

Is there enough water available?

1 Feb 2006

If you go through some heat transfer charts you'll see that if the Reynold's Number is between 4,000 and 10,000 you get turbulent flow which is considered optimal heat transfer. I recently had a wonderful debate with a guy who came complete with a PhD from a Snooty University to the East who must have had a calculator surgically grafted to his chest.

He profoundly told me that if you hooked one circuit to the machine manifold and looped it through the entire mold then back to the machine's return manifold you'd get better flow because all the pressure from the system would be put into one circuit as opposed to putting as many circuits as possible from the machine's manifold to the mold. All his arguments were based on some fairly spiffy calculations. I did have to admit if you could daisy chain all the circuits together and still get a gallon per minute flow the difference in heat from the first cavity to the last would probably be negligible so this *could* have merit.

One reason I love the guys with calculators is that when you take them out to the floor and physically measure something it is (1) faster than their fourth order quantum physics equations, (2) throws the theory into the trash and (3) looks directly at reality. Kinda fun, yes?

So let's do a reality check:

Plant water systems usually have a simple flaw that is easily forgotten: The supply pipe is the one with the pressure. It delivers it either directly to the press or to a heat exchange unit. The return pipe takes the exited water back to the tower or central chilling system. Good systems have the return pipe a larger diameter than the supply pipe. Why? If the return is the same or a smaller diameter it will offer a back pressure that will resist flow: If the supply is 50 PSI and the return has a back pressure of 40 PSI you really only have 10 PSI to deliver to the mold. In a perfect world you'd have a positive pressure pump on the supply line and a negative pressure pump on the return.

The "one circuit is better than multiple circuits" philosophy comes from pumping capacity: If the delivery capacity (the ability to maintain pressure) is limited because of restricted flow in the system using multiple outlets will simply 'out run' the pumping capacity and therefore reduce flow. In the scenario using a single line, even with all the line resistance of this circuit will have more flow.

I saw this once in a plant that was stuck in a quandary that a certain mold would only work in two of their twelve machines. All the machines were the same make, model, size etc. We all scratched our heads for a bit and then I literally tripped over the solution: Someone had 'saved' money by not putting a return line in the plant water system. The water literally went through machine #1 first, then #2, and so on. They ran every mold with 'tower' water unless a heater was required. If an 'upstream machine' had a mold with tricky bubblers or restrictive lines there was literally no flow or pressure to the rest of the machines. Duh!! Normally they ran molds with huge water circuits in them. This way they rarely encountered any problems unless the 'upstream' machines had the bad taste to steal the pressure from the system. Solution? Instead of re-piping the plant, buy temperature controllers that would both regulate the temperature and had their own pumps for each machine.

Temperature controllers (heaters or chillers) also give you the luxury of putting a booster pump on molds with a significant amount of resistance to flow. Here's where I parted ways with the 'expert' PhD. So long as I could maintain pressure (meaning the pumps could deliver enough water to the machine manifolds) it was always in my best interest to hook up as many non-looped lines as possible.

The demonstration was a simple one (and I also bet him lunch). We had a mold on a chiller unit with ten circuits on one side. First we did it his way (in this case it came to two circuits) then my way (ten circuits hooked into a two inch ID manifold ((yes it was custom built))). I took out my trusty flow meter and hooked it to the outlets of each circuit. Flow had to be going OUT (meaning the back pressure of the circuit had to be less than the pressure flowing through the mold – don't laugh I have seen reverse flow and no flow in some circuits even with pressure). We also looked at the pressure the chiller was generating. All of my circuits measured between .75 and 1.8 GPM. The pressure from the chiller was 60 PSI. Hooked up his way the flow was .3 GPM with the chiller maxing out developing a hernia at 120 PSI.

I won lunch. He was puzzled. What his calculations missed was the obvious: the equation for a Reynolds number includes the line resistance. Even though most water lines are 7/16" diameter once you put a quick disconnect nipple on it, the diameter reduces to 1/4" diameter. Add to that all the kinks in the hoses for looping and you have one long very flow resistant waterline. To get any flow you need pressure to overcome the line resistance. The one circuit approach also has the failure of wearing out the pump and consuming excess electrical power.

Here's an excellent example: My client was a contract manufacturer in Mexico who had just landed a huge contract to produce IV drip chambers from a medical company. He had the mold built in Italy and sent his engineer and I over to the tryout to be sure the mold was built properly and would run seamlessly in Mexico. The mold was 48 cavities and projected to run at a 15 second cycle. We completely dismantled the mold then put it back together pronouncing all cavities to be interchangeable and fit for tryout. My client also had a molding facility Milan so he had the mold shipped there for tryout even though the mold builder also had a production facility. We arrive at the tryout and the mold is stumbling along at a 27 second cycle producing parts. Unacceptable. The molder said it was the best he could do and blamed the mold builder. I called the mold builder who had magically acquired the ability to speak English when previously he only spoke Italian. I told him the cycle time and I suggested I should tell the molder how to fix it. The mold builder immediately went ballistic and demanded we ship the mold back where he'd run it in his machine the next day because he would **never** teach a competitor how to mold parts. Sure enough we show up the next day and the mold is spitting out parts on a 13 second cycle. The engineer looked at me wondering what happened.

I reminded him that his in-house molding facility had a standard set of manifolds: 8 circuits in and 8 circuits out. The mold had 24 circuits so the molder looped where he thought he had to. Looking at the back of the mold builder's machine was a five foot high stack of manifolds with 24 circuits on each. The hoses on the floor looked like a snake's nest. He also had HUGE pipes delivering and exiting water, therefore having little or no pressure drop in this massive system. This guy had run this type of mold before and had the equipment to run it. As simple as that. In my final report I strongly recommend a machine manifold with a similar number of circuits and pumps capable of handling the required volume of water.

It is fairly inexpensive to put banks of manifolds on machine platens. This gives you the luxury of then putting large diameter feed hoses to your main source of coolant. Faster cycles come from better heat exchange (flow) not temperature. Do the math: When does the cost of a manifold pay for itself compared with a 5% reduction (for example) in cycle time? While you're at it, the same folks who sell manifolds also sell flow meters.