, the faster the plastic will cool down. We've already verified our plastic temperature way back in question number 1, but mold temperature will have to also be checked.

The best way of doing this is by measuring steel temperature directly from the mold or measuring part surface temperature after ejection and comparing these numbers to values that we recorded when we created the process initially. If we observe a change, it's time to look at things like actual water temperature, mold cleanliness, condition of water lines and passages, etc.

If we come to the end of our seven questions and we have proven that the *process* is the same as before, but that the parts are still different, the problem *must* lie somewhere else: perhaps with the mold or the material itself. At the very least, if we can answer these seven questions, then we've been able to *systematically* eliminate the process itself as the source of our variation. A systematic way of finding changes is the first step to moving away from the "finger pointing" that plagues far too many shops and moving toward a focus on finding solutions.

Chris Nomura is an RJG Consultant/Trainer. Chris is a certified Master Molder[SM] that is qualified to teach Scientific and DECOUPLED MOLDING[SM] methodologies and techniques. Chris is the only RJG trainer who is certified to provide RJG training courses in Pig Latin. He enjoys curling up with a good book, loves caramel macchiatos, and is the 3 year champion of the RJG hot dog eating competitions.