Chris Czeczuga Host 00:03

I am Chris Czeczuga and welcome to the Plastic Pro Insights podcast. I am a degree Plastics engineer and have been a consultant in the plastics industry for over 20 years, with a primary focus on injection molding. I'm excited to share my knowledge about plastics and their applications, from the chemical level up to the final performance level. My work includes consulting optimizing optimizing plastic parts and injection molds. I employ root cause analysis methods and am I'm a certified expert in the Autodesk mold flow software. I have created this podcast to help educate people in all facets of the plastics industry. So let's get started. Welcome to our first episode of Plastics Pro Insights. Today, I Today will talk about the viability of utilizing recycled plastics for injection molding, specifically in the automotive industry.

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Recently I was at the automotive TPO conference in Michigan. There were a lot of OEMs there, tier ones, material suppliers, and many others from the industry, and it was a great opportunity to capture the attention of all of these folks, many of whom I've worked with. There was a heavy focus on utilizing more recycled content. One of the primary discussions was about how to push the industry to adopt utilizing more recycled materials in the injection molding process, in some cases even up to 100% recycled content whenever they could. I had the opportunity to propose some of my learnings from my experience with the molders and how the folks on the floor have recently offered their opinions on the subject. When I've worked with them and received their feedback, I've learned that they really don't trust the recycled materials, which was very interesting. Because what's trust when you come to injection molding? Well, trust is about being able to make consistently good parts on the floor. If your process is consistent and trustworthy, then you're going to be making good, consistent parts. Unfortunately, they don't trust these recycled materials because the recycled materials are not consistent, therefore their process isn't consistent. And if their process isn't consistent, they can't control the quality of their parts. As soon as they recognize that, they just immediately don't want to use it. I shouldn't say it, but they just throw away that recycled material. They don't even use it. They try to use the least amount of the recycled material, but most of the time, because they can't trust it, they'll simply not use it at all and just stick to the virgin resin. I thought this discussion would be a good opportunity to create this podcast so we can discuss it and take a deep dive into the life cycle of recycled materials as it relates to the injection molding industry. Let's dive into the life cycle of injection molding plastics, from molding the part right up to the field use and the reclamation process and back to the injection molding process. Let's look at this life cycle.

03:04

To start off, the plastic goes through the injection molding process and the injection molding process can impact the quality and the properties of the plastic. If you think about it, the plastic enters the injection molding machine and hits the screw. The screw starts spinning, grinds up the plastic, the plastic starts getting beaten up by the screw itself and it starts to experience some thermal heating. There'll be thermal cycling and abuse and with both of these, and the molecules of the plastic can get broken. And when we talk about the molecules, the length of the overall starting molecule is the molecular weight and whenever that chain is broken through one of these processes. This abuse, that is what we'll call the molecular weight reduction, and that molecular weight reduction is actually polymer degradation. After the polymer goes through the injection molding process, and the makes the part. That's the best quality

experience of the material- the least broken down, the least beat up, so you get the best quality part, best properties, both when it comes to the chemical properties, the mechanical properties. That's your best part. Now let's say the part is gone through its useful life and it starts the reclamation process.

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Well, what happens in that reclamation process? If it's a part of a vehicle and it goes to a scrap yard and the parts pulled out? Where's the part? Is it indoors? Is it outside somewhere? What environmental factors is it exposed to? Does the consumer rip off maybe a fascia and they use it on another car and it goes through the second process, where it's being exposed to UV, more temperature cycles and changes, or even chemical exposure.

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In the automotive industry there's a lot of chemical exposure. You've got fuels, chemicals like brake fluid, gasoline. You got diesel. You've got radiator fluid, you've got the salt and corrosive environment of the harsh winters and those kinds of climates, again, the thermal cycling. Your vehicle sitting in a parking lot right up to once it's been reclaimed, is it just sitting out in the fields and being exposed to the sun, day in out different seasons, and so on? What are we looking at here? What exactly does the customer do with the products? Maybe it goes in the trash bin and goes right to the dump. For a vehicle that might not be the case. It'll probably get reclaimed by some recycling scrap yard and such, and then you have to be concerned about whether or not it's been indoors or outdoors, but nevertheless it's seeing some exposure to some breakdown. That recycling experience is what we're talking about.

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Does that part now get picked up and go through a sorting process? A sorting process is simply just taking it and putting it in its appropriate location or bin. That's fairly benign. But you have now another process the cleaning process. Now the cleaning process can be thermal or chemical and either one is going to create some degradation, breakdown of the polymer. When we look at chemical exposure for cleaning and so on, you want to remove any adhesives and you want to remove any oils and byproducts on that part. It's cleaned with chemicals. Then there's also the thermal process that's also used, like if it's a hot chemical bath or water bath, that'll remove any adhesives. There's steam treatments and then you have the drying and sanitation process more and more thermal exposure and thermal cycling. Finally, during this reclamation process, you're going to grind up these parts. Once they're sorted, separated, cleaned, you have to go through grinding. Grinding reminds me of what an old professor has told me is it's bastardized as the material. I know that's a crazy term, but it just beats and pulverizes that material. It's going to go through an excruciating process during the recycling process. When it's ground up like that, it's further degraded its quality, the materials now in its recycled form and it's ready to ship to the molding facilities.

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Understanding how recycling has an impact on the quality of the polymer is extremely important. When we talk about this degradation, what does it mean? Well, on a chemical level, as a plastics engineer, we refer to that as chain scission. That's when those molecules, the molecular weight, is broken and the chains become smaller. Now what happens when a chain becomes smaller? That's a lower molecular weight. So when it is lower, the chains don't entangle as much and they flow easier because there's less

entanglement, so that lower molecular weight equals lower viscosity, so it flows easier. But when you have lower molecular weight you have a loss of properties. It impacts strength, toughness, transition changes and so on.

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This discussion about molecular weight this is the big discussion, because you want to be able to control the quality of this material, ie the molecular weight. And there's two things to think about with molecular weight. That's the variation and distribution. You want to not have a whole lot of variation in your molecular weight. You want it to be if you think about the Gaussian curve or the Bell curve you want it to be under a certain part of that Bell curve so you can control that molecular weight distribution. And that's critical.

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The big question, the outstanding question I have for the industry and I've been really confronted when faced with here is how does the recycling process, how does the recycling industry control their product? How do they control that molecular weight variation and distribution? Because that's going to have your impact on the polymers properties, ie part properties. We have to think about this quality control. How do you control the molecular weight variation distribution? How do you test for it? Even bigger? I mean, if you're going to control it, you have to know how to test it and what happens when you can't control it, which is the case that we are living in right now.

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Now there might be some recyclers in the industry who claim that they are controlling it, and I've had actually somebody come up to me, multiple people come up to me and say, well, it is controlled. And I asked them well, what do you mean controlled? Do you actually test the material? And they say, yeah, we have test methods and by that, most times their testing methods, as I've learned, are the MFR. Now, the MFR, the Melt Flow Rheology, or MFI, Melt Flow Index. It's a single data point viscosity test. It's a zero shear viscosity test, so it doesn't represent the actual experience that the material is going to go through during the injection molding process. It's close to zero shear. So they're basically saying the material is going to flow this amount over this time period with almost no shear experience. So it's not a fair test. It doesn't capture the viscosity over a shear rate experience. In order to properly capture material, you can do it one of two ways. Use the dual capillary rheometer, which is a traditional method. It's a little bit more of a lengthy process, but it uses a benchmark capillary versus a changed capillary, so you can actually test the material over a wide range of shear experience, a wide shear rate range, and then you can really capture exactly what that material is doing. What they can also do, the other test method is an instrumented injection molding machine with a slit die. That is the most comprehensive way to test material and that way is the best. If you're going to do any kind of flow simulation, you have to capture all the mechanical properties, the PVT properties and, most importantly, the rheology, that shear rate curve that we're talking about, that viscosity versus shear rate.

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The big thing that really strikes me is if you're going to recycle, you have to be able to control your material. You have to test it. Now, if you test it, are you controlling it? No, you're just learning that your

material has this kind of viscosity. Well, this batch has this kind of viscosity. Well, what about the next batch?

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Well, all of these plastic parts have come from different locations, different experiences and they're going to have different molecular weights. There's going to be a tremendous amount of variation. How do you control that? You really have to go upstream and start with as soon as a vehicle hits its end of life. Just as an example, let's just say that the OEM reclaims that vehicle and they take the parts out.

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Now they can control all those plastic parts in a recycling stream, so they can control the thermal experience or the mechanical degradation experience, the chemical exposure, and create a more consistent breakdown, molecular breakdown, of the material. If they have that kind of control. Most likely you're going to be able to control your molecular weight variation, but right now we're counting on third party reclamation people who reclaimed materials for the reclamation process. So we've got to make sure that, even though we're testing the materials, we know what we're actually testing for. Okay, so until they get a control over the actual experience of these parts the experience meaning the thermal experience, the chemical experience, the mechanical experience the existing solution that they're using is going to be used and that's not going to be accepted in the industry. It's just not. And fortunately I have to speak the truth here because of what I've learned in order for the guys on the floor to trust these recycled materials, they have to be consistently controlled and have to be high quality resins, and we're just not seeing that right now, which is the whole point of this podcast. So if we can get that control of the molecular weight and the molecular weight variation, we're going to be able to use more recycled materials.

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Now, if there's not a way to get a great grasp, but we get very close to it, we can start incorporating more of the recycled resin and blending it with the virgin material. Because when you blend recycled materials, if it's really a poor recycled material with a tremendous variation and no control. So batch to batch to batch is totally different. You can't use a whole lot of that recycled resin because you're not going to have a process that's controllable on your injection molding machine. So you can only add a little bit of that to the virgin resin you know, and vaguely dilute the virgin resin. Now that virgin resin is going to take over and you're going to have control. But if you start controlling your recycled material, you can add and incorporate it and blend more of it in with your virgin material. So you'll be using more recycled content.

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And what I neglected to say and I did bring this up in a recent meeting with a major OEM is the OEMs have to start designing parts for recycled resins. Now what's that mean, designing parts for recycled resins? Well, certain parts are in certain areas of the vehicle that are less seen, less class A surface in the industry terms. So if they are like a fascia bracket and under the hood bracket, let's just say bracket, something that needs good mechanical control. But you know it doesn't. It can warp a little bit. The glass transition is not critical, it's just basically holding something in place. It doesn't have to be, you know,

aesthetically pleasing at all. So you can use more recycled materials, maybe up to 100% if it's quality recycled resin on certain parts like that.

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And then, once again, if the OEM let's just say, reclaims the car at the end of life and controls that recycled process, then they can take those parts, put them in their recycle loop and utilize certain parts controlling a recycled process for certain applications. So the second recycled pathway, so the downcycling of that part is again used in a car, but just in a different location for a different purpose. We can do that until the resin is just totally beat to crap and you can then use it to make plastic lumber or car stops in the parking lot, just things that you still don't have to throw the polymer away. It still has a use. But it cannot be used in the automotive industry just because it's just been beat up too much. So you have to be able to recycle it, capture it into your recycle loop, but then also maybe stamp or keep control on the part revealing how many times it has experienced recycling. Once it's been degraded to a point it can't be used at all anymore. It's just no good. So the big focus here is on this reclamation process.

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To summarize this whole discussion, using recycled plastics is currently challenging. It's challenging because it's got variation in molecular weight which affects the process control and part quality. It's difficult to ensure the consistency of that recycled material and the lack of knowledge about the materials history leads to unpredictability. So this material is just out there, whether it's in a vehicle or somewhere else. Is the consumer reclaiming it? Is it going through a third party? What are they doing to the material?

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Its history is very unpredictable and unknown and that history needs to be captured to create this control.

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Once it's captured and there is control, there has to be good existing test methods. More of the industry is relying on flow analysis and without proper testing, flow analysis cannot predict properly. So there has to be good process test methods in order to run flow analysis that have confidence in prediction, like warpage and quality prediction, as well as having the confidence in processing. So that brings us to the end of this podcast and I think this is a very important topic and it's going to be challenging and I'm sure this topic is going to resurface many times after this podcast and I'll do follow-ups as things go on, but right now I'm really pushing the industry, and by pushing I mean just mentioning, like this podcast, to everyone that we need to be able to control this recycling process and then control the test methods so that everybody in the engineering group and processing group, everybody on the whole production stream has confidence and is willing to use these recycled materials. So thank you for your time today.

Carol Dorsey Host20:39

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