JEFF HIGGINS: OK. Wow, when I say "OK," everybody gets quiet. Let's try that again. OK.

Everybody awake this morning? There's no hangovers? Much? All right. OK. Just checking. Well, somebody told me they went out for a run this morning, and I think that just means we went for a walk with some aspirin.

So good morning. If my schedule is correct, this is the first class of the morning for the Moldflow stuff. Those of you in the room probably know me. My name is Jeff Higgins. I'm a technical specialist with Autodesk.

Lucky for you, you don't have to hear much from me today. I didn't do much on this. Most of the credit-- in fact, almost all of the credit-- goes to this gentleman behind me. His name is Curt Randall.

Give everybody a little bit of background on Curt, and if I mess this up, I'm sure he'll correct me. Curt, when I met him, actually was at C-Mold. So those of you who remember C-Mold. Franco, you remember C-Mold. You might as well put your hand up.

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: I didn't say you had to like it. I just said you had to remember it.

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: Curt's had quite an extensive career, let's say. He's been to a few different companies. I knew he went to Fisher-Price for a little while. Moved around for a little bit, has now ended up at GE Appliance, which is a something company.

CURT RANDALL: Haier company.

JEFF HIGGINS: Thank you. That'll work. You've had quite an extensive run. We lost you from our Moldflow community for a little while, and we brought you back, so this is a really interesting world to bring you back into. And you've done a great job putting this information together.

So I'm going to turn this over to you, and let you go through a lot of what you've actually done here. But we took a-- or Curt took a look at Moldflow as an engineering tool, which is what it's intended for. And how do you make decisions? And how good is it at making some of these decisions? And he's got some great action items for us to continue on after this.

CURT RANDALL: You might want to talk about your--

JEFF HIGGINS: Oh yeah, I don't want to forget about this. So how many of you actually made it down to the Idea Exchange? Any of you made it there?

If you haven't, this is the last day. Good luck. Run after this. Ignore all the other classes, because we're the most important one today.

Go down to the Idea Exchange, talk to those folks for a little while. You do have the opportunity to earn an Amazon gift card and even enter the sweepstakes to win a GoPro 4. If you don't make it, please, that's OK. Don't forget that inside of the synergy interface or inside of even the advisor interface, there is the Submit an Idea function.

Now, how many of you guys have used that? One person. OK, how many-- please. I know Naz and Don have used it too. Don't even start that with me.

How many have actually voted for ideas on the Ideas Station? And how many times have you stressed Franco out with ideas on the Ideas Station? Just checking.

That's a really good place to do it. There are some crazy ideas out there. But there are some very functional ones. The more you vote on them, the more attention they get on the Ideas Station, so please take a look at them.

And we do pay attention to it. It's not just a place to make you guys go complacent and get you away from us. We are actually reading those, which is a good sign as well. So, was there something else I'm supposed to talk about?

CURT RANDALL: No.

JEFF HIGGINS: OK.

CURT RANDALL: That was it.

JEFF HIGGINS: It's your turn now, so take it away, Curt.

CURT RANDALL: So yes, Louisville, Kentucky, has started out, like Jeff said, C-Mold in Louisville, Kentucky, back in '92. And that's where we met. And back and forth a few times up to Buffalo, New York, back to Louisville, and then one stop in Mexico, when I was with Fisher-Price.

And automotive. When I went back to Kentucky, I went to automotive, and it was a tier 1 supplier to Toyota. And that's where I kind of lost touch, because I didn't-- I was a tooling engineer doing sourcing. So a lot of travel and setting up tools. So I got back into it when I came to-- at the end of that automotive supplier. So I got back into Moldflow, got them to purchase the software, and then-- now I'm at GE Appliances in Louisville, Kentucky.

So question. Who can tell me who won the Kentucky Derby 2015? Anyone? What horse? There's a little gift, a little present for you, if you get it right.

AUDIENCE: American Pride.

CURT RANDALL: No. Close. He's the Triple Crown winner too.

AUDIENCE: [INAUDIBLE]

CURT RANDALL: What was that? American Pharaoh. 2015 Kentucky Derby winner. Here's a hat.

What about this year, who won? Does anyone know? Nyquist. Nyquist won this year. So, couple more handouts. We'll get some quizzes that Jeff's going to take you through. But maybe there's a few more handouts for those who participate.

Validation. This has come up recently at GE Appliances for the simulation groups, not only plastics, but also they do stamping and some other factory simulations. And one of our tasks is to validate our results. And as an engineer, we look at validation, and it's to check or prove the validity or accuracy of something.

So we go into the simulation to give some answers. We give the answers, and then we kind of wait. Tool's not built yet. We're not running it. We get to the end and we have to validate it.

So that's one of our tasks now at GE. Not only do we have to do the simulation, but we have to validate. So that's our process right now.

You've all been asked the question. All right. The part designer asks you something, how accurate is Moldflow? We've all been faced with that question one time or another.

But how do we answer that question? I know we'll have skeptics that are asking that question, trying to challenge the simulation. And we'll have managers asking because they're trying to make a decision. So what's the answer that some engineers will give to that? Anyone?

AUDIENCE: My software is more accurate than your reality.

CURT RANDALL: OK. Is Tim in here anywhere? Where's Tim?

JEFF HIGGINS: No, Tim's down in another meeting.

AUDIENCE: [INAUDIBLE]

CURT RANDALL: OK.

AUDIENCE: [INAUDIBLE]

CURT RANDALL: OK. So as an engineer, as an analyst, what do you tell them when they ask you that question? What's the answer? The $0.05 answer. It depends. Right?

So they're asking us a question. As an analyst, we know it depends on a lot of different things-- what information you gave me, what information I'm using for the simulation. So we have our $0.05 simulation expert that will give us an answer. Right? The truth is that it does depend on many different items, different things. And we'll go through some of those.

So, learning objectives. We're going to walk through some of the tasks that I was assigned, looking at the importance of material characterization and how that relates to validation, pressure transducers in your cavity and thermocouples. We'll talk about that a little bit.

3D scanning. I know that's been brought up recently. Last couple of presentations-- Tuesday, we talked about it. That's a big item, and I think that's something maybe we can look at future presentations. 3D scanning, how do we validate our results?

Process conditions and simulation set-up, how important that is. And how do they compare to reality? I'm going to walk you through a case study we're still in the process of completing, and Jeff and I are working on some items, and we're going to work with a Autodesk validation team, simulation validation team.

First one, material characterization. We all know all those material that we have in the database, the accuracy is going to depend on the material that we select. Gold, bronze, and silver, different levels. We have it for filling, pack, and warpage.

So we can go through and search, knowing what-- if you're going to validate something, you may take a different path, right? If you're going to validate something, you want accurate data.

If you're just doing a simulation to provide some answers for somebody, we may be able to get some generic or something with supplemental data.

So gold rating, high confidence in the quality material data that you have. Silver rating, combination of the well-tested and supplemental material data. And of course, bronze, where we have the incomplete data sets and extensive use of supplemental data.

So using characterized data, gold level, will get you the most accurate results. And talking to multiple plastics labs have been working with Beth. We've gone through and validated 20 of our most common materials we're using in house, all the way through warpage. We put it confidential. But I put a plug-in there for them to contact. But you need to be able to have confidence that what you're putting in is accurate, and using that gold-level data is the way to go.

So Jeff, you want to give them a little quiz here, a little pop quiz?

JEFF HIGGINS: So Jay, just to start this off, you're not allowed to answer any of these questions. You're not allowed to give tips to anybody else in the room, and you will not win a prize, other than your own handsome face. So--

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: The one you stole from somebody else. But we won't talk about that. So since we're talking about material data, you've all heard me harp on the fact that material data is going to be critical to the overall process, all of the accuracy of your analysis. In fact, we've got some material suppliers in the room. These guys have done a great job testing materials to make sure that we've got accurate information in the database, and their own private databases to go with it.

So there's a quick question. Can a material in the database have a silver filling and a gold packing data levels, or gold warpage? Now, there's a little bit of a caveat to this, but we're not going to get too heavy into this. But we're going to say, in general, can you have a gold packing quality indicator and a silver filling indicator on a given material file? Franco's over here smiling. You're not allowed to answer either, Franco.

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: Oh, crap, no. Ian's in the room. Ian, you can't answer this. So this whole row right here, you're just excluded. Except for Naz. So what do you think? Can you have a-- and I'm going to pick on somebody here for a second. You have a silver--

CURT RANDALL: And remember, there's gifts for participation here.

JEFF HIGGINS: I wasn't going to tell them that. I was just going to throw them stuff later. Now you're shaking your head no. No. Tell me why not.

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: So you're right. So, in order to have a gold packing, you actually have to have the filling stuff done first.

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: There's a little bit of caveat in there too. But for the most part, I'll say you're right. In order to get a fully-characterized material, you have to start at that filling phase. So we'll give-- do you have a prize for him?

CURT RANDALL: Kentucky Derby, we talked about. What else is Kentucky famous for?

AUDIENCE: Bourbon.

CURT RANDALL: Bourbon. What else?

JEFF HIGGINS: Oh, crap. Am I going to have to card him now too? Oh, OK.

CURT RANDALL: So we got tobacco, right? Bourbon. We have--

JEFF HIGGINS: A Louisville Slugger.

CURT RANDALL: I mean, I don't know if that's good for Kentucky, to be known for all that. But you know.

JEFF HIGGINS: It all depends on what order you use them in, I guess.

CURT RANDALL: You know, we're in Vegas, so I guess horseracing, bourbon, tobacco, Louisville slugger baseball bats. Which one?

AUDIENCE: Cigar.

CURT RANDALL: Cigar. The cigar now is Maker's Mark Seasoned. So Maker's Mark.

JEFF HIGGINS: Congratulations. You'll have to tell me if you get drunk when you smoke it.

CURT RANDALL: Barbecue sauce. Maker's Mark. And you're Chicago Cubs. So those are for future questions.

JEFF HIGGINS: Stay awake. This is the last prize.

CURT RANDALL: So next thing we want to talk about is cavity pressure. In order to validate, we have to be able to find out what we're actually getting in our mold. So we use pressure sensors. There are a bunch of different reasons. We can use it for transfer of our process to V/P switchover, monitoring your process for quality, short shots material variation.

Transferring from machine to machine. This is important. Sourcing a tool. I build it in Michigan in a tool shop. I got to sample it, and I have to take it back to Louisville, Kentucky, and run it. If I can qualify my mold in Michigan with cavity pressure transducers, I can bring it down to Kentucky and set up the same process. I use-- we're using RJG, and we'll talk about that in a minute.

Traceability, genealogy. If you want to trace shot to shot on your part. Some of the medical, you know, air bag stuff, safety-critical items in automotive, you have to have traceability.

Quality control. We use it-- it's tied to the robot. If the pressures are out of our alarm band that we put in for each sensor, or temperatures, we have thermocouples. We can reject that part and it drops it in a different area for inspection, or just to scrap.

Who can tell me what that is in the bottom right there? Just another quiz question here. Anybody? Didn't answer yet? Wheatstone bridge? Barbecue sauce or baseball bat? Maker's Mark.

So cavity pressure. And we're going to talk about this more for validation when we look at our pressure traces.

So we have sensors in our mold. Any mold that we build now at GE that's in-house-- not every mold, I'd say. The critical molds. We will put sensors in our mold. And I'm putting thermocouples in as well, and we can talk about that.

We have an end of fill and a post gate sensor. So if we have nine valve gates, I'll have nine post gate sensors, and usually one end of fill. And that's what-- we'll use the simulation to determine where that sensor is going to be located, as close to the end of fill as possible.

So there we get our pressure trace from RJG. And we'll look at some validation in how accurate this is compared to what we ran in Moldflow. So we have our whole pressure, a maximum machine pressure, and then our red is the post gate and blue is end of fill.

Next, this is the hot topic now, is how do you determine what your actual deflection is? And we've been going through a lot of different studies at GE on CMM, fixed check fixtures, whatever we can do to get more accurate in our measurements.

Three-laser scanning is what we're going with now. And we're trying to use it to qualify our molds. And it's a long process trying to get people to change, because everyone's used to the CMM, to going through this, setting it up, and running the programs. But you'll see how, scanning, you can get results pretty quick.

We take a part, the part that we're doing our case study on. They put all these targets on the part, little white dots, both sides, all over the part. Sometimes they paint them, depending on the color, so they can get a good scan. And we're using a blue laser light, blue light laser scan.

You can tell the fixture's pretty straightforward. We're setting the part on there, scan, taking pictures, flip it over, take more pictures. It knows where all the dots are and lines everything up and creates your point cloud.

So here's some scan results. You can tell how accurate. You can see some of the text on this. But that's the data you'll get out of the scanning equipment. Now, the hard part now is comparing this to something and giving deviations.

So what we're doing, in this case, we're comparing the scanned parts to our warped part shape, so going through Moldflow, running the warpage analysis, we exported the warped shape as a CAD model, brought that in on top of the scanned part, which is our actual warped part. We can set up any anchor plane we want, move it around, and then look at deviations.

In this case, we're seeing-- you can see up there 6,056/80,000 deviation from predicted to actual. Now, we're not looking from CAD to predicted, so this is from predicted to actual warpage. And you can use GDNT, custom reports from within the analysis. This software allows you to do reports and inspection and look at all the deviation.

Process conditions are also the next item that we have to ensure that we're accurate in our set-up. Material, we talked about. Machine is also critical. We'll talk about RAM speed profiles and those things in a minute. And the mesh as well, making sure you have an accurate mesh.

So for our mesh, using a Moldflow theory and concepts, manual model requirements, make sure you're following all the requirements-- aspect ratio, number of elements through a thickness change, modeling your cooling lines, putting your mold materials in steel material on your part. And we'll look at that a little bit later as well. Mold Max, we have slides.

Machine nozzle, another important item, and we'll see that in our pressure results. Most cases, people don't put the machine nozzle. They don't model that or mesh that in their analysis. They'll pick-- maybe they'll do their hot runner and just pick the top of that. But we'll see how that will impact.

Here's one a lot of people overlook, is the accurate wall thickness. You do the simulation. You build your tool. Get it in-house, and you run it. And you compare the flow pattern or all the information to see, and maybe it's off a little bit.

You've got to take the time to check your part, check your wall thickness, because even tool shops will make mistakes, right? They say they don't, but they will. We've had some parts where some shift in some coring cavity, causing a thin wall on our one side and thick on the other. That's not how I modeled it. That's not how I meshed it.

First thing we do is we'll cut our parts up and measure them. Or ultrasonic thickness gauge, and we'll measure it. Make sure that what we're doing is-- in a simulation, is the same. And we'll go back and change our mesh and rerun it.

Expanded data, another item that was talked about a lot the last couple days.

So what is-- expand or not to expand, that is the question, right? But if you're doing simulation validation, I think it's important that you use expanded data. I think Jeff mentioned it, or someone mentioned it, at one of the Tuesday sessions. If you have a large part and you're not using expanded data, your cooling lines, everything could be off just a little bit, based on that, because of the size. Smaller parts, you maybe won't see that big of a difference.

But making sure that we match what reality is. And you're cutting the steel to an expanded size. So I would run the simulation in expanded mode.

Now, if you're doing initial simulation, I wouldn't. Look in a gate location, maybe clamp tonnage. You're trying to get an idea up front to see what you can do. I would go ahead and run that right off the CAD. Mesh it and run it that way. But once you go into validation, you're going to have to be more consistent with your mesh size.

JEFF HIGGINS: Oh, goody. So pop quiz. You guys thought you were going to get out easy today, didn't you? How does the software calculate the projected area of the part mesh? And I'm guessing this is going to be in relationship to clamp tonnage.

CURT RANDALL: Yes.

JEFF HIGGINS: So how do we calculate the clamp tonnage? How is that-- we'll start with that question. How do we calculate clamp tonnage? Who knows that? Well, OK, Jay, fine. I'm not giving you a prize for this one, but how do we calculate clamp tonnage?

AUDIENCE: The xy plane is [INAUDIBLE] so we're looking at that, and figure out the projected area for each [INAUDIBLE] and pressure in that element, and add it up.

JEFF HIGGINS: OK. So how do we calculate the projected area? You basically just gave that answer away. How do we calculate that?

AUDIENCE: Yeah, so if the xy plane--

JEFF HIGGINS: OK, you need to shut up. Go ahead.

AUDIENCE: It would be the xy plane of all of the area of the part [INAUDIBLE]

JEFF HIGGINS: Right, so we take the projected area, we throw it down along the z-axis onto the xy plane, and we calculate the clamp tonnage. Is there another part to this question or not? OK. What?

AUDIENCE: [INAUDIBLE]

CURT RANDALL: What is the-- yeah. So what-- I guess the-- we'll just show it.

JEFF HIGGINS: There you go. So it's the sum of the surfaces. Right, so it's basically what Don and Jay said. We project it down on-- now what happens--

CURT RANDALL: What's the problem with this?

JEFF HIGGINS: When we've got this undercut right here? What does this do to us? Anybody? Ted, what's this do? And I'll pick on you, man.

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: In theory, you would think that, right? Our software should be smart enough to figure that out.

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: OK.

AUDIENCE: Just be careful. [INAUDIBLE]

JEFF HIGGINS: In theory, we should be able to do that. But realistically, what we're doing is we're projecting down the sum total of all those projected areas. So what can technically happen, even though you've got a little bit of this undercut, is we can project down a little bit of an extra volume, a little bit of a projected extra area.

So there's a little trick inside the software that you can take some of that out. So you can actually exclude some triangles from the calculation in any of these places where you've got an undercut, in order to get a more accurate clamp tonnage. So you can help alleviate some of those extra tonnage calculations, extremely high tonnage calculations by excluding some triangles from the calculation. They do OK there, Franco?

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: Ooh, I like that too. See, I learned something today too. Thanks, Jay.

AUDIENCE: No problem.

CURT RANDALL: So yeah, so the expert tip, in that Element Properties dialog box, there's a little check, Exclude Elements from Clamp Force Calculation. Now, if you're not doing clamp force validation, and it's not a very large undercut, I wouldn't really worry about it. But if you're doing the validation on clamp force, you have to take that into account, right?

You know, and I get in the habit, I'll go in and I'll do it even if I might go too far with it, right? I might exclude a lot of stuff and then-- yeah, that's not going to make that much of a difference in the size of my part. So, any questions on that?

JEFF HIGGINS: Yeah?

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: Not necessarily. If you think about-- it's a relative volume. Right? So if you've got a small part with an undercut that is, say, 50% of the part, it's not necessarily the size of the part, but, say, a percentage of the part that you need to be concerned with.

AUDIENCE: [INAUDIBLE]

CURT RANDALL: Right, if you're limited on clamp force, and you-- you know, you don't want to be within 80%, 90% of your clamp force, then you may have to start looking at all those undercuts to see what the software's predicting. Because you're going to overpredict, right? You may be in a machine that's too big for what you really need, because you could be overpredicting. But only, again, if you're looking at validation. Yes?

AUDIENCE: I'm trying to figure this out. [INAUDIBLE]

CURT RANDALL: Yes.

AUDIENCE: [INAUDIBLE]

CURT RANDALL: No. So-- right. On long draw, you have some draft, you have to add some back in, right? You can't just remove it. So if you have a--

AUDIENCE: [INAUDIBLE] relative to the size of the part [INAUDIBLE]

CURT RANDALL: Right. So in the part that we're going to look at, we're in a 500-ton machine, because of the size of the mold in the slides. I don't need that for the tonnage. But do I really need a 500-ton-- you know, it all depends on what you're trying to do, where you're trying to put this mold.

AUDIENCE: [INAUDIBLE]

CURT RANDALL: So we have some parts that have a top and a bottom, and slides come in from both sides. But it's not very deep. So I can get this mold down into a press, and I still have plenty of room this direction. But if I look at my simulation, I have four cavities in line, and I'm now doubling-- not doubling, but I'm adding all that extra, you know, projected area.

AUDIENCE: [INAUDIBLE]

CURT RANDALL: That's right. Just something to consider if you're doing validation. That's the whole purpose.

So the heart of the simulation, right, is the process conditions that you put in. Just giving an example of a set-up sheet, you know, this is one for-- it's not this part that we're doing, but a lot of information, right? We have to know what we're actually running, not just putting in whatever fill time we want and switchover and part removal, mold open and close time. We have to figure this out and put this in.

And finally, the mold and melt temperature, that's a big one that is sometimes difficult, right, for us to validate. And we'll talk about those. Ooh, another one. Next one.

JEFF HIGGINS: So I need the image, though. There we go. So what is the shot size on this machine? Who can tell me that?

If you look at this image, and again, not you, Jay, because I can already see the corners of your mouth going up. What's the shot size on this? When we take a look at where the screw ends up, where the transfer position is, what our decompress is, who can tell me what the shot size is?

CURT RANDALL: I got another bat.

JEFF HIGGINS: I know it's pretty early in the day after a long party last night, right? It's hard to do that higher-level math today.

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: You should have just taken a [INAUDIBLE], Don.

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: All right. Let's pull the math up. Let's see where he ends up.

CURT RANDALL: Right, so we have a cushion of 0.7, transfer at 1.4. 5.25 is our screw position, but is that our shot size?

JEFF HIGGINS: Ooh, trick.

CURT RANDALL: All right? What about your decompress? So when you get your shot size, and you pull back whatever you're checkering-- [INAUDIBLE] 0.25 inches, usually, depending on that. Is that part of your shot size or not?

JEFF HIGGINS: Who thinks decompress is part of your shot? Get out!

AUDIENCE: Analytically, because technically, it is not. You stop at five inches. But when you suck back that quarter of an inch [INAUDIBLE] you added maybe 0.05, or 0.1. [INAUDIBLE]

JEFF HIGGINS: Yeah, there is a little bit of movement in that entire process, right, because you still have-- unless you've got some type of a shut-off on the hopper, you still have material coming in. You still have things going around the [? check valve. ?]

AUDIENCE: [INAUDIBLE] five inches.

JEFF HIGGINS: Right, which is what we're going after.

CURT RANDALL: Yeah, so we'll take the five minus our shot size, right? Or our cushion.

JEFF HIGGINS: I'll buy you a drink later, Don.

CURT RANDALL: So we talked about our fill. So our fill stroke is, of course, our 5 minus the 1.4 is our transfer. That's our filling. Then we have that little bit of a decompress.

Now, smaller parts, we're not going to see a big difference, right? But once you have 11, 12-pound shots or bigger, and your screw diameters are much bigger, that's where you're going to start to see a impact on your decompress.

So the reason for that was to talk about absolute profiles, instead of-- we're in the habit of just putting a fill time in and picking 98%, right? Kick off a simulation. Most cases, that will probably be close. But you never know. I mean, based on a shot size of the machine that you're-- you walk down to the floor and look at it and do the calculations, you may be at 87% as your switchover, not your 98% that you pick.

So talk a little bit more about decoupled molding. RJG has a service mark. It's Decoupled II. There's Decoupled III. This is what we're using with our data acquisition is RJG, and we're looking-- our transducers, our thermocouples, and we're putting our process monitoring process control on that. So we're filling as fast as the machine, the mold, and our part quality will allow, without being pressure limited, to 95% to 98% full. We're transferring to pressure control to finish filling and then complete the packing.

And the packing pressure is going to range 50% to 80% of the maximum fill pressure, and we see that in the software. When you go in and you pick 80%, that's the default that's in there for if you're using percent pressure, maximum pressure.

But that's in your cavity, right? When you add a runner system, 5,000 more PSI in your runner system, you don't want to be packing at that 80%. So looking at what that pressure is for the cavity. And that's why we have our transducers.

Most challenging for us, melt and mold temperature, right? How do you get accurate information from your machine? Handheld pyrometers, melt temperature, eh, it's not so bad. But you have to be quick and move around and watch this thing to get a reading.

Thermal imaging cameras, we can use. We've used that on our mold temperatures. What we're going with now is in mold thermocouples. Along with our pressure transducers, we're putting thermocouples in.

A mold I'm building now is a dishwasher tub, 3,300-ton machine, many slides and lifters and I think there's going to be 12 thermocouples in this mold, one on each slide in different positions. So we can monitor that temperature through the process and put alarm bands around that to know where our quality part is.

So we can take these thermal images. Now, the difficult part about the mold temperature is stopping the machine, opening the door, getting room to get in there and get a picture. Focus the camera and get all the pictures. So you're losing a lot when you're doing that. Or the surface, you know, pyrometer that you stick on the steel. You have to get in there and check multiple locations.

Along with the part of the process condition requirements is our machine information. So using a custom injection molding machine database is crucial if you're doing the validation. Putting the machine that you're actually running it in into the database and using that information, that's how you're going to get your absolute RAM speed profile.

So these are the items that you need to put in for your custom machine. And we put all of our presses that we have in. Even when we go to a tool shop for a trial, we'll put that information in and run it, so we know what it is at the tool shop, and bring it in house, and we can transfer that to our machine.

JEFF HIGGINS: How many of your presses, Curt, respond in 0.01 seconds?

CURT RANDALL: Yes, so, yeah. The super-machine that's the default in Moldflow is 0.01-second hydraulic response time. Yeah. Again, for initial analysis, I think we're OK doing that. Clamp tonnage, you know, you got plenty. Maximum pressure, I mean, you've got everything you need, right?

JEFF HIGGINS: So is that your way of saying none of your machines respond that fast?

CURT RANDALL: No.

JEFF HIGGINS: Oh, crap.

CURT RANDALL: OK, here's the case study. And we're still going through some simulation. Jeff's working with me. We're going to have this validation team down, and we're going to look at some more things.

It's appliance part, filled polypropylene, one of the materials we sent up to have it characterized all the way through warpage. It's a valve gate, valve gate on the top up here. Can't see it right now, but we'll see it in a little bit. I've run this in Dual Domain and 3D part mesh. Yes?

AUDIENCE: [INAUDIBLE]

CURT RANDALL: Percentage of fill for-- oh, it's a 50% calcium carbonate. Yes, 50% calcium carbonate filled polypropylene. So it's a dishwasher, hot-water-type application. Analysis sequence, fill cool pack, or fill cool, fill pack warp is what I ran. And mold shrinkage. And we built this [? tool ?] out.

I didn't do a simulation on this before it was built. This tool, we have five other tools, five other cavities had been running. This cavity, they wanted to do something different, because they had some flatness issues. And it was even before I came to GE.

So they built this tool. They cut it to the same as what they cut the other ones to. The other ones had two gates, one on the bottom here, and bottom over here, backside. And this mold, they built without-- they may have done simulation before I came, but I haven't seen any. They have one gate now at the top.

So the mold was already built, cut to 12,000 inches per inch shrinkage. But we did have them put transducers in it. No thermocouples, just two pressure transducers.

So modeling the cooling, our Mold Max slides, I have three. There's one here and one on the backside you can't see. There's our gate, valve gate. We ran this in a Dual Domain, and we did a 3D mesh. The cooling and a mold boundary. We didn't do a 3D mold mesh. That's some future work that we're going to be doing.

So we talked about, there's our Mold Max. So looking at the simulation, we picked various items to look at today. Filling pattern was one. Looking at our short shots, compared to simulation.

Now, you can see they're pretty close for the Dual Domain. We do have some inconsistencies here on the top, on the edges. So going through that, I went back and remeshed the outer edge on the edge element, or the edge around the part. I put some more elements in there. There's a rib on the bottom, right along the entire outer rim that I added some more elements through the height to that, to give us some more accuracy. But it improved a little bit, but still not what we're seeing on these outer edges.

And Jeff, you ran it in 3D, and maybe a little bit more improvement.

JEFF HIGGINS: We saw a couple of things that were really interesting on this, and I know [? Ralston's ?] back here licking his chops. We'll talk later. But we saw a couple of things that were really interesting on this when we meshed it in 3D.

In fact, to Curt's point about changing the mesh density, this was one of the things that we found to be very interesting on this, because even though we had a good-- when I meshed it, when Curt ran it in 3D, it put six layers through the thickness. I did 10 layers through the thickness. We just did not have enough resolution yet on the height of the rib and on the edge elements in order to pick up some of the shear dependence we think are causing this. So there are still some things we want to look into with our validation team as we keep moving forward on this part of it too.

And I think going 3D on this is going to pick a little bit more of that up. And I know the Beaumont guys have done some research on this too, if you guys want to talk to them. I'm going to put you on the spot a little bit, John. If you want to talk to them about some of the phenomena they've seen for shear in disk flow like this, that's actually what we think we're getting into. Yes?

AUDIENCE: [INAUDIBLE] edge elements are 75% [INAUDIBLE]

CURT RANDALL: The edge.

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: So the edge itself does something really interesting. So when you define the edge, it does a whole series of characterizations in order to represent what's actually happening. The biggest issue that you're going to run into with the edge is there is no perpendicularity to the actual flow. So when you're rolling around the outside edge, it kind of ignores what's going on if there is some shear dependence that's going around the edge of the disk.

It also doesn't have any temperature transfer. Right, so you're washing away a lot of the things that are actually happening. For the most part, what we're doing on this part, the Dual Domain model works really, really well. But we're seeing small little inconsistencies on the edge of the part.

Now, in the grand scheme of things, as an engineering decision, might not be a big deal. We're still getting valid information out of this, and we're still doing it with a very accurate representation of the part. But if we are looking for some of those little phenomena that are actually happening, if it's causing a surface defect or causing something else that's going on, we need to change the way that we're looking at it. And that might mean going to a three-dimensional mesh.

So those are some of the things we have to consider. If this were a bigger part or an automotive part or something, I might even just completely ignore it and not care. But because we're doing validation, I do. What?

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: I'm going to blame it more probably on shear, but that's part of what we want to look at. And that's why we're doing part of this too.

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: This one did, yes.

AUDIENCE: [INAUDIBLE] Can you back up one slide [INAUDIBLE] I noticed on the [INAUDIBLE] areas, you have very nice, clean, sharp lines [INAUDIBLE]

CURT RANDALL: These? So, interesting way. So I started in Sim Studio, and I intersected surfaces and put lines in there, in my surfaces, and then brought that in. When I meshed it, it didn't follow that line in Sim Studio. There was a line in the surface split, but when it meshed, it did not pick up that line. So that's something we'll talk about on that. But what I did is I just did a line nodes, so I picked a node here, I picked a node--

AUDIENCE: [INAUDIBLE] I would have done it [INAUDIBLE] being a flat surface, but sometimes you're dealing with curves.

CURT RANDALL: This is a curved surface, yeah. It has a dome shape to it. But it still gave me a pretty straight line. Same here. I just picked nodes, two nodes, and then the align function.

AUDIENCE: [INAUDIBLE]

CURT RANDALL: Well, yeah, so this surface is flat, and this one is, I mean, almost flat. It's very close. I checked to make sure I wasn't getting any waviness in there.

AUDIENCE: [INAUDIBLE]

CURT RANDALL: That's a good question.

AUDIENCE: [INAUDIBLE]

CURT RANDALL: So if I'm going to 3D, which we're going to do the mesh on the inserts. We'll talk about future work. We're going to bring the whole mold core cavity, all my inserts and mesh them in 3D, instead of having to go through and assign.

Now, the other thing is, after I did this in Dual Domain, I assigned all this, I mesh my part in 3D, I go back and do it again. All right?

AUDIENCE: Curt?

CURT RANDALL: Yes.

AUDIENCE: [INAUDIBLE]

CURT RANDALL: Yes, I don't think I did.

AUDIENCE: [INAUDIBLE]

CURT RANDALL: Yeah, I'll go back and try it.

AUDIENCE: [INAUDIBLE] Well, I think the point is, in Sim Studio, instead of cutting just the top, you cut the top and the bottom [INAUDIBLE]

CURT RANDALL: OK, yeah, I didn't do that.

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: I've had our software outsmart me a couple of times on that too, where I've taken a solid, cut it, and it still sees it as a solid and washes everything away. So if you break it more into a surface output, that sometimes helps too. This is a conversation Curt and I actually had yesterday about this.

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: Yeah, go for it.

AUDIENCE: Can we go back to the previous one where you said you were going to take this to 3D, you can do a 3D modeling simulation as well? [INAUDIBLE]

CURT RANDALL: Everything.

AUDIENCE: Everything is going to be [INAUDIBLE]? So you're going to mesh the [INAUDIBLE]?

CURT RANDALL: Cool FEM. We're going to do the complete mold.

JEFF HIGGINS: Just for you, we're going to mesh the crap out of it.

AUDIENCE: So when you mesh the insert, it's going to be Mold Max. Then, do you have to tell the part that it's [INAUDIBLE]

CURT RANDALL: No. Yeah, that was interesting part. So Dual Domain, yes. Stick in all those elements and--

AUDIENCE: [INAUDIBLE]

CURT RANDALL: On this one, I think it was 150,000, something like that. In 3D, I think we're 2.5 million. Maybe yours was more with 10 layers.

JEFF HIGGINS: Going to say, mine was more than that. But yeah.

CURT RANDALL: I think I did mine at the default six layers, and it was like 2.5 million. Just the part.

JEFF HIGGINS: For the record, too, all this work was done in 2016. So when I was doing this, I jumped back into 2016-- I know 2017 is out. That's part of the future work we're getting into. But this was all done in 2016.

CURT RANDALL: So going to our pressure predictions here, so from our RJG curve, we have a time up here of

4.9 seconds. So I'm looking at the same spot here on our curve. Post gate sensors up here in red, and the end of fills in blue right there.

When you look at these numbers, I mean, we're almost exact on Dual Domain when I was looking at these numbers. Now, initially, I didn't have a nozzle molded in there, or meshed in there, for Dual Domain. So you can see the max pressure was off. Our packing pressure was 5,600 PSI. You can see here, or see here.

Once I added the nozzle, meshed that in and beam elements, I didn't do 3D on the runner system, it brought our pressure up. 1,776 is the pressure through that nozzle. So adding that in will get us closer.

And then with 3D, this is the one with six elements through the thickness, we had that slightly higher pressures in the cavity. But it was-- if I add the 1,776 into here, I'm even a little bit closer on the max pressure.

So one item of concern was the decay of my pressure at end of fill. So in my transducer, it's showing I'm dropping off a lot sooner, before my end of pack and hold. Here, we can see it's hanging on a little bit longer.

Now, I think once we look at this and we add in our 3D mold mesh, the cool FEM, maybe I'll get a little bit more accurate with our pressure decay in that area.

AUDIENCE: [INAUDIBLE]

CURT RANDALL: Yes. Well, it's end of fill here. I mean, that's where you saw the short shot. I mean, we're right there at the end of fill. So, and then it's a valve gate, so I'm shutting off right there. My valve gate. But you can see that decay even while I'm still holding.

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: In 3D, [? Mohan, ?] we saw a little-- so the question was, how does 3D kind of compare to this? In 3D, we saw a little better representation of the taper of pressure. But we're still seeing a higher trend in general.

AUDIENCE: [INAUDIBLE]

CURT RANDALL: No. In this one, no nozzle. I'll have to add that in. Once I found out what my pressure drop was through the nozzle, I could just assume I could add that in right now until we complete our 3D mold mesh. May even do 3D.

JEFF HIGGINS: Well, we stopped a little bit too on a 3D mesh too because we start talking about the difference between six layers and 10. So there there was another conversation that took place in here too. For those of you that don't know, and I'm assuming most of you hopefully do, the default number of layers in 2017 is now 10, not six, which is kind of a big deal.

CURT RANDALL: Shrinkage. You know, we're looking, again, at we did cut this tool to 12/1,000 inches per inch. So actual-- I took my measurements of my part, I'm at 11.26 diameter, 1.05% shrinkage. Dual Domain gave me 11.25, 1.2%. 3D, 0.81%.

So again, you know, only six layers through the thickness. And we're in the process of increasing that and then looking at the Cool FEM and the whole mold as well. So we are overpredicting shrinkage. But we have five other cavities, as I mentioned, and they all cut those to 12/1,000, but that was with two gates. But actually we are 10.5 inches per inch.

Looking at mold temperature now, of course, our temperature in Dual Domain, it's a cycle average temperature. So I'm going to be higher in my predictions on temperature. I'm looking-- it's difficult to see because the part's actually inserted in opposite way into the mold. We're looking into the cavity over there and I can't see the entire cavity on this, but these are the temperatures from the thermal imaging camera.

You can see our Mold Max slides on both of these sides, and there's one down this way. But we are higher in the predictions. I think once we go to Cool FEM and do the 3D mesh, we'll be able to see the transient.

JEFF HIGGINS: Yeah, all these are done with a boundary element method. So the temperatures we were looking at on the mold were averaged through the cycle. So the numbers should, in general, be higher.

And I think this is something that you did a few years ago, Gail, where you ran a transient analysis versus the boundary element method just to do a bit of a comparison. So even though we're doing this as kind of an engineering perspective, we're looking at what the variations are right now, with the understanding that there is a transient effect that is taking place here. This mold is actually getting colder when it opens.

CURT RANDALL: Right, and that makes it difficult with this. As I mentioned, we got to stop the machine, open the door, actually probably open the mold a little bit so I can get in there, take a picture.

JEFF HIGGINS: I know you and I talked about it. Is it in the presentation, the temperature in one of the cores?

CURT RANDALL: On what?

JEFF HIGGINS: You went in one of the cores, because we were getting a warning message of the mold didn't freeze.

CURT RANDALL: Yeah, in one of these, at the bottom of one of these posts, I was getting some elements that didn't freeze.

JEFF HIGGINS: So there's even a point in this--

CURT RANDALL: But we're molding the parts.

JEFF HIGGINS: They are freezing. We're not pushing goo out. So there's even a point in this too using the average through the cycle, the boundary element method, where the mold itself isn't getting below the transition temperature on some of the cores, because the average is staying higher than that. So when we actually go into the cool analysis, that warning message was coming out.

CURT RANDALL: Any questions on mold temperature? Again, once-- I think if you use thermocouples in your mold, you can get a lot more information. You can even probably see the transient. Yes?

AUDIENCE: [INAUDIBLE] once the part was outside the mold, did you at all [INAUDIBLE]

CURT RANDALL: No, we haven't. I haven't cut it. After I saw these results, I'm going to have to do that. But holding the parts, I didn't see anything or notice anything. But I will have to cut those and see what the-- maybe there is some molten material in there, on the inside. But they are-- some of the areas are hot. There are some pretty thick areas in this part, localized, but they are.

Deviation analysis on our deflection plots. So again, we're comparing the scanned part from our 3D scanning to the Moldflow exported warped part shape.

How many have used that warped part shape? That's something we've been doing. And of course, we send it to have a 3D printed part, and we'll give it to our designers so they can do their early builds and look at assembly and things like that, as long as we can kind of get a good material for that.

But we've been using it more to do that kind of activity. So it's a very nice tool. We'll export that.

So we took this. I sent that CAD to our 3D scanning group. And what you're seeing-- yes?

AUDIENCE: So [INAUDIBLE] instead of having your 3D scanning group actually [INAUDIBLE]

CURT RANDALL: Correct. No, they can compare all of them. Right, they can put the original CAD. They can put the scanned CAD. They can put the warped shape all in there and look at them all together, and turn them on and off. That's the nice part about the analysis software we use for the scanning comparison, the deviation. Yes?

AUDIENCE: Did you use the nominal report, or did you use the--

CURT RANDALL: No, so I did my analysis with the expanded, and got my--

AUDIENCE: So you have the [? total. ?]

CURT RANDALL: Right, I have the expanded data. I ran my warpage analysis, exported that to our scanning group.

Go back one slide here just to show you the-- so again, our numbers 60/1,000 to 80/1,000. And we'll talk about that here in a minute.

So the red is our 3D scanned part. Blue is the warped part. What we did is, in the software, you can assign the anchor planes. And we used the feature of the part where it's very rigid. You can probably-- the structure is very good, so I can use that and assume that there's not going to be much of a difference between the two. So we used that as our anchor plane.

And then you can look at the-- as it starts to go up the wall, you start to see the deflection. And this section was taken through-- you can see it through here. This is the area where we were looking out of our z direction warpage.

AUDIENCE: This is what I would like to be able to do [INAUDIBLE]. I would like to take a session [INAUDIBLE]. Relative to the CAD, because I think it's more powerful. And maybe there's a way to do it now, but I just don't know how to do it. But this is a very powerful [? plane ?] to share with my customers.

CURT RANDALL: So again, if you look closely, you can see some of the scanning errors, where they're not picking up the-- this little area is sometimes hard for the scanning to get down in those. But not a big deal.

But you can see in mine where I would simplify this model. So there's the anchor plane. Here's a close-up. The mesh is on the blue, and of course, I went in and removed some small [? fillets ?] and things like that when I did my mesh. So you can see that there and the differences. But what we could see is the difference in the 60/1,000 from warped shape to the actual scanned part. Any questions? Yes?

AUDIENCE: [INAUDIBLE]

CURT RANDALL: Have I tried to do--

AUDIENCE: [INAUDIBLE]

CURT RANDALL: One, two, three--

JEFF HIGGINS: 123D Catch?

AUDIENCE: Yeah. [INAUDIBLE]

JEFF HIGGINS: I've done some tinkering with it myself. By the way, 123D Catch, for those of you that don't know, is an Autodesk product. It's based off of our recap technology.

I will say I'm not comfortable with the resolution that it has yet, in order to do that. But it's a good start, and it's something I'm definitely keeping my eye on, at least in short term, because I think it could potentially do what we're looking for. But not yet. Yes?

AUDIENCE: [INAUDIBLE]

CURT RANDALL: Yes, but again, we're exporting the warped shape.

JEFF HIGGINS: My disagreement with that, on that, Don, is if you look over on the side here, which is the top of the wall--

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: Yeah, yes. Yes.

AUDIENCE: [INAUDIBLE] so I'm just saying that 12/1,000 [INAUDIBLE]

JEFF HIGGINS: I would expect to see--

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: Yeah, so go back to that. So I would expect to see this at the same level then, too, if it's just a shrinkage issue. The fact that that matches and that doesn't tells me there's a differential on the deflection. Right?

CURT RANDALL: Right here. So as I mentioned, all this pretty much is lying right on top of one another, and then it starts to change, going that direction.

AUDIENCE: [INAUDIBLE]

CURT RANDALL: I'm sorry?

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: Oh, did it have the same type of deflection? It actually waves a little bit. So we were looking just at this cut plane, but we can talk a little bit more about-- it does a little bit of a chipping effect.

CURT RANDALL: I was focusing on the area that our concern was in the z direction in that-- where the end of fill was.

AUDIENCE: [INAUDIBLE] same question. Your scanned part wasn't sectioned physically. [INAUDIBLE]

CURT RANDALL: No. That's correct, sectioned on the 3D analysis software to do the comparison. And that was-- I think Polyworks was the software that we brought all the data into and then did sections. You can do a lot of different things with it.

And that's something I talked with Jeff and some of the people from Autodesk about maybe next year doing a more focused presentation on 3D scanning and doing comparisons to this, because our group in GE is doing a lot of work with that 3D scanning, and we're going through a project now. I talked about the dishwasher tub. We're going to try to validate that part using 3D scanning. So I'm just starting that project, which will be good to get into that.

JEFF HIGGINS: Oh, this is me. So by the way, I don't know why you would think the DOE stuff is me. Oh, I get the clicker.

So one of the things that Curt and I started talking about, I loved all the research that was going on here, but I wanted to start finding what were the bigger influence variables in this whole process. Now understanding, of course, that we started with some basic assumptions, we didn't do the entire mold in 3D, we didn't model the inserts in, so we were doing the thermal properties out from the part to the mold. But there were some things that we were considering.

But the reason why I wanted to do this wasn't specifically because I necessarily want to show off DOE. Kind of did, but that wasn't the only reason. I wanted to start finding some influence variables. In fact, if you look, I ran my standard Taguchi then factorial and I told it to pick out the top four variables, in this case, to focus on.

When I did this, it actually pulled out some very interesting pieces of information, and it highlighted some areas for us to focus on as we start going into this next year. One of the big ones was you'll notice that melt temperature and coolant inlet temperature on one of the circuits were the biggest controllers for the global variables, as well as the warpage indicators.

Now, you can break out the flexion by the cause of warpage, but that still doesn't tell you how much influence it's having over the entire part. By running the DOE, I could figure out what my influence variables were, if there was a shrinkage or some process variable that was actually contributing to this.

But it was really interesting to me to see about 47% of my warpage was being controlled by my melt temperature. And about 24% of that was being controlled by one particular cooling line. So that tells me how critical it's going to be for us to focus on things like mold temperature next year, when we start looking at modeling the entire mold, putting the inserts in, and seeing how the influence is going to take place.

Now again, that doesn't tell me how much influence this has, but that's the next cool step I can do with this. So by completing the Taguchi, I can actually see how much influence it has, and then doing the factorial step to this, I get the ability to play with those variables and see the impact.

Now, if I look at the baseline, you can see-- to your point, Naz, it's got a little bit of a chipping effect to it. You can see what the shape of the part looked like. But when I grabbed that melt temperature and pulled it down, my part went down. Right?

So now maybe it's the impact of the insert. Maybe it's the impact of maybe doing a transient analysis. But we could actually see they were influenced by dropping the temperature on the part, and I could see the impact on warpage.

I did the same thing, then, with the cooling temperature inlet, and it did the same thing. It went down even further. And they were noticeable changes. Like, when I did that on the part, you can actually see the part move. Right, so there's a big impact right there on the overall prediction of what we're doing to this part, and the fact that maybe in this case running the DOE to highlight the fact that I do have a very significant temperature influence on this part is going to be something critical for us to pay attention to.

AUDIENCE: Can I ask you a question?

CURT RANDALL: Yeah.

JEFF HIGGINS: Yeah.

AUDIENCE: [INAUDIBLE] if it's possible to-- if anybody else is using Minitab to [INAUDIBLE] their [INAUDIBLE]. And is it possible to extract data [INAUDIBLE]

JEFF HIGGINS: Haven't tried yet.

AUDIENCE: And the only reason why we want to do that is because, again, that's what our owners are used to. So if we could put it in a format that they're familiar with--

JEFF HIGGINS: So we do have the tabular output that we can do.

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: Yeah, that actually is part of the DOE. So we can actually take a look at that. OK.

CURT RANDALL: So let's wrap up here. Keys to the successful validation, simulation validation. We talked about material characterization, the mesh type and the analysis sequence, the model and the mesh preparation, custom machine information, using absolute data, accurate process conditions, and in-cavity process monitoring. I think that's one of our big keys.

But the biggest thing, metrology for injection molding, and how we need to change what we're doing as GE is changing. We're trying to find a better way to do that, instead of the old CMM method. So many issues with that and set-ups and clamping and forcing parts into different configurations to try to get measurements. And that's just not the way, as engineers, we want to do that. So going to 3D scanning, I think, is going to be crucial.

So we did look at the pressure predictions. Short shots are very close to the actuals, with some differences that we're going to address in our 3D mesh and 3D mold mesh. Modeling of the nozzle is critical, because you have to get that pressure drop to get close to your predictions. 3D part mesh to capture some of the flow inconsistency is what we just talked about.

Mold shrinkage, again, we were just overpredicting, as we talked about the last few days, a little bit on the Dual Domain, and then the 3D, but we'll look at that more when we do our next analysis with a complete 3D mold mesh. And the deflection was underpredicted. Again, 3D mold mesh and Cool FEM is what we're going to go after next.

So the future work, we've already talked about those. Version 2017, we're going to run it through that. Cool FEM, the optimization analysis. And finally, I have-- we're working to get [? Sayad ?] down to GE, trying to get that scheduled. He can go out, we can play with the machine, we can-- it's run in production every day, so we can see it, make changes if we have to, and do some comparisons that way.

JEFF HIGGINS: I know some of you that talked to me. How many of you are familiar with [? Sayad? ?] You've at least heard me mention the name a few thousand times. OK. We have a validation engineer on staff whose entire purpose of life is validation, because that's his title, validation engineer.

AUDIENCE: Based in Novi.

JEFF HIGGINS: Based in Novi, so he has to put up with Jay and I on a regular basis. I'm not sure which is worse. But--

AUDIENCE: [INAUDIBLE]

JEFF HIGGINS: Sure. We'll go with that.

AUDIENCE: My personal opinion. [INAUDIBLE]

JEFF HIGGINS: Sorry. So yeah, our next step with this is to actually start working through some of the validation team. Because these molds are so highly instrumented, we can pull a lot of data off of these and see where we have even some gaps in what we're looking at. So this is a big next step for us.

CURT RANDALL: So I think the new mold, just like you mentioned, this dish tub, I have five valve gates and 12 thermocouples we're putting in. So now, yeah, it can be expensive upfront, but to do the validation and to do the process control, process monitoring, it's critical. I mean, and it'll help us, I think.

So how did I do? We can go on and fill out the survey. Questions?

AUDIENCE: [INAUDIBLE]

CURT RANDALL: Yes, so again, I sent 20 materials up there to the plastics labs, and they completed all the way through [INAUDIBLE]. Yes.

JEFF HIGGINS: So the material should have full mechanical characterization.

CURT RANDALL: With D3. That's right. Pressure dependent. Yes?

AUDIENCE: [INAUDIBLE]

CURT RANDALL: No, I didn't do clamping force, because the machine is bigger than what we really need for the clamping force, just because of the size of the actions, as we discussed earlier. So I didn't do any-- but we do have-- machines have mold deflection sensors. So we connect those along with our pressure transducers. So we can look at that. I just haven't done that portion yet. Any other questions?

Well, thank you very much for coming, and-- yeah, another question?

AUDIENCE: [INAUDIBLE]

CURT RANDALL: So doing the purge through the nozzle is the way we captured melt temperature. The settings weren't-- so the settings in the barrel were different than the hot runner, yes. The hot runner was a little bit warmer than what the barrel settings were.

AUDIENCE: [INAUDIBLE]

CURT RANDALL: Yes. Correct.

JEFF HIGGINS: Yeah, as we start to get more into the mold itself, we want to take a look at some of the other influences. You can-- in Moldflow, you can even model the heater bands and do a little bit more with temperature trace through the cycle. So there's going to be some conversation that take place around that too, because there are some assumptions that are being made by a beam hot runner versus actually modeling the heater band. Yes?

AUDIENCE: Did you do a purging out of your hot [INAUDIBLE] so you can take the melt temperature actually entering the part? Is that something that's possible?

CURT RANDALL: I think that's possible.

AUDIENCE: So that would kind of partially answer it, if some of the questions from the previous guys.

CURT RANDALL: I just don't know. I think the machine would limit you on speed. I don't think you can open the door and shoot the full speed.

AUDIENCE: Full velocity. So you're going to miss the shear a little bit. But, I mean, if you're essentially breaking cycle, right, you still have the residence time in your barrel, and so you might miss a little on shear, but, you know, you're going to get a sense for--

CURT RANDALL: I can do that.

AUDIENCE: OK, you know, a barrel was measured at 500 F and it's coming out at 510 or whatever.

CURT RANDALL: Think the Milacrons have a mold purge option. But again, it's at a lower velocity. I can max that out, but we can--

AUDIENCE: I think on my machines, I can actually manually eject that [INAUDIBLE]. Not sure I fully capture the melt [INAUDIBLE]

CURT RANDALL: Any other questions? Go have lunch. That's right. Thank you.

[APPLAUSE]