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Automate ... or Else

If your molding process isn't automated, it's likely not as efficient as it can be.

Photo:Piab

I remember the first time I went up to Bolton, Ont., to visit Husky, the injection machine builder and moldmaker. It was more than 25 years ago. Their marketing executive at the time took me on a tour of the multiple-building campus. He loved doing these tours. He proudly pointed out how pristine each and every corner of every building was. He didn't have to emphasize that, because even back then, as an up-and-coming plastics reporter, I knew that making and assembling industrial machinery could get pretty messy, but there was nary a spot of grease on the floor on any of the multiple buildings I visited, and I visited them all.

Jim Callari
Editorial Director

I recall reaching an area on the ground floor of one building whose walls were adorned with plaques and framed images of advertising, marketing and editorial materials by or about Husky. One in particular caught my eye, and obviously left an impression. In my mind's eye, even today I can see a two-page blow-up of an article that Robert Schad, Husky's founder and then owner, had written for one of the many plastics industry publications at the time (I think it was *Modern Plastics*). I remember Schad's black-and-white picture was part of that two-page blow-up. I'm fuzzy on some of the other details, but I vividly recall the headline of the article: "Automate or Die." Wow, I thought to myself. Pretty dramatic stuff.

That article was written more than 30 years ago. Bob Schad was clearly a man of vision. (And still is: he ultimately sold Husky and went on to start another machine builder, Athena Automation, now known as Niigon Machines Ltd.) But over the years, I couldn't help but wonder if U.S. molders were heeding his prescient words of warning. For a long time, my feeling was, "Not fast enough, certainly not at the pace of European molders." But things now are changing, and fast.

Our parent company, Gardner Business Media, has a marketresearch division called Gardner Intelligence. I wrote about this division in the June issue. Among other projects, Gardner Intelligence does an annual Capital Spending research project. Conducted in late summer, this survey asks our audience of custom and captive processors to indicate where they will be investing their capex funds in the coming year. Over a 10-yr period that began in 2008, capex investments in robots have almost doubled.

I saw this report recently, and figured the increase in spending was likely explained by the ongoing "workforce development" problems that plastics and most other manufacturers are confronting. But digging deeper into the most recent study, I found that was not the case. Some 20% of the survey respondents said they'd be investing in automation to improve productivity and efficiency; 19% to increase capacity; 16% to improve quality; and another 16% to update existing technology.

I bring all this up because molders today are confronted with more choices in robotics and automation, and in this issue we devoted 10 pages to helping you decide which among the three major types of robots are right for your operation. I invite you to take a look. The world of manufacturing is evolving rapidly, and if you haven't taken the time to evaluate automation in your plant, best to do so. Because in the time between when this article is sent to the printer and when it reaches your hands, industry will have changed some more. Automate or die? That's maybe a bit scary. But the alternative is scarier. Automate or else. PT

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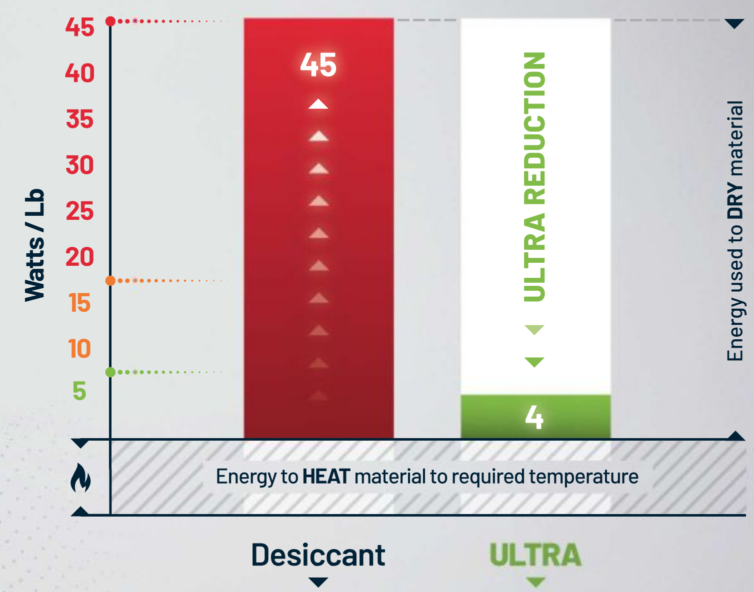

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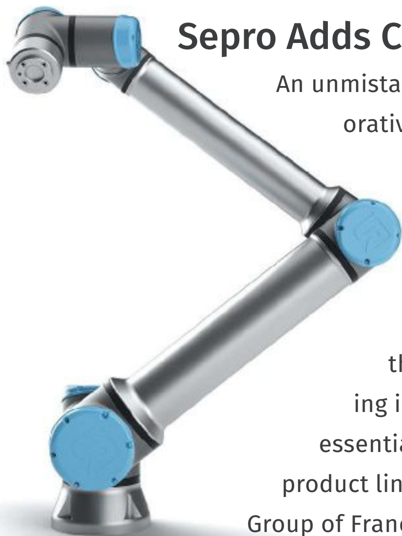


Sepro Adds Cobots to Its Line with Universal Robots Partnership

An unmistakable sign that collaborative robots ("cobots") are taking hold in plastics processing is growing evidence of conventional robot suppliers concluding that cobots are becoming important, perhaps essential, additions to their product lines. Most recently, Sepro Group of France announced a partnership with leading cobot maker Universal Robots of Denmark. This means that Sepro will integrate its Visual control system with UR cobots sold by Sepro as part of an automation system. The Visual control platform was developed by Sepro especially for robots used with injection molding machines, and is used with Sepro's own Cartesian robots and co-branded articulated robots from Staubli and Yaskawa Motoman. Sepro says the Visual control will now ensure seamless integration of the UR cobots with other Sepro robots and the molding machine. What's more, Sepro will now provide global service for automation systems including robots from Sepro and UR, using Sepro's 42 service centers around the world. Sepro will show off its new cobot solutions at the K 2019 show in Düsseldorf this October.

SABIC to Expand Capacity of Ultem PEI and Extem TPI

Significant investments in adding capacity for its high-heat engineering resins Ultem PEI (polyetherimide) and Extem TPI (thermoplastic polyimide) are planned by SABIC. Announced at Chinaplas 2019, this expansion will come on stream at a new plant in Singapore, which will boost capacity for these resins by more than 50%. In addition, investments to stretch the company's short-term capacity were made to support immediate growing demand, especially in electrical/electronics markets.

Borealis Starts Up U.S. Compounding Plant for TPO & Short-Glass PP

Austrian polyolefins producer Borealis has made its entry in North American production with the recent inauguration of its PP compounding plant in Taylorsville, N.C. The 50,000 ft^2 facility, with rail siding in place, adds an additional 66 million lb/yr of capacity for TPOs and short-glass-fiber PP compounds. Among the first products made in the new facility are those for auto interior and exterior parts. In addition to compound manufacturing, the new facility also features testing and product-development capabilities.

Haidlmair Spins Off New Hot-Runner Company to Sell Novel FDU Nozzle

Since 2016, Haidlmair Group of Austria has offered injection tooling incorporating a unique hot-runner nozzle design shaped like a sheet extrusion flat die. Called the Flat Die Unit (FDU), it passes melt through a long slit (roughly 120 to 280 mm long and 6, 25 or 44 mm wide) instead of a circular hole like a conventional nozzle. The result is said to be faster injection of more melt through a thinner gate opening, with lower shear and injection pressure, lower melt temperature, and up to 25% faster cycle time in several projects. Haidlmair says the FDU is particularly suitable to polyolefins, including recycled material. Up to now, the FDU has been available only with Haidlmair molds. But now, a separate company, FDU Hotrunner GmbH in Frankenthal, Germany, has been launched to supply the nozzles to other moldmakers. In development is a valve-gate version called FDU SLS (Slot Lock System). The new firm (***fdu-hotrunner.com***) is headed by Andreas Kissler, formerly Haidlmair's FDU manager, and before that he spent 26 years with German hot-runner supplier PSG. The new company will exhibit at the Haidlmair booth at October's K 2019 show in Dusseldorf.

Agr International Adds PET Bottle Line Optimization Services

Agr International, supplier of process-control and online QC systems for PET blow molding, is offering a new service to help bottle makers optimize their production systems. Agr's new Process Performance and Optimization Group can provide production-line auditing and optimization planning, as well as job-specific services such as recipe design and startup assistance. Its services are not tied to any particular brand of blow molding machine, and Agr's Process Group takes a "holistic" approach towards optimization that focuses not only on the blow molder, but includes container flow downstream, leading to improved pack rate. Its services can include use of the company's Pilot Profiler and Process Pilot automated QC and process-management tools, but are not limited to plants using its equipment.

Absolute Haitian Opens Its First U.S. Machine Assembly Plant

In May, Absolute Haitian Corp. opened its first U.S. assembly plant for injection machines from Haitian International in China. Measuring 116,000 ft^2, the just-completed building in Moncks Corner, S.C., near the port of Charleston, houses not only manufacturing and warehouse space, but also demonstration, training, spare-parts, and sales facilities. Equipped with drive-in dock, two 25-ton cranes, one 50-ton crane, and a central chilling system, the new operations center will assemble and test larger presses—to start with, roughly 700 tons and up. These will include mainly Jupiter two-platen, servohydraulic machines; Jenius hybrid two-platen machines; and servohydraulic Mars 2S toggle presses—Haitian's top seller in the U.S. A mold-test area is equipped with individual chillers and temperature-control units (TCUs) to duplicate conditions in the customer's plant. The new operation will bring in major mechanical subassemblies from China, as well as controls and other electrical and hydraulic components from various domestic and international suppliers.

The grand opening ceremony was attended by the CEOs of both the Haitian Group and Haitian Plastics Machinery, as well as the three co-owners of Absolute Haitian—Nathan Smith, Michael Ortolano and Glenn Frohring. The new facility "positions us well to reduce lead times on delivery and enhance support to our customers," said Ortolano. On display at the opening event were a Mars 2S MA 3200 (320 metric tons), Jupiter JU 6500 II, Jenius JE 6500, Venus VE 2300 all-electric unit, and Zeres ZE 2300 electric press with integrated hydraulics for core

pulls—Haitian's fastest growing line in the U.S. At that time, the plant held in stock an additional 45 or so Mars, Zeres and other machines from 60 to 190 m.t. As explained by Frohring, customers benefit not only from the large stock of machines for quick delivery, but also from the ability of customers to attend run-off of a large press here rather than in China. The new assembly capability also gives Absolute Haitian added flexibility because drives, for example, may be interchangeable between different machines. Frohring also noted that the new tariffs have only a small effect on prices of these machines, which remain highly competitive.

It was announced at the event that Absolute Haitian just broke ground for an even larger assembly plant — 259,000 ft^2 — with similar capabilities in Mexico, due for completion in two years.

LSR Molders Now Can Tailor Cure Speed, Temperature & Durometer

Elkem's LSR Select is enabling faster cures at lower temperatures and custom durometer blends. Dosing equipment has caught up with the capabilities of this novel material system.

By Matt Naitove
Executive Editor

After five years in development, a radically different approach to LSR processing has made its commercial debut. Called LSR Select, the technology allows injection molders a new freedom to adjust the cure time and temperature, as well as the durometer, of their LSR formulation, no longer limited to the choices among standard two-part systems on the market. In many cases, faster cures and/or lower cure temperatures are possible, as well as fine-tuned durometers different from those offered in standard LSR systems.

LSR Select was introduced publicly at the Molding 2014 Conference in January 2014 in San Diego. It achieved limited production use while it underwent further development, until its commercial launch in 2018. LSR Select was originally developed in the U.S. by Rhodia Silicones, which later became Bluestar Silicones, a Chinese-owned company. The technology is now under the wing of Elkem Silicones, div. of a Norwegian company (Elkem ASA), purchased by China National Bluestar in 2011. All the Chinese parent's silicones activities are now under Elkem Silicones.

Ability to "dial in" cure time, temperature, and Shore hardness offers new flexibility to LSR molders. (Photo: Elmet)

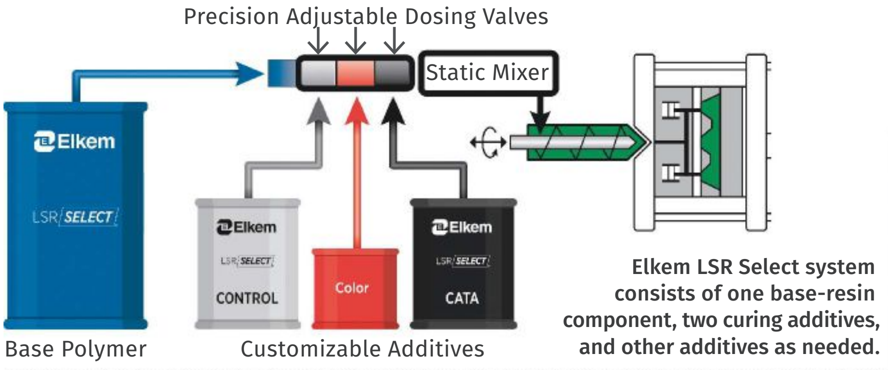
NOVEL ONE-PART LSR SYSTEM

The first thing that distinguishes LSR Select from standard two-part ("A" and "B" sides) systems is that it has only one base-resin component, two curing-agent additives, and potentially other additives to achieve specific properties. A typical two-pot LSR system has one base resin component with catalyst mixed in and a second base-resin component with inhibitor blended in. The two are typically blended 1:1 by the pumping/dosing unit. The curing behavior is built into the system, though it can be varied to some extent by adjusting temperatures of the mold and/or injection-machine barrel.

The arrival of Elmet's TOP 5000 P high-precision dosing system was a "game-changer" in enabling commercialization of the LSR Select technology.

According to Chris York, president of Elkem Silicones Americas, E. Brunswick, N.J., "We took apart the two-component LSR system and put it back together as three components." An LSR Select formulation consists of one resin component plus a catalyst masterbatch additive ("LSR Select Cata") and a cure-control agent ("LSR Control"), which serves the function of the inhibitor in the two-part package. The platinum catalyst masterbatch is added at a fixed percentage—typically 1%, while the amount of control/inhibitor additive can be varied over a range of 0-6%, according to the cure speed desired. Adding more of this agent delays the gel and overall cure, and vice versa.

Separating these components and allowing the molder more control of the cure profile "sets the chemistry free to do things it has been ready to do for many years," says York. For example, a lesser amount of the control/inhibitor additive can help speed curing of smaller parts, while a larger addition of control/inhibitor could ensure complete filling of larger parts without pregel but achieve faster overall cure than would otherwise be possible. Elkem claims—"very conservatively," according to York—that molding productivity can be improved by 20% to 60%, though improvements of up to 125% been verified in some trials.



Elkem LSR Select system consists of one base-resin component, two curing additives, and other additives as needed.

As the technology continues to evolve, Elkem anticipates coming out with specialty additives for antimicrobial, self-bleeding, self-bonding, and other properties. These additives will be used with standard base resins, eliminating today's need to buy specialized A-B formulations to achieve these properties.

Although speed was the first goal in developing LSR Select, York says that two other benefits have emerged more recently. One is the ability to mold at lower temperatures, which can save energy and permit overmolding LSR onto lower-temperature thermoplastics like PP. LSR Select has been molded at temperatures down to 75-80 C or lower, vs. a more typical 165-170 C or higher, with little or no sacrifice in cure speed. For example, a part molded with a 50-sec cure at 165-170 C can now be molded in 50 sec at 100 C.

A second newly realized benefit is the ability to blend base resins to tailor final product durometer. Two different LSR Select base resins can be placed in the same two-part pumping system to achieve intermediate Shore durometers, even more so if the metering system is capable of adjustable A-B ratios.

Elkem's LSR Select base resins are currently available in four hardnesses from 20 to 70 Shore A, and in Silbione LSR Select medical grades over the same range. York claims that LSR Select materials are more consistent within the same batch, so that the usual durometer variability of ±3-5 Shore A units now can be held to ±1-2 units. Part of that improvement is also due to the advent of more precise metering machines.

SPECIAL EQUIPMENT NEEDED

The number-one factor in the long gestation of LSR Select technology, according to York, is that "the equipment finally caught up with the materials technology." The key factor was developing the ability to meter precisely and repeatably to two cure additives. Although Rhodia (now Elkem) began by working with Graco to develop a special metering system, this was never an off-the-shelf product and only a few were built.

The breakthrough, says York, was the arrival in 2016 of the high-precision TOP 5000 P metering/pumping system from Elmet of Austria. "It's a game-changer," states York. Its extremely stable pumping of the base resin for precise durometer blends, and additive metering accuracy of ±0.1%, plus various software improvements, are said to provide reliability and traceability. Software adaptations also provide for variable A-B ratios in order to tailor durometer blends. Elkem is working with several other equipment suppliers to provide systems suitable for LSR Select.

Elkem says it has a handful of commercial users for LSR Select in healthcare and industrial applications, and several more in trials or "on the verge" of commercialization.

MATERIALS

PART 1

The Importance of Mold Temperature When Processing Polycarbonate

An often overlooked factor in optimizing the ductility of PC is the rate at which the polymer is cooled in the mold.

By Mike Sepe

Polycarbonate has been a commercial material for more than 60 years. At the time of its development it represented a significant extension of the properties that were available in a transparent material. Clear commodity materials like general-purpose polystyrene and acrylic that had been available for decades before the invention of PC tend to be brittle unless impact modified, and they lack the heat resistance that PC offers. Higher performing transparent polymers such as the family of sulfone-based materials that were developed after the introduction of polycarbonate are typically not water white and also exhibit greater notch sensitivity even though they display good inherent ductility.

Polycarbonate has an established history of being utilized in innovative applications in the E/E and automotive arenas. On the horizon for the material are applications in new “e-mobility.” Photo: Covestro

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PC, therefore, occupies a niche that has allowed it to grow to a level of global consumption that is approaching 10 billion lb. As such, it represents a little over 1% of all the plastic that is consumed worldwide in a given year. However, those involved in failure analysis will tell you, anecdotally at least, that approximately 15% of the failed parts that they evaluate are made from PC. And despite its reputation as a “bulletproof” material, many of the fracture features we observe under the microscope are brittle.

An often overlooked factor in optimizing the ductility of PC is the rate at which the polymer is cooled in the mold.

This is not an indictment of the polymer. It is, however, an illustration of how things work when the real world collides with the expectations of designers and engineers that are based on published properties. One of the most well-known performance characteristics of PC is a property that is always included on the data sheet: the notched Izod impact resistance. PC routinely registers values of 12-18 ft-lb/in. (640-960 J/m). Most polymers fall well short of these numbers. If they do approach them, they usually do so because they rely on impact modifiers and consequently sacrifice strength and stiffness. But there are many influences that can erode the impressive numbers that contribute to the reputation of polycarbonate as one of the toughest polymers on the market.

Probably the best known of these is sensitivity to a wide range of chemicals. These promote chemical attack or environmental stress cracking (ESC). At NPE 1979 one of the major manufacturers of PC at that time devoted a significant amount of floor space to demonstrating the impact resistance of a PC front bumper for automobiles. The bumper was put through a very ►

impressive demonstration of its toughness several times each day. The application never happened in the real world, largely because of the number of fluids that are part of the automotive end-use environment. The final material of choice, at that time, was an alloy of PC and polyester, with the semi-crystalline polyester providing the needed chemical resistance.

The addition of color can have a substantial effect on the toughness of the base resin. The degree of change in impact resistance will depend upon the color, the chemistry chosen to create it, and the amount of colorant added. The effects on ductility are more noticeable in specimens that are notched than in those where no stress concentration is present. The molecular weight of the PC being colored will also influence how the impact performance of the material is affected by the color. Higher-molecular-weight grades preserve their impact properties better than lower-molecular-weight grades, especially in the case of opaque colorants.

Many industry practitioners are also aware of the fact that PC is sensitive to the effects of moisture at elevated temperatures. This can cause problems for molded parts that are exposed to high heat and high humidity at the same time, such as in the so-called 85/85 test for electronic enclosures that involves 1000 hr of exposure to 185 F (85 C) and 85% relative humidity. While neither this temperature nor this level of humidity alone presents any challenges to the performance of polycarbonate, the combination will produce a substantial reduction in the molecular weight of the polymer.

One of the most notable early failures of PC came in the small-appliance industry when the material was molded into parts that routinely handled hot water. The short-term effects of this application environment were negligible. But over time with repeated exposure the material began to embrittle and crack. The same mechanism, known as hydrolysis, will take place very rapidly if the polymer is processed without first properly drying the resin. What occurs over hundred of hours in the solid state takes place far more rapidly when excess moisture in the pellets is exposed to processing temperatures of 536-608 F (280-320 C)for several minutes. The resulting polymer degradation reduces the ductility of the polymer.

But an often-overlooked factor in optimizing the ductility of PC is the rate at which the polymer is cooled in the mold. Many years ago, I had a client that perennially complained about its brittle PC parts. The client blamed this on the resin manufacturer initially, and when the client did finally turn its attention inward, it focused on drying as the key to improving performance. While this was good, it did not solve the problem. The missing piece was the mold temperature. This processor that molded parts for its own product line, routinely ran its molds at 110-120 F (43-49 C) in order to minimize cycle times. Several times, it was demonstrated that when the parts were produced in molds that ran at 180-190 F (82-88 C) the parts displayed excellent toughness. This was done with no penalty in cycle time. But old habits can be hard to break, and soon after the changes were made, technicians within the plant intervened, turning the mold temperatures back down and reintroducing the brittle condition.

Lower mold temperatures and the associated faster cooling rates produce higher levels of internal stress in the molded part. This arises in part because of the more rapid development of the frozen layer as the material flows into the mold. This can result in flow lines that are visual evidence of impeded flow. It also produces a higher degree of retained orientation in the more rapidly cooled layers at the exterior surface. Orientation is useful for promoting shear thinning and reducing the viscosity of the material as it flows into the cavity. But if too much of the orientation is retained in the final part, the properties become anisotropic, maximizing strength and stiffness in one preferred direction but creating a weaker condition in other directions.

An even larger contributor to internal stress is the difference in cooling rate between the layer of material that is in direct contact with the mold surface and the interior material. Plastics are poor conductors of heat. Therefore, the interior layers in a part cool more slowly than the surface layers. Running a low mold temperature exaggerates this difference in cooling rate. Variations in the cooling rate in the different layers of material that make up a part produce differences in shrinkage. This problem becomes magnified as the walls get thicker. This shows up as a phenomenon known as critical thickness, a property particularly well documented in polycarbonate. This behavior is observed as a very large reduction in notched Izod impact resistance as the wall thickness of the test specimens increases.

Lower mold temperatures and the associated faster cooling rates produce higher levels of internal stress in the molded part.

All this supports the argument that hotter molds produce parts with better properties, even in an amorphous polymer like PC where there is no expectation that a crystal structure has time to form. But what is the optimal mold temperature? In our next segment we will cite case studies where mold temperature was used to improve performance as a way of answering that question. PT

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INJECTION MOLDING

How to Deal With Residual Stress in Molded Parts

Here are design, molding, and fixturing considerations to help you handle this unavoidable issue.

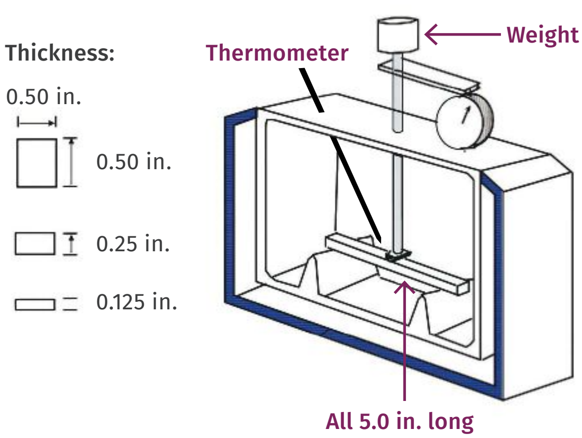
By John Bozzelli

I often start my articles noting the large number of variables involved in injection molding. And I do appreciate feedback from readers, so my thanks to Rick White of Thermal Tech Equipment in Kansas City for pointing out one variable that I have completely ignored: the residual stresses in injection molded parts.

This is an issue in all injection molded parts and the fact is, we cannot mold even the simplest plastic part without some residual stress. This residual stress should be evaluated during design, molding, fixturing and part performance. Residual stress can be significant and often shows up as part failures after the part has been shipped, assembled and in use for a while. How and why is this?

The answer is straightforward. A part fails when the sum of the internal or residual stress and the external stress exceeds the strength of the plastic. We will start with an easy-to-mold part, a test specimen for DTUL (heat-distortion) testing

FIG 1 **Common DTUL Bar and Test Apparatus**



The common DTUL test bar is 5 in. long × 0.5 in. wide × 0.125, 0.25 or 0.5 in. thick. The test sample is shown in Fig. 1. Note that the thickness of the test sample can vary and it can be made by injection or compression molding. Also, you have the option of testing it as-molded or annealed. Annealed means the part was warmed to a temperature that allows most of the molded-in stress to be relieved. The point is that this an easy part to injection mold, yet when tested under ASTM 256 test conditions there is a significant difference between an as-molded part (unannealed) and an annealed or nearly stress-free part.

The data shows a 40° F (22° C) difference between unannealed and annealed for an injection molded part, and 39° F (21° C) for the unannealed vs. annealed compression molded specimen at the specified thicknesses (Fig. 2). Clearly, there is residual stress in this relatively simple, uniform-thickness part.

We cannot make even the simplest injection molded part without some residual stress.

Note: I am not in any way justifying the ASTM DTUL test. My fellow *Plastics Technology* Know-How columnist Mike Sepe has written several articles detailing the flaws of this test and I agree that it provides little, if any, practical information. I am using it only as an example of a relatively simple part that is easy to injection mold and yet it has significant residual stress.

Let us move on to more typical injection molded parts that have significant changes in nominal wall thickness and often include complex geometries. When these parts are injection molded, far more internal residual stresses are developed. Why?

Here are some factors that cause residual stress in plastic parts:

1. Thermoplastics are long-chain molecules. Their resting or stress-free state is a coiled chain, something like a slinky. When pulled (stressed) the slinky straightens out, but you can feel the "residual" forces that are trying to return it to its resting coil shape. The stretching out of the coil is something like what happens to plastic molecular chains when flowing under the shear stresses of injection molding.

2. During filling of a part, we are forcing the uncoiling of the polymer chains; and, depending on nominal wall thickness, they may or may not have time to re-coil. In thin-walled parts, most are frozen in the stretched-out or stressed state. In thicker parts, the polymer chains have more time to re-coil before solidifying,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You will learn a lot about residual stress if you thermally cycle your parts after molding.

and there is less residual stress. It gets even more complex, because cooling is not uniform throughout the wall thickness. The surface of the part cools quickly because it is up against the relatively cool steel. Below the part surface, the plastic is somewhat insulated by the outer skin, as plastic is a poor conductor of heat. Therefore, the polymer chains in the middle of the part have more opportunity to re-coil themselves, and have less residual stress, than the polymer near the surface of the part.

3. Injection rate plays a role—faster fill times develop more shear, molecular orientation and residual stress. Slower injection provides less orientation and stress. Plating and painting applications usually require slower fill rates to keep orientation low.

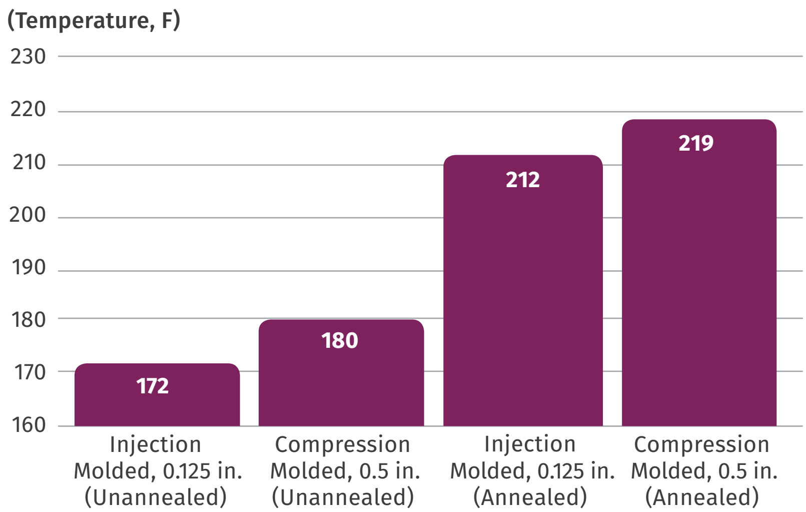
4. High mold temperatures usually provide less residual stress. Lower mold temperatures provide more residual stress. You can make a part a bit bigger with low mold temperatures, but it is going to have more residual stress and if it goes through a thermal cycle—like, for example, a part for the interior of a car—it will slowly continue to shrink, forcing the part to warp, crack, or fail in its application. In addition, plating and painting applications often require higher mold temperatures so the plating or paint sticks properly. They do not stick as well if the surface is highly stressed.

5. Once a part is ejected from the mold, there is nothing to constrain non-uniform shrinkage, so some parts warp or bend out of shape as they cool. So, some molders like to fixture the parts to hold them in the desired position until cooled. The problem is that they develop even more residual stress when fixtured. You are really inviting “Murphy” to the party at your expense.

6. Pack-and-hold time causes gates to freeze or not freeze. Polymer molecules are something like humans. We have a social distance that we are comfortable with. For example, when talking with another person it can get uncomfortable if they are too close or too far away. Molecules are similar; they do not like to be too compressed or close together or too far apart. The gate area of most parts is often a highly stressed area due to this packing or unpacking caused by gate seal or unseal (frozen or unfrozen) and the shear forces of injection.

7. Thin sections of a part cool faster and shrink differently than thick sections. Tie them together in the same part and you get high internal stresses. The part may deform over time.

FIG 2 **DTUL Data for Injection and Compression Molded Test Bars**



DTUL test bars, when tested under ASTM 256 conditions, show significant differences between as-molded (unannealed) parts and annealed or nearly stress-free parts.

8. Ejection not done properly can cause residual stress. Breaking the part away from the mold needs to be done evenly across the part with no sticking, binding or distortion.

Due to these and other issues not discussed here, it is wise to ask of the part, "Can it handle the stress?" This needs to be done before production and initial sampling. How?

This is relatively simple and should be done for all molding programs. You will learn a lot about residual stress if you thermally cycle your parts after molding. That is, put them in an oven and see what happens at around 230 F (110 C) then cool them down to -40 F (-40 C). And repeat. A bit time-consuming, but better to learn about problems before production rather than after the part is in the field.

Bottom line: Just because the part seems OK as it comes out of the press, it may not function properly in the long term. Parts continue to shrink and move over time. For those of you fixturing parts to force them to hold the desired shape, beware. You are trying to beat "Mother Nature," and few people win that game.

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A Bright Future for Thermally Conductive Plastics

Lighter weight, lower cost, and greater impact strength, moldability and customization are rapidly driving demand for thermoplastics that help keep electronics, lighting and car engines cool.

PolyOne's thermally conductive compounds are used in automotive and E/E applications such as LED lighting, heat sinks and electronic enclosures.

By Lilli Manolis Sherman
Senior Editor

OEMs in industries such as electrical/electronics, automotive, lighting, medical devices, and industrial machinery have been hot for thermally conductive thermoplastics for several years now, as they seek new solutions for applications that include heat sinks and other heat-removal devices, LED enclosures, and electric battery housings.

Industry studies have indicated these materials are growing by double digits, driven by new applications like all-electric vehicles and complex automotive and large commercial LED lighting assemblies. Thermally conductive plastics are challenging more traditional materials such as metals (notably aluminum) and ceramics because they offer a gamut of advantages: Plastic compounds weigh less, cost less, are easy to mold, can be customized, and also offer more in the way of thermal stability, impact strength, and resistance to scratching and abrasion.

Additives that boost thermal conductivity include graphite, graphene and ceramic fillers such as boron nitride and aluminum oxide. Technologies for their use are also advancing and have become more cost-effective. Another trend is the entry of lower-cost engineering resins such as nylons 6 and 66 and PC in thermal conductive compounds, making inroads against higher-priced materials that were more typically selected, like PPS, PSU and PEI.

> ***"Ability to mold net-shape parts, reduce component counts and assembly steps, and reduce weight and cost are all drivers for the adoption of these materials."***

WHY DEMAND IS GROWING

What's the fuss about? "The ability to mold net-shape parts, reduce component counts and assembly steps, and reduce weight and cost are all drivers for the adoption of these materials," says a source at RTP. "For some applications, such as electrical housings and component overmolds, the ability to transfer heat while being an electrical isolator is a large point of interest."

Adds Dalia Naamani-Goldman, market segment manager for E&E transportation in BASF's performance materials business, "Thermal conductivity is rapidly becoming a growing concern for electronic component manufacturers and automotive OEMs. As applications miniaturize due to technology improvements and space constraints, heat buildup and dissipation become more of a focus. Adding metal fins or inserting metal components is difficult if component footprints are limited."

Higher voltage applications are penetrating motor vehicles, and processing power demands are growing, Naamani-Goldman explains. In electric-vehicle battery packs, using metal to disperse and dissipate heat adds weight, making it an undesirable option. What's more, metallic components running high levels of power can create dangerous electrical shocks. A plastic resin that is thermally conductive and *not* electrically conductive can allow for higher voltages while remaining electrically safe.

Celanese's CoolPoly TCP thermally conductive nylon 6 compound is used in Ford headlamp heat sinks.

James Miller, field development engineer for Celanese (formerly with Cool Polymers, which was acquired by Celanese in 2014), says electrical and electronic components, particularly those in electrified vehicles, continue to shrink as component spaces become more physically crowded. "A factor limiting the size reduction of these components is their ability to manage heat. Improvements in thermally conductive packaging options enable smaller and more efficient devices."

In power electronics, Miller points out that thermally conductive plastics enable overmolding or encapsulation, a design option not available with metals or ceramics. In the case of heat-generating medical devices, such as those with cameras or cauterizing components, the design flexibility of thermally conductive plastics enables lighter-weight functional packaging.

Noting that the automotive and E/E sectors have the greatest demand for thermally conductive compounds, Jean-Paul Scheepens, general manager of PolyOne's specialty engineered materials business, says these products meet multiple customer and industry needs, including expanded design freedom, enabling designs with increased surface areas for more thermal variability. "Thermally conductive polymers also offer greater lightweighting options and parts consolidation, such as incorporating a heat sink into the same component as the housing, and the ability to create more uniform thermal-management systems. The favorable economics of the injection molding process is another positive factor."

Joel Marsco, senior marketing manager for polycarbonates at Covestro, sees thermally conductive plastics finding traction primarily in automotive applications. "With approximately a 50% density advantage, they can contribute significantly to lightweighting. This can also extend to battery electric vehicles. Many battery modules still use metal for thermal management, and since most modules use many repeating structures internally, weight savings from replacing metal with a thermally conductive polymer adds up quickly."

Covestro is also seeing a trend toward weight reduction in large commercial lighting assemblies. "A high-bay light weighing 35 lb rather than 70 lb requires less structure and is easier for installation crews to handle on a scaffold," notes Marsco. Covestro also has projects for electronic housings such as routers, where the plastic component serves as a container and provides thermal management. "In all markets, we also find a cost reduction of as much as 20% can be realized, depending on the design," says Marsco.

BEATING OUT METAL

PolyOne's Sheepens says key automotive and E/E applications for its thermally conductive technologies include LED lighting, heat sinks and electronic enclosures, such as motherboards, inverter boxes, and power/management/safety applications. In a similar vain, RTP sources see their thermally conductive compounds being used in housings and heat sinks, as well as more integrated heat-spreading components within industrial, medical or electronic devices.

Covestro's Marsco says the primary application in commercial lighting has been metal heat-sink replacement. Similarly, thermal management of high-end network applications is growing in routers and base stations. Electronic components specifically noted by BASF's Naamani-Goldman include bus bars, high-voltage junction boxes and connectors, motor insulators, and forward- and rear-view cameras.

Thermally conductive plastics thrive in delivering 3D design flexibility for the higher thermal-management requirements of LED lighting, says Celanese's Miller. "In automotive lighting, our CoolPoly thermally conductive polymers (TCP) have enabled enclosures for low-profile overhead lighting and aluminum-replacing heat sinks for external headlamps," he adds.

Celanese's Miller says CoolPoly TCP provides a solution for the growing segment of automotive heads-up displays (HUD)—an application that requires higher heat dissipation than lighting, due to the confined dashboard space, which has limited airflow, as well as the heat from sunlight that bathes this location of the car. "The lightweighting advantage of a thermally conductive plastic over aluminum reduces the effects of shock and vibration in this part of the vehicle, which might cause image distortion."

In battery housings, Celanese has found creative solutions with CoolPoly TCP D-Series, which provides thermal conductivity without electrical conductivity, to address the relatively stringent critical-to-quality requirements of the application. Sometimes the reinforcements in thermally conductive plastics limit their elongation, so Celanese material experts have developed a nylon-based grade of CoolPoly TCP that improves toughness 50-100% over typical grades without sacrificing thermal conductivity or density.

RTP's thermally conductive compounds are used in housings like this battery case, as well as heat sinks and more integrated heat-spreading components.

CoolPoly TCP provides flexibility in convective design to meet the heat-transfer needs of numerous applications that historically used aluminum, with the benefits of injection molding using one-third as much energy as aluminum die casting and offering a six-fold longer tool life.

In automotive, the primary applications are replacement of heat sinks in headlamp, fog-light and taillamp modules, according to Covestro's Marsco. Heat sinks for LED high- and- low-beam functions, LED light pipes and light guides, daytime running lights (DRL), and turn signals are all potential applications.

"One of the key drivers for thermally conductive Makrolon PC is the ability to integrate heat-sink functionality directly into lighting components such as reflectors, bezels and housings, using a multi-shot molding or a two-component approach," Marsco states. "Also, in the realm of electric vehicles, we see opportunities in thermal management and support structures in battery modules."

Also in electric vehicles, BASF's Naamani-Goldman says battery-pack components like cell separators are very promising. "Lithium-ion batteries generate a lot of heat but need to be in a constant environment about 65 C or they degrade or fail."

WHICH RESINS ARE GAINING TRACTION?

Initially, thermally conductive plastic compounds were based on higher-end engineering resins; but in the last few years, volume engineering resins like nylon 6 and 66, PC, and PBT have been getting a lot of play. Says Covestro's Marsco, "All of these have been seen out in the wild. However, the market seems to be settling mainly on nylon and polycarbonate due to cost."

While PPS is still used fairly often, PolyOne has seen growth in both nylon 6 and 66 as well as PBT. RTP says that nylons, PPS, PBT, PC and PP are the most popular resins, but many higher-performing thermoplastics such as PEI, PEEK, and PPSU can be used, depending on the challenges of the application. Says an RTP source, "For example, a heat sink for an LED light can be made from a nylon 66 compound to provide thermal conductivities up to 35 W/mK, whereas the case for a surgical battery that must withstand frequent sterilization requires a PPSU compound to maintain electrical insulating properties and reduce moisture buildup."

BASF has several commercial thermally conductive compounds, including nylon 6 and 66 grades, says Naamani-Goldman. "Several applications like motor housings and electrical infrastructure are in production using our materials. This is an active development area as we continue to identify customer needs for thermal conductivity. Many customers don't know what level of conductivity they need, and materials must be tailored to specific applications to be effective."

DSM Engineering Plastics recently launched Xytron G4080HR, a 40% glass-reinforced PPS, to optimize the performance of electric-vehicle thermal-management systems. It is engineered for heat-aging performance, hydrolysis resistance, dimensional stability, chemical resistance at elevated temperatures, and intrinsic flame retardancy.

ADDITIVES HOLD PROMISE

Depending on the application requirements, any one of a wide range of additives might be used for thermal conductivity, says RTP, noting

that "the most popular continue to be additives like graphite, but we are always exploring new options like graphene or novel ceramic additive systems."

An example of the latter was launched last year by Huber Engineered Polymers' Martinswerk Div. Based on aluminum oxide and targeted for new mobility trends such as electrification, the Martoxid line of additives reportedly outperforms other aluminum oxides and other conductive fillers. Martoxid has been enhanced via control of particle-size distribution and morphology to offer improved packing and density, along with unique surface treatment. It reportedly can be used at filler loadings over 60% without compromising mechanical or rheological properties. It has shown excellent potential for use in PP, TPO, nylons 6 and 66, ABS, PC and LSR.

Covestro's Marsco says both graphite and graphene have become commonly used, noting that graphite has a relatively low cost and moderate thermal conductivity, whereas graphene is generally higher cost but with significant thermal-conductivity performance advantages.

PolyOne's Scheepens sees both carbon-based fillers and ceramic fillers as promising to achieve desired thermal conductivity and balance other electrical and mechanical properties.

Celanese's Miller says the company has explored a wide variety of additives that combine the industry's broadest selection of vertically-integrated base resins to deliver proprietary compositions that enable a thermal-conductivity range of 0.4 to 40 W/mK.

MULTI-FUNCTIONAL COMPOUNDS

There also appears to be an increasing demand for multifunctional conductive compounds.Covestro's Marsco notes that as soon as that firm launched its thermally conductive Makrolon TC8030 and TC8060 PCs, customers immediately began to ask if they could be made electrically insulative. "The solutions are not that simple, and anything done to increase EI negatively impacts TC. We now offer Makrolon TC110 polycarbonate and have other developments in the pipeline to address these requests."

BASF's Naamani-Goldman says that different applications require thermal conductivity and additional properties, noting as examples battery packs and high-voltage connectors, both of which need to dissipate heat as well as comply with rigorous flame-retardant standards in case of a lithium-ion battery-pack fire.

PolyOne, RTP and Celanese have all seen a large demand for multifunctional compounds from all market segments and are providing compounds that offer thermal conductivity along with such functionalities as EMI shielding, higher impact, flame retardancy, electrical insulation, UV resistance and heat stability.

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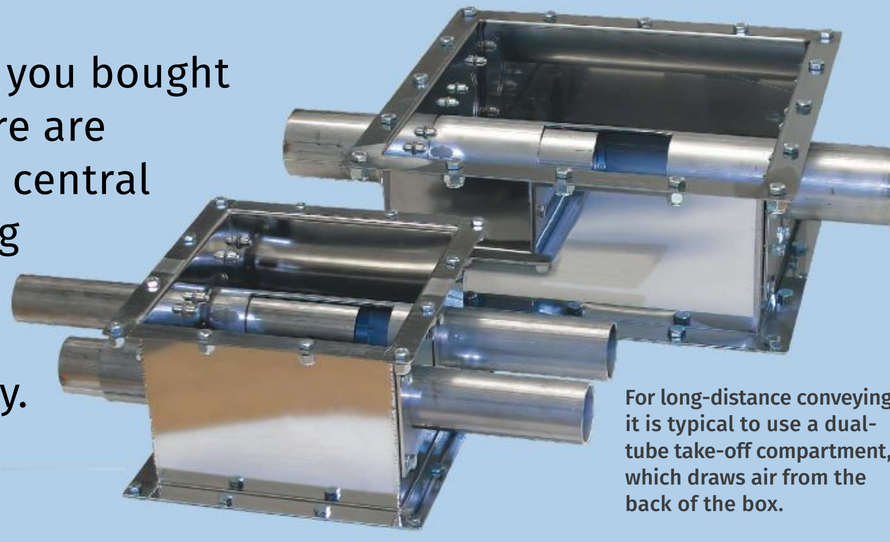
READY FOR YOUR PRODUCTIVITY TO SOAR?

Follow These Steps to More Efficient Central Pneumatic Conveying

Depending on when you bought and installed it, there are ways to 'tweak' your central pneumatic conveying system to improve its performance and save you some money.



For long-distance conveying, it is typical to use a dual-tube take-off compartment, which draws air from the back of the box.

By Joseph Dziedzic
AEC

In our economy today, as energy costs rise and the cost of manufacturing increases, it is becoming more of a challenge to stay competitive in regional and global environments. Manufacturers are constantly looking for ways to improve their processes and boost their competitiveness. Plastics processors who have central pneumatic material-handling systems are already benefiting from lower prices of bulk resin purchases compared with lower-volume purchases. Depending on when the centralized conveying system was installed, there may be ways to make incremental improvements to enhance performance, efficiency and ultimately add savings to the bottom line.

It is easiest to start at the beginning of the line and follow the pellet, powder or granulate on its journey from the source or the pick-up point. It is good practice to adjust your conveying system at the pick-up point, with your wand or take-off tube, so that it will provide a good mixture of air and material. This will allow the material to flow smoothly throughout the system without slugging.

There may be ways to make incremental improvements to enhance performance, efficiency and ultimately add savings to the bottom line.

Using the right type of pick-up device can enhance your system performance and improve efficiency. For long-distance conveying, it is typical to use a dual-tube take-off compartment, which draws air from the back of the box. This makes it easier for the air flow to entrain the material as it travels through the pipe to its destination at the process machine. Finding a good mixture of air to material is critical to proper conveying.

One of the most common issues in a conveying system, and one that can easily enhance and improve efficiency, is to *keep material flowing into the process*. A simple rule to follow is: "Put the wand in the box!" Many times, a system issue is caused by lack of material supply. This typically occurs when the material probe has fallen out of the box or the gaylord, the material source has run out of material, or the bag liner has obstructed the flow of material. Be sure that the supply of material is constantly flowing into the pick-up point.

The perfect vacuum or pressure piping system consists of one straight length of piping with no bolted couplers, no diverter points, no elbows and no flex hose. This is an example of a system with minimal obstacles and minimal pressure drop, assuming it is properly sized for the system. But it's not realistic. In the real world, piping must always be routed up or down and around in a plant to avoid obstacles to get the material from the source to the destination or use point.

Piping should always be installed with the minimum number of elbows and should use the shortest amount of flexible hose. Reduce excessive amounts of flex hose at quick-coupling stations. Reduce long loops of coiled flexible hose and pare the amount of flexible hose that connects the hard piping to the quick-change stations and/or material probes. These are quick and easy ways to gain conveying capacity by eliminating pressure losses within the conveying system.

Elbows that are installed back to back can cause material to drop out of the air stream. Add a sufficient length of straight pipe between them. This will allow the material to pick up in the air stream and gain velocity, improving the overall system efficiency.

Air leaks in piping will reduce the system capacity and, in some cases, can lead to material slugging or lines plugging. Check for loose bolted couplers between piping connections and worn or missing gaskets. Fix or replace them and tighten all couplers. Replace worn-out piping and elbows. Set up a regular inspection schedule for system piping. Running a system with air leaks and worn piping will reduce the potential rate of the system. In extreme cases, there will be plugged lines and multiple maintenance issues with the system.

Reducing excess piping, elbows and flex hose in a system will improve conveying system efficiency and reduce the overall energy required to run it. Eliminating air leaks will allow the energy put into the system to be used for conveying material and not be wasted. It allows material to flow smoothly through the system as designed.

ELBOWS, AIR VELOCITY, SYSTEM TYPE

There are many different types of elbows available, depending on the application. Aluminum tubing and elbows are used for most general conveying applications. Stainless steel is used for most general, mild-abrasion conveying applications. Specialty elbows can replace standard elbows to reduce wear and minimize material degradation. They can also reduce system maintenance and replacement costs caused by wear issues. Several suppliers offer elbows designed specifically to reduce streamers or fines. Ceramic-lined or wrapped elbows, porcelain-lined elbows, heat-treated or nickel-plated elbows can be used for abrasion resistance. Glass elbows also can be used for abrasion resistance. They are good for use with engineered resins and especially with glass-filled materials.

Tee elbows, blind tees, or similar designs can be used for soft, hard or glass-filled materials. In some cases, there can be extreme pressure drops with these types of elbows. This can reduce the original system conveying capacity. Carefully review the system design when using this type of specialty elbow.

Air velocity is a very important factor in any conveying system. Making sure that material is moving at the right velocity in the tube or pipe will ensure that it will be delivered from the storage or pick-up point to the end point or process machine. If material is moving too slowly and/or the air velocity is low, the material may have a hard time moving in the air stream at the pick-up wand or the material take-off box. Material may tend to plug at the bottom of long vertical rises or after elbows.

Selecting the correct type and size of vacuum receiver for the process is important in order to keep the conveying system running at maximum efficiency.

Lowering the air velocities while material is moving may cause the material to fall out of the air stream. Care must be taken that adjustment is done properly with considerations for the entire system:

- If the material is moving too fast, and the air velocity is high, this may damage material.
- If the material is soft, and the velocity is too high, angel hair may form.
- If material is hard, it may shatter, creating dust
- If material is glass filled and velocity is too high, it can wear through pipes and elbows
- Heavier materials may require a higher air velocity to allow them to flow properly in the air stream.
- Lighter materials may require a lower air velocity to minimize material degradation when traveling through the pipe.
- Particle shape and weight affect the way materials travel and are picked up in the air stream. For example, flake regrind, glass-strand material and calcium-carbonate loaded pellets have different conveying properties and require different considerations. These variables may require a change in air velocity to accommodate the change in material shape and bulk density.
- Material characteristics and flow properties are learned through testing processes and experience with these materials.

If you want to use a purging system, care must be taken in sizing the conveying pump. The time it takes to convey a "shot" of material from the source to the destination must be considered.

Typical conveying velocities can be fixed and set at a standard industry value suitable for most resins. On occasion, conveying systems are designed and adjusted to accommodate the special needs of heavier engineered resins (i.e. calcium-loaded pellet). If an older system was designed for a heavier resin and the design parameters have now changed to a lighter resin, then the air velocity of the system may be set too high. This can create a material problem with dusting (hard materials), angel hair (soft materials) or pipe damage (glass-filled materials).

To adjust the air velocity for a particular material, the vacuum pump can be re-sheaved by reviewing the blower curve based on the blower manufacturer's data and recalibrating the motor/blower rpm ratio. This improves the overall efficiency of the entire system and reduces the maintenance on the system components. ►

The quality of the process can be maximized if the proper type of conveying is implemented. In most cases, open-loop conveying is adequate, and no special requirements need to be considered.

But when a material has been dried and needs conveying, some resins are very sensitive to moisture regain. In such cases, the process would benefit from a closed-loop conveying or a purge conveying system. Closed-loop systems are used for materials that are sensitive to moisture regain in short periods of time and must be contained to prevent or minimize the possibility of moisture regain after drying. A closed-loop system minimizes the amount of time the dried material is exposed to ambient (outside) air from the time it is dried until the time it enters the process machine. The material is conveyed from the central drying station to the process machine using a source of recycled or pretreated air that has a lower dewpoint than the surrounding ambient air.

The benefit of the closed-loop system is that the ambient air is eliminated. Dried material quality is improved and part defects are reduced. Even minimal air from outside can contaminate the material.

If a purging system is desired, then care must be taken in sizing the conveying pump. The time it takes to convey a "shot" of material from the source to the destination must be considered. The size and capacity of the vacuum pump must be large enough to allow for the "lost time" when the vacuum pump is conveying only the one shot of material in the line and the remainder of the time when it is not conveying any material (lost time/lost capacity). In some cases, there is almost a 50% loss in system capacity when purging systems are utilized, depending on the distance of the source material from the process.

Often, a system issue is caused by lack of material supply.

KNOW YOUR RECEIVERS & FILTERS

Selecting the correct type and size of vacuum receiver for the process is important to keep the conveying system running properly. Verify that the receiver is large enough to match the throughput of the process machine. Replace undersized receivers with larger-capacity vacuum receivers to reduce the total number of fill cycles per hour on the system. This will improve the overall efficiency by eliminating some system delay time. Most vacuum receivers range in size from 0.1 to 6 ft³ capacity and are available with options that will enhance the performance of the system. Adding the correct option will allow the receiver to operate more efficiently. Some options include wear wraps for abrasive materials, air-operated discharge gates, butterfly-valve discharge gates, vibrating pads, 70° cone options for hard-to-flow materials, special filter options, and a variety of level sensors.

There are pellet receivers, filtered receivers, filterless receivers, cyclone receivers, hopper/filter-chamber combination receivers. Each is designed to be used to convey different materials with different flow properties. Using the correct type of receiver configuration will improve your overall conveying system performance.

One of the easiest ways to enhance an existing central conveying system is to improve the central filter system that protects the pump/blower. Make sure the filters are large enough for the blower on the system and have the correct filter media for the material being conveyed.

Using the correct vacuum-sequencing valve with the receiver is important for efficient central system operation. A non-vented sequencing valve can be used in any part of a system. It should always be used when filling a drying hopper to prevent ambient air from leaking into the drying hopper and dryer air loop. A vented sequence valve can be used in any area that is not near a drying hopper. The benefit of a vented sequencing valve is that it will provide a short burst of atmospheric filter-cleaning air across the filter when the valve shifts after the conveying fill sequence. This is a cost-effective way to keep the filter screen clean and reduce maintenance on general conveying systems. The effectiveness of this process depends on pressure differential and material quality. When compressed-air blowback is used for filter cleaning, a non-vented sequence valve is typically a better option because it will keep the pressurized burst of compressed air inside the vacuum chamber to provide a more effective filter-cleaning burst.

One of the easiest ways to enhance an existing central conveying system is to improve the central filter system that protects the pump/blower. If a filter is too small and not cleaned properly, it can result in excessive pressure drop that reduces the overall conveying potential and increases the brake horsepower required to run the system.

Make sure that the filters are large enough for the blower used on the system and have the correct filter media for the type of material being conveyed. Check to see that all dust-holding containers are serviced regularly to prevent overfilling. This will also prevent dusting near the pump area. All filter media should be genuine OEM quality and gaskets should be properly seated in the filter housing to prevent leakage past the filter through the blower, which can cause blower damage.

Using a large filter with media that has good release properties, and setting the filter-cleaning pulse parameters for the dust loading of the system, will reduce system pressure drop, keep the general area cleaner, and reduce the overall power consumption of the entire conveying system. ►

Comparing Vacuum Pump Options

Cost Point	Name	Type	Typical Use Range, ft	Typical Vacuum Range, in. Hg	Maximum Vacuum Range, in. Hg	Noise Level (Without Silencer)	Noise-Level Options
$	Regenerative Single-Stage	Centrifugal	0-50	6-9	10	Low	Yes
$+	Regenerative Multi-Stage	Centrifugal	0-200	10-11	12	Low	Yes
$$+	Regenerative Hybrid	Centrifugal	0-500	12-13	14	Low	Yes
$$	Rotary Dual-Lobe	Positive Displacement	0-500	12-13	14	Medium/High	Yes
$$$	Rotary Tri-Lobe	Positive Displacement	0-500	13-14	15	Medium	Yes
$$$$	Rotary Claw	Precision Pos. Displacement	0-1000	17	18	Low	Yes

ANGEL HAIR, STREAMERS & DUST

If your conveying system has angel hair or streamers, the simplest thing to do is to re-sheave the vacuum pump. This will recalibrate the air velocity to the material properties and reduce the softening and streaking of the material against the walls in the piping. If there is excessive heat buildup in the piping, then there are times when re-sheaving is not the answer. In those cases, the streamers can be collected using an angel-hair collection trap in-line with the system piping, or an angel-hair trap box below a bin or silo. In some cases, a combination of the two (re-sheave and trap) is used to reduce the formation of, and to collect, angel hair.

Some companies offer variable air flow, or air flow monitored with sensors, to control the velocity of the air and the material in the conveying line. This results in reduced wear on piping and elbows. However, the maintenance of the system as well as the controls themselves become more complex. Review the benefits of each option to decide what is best for the operation. Keep it simple to avoid unnecessary complexity in control and replacement maintenance by using a simple, standard system that will perform just as well with good preventive-maintenance routines.

If conveying lines are running too hot, a good idea to prevent material degradation is to use an in-line heat exchanger to pre-cool the conveying air. This will reduce conveying air temperatures and minimize material degradation in the piping. Sharpening granulator knife blades and improving general granulator maintenance will reduce dusting issues in many central conveying systems. This simple preventive-maintenance task has a huge impact on other parts of the entire process.

Dust and streamers tend to clog vacuum receiver filters and central filter elements. Finding ways to minimize this will improve conveying-system efficiency and reduce your energy usage. Install specialty wear components and wear wraps to protect against glass-filled material damage.

PUMPS & CONTROLS

Several types of vacuum pumps can be used for central conveying. Each type has advantages and disadvantages, depending on the use and application. Choose the right pump for the application (see table).

There have been many changes and improvements in central conveying control technology in the last few years. Most control panels are easy to use with "off-the-shelf" components. These panels are easy to navigate and typically come equipped with color-touchscreen navigation. Improvements often include built-in troubleshooting diagnostics and product manual information.

Here are some improvements that can be made to existing control systems:

- Ensure that all wiring connections are secure.
- Use Energy Star components to reduce overall energy consumption in a panel.
- Utilize distributed control platforms to reduce diagnostic/troubleshooting time.
- Perform regular maintenance checks of sensors and sensor function.
- Add additional alarms to signal no-fill conditions in a process and prevent system shutdowns.
- Add hour meters on control panels to track and schedule routine service on equipment.
- Add predictive-maintenance controls—"smart" sensors to identify when there are system faults or problems.
- Add a "smart" system with built-in diagnostics for monitoring of the system from a central location.

Industry 4.0 is a control technology that leverages the data of your plant to help you make better decisions. It is a focused SCADA (Supervisory Control and Data Acquisition) system intended to minimize downtime and develop intuitive and predictive control of the plant floor. The goal is to keep machines and plants up and running with minimum downtime using predictive diagnostics through data collection and analysis of the input and historical data trends throughout the plant. Although there are some technology, price and firewall-security concerns, Industry 4.0 protocol continues to develop and improve. Standardization of equipment connectivity is being developed for injection molding and extrusion.

Compressed-air systems are often overlooked in a plant. They are used to operate air cylinders and pulsed filter cleaning in a

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Several types of vacuum pumps can be used for central conveying. Each type has advantages and disadvantages, depending on the application.

conveying system. In some cases, the compressed air is used for Venturi loaders for minor ingredients or low-throughput conveying. A rule of thumb for compressed air is that it takes approximately one brake horsepower to produce four standard compressor cubic feet per minute at 80 psig/4 bar. If there are leaks in the system, then there is wasted energy and the compressor has to work harder. Look for ways to optimize compressed-air pipe runs and run the compressed-air systems at lower pressures. Install air-leak alarms to identify sudden pressure losses. Identify teams to review piping and find system air leaks or to suggest improved ways of running compressed-air lines to reduce overall system pressure drop and load on the system. Depending on how changes are made, improving the compressed-air system operation can result in annual operational savings up 30%.

One of the easiest ways to improve efficiency in a process is to review existing equipment and examine motor efficiency. Government laws and regulations have changed on the sale of new motors. By installing a more energy-efficient motor in place of an older motor, you can reduce the overall energy consumption and increase the operational efficiency of a process. Review all upgrades with your staff electrical engineer and/or maintenance engineer.

Material-handling systems can range from simple to complex. Many of the larger central conveying systems would benefit from careful calculations of piping layout and equipment selection based on rate calculations and system sizing. Take advantage of the knowledge, experience and expertise of your equipment supplier. These experts can help with the evaluation of your system and suggest ways that will help improve the process. PT

ABOUT THE AUTHOR: Joseph Dziedzic is the manager of the technical sales team for AEC. In his current role, he is responsible for implementing equipment and system design solutions to support customer needs for process solutions. Contact: *847-273-7801*; *jdziedzic@acscorporate.com*; *aecplastics.com*.

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PART 1

Why Cartesian Robots Are the All-Around Choice for Injection Molding

This first of three articles on automation for injection molders explains why Cartesian (linear) robots are molders' first choice in a large majority of applications. Two following articles make the case for, respectively, articulated and collaborative robots.

By Jason Cornell
Wittmann Battenfeld

"Cartesian, articulated, collaborative; what is the best type of robot for my injection molding application?" I have had this question asked of me a few times lately, so I am providing my thoughts on the subject. Some may say I am biased because I work for a Cartesian robot manufacturer. This may be correct; however my almost 25 years of experience working with robots in the molding industry may lend some credence to my bias.

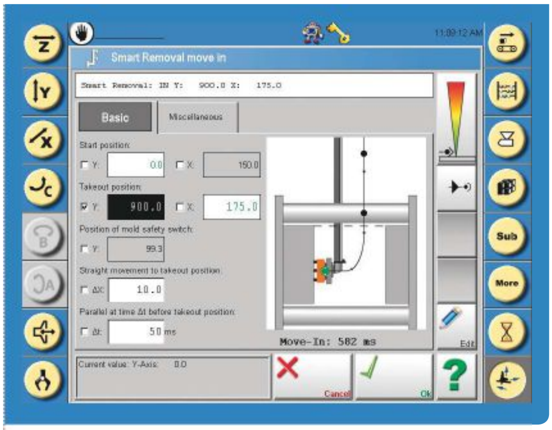
Cartesian robots normally have three axes of motion, but servo wrists can add two or three more axes.

Terminology. First off, let's define terminology that will be used throughout this article for each robot type:

- Cartesian robots—also called linear, three-axis, or gantry types.
- Industrial six-axis robots—also called articulated or articulated-arm robots.
- Collaborative robots—also called cobots. These are typically articulated types, so many of the points made here about six-axis robots also apply to cobots.

When I talk about Cartesian, I am referring to robots designed specifically for injection molding. Because these robots are industry specific, all their terminology is built around the injection molding machine. This makes it ideal when a user switches from working on the injection-machine controller to working on the robot controller. This commonality also makes learning to use Cartesian robots very simple and intuitive.

On the flip side, six-axis robots make up a very small percentage of those used in injection molding applications. This means that the nomenclature and terminology used in their controllers and manuals may have little, if anything, to do with molding.



Cartesian robot manufacturers have programmed special routines for minimizing mold-open times, such as Wittmann Battenfeld's Smart Removal.

Given that linear robot manufacturers have been working exclusively in the molding industry for years, they have been able to come up with features designed specifically to reduce the part-removal time. Features such as Wittmann Battenfeld's Smart Removal intuitively move the robot arm into the mold area prior to the complete mold-open signal, thus reducing take-out time. This is accomplished without the need for additional transducers or other modifications to the machine.

Controls. The topic of terminology leads us into some points about robot controllers. From day one, linear robot manufacturers have been refining their control platforms around the molding process. This has allowed them to create control languages and programs that are ideally suited to injection molders. Users will find terms, graphics and videos that they are familiar and comfortable with from the molding world.

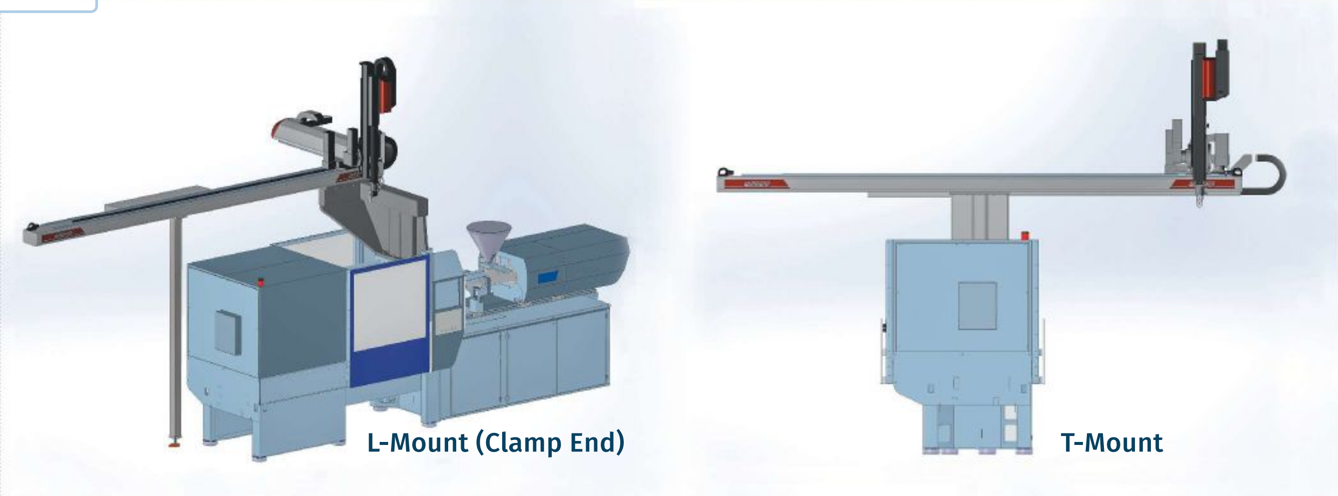
Payload is an important consideration, but six-axis robots don't have the same payload capacity at short or long reach positions.

Machine interfaces. Cartesian robots have clear definitions of industry-standard interfaces between the robot and injection machine. Be it E67, E12, SPI or others, Cartesian robots used in this industry are all set up to adapt and connect easily to a molding machine. Articulated robots may not be as easily connectable to an injection press. There may be additional costs required to adapt six-axis robot interfaces to the molding-machine standards.

Speed. In the molding world, it is all about minimizing your mold-open time and thus reducing overall cycle time. This is where Cartesian robots really shine. The speeds of these robots are generally known to be superior to six-axis types and dominate collaborative robots. Faster in and out of the press means more parts are produced per hour, shift or day. This equates to a faster ROI for the equipment.

Payload. Cartesian and articulated-arm robots can both handle substantial payloads. The main consideration with six-axis robots is that the payload rating can vary, based on the axis positions, or where the robot is within its work envelope. Speed is also impacted by the payload. Cartesian robots on the other hand, keep their rated payload capacity throughout their full range of motions, and they can maintain their maximum payload capacity at all speeds. Collaborative robots typically have a much lower payload capability than both Cartesian and standard articulated-arm robots. ►

Cartesian robots save floor space by incorporating the control cabinet into the robot beam.



Cartesian robots are available with special removal configurations that would be hard to duplicate with an articulated robot.

In molding, payload plays such an important factor in choosing robots. Because most molders never know what job may be coming down the line, it is important to choose a robot with enough payload capacity not only for today, but for the future as well. I always say it is better to have the payload capacity and not need it, then need it and not have it.

When considering payload, note that the part and runner weights may be a very small portion of the total load. End-of-arm tooling (EOAT) can have docking features, shuttle cylinders, rotatory units, multiple grippers, sensors, quick change mechanisms, etc. The weight of these can add up very quickly. And when you consider high-cavitation molds, even very small-tonnage molding applications can require extremely high robot payloads.

> ***More often than not, it makes sense to use Cartesian robots to remove parts and use other robot types in downstream and offline operations.***

Flexibility. There is no disputing that six-axis robots provide a wide range of motion flexibility. That being said, Cartesian robots can be equipped with servo rotational axes at their wrists. These additional axes can provide up to six axes of total motion on the linear or gantry robot. Although this still doesn't compare to the total motion flexibility of an articulated arm, these features can provide linear robots with much more flexibility than many commonly assume.

Floorspace. The floor space around a molding machine is a scarce and valuable commodity. With equipment such as temperature controllers, blenders, granulators and operator work stations all competing for space around a molding cell, most manufacturers want to minimize any additional equipment's impact on the area. A floor-mounted six-axis robot will require an immense amount of room around the machine, and the press may have to be modified to allow the safety guarding to remain open during robot operation. This adds to safety concerns, as well as costs to modify the equipment.

The counterpoint to this is a top-entry gantry robot, which frees up valuable floor space. If a six-axis robot were mounted on top of the machine, it would typically have to be oversized to allow the reach required to pick the part and move it all the way outside the machine to deposit it on a conveyor or pallet.

Makers of collaborative robots promote that they don't require guarding. This may be true for the robot itself, but this may not reflect the entire picture. What if the robot was entering the injection machine from the back side of the press (rear gate opened)? What if degating of the parts was required? What if you were running a high-temperature material, and the parts need to be cooled prior to an operator handling them? In these scenarios, even though the robot itself is "collaborative," other parts of the process may not be, so guarding would be required.

If you considered mounting the cobot on the operator side of the machine, that indeed might be a layout where guarding would be unnecessary. But think about what that would do to the molding cycle time. The robot would have to open the front gate, extract the parts, close the gate and the press would start the next cycle. Although you would have more consistency than with an operator performing the same functions, this increase in cycle time would be very detrimental to overall production output.

With industrial robots, when guarding is a concern, many times we simply utilize a conveyor package with integrated guarding. The guarding would be attached to the conveyor, and the entire system could quickly and easily be rolled away from the press to use on another work cell, or simply move away during mold changes. ►

Control cabinets. Because Cartesian robot manufacturers understand that floor space is at such a premium in a molding shop, they have almost exclusively moved to mounting the control cabinets onthe robot traverse beam. Six-axis robots require a separate control cabinet that requires additional floor space.

Features specific to the injection molding process. Gantry robot manufacturers have been working constantly to help make the molding process more efficient. We now have features such as Soft Torque, which allows the ejectors to push the arm back with assistance from the robot. The robot monitors the force applied during this motion and applies a counterforce to move the arm back.

Find & Pick is a feature for use with robots on older hydraulic presses that may have a tendency for their clamp position to vary from shot to shot. With this feature, the robot will vary the part-removal position based on fluctuations in the clamp position. Six-axis robots don't necessarily have features like these that are specific to the injection molding process.

Robot layout configurations. Cartesian robot manufacturers offer a variety of mounting options to accommodate project needs and space constraints. Although traditional "operator side" and "rear side" configurations are still popular, we are seeing more and more varied layouts. Configurations such as "T-Mount," "Clamp End" and "Reverse Mount" are becoming more popular.

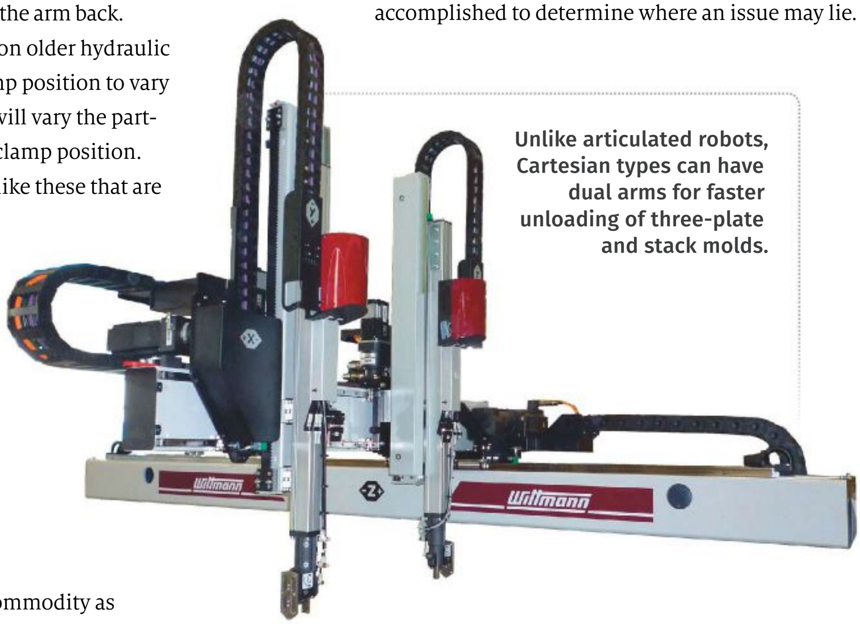
Floor space becomes an increasingly hot commodity as more and more companies try to figure out ways to squeeze more machines into their plants. One way to accomplish this is by setting up the robot to release the parts at the clamp end of the molding machine. This allows machines to be placed closer together. With this setup, it is easy to configure a gantry-style robot to traverse along the machine to drop the parts at the clamp end. On the other hand, this is almost impossible for a six-axis robot.

Three-plate & stack molds. To run these popular applications efficiently, robots must be equipped with two arms to extract the parts and runners between each set of plates. A single-arm six-axis robot would not be ideal for these applications, as it would dramatically impact the cycle time.

Support. Of course, articulated-arm robot manufacturers have technical support. The main difference is that their personnel may not necessarily know the injection molding process and equipment. When calling support, it certainly must be helpful when supplier personnel understands common terms related to robot sequencing in molding applications—like core pull, screw recovery, air blast, cooling time and ejector sequencing.

Many issues that arise are related to the molding machine and robot interface. Again, gantry robot manufacturers understand how that interface functions. This allows them to quickly ascertain what the problem may be and whether it is robot- or machine-related.

Robot/press integration. Some Cartesian robot manufacturers allow their robots to be integrated with the molding machines. This integration allows the robot programs to be accessed and saved directly through the injection press controller. Also, remote diagnostics of both the machine and robot can easily be accomplished to determine where an issue may lie.

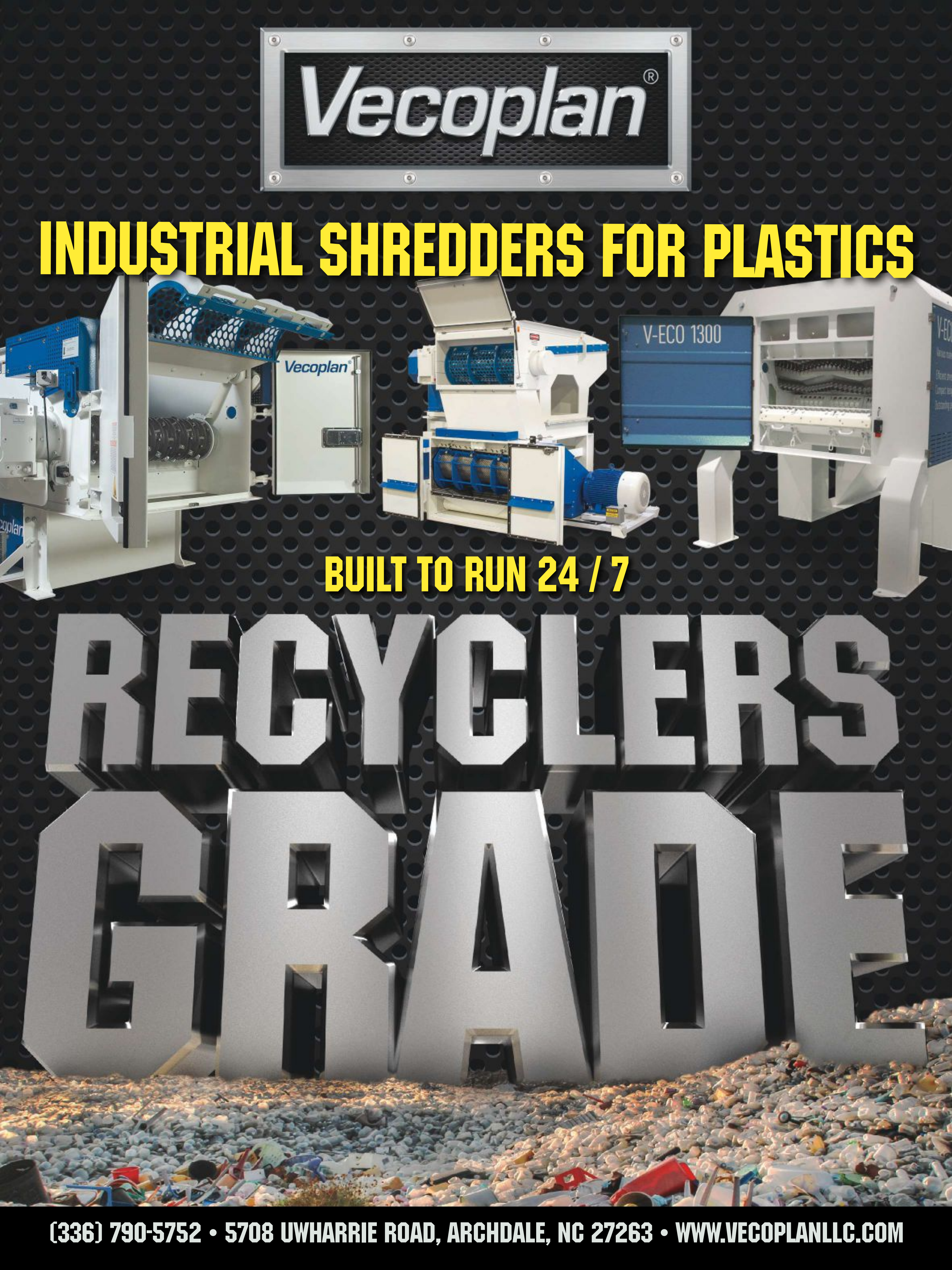


Unlike articulated robots, Cartesian types can have dual arms for faster unloading of three-plate and stack molds.

In conclusion, six-axis and collaborative robots definitely have a place in the plastics industry, but are not ideally suited to the removal of parts from molding machines. In almost 25 years of working with automation in the plastics industry, I have seen only a small number of companies utilize six-axis robots to remove parts from molding machines. Many of those same companies later switched back to Cartesian-style takeout robots.

More often than not, I believe it makes sense to use Cartesian robots to remove parts and then use the other robot types in downstream and offline applications within the factory. That being said, do your homework to determine what is best for your requirements.

ABOUT THE AUTHOR: Jason Cornell has worked in the plastics injection molding industry for 25 years, specializing in robotics and automation. He started as a service engineer with Star Automation, and also worked at Husky and Yushin America. At Wittmann Battenfeld, Cornell has been the Western Regional Manager of the Robots & Automation Div. for the past eight years. He is based at the company's Southern California Technical Center in Placentia, Calif. Contact: *jason.cornell@wittmann-group.com*; *wittmann-group.com*.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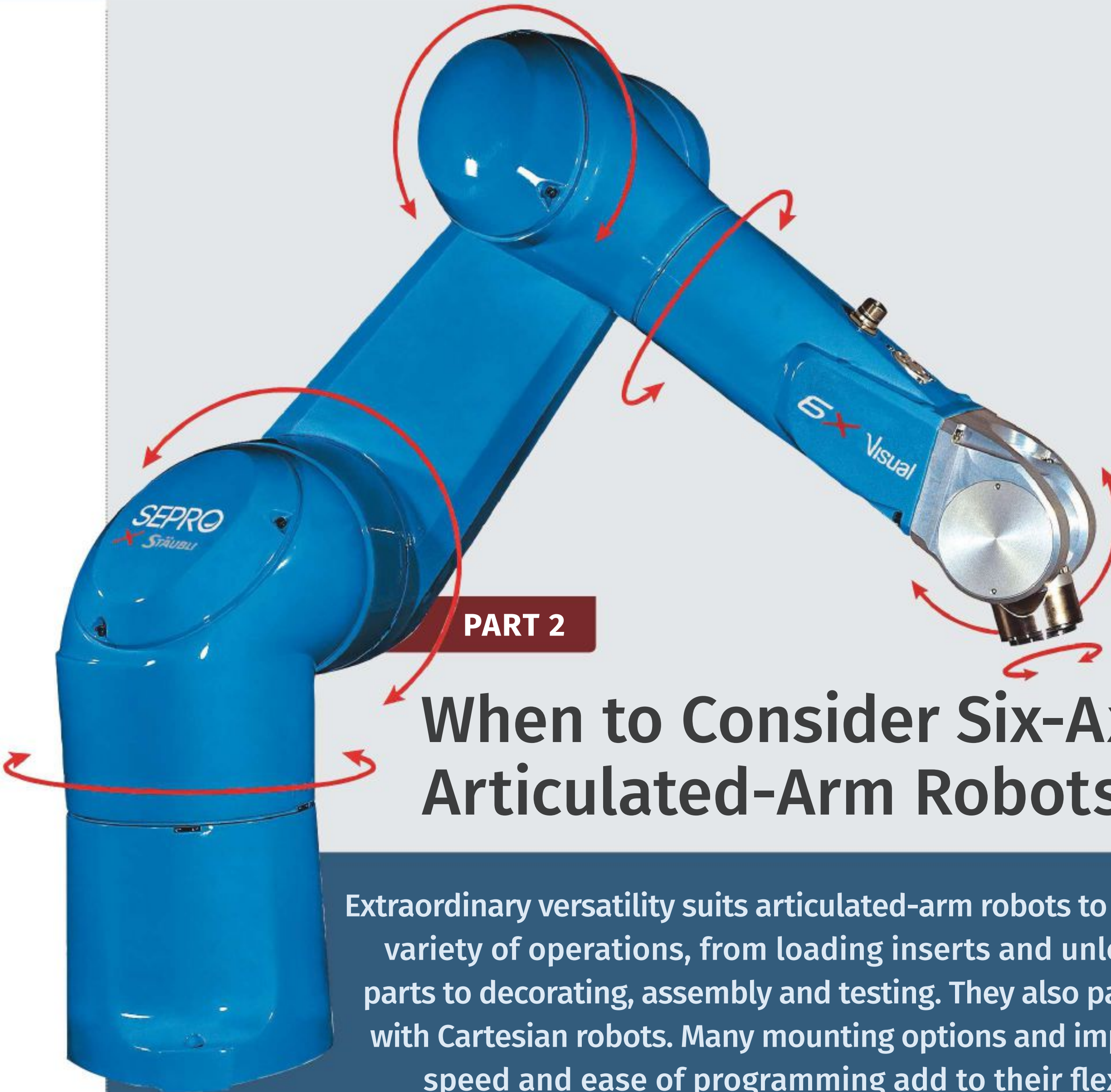


PART 2

When to Consider Six-Axis Articulated-Arm Robots

Extraordinary versatility suits articulated-arm robots to a wide variety of operations, from loading inserts and unloading parts to decorating, assembly and testing. They also pair well with Cartesian robots. Many mounting options and improved speed and ease of programming add to their flexibility.

Six-axis articulated-arm robots get their name from the six distinct rotations that allow them to grip an object at almost any angle and at almost any point within their reach.

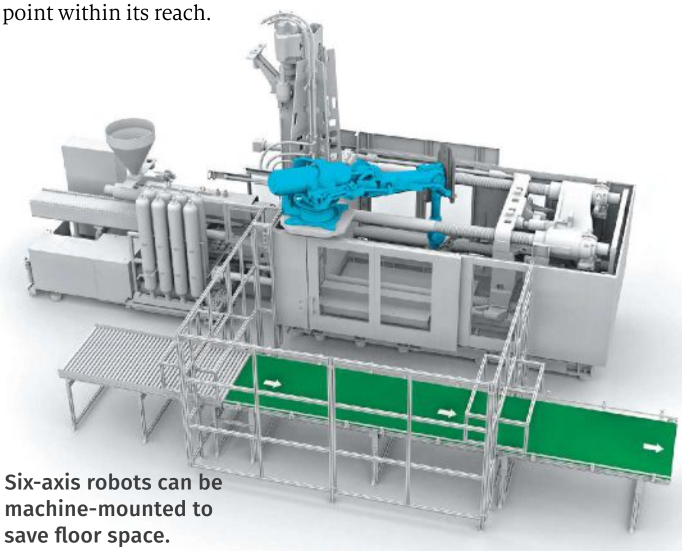
By Claude Bernard
Sepro Group

Which is better for injection molding applications—Cartesian beam robots, six-axis articulated-arm robots, or collaborative robots (cobots)? That's a little like asking which is better for cooking—a frying pan or a spaghetti pot. You could scramble an egg in a spaghetti pot and you could boil pasta in a frying pan, but you probably wouldn't like the results. Each tool has its place in the kitchen. The trick is to know which is best for your application.

Sepro sells more Cartesian units than articulated-arm robots. Today, we offer plastics processors a choice of all three major robot technologies, as well as integrated automation solutions that may incorporate more than one configuration working together to perform different functions. But let's look specifically at where six-axis articulated-arm robots fit in an injection molding plant.

ARTICULATED-ARM FLEXIBILITY

Probably the greatest strength of articulated-arm robots is their versatility. The typical six-axis unit has an arm that is similar, in many ways, to the human arm. It can rotate around its base like the human limb rotates around the shoulder. It can bend in the middle like a human elbow and it has a wrist that can rotate and move the hand in an up-and-down or side-to-side arc. Thus, an articulated-arm robot can grip an object at almost any angle and at almost any point within its reach.

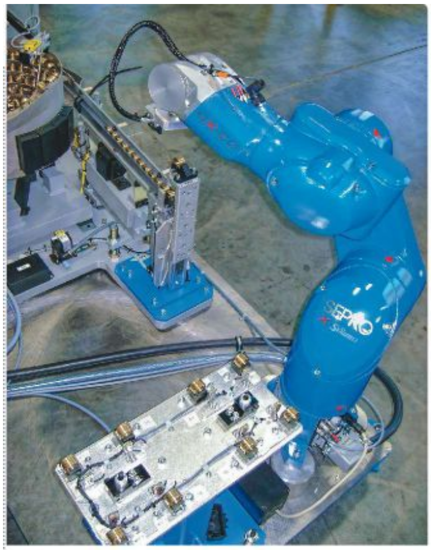


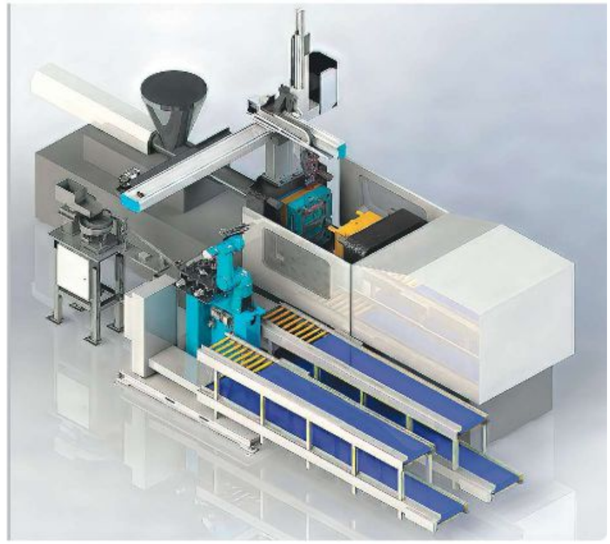
Six-axis robots can be machine-mounted to save floor space.

This is probably why it is the most common design across the general industrial landscape. Six-axis robots are used for welding, painting, material handling, laser cutting, gluing, assembly, quality testing, etc. And they can be used for machine tending, including part removal from injection molding machines.

This flexibility of operation, however, also means that their control systems must also be flexible, able to operate the robot in almost any application. With some exceptions, which we will get to shortly, this means that programming an articulated-arm robot for part removal can be much more complicated than programming a Cartesian robot that comes with a control system developed specifically for injection molding. Even straight-line movement of an articulated-arm robot requires coordination of several different articulated joints. Some molders feel they need specially trained personnel to handle the programming and maintenance of these robots.

All that has changed. For example, Sepro recently introduced its 6X Line of articulated-arm units adapted to use the same Visual control systems as its Cartesian robots. Using simple pick-and-place programming, the user only needs to identify step-by-step the different points and positions in the robot cycle (picking, quality inspection, unloading, stacking, etc.). Then the operator manually "teaches" the robot the path





Here, a six-axis robot picks inserts from a bowl feeder and places them in a fixture for pickup by a three-axis Cartesian robot, which puts them in the mold and removes finished parts, as shown in the overall cell view.

between each point, and the trajectory (either straight-line or curvilinear) is computed automatically. Thus, injection molders today will find six-axis robots much easier to program and operate than in the past. They can now evaluate Cartesian and articulated-arm configurations solely on the basis of which suits their application best.

FLOORSPACE REQUIREMENTS

Another common criticism of six-axis robots is the amount of floorspace they can require. While Cartesian robots are generally mounted above the fixed platen of a molding machine and operate mostly above and near the side of the machine, articulated-arm robots are most commonly positioned on the floor beside the press. For plants with limited overhead clearance, this can be an advantage, but it does mean that they can require a lot of floorspace. ►

The SeproBot concept uses the speed and versatility of a conventional six-axis robot (or a Cartesian model), surrounded by physical guarding but giving operators safe access through openings protected by sensors, light curtains or other safety devices. The robot will slow down as a person approaches, and stop if approached closer. As the person moves away, the robot will resume motion—first slowly, then at normal speed.

What's more, they can only operate on one side of the molding machine—usually the back of the machine where they will not interfere with access to the operator control panel.

Sometimes, floor mounting can be an advantage, as in vertical-clamp insert molding. Positioned beside the machine, their movement is not limited by the vertical clamp and they can easily reach multiple stations on the rotary table often found on those machines. (For a case where Cartesian robots were an efficient choice in vertical molding, see Dec. '18 Close-Up.)

However, six-axis robots do not have to be floor-mounted. They can be mounted above the mold, on the fixed platen, on a nearby wall or even the ceiling, when the application and the working environment allow.

OTHER FACTORS TO CONSIDER

There are other factors that set articulated-arm robots apart from their Cartesian cousins:

- **Speed.** The speed of articulated-arm robots has increased in recent years to a point where it is comparable to Cartesian types in many motions; but beam robots are generally regarded as being faster at moving into and out of the mold space to retrieve parts. This is why most fast-cycling molding applications employ Cartesian beam robots or purpose-built side-entry units.
- **Payload.** The largest of Sepro's beam robots can manage a payload (part plus EOAT) of about 200 lb. In contrast, its largest six-axis robots, sized for molding machines of the same tonnage, can handle 250 lb or more, depending on how long a reach is required. Maximum payload generally is lower as reach gets longer.
- **Cost.** The cost of articulated-arm robots has been coming down lately, but as a general rule a Cartesian robot—even with the addition of the servo-driven wrist—will cost about 30% less than a six-axis unit.

Cartesian and articulated-arm robots are sometimes used together. The machine-mounted beam robot picks the part and presents it to the articulated-arm unit for secondary operations. This may be the ideal setup when molding cycles are relatively short and downstream functions are especially numerous, complicated or time-consuming.

A WORD ABOUT COBOTS

In the plastics industry, most so-called "collaborative robots" or "cobots" are quite similar in design to six-axis articulated-arm units. The big differences are the sensors and other features that allow cobots to recognize the presence of human operators and avoid conflicting movements that could cause injury. Proponents say cobots are even more flexible than six-axis robots and easier to program. The advantage of standard six-axis robots over cobots are generally higher speed and payload capacities, and the primary negatives are lack of portability and the need for guarding.

Cartesian and articulated-arm robots may be used together: The machine-mounted beam robot picks the part and presents it to the articulated-arm unit for secondary operations.

Sepro Group is now partnering with Universal Robots, market leader in collaborative robots. This allows molders to implement cobots more easily into their operations. In addition, by adding the Visual control to the leading cobot for the first time, Sepro Group ensures seamless integration of the UR technology with other Sepro robots and the molding machine.

Sepro has also developed systems that offer a middle ground. Called SeproBot, this approach uses a conventional six-axis unit or Cartesian robot surrounded by physical guarding, yet giving operators safe access through openings protected by sensors, light curtains, or other safety devices. Most of the time, the robot operates at full speed, slowing down or stopping only when humans enter the guarded space and returning to full speed when they depart. This enables the SeproBot to operate two to three times faster than a typical cobot, while still allowing safe interaction between robot and human.

Just as Cartesian and articulated-arm robots may be used together to integrate machine tending with downstream operations, cobots with Visual control can also be used to develop safe, open, multi-robot configurations for various types of processes, including peripheral operations or advanced automation cells. PT

About the Author: Claude Bernard has spent most of the last 30 years with Sepro Group in France, where he currently holds the titles of director of product marketing and key accounts manager. He holds a degree in Automation and Robotic Engineering from École Centrale de Nantes, France. Contact: *communication@sepro-group.com*; *sepro-america.com*.

PART 3

Cobots: The New Option for Injection Molders

Take all the versatility of an articulated-arm robot, and add the ability to work safely in proximity to humans without guarding, and you have a new option for freeing workers from repetitive operations.

By Joe Campbell
Universal Robots North America

Thirty years ago, fully servo-controlled robots of any kinematic configuration were rarely deployed in injection molding applications. The most common approach was to deploy a simple three-axis, point-to-point Cartesian robot that was machine mounted. With enough Z (vertical) stroke to reach the centerline of the platen, these very simple robots quickly extracted parts from the mold and delivered them to totes or conveyors.

Twenty years ago, fully servo-controlled Cartesian robots became common, providing greater precision and control of the end-of-arm tools. Fifteen years ago, molders began applying six-axis robots in increasing numbers. This evolution was driven by several technical and business drivers that continue today:

At Dynamic Group, a small injection molder in Ramsey, Minn., a Universal Robots UR10 cobot handles the entire injection molding process. It picks and places "book frames" of inserts (near right) into the mold; removes the frames with overmolded parts; places frames in a trimming fixture (far right); and then places frames in front of an operator for further handline. Finally, the cobot pushes a button to start the next cycle.

Cobots can easily be moved from press to press, as seen here at Dynamic Group.

• **Post-mold processes.** Customers are requiring molders to deliver more complete parts and assemblies, and molders are glad to increase their value. Degating, trimming, polishing, decorating, assembly, wrapping and packaging are now common tasks that are perfect candidates for automation.

• **Improved surface finish.** Customers are setting very high standards for surface finishes, which require parts to be handled carefully from the mold to the final package or shipping container.

• **Shorter product life cycles.** The pace of product updates and new introductions requires constant change in manufacturing processes.

• **High mix/low volume.** Product customization, small lot sizes and on-demand production to reduce inventory are driving short runs, making setup even more demanding.

In the last 10 years, and with increasing frequency of late, plastics processors have begun adopting a new level of automation, called collaborative robots, or "cobots." Generally based on articulated-arm technology, these cobots add a layer of safety, user-programmability, and mobility to standard six-axis robots. To understand the cobots' attraction, it helps to start with a review of what makes articulated-arm robots popular in the first place.

The positioning flexibility and overall work envelope of six-axis robots are keys to their success in injection molding. The additional degrees of freedom translate into more choices and options in all phases of the material handling, assembly, and other applications, which translate into real process advantages:

• **Flexibility to execute pre- and post-mold processes.** Placing inserts into the mold and moving parts through post-mold processes means complex motions and demanding angles and positions.

• **Reduced tooling costs.** Four-axis Cartesian robots often require complex tooling to make up for their kinematic limitations. The range of motion and flexibility of six-axis articulated robots simplify tooling and gripper costs and complexity.

• **Flexibility to load precision inserts.** Acquiring and inserting precision inserts is enabled by the positioning flexibility and repeatability of six-axis robots.

• **Complex part extraction simplified.** Complex parts are difficult to remove without ejectors, but the dexterity of six-axis robots allows parts to be pulled gently out of the mold. ►

At Dynamic Group, a UR5 from Universal Robots works in tandem with a Cartesian robot. When the Cartesian robot drops the molded part down the slide, a proximity sensor alerts and activates the UR cobot, which picks up the part, places it in a degating fixture and then on a table, where an operator does a final quality check

At 2D&S in the Czech Republic, a UR10 inserts IML foils into the injection mold.

- **Flexibility to avoid obstacles.** Tiebars, slides, hoses and clamps often interfere with part motions. Six-axis robots provide the greatest flexibility to navigate around the mold.

- **Maintenance life.** Six-axis robots are sealed, with reduced maintenance, and increased uptime. Most Cartesian robots in injection molding require regular maintenance, as their drive trains are exposed.

- **Flexible mounting options.** Many six-axis robots can be mounted in various orientations to optimize layout, reach and cycle time. While the typical installation is floor or pedestal mounted at the back-side opening, other options are available for wall or ceiling mounting. For most six-axis robots, the mounting orientation is fixed, and must be set at the factory during the robot build. Other models allow orientation to be set quickly in the field.

- **Low overhead clearance.** Cartesian robots have a major drawback—the vertical (Z) axis extends above the robot centerline. Without a complicated and expensive telescoping Z-axis, ceiling height must be at least as high as the Z-axis extension. In many plants, conduit, wire trays, water, steam, and fire-suppression piping make this difficult, if not impossible. Mounting a six-axis robot over the injection machine can be accomplished even in very low-ceiling facilities.

- **Efficient use of floorspace.** Floorspace is always expensive, in any factory. And as molders add more and more pre- and post-mold processing to their offerings, the floorspace around a machine is in even greater demand. Machine mounting a six-axis robot provides the six-axis flexibility benefits, while freeing up floorspace for secondary operations.

- **Easy machine access.** Molds do have to be changed, and the maintenance department needs access as well. Mounting a six-axis robot on the machine or overhead also means clear access when required.

THE COBOT ADVANTAGE

Use of cobots is exploding in the injection molding market. While cobots deliver all the six-axis benefits noted above, they also deliver significant advantages not available with traditional automation:

- **More space-saving.** Collaborative robots were so named for their ability to work safely in close proximity to humans. When properly applied (after a risk assessment), cobots often do not require the heavy, expensive and space-intensive safety fencing and access doors associated with traditional automation. Their collaborative nature frees up even more floor-space, even for floor or pedestal-mounted installations, and allows for quick access to the cobot's work area without opening safety gates, disabling alarms, etc. (Note, however, that while the robots themselves may be designed with sensors and speed and torque limitations to make them safe around humans, their end-of-arm tooling, or the parts they are handling, could present hazards without some mechanical or electro-optical guarding.)

- **Operators engaged.** Cobots are designed to operate safely in close proximity to operators, other cobots and machinery. Maximizing the interaction between skilled operators and cobots can be more productive than using either robots or human operators alone.

- **Portability.** Lightweight and easy to set up and program, cobots are often treated as a manufacturing tool, moved from machine to machine as the production mix and schedule demand. Cobots have been successfully mounted on rolling bases or carts and wheeled into position for a short part run. Other installations have utilized magnetic bases or a high-precision collet mounting to enable cobots to be moved from machine to machine.

Simplified programming and setup, pre-engineered peripherals, and reduced or no guarding, all add up to automation at about half the cost of traditional robots.

- **Easy to program.** Some cobots offer extremely intuitive programming, making the setup, programming and interfacing to molding machines and other peripherals very straightforward. With no special software language to learn, even using lead-through teaching, operating costs are low and even small and medium-sized operations can successfully implement robot automation.

- **Low cost/fast ROI.** Cobots are changing how automation is implemented. Simplified programming and setup, pre-engineered peripherals like grippers and vision systems, and reduced or no guarding, all add up to automation at about half the cost of traditional robots. Cobot systems are routinely being installed in the $75,000 range, which means incredibly fast ROI, typically within six to nine months.

Watch cobots from Universal Robots tend injection molding machines at Dynamic Group in Minnesota, Alpha Corporation in Japan, and at Xiamen Runner in China—at http://short.ptonline.com/URcobot PT

ABOUT THE AUTHOR: Joe Campbell is the senior manager of applications development for Universal Robots North America, where he is leveraging his 35+ years' experience in robotics and factory automation. Prior to joining Universal, Joe was v.p. of sales and marketing for the Swiss based gantry-robot and track manufacturer Gudel. Previously he had executive roles in sales, marketing, operations and customer service with industry leaders including ABB, Kuka, AMT and Adept Robotics. Contact: *joca@universal-robots.com*; *universal-robots.com*.

How to Avoid Unpleasant Surprises in Size Reduction

Size-reduction equipment doesn't get much attention unless there's a problem or an entirely new application challenge. So when it's time to repair or upgrade, take these steps to avoid any unpleasant surprises.

By Dave Miller
Conair Group

There's an old saying: "The older I get, the less I know for certain." After 35 years of answering questions about shredding and grinding equipment, I continue to learn about what equipment will—and will not—do and I am often reminded why this statement rings true. For this reason, I tend to ask more and more questions about every application.

At the same time, however, I find that there are a number of comments, questions, problems and circumstances that are quite common—and often a little surprising. Let me share a few of them here.

Shredding heavy, dense purging scrap can be a challenge, depending on the formulation of the purge material.

"But the throughput rating is . . ." I take a lot of calls with questions about throughput. Some involve potential customers who have identified equipment they want to purchase for a new application based on its size/throughput, while many others involve throughput changes when an existing granulator moves to a new application.

In the case of a new machine, someone might say, "I'm thinking of this machine because I need 400 lb/hr." But as we talk about the application, I often make a different recommendation and tell them, "If you need to granulate 400 lb/hr of that particular material, this machine won't do it. You're going to need to look at this model instead."

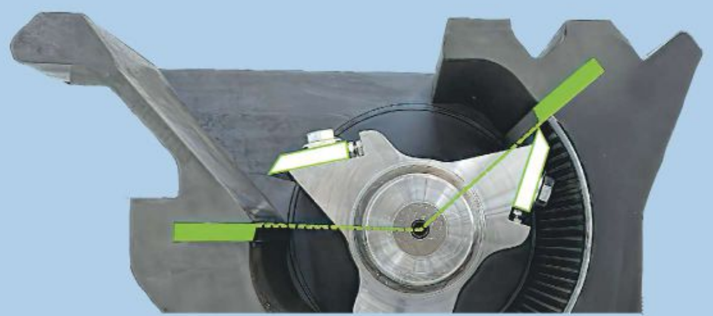
"But why?" is the question. "Your website said 400 lb/hr."

"Yes," I reply, "but 400 lb of this material isn't the same as 400 lb of that one." It's a fact that some materials are a lot harder to granulate than others. For example, the easiest material in the world to granulate is polystyrene. It processes considerably faster than something like polyethylene or polypropylene. The difference in throughput is night and day, probably 40%.

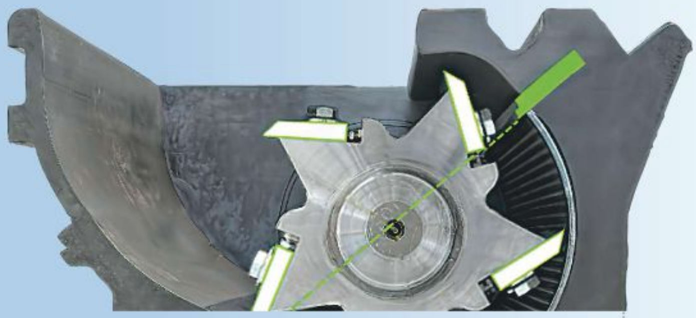
> ***It's a fact that some materials are a lot harder to granulate than others.***

But even if you're granulating the same material, throughput and performance differences can still be substantial. A granulator that works beautifully in one application often won't work for another. For example: a customer buys a grinder for injection molded PET preforms—very dense, small parts that are going to be blow molded into much larger bottles or jugs. If you select a machine to grind PET preforms, you don't need a large hopper or cutting chamber, though you do need the ability to cut through a fairly thick part. So you can use a smaller grinder, equipped with a tangential chamber, a three-blade rotor, and a little extra horsepower. Because the regrind is so dense, you don't need a huge discharge bin.

QUESTIONS ABOUT GRANULATING/SHREDDING?
Learn more at PTonline.com
Visit the Scrap Reclaim Zone.



A granulator with three-blade rotor and tangential cutting chamber, which works well for PET preforms, won't necessarily work for PET bottles (see next image).



Granulating both PET preforms and bottles takes another solution: a five-bladed rotor and a super-tangential chamber, plus a larger discharge bin, a larger motor, and a blower system to evacuate the bin and draw light bottle regrind smoothly through the machine.

But if you move that granulator down the line, to where you're generating PET bottle scrap, you may find that the tangential chamber is too narrow—the bottle either won't fit or you can't get the bottles to flow through the chamber, hopper and rotor smoothly enough to keep up throughput. And, because the bottle wall material is much lighter—lower bulk density—it's not going to fall as easily through the screen to the discharge bin. It's also going to overflow that bin much more quickly.

So, if you want a granulator that would deliver required throughput for both applications, you'll want to do a little homework up front. A better granulation solution, depending on the specifics, would probably involve a larger hopper, super-tangential chamber, five-bladed rotor, larger discharge bin and, very probably, a blower system that not only evacuates the bin, but draws light bottle regrind smoothly through the machine. You won't need the big hopper or blower when you switch back to preforms, but you'll appreciate the five-bladed rotor and the extra horsepower.

In a world with hundreds of additives and fillers, the need to granulate scrap from a "designer polymer" is always a possibility.

"Same material. What's the difference?" In a world with hundreds of additives and fillers, the need to granulate scrap from a "designer polymer" is always a possibility. In this case, I've learned to make fewer and fewer assumptions about what materials will, or will not, shred or granulate easier than others. When in doubt, one must test.

So recently, I set up a test to shred and granulate two gaylords full of purgings—about 1000 lb of each. All were comprised of the same base material—a PP/HDPE blend with additives—and were roughly the same in size (10-40 lb), composition, and color. For all intents and purposes, the purgings looked identical.

I selected a test shredder for the job, based on experience and input from the processor that produced a lot of these purgings. The processor needed a solution that would provide the throughput needed to meet the "purge surge" that happened with every production changeover, as personnel "dialed in" a new formulation.

To reduce frictional heat and improve shredder performance on very tough purgings, the solution may be a water-cooled rotor and a boost in horsepower.

We turned on the shredder and dumped in the first gaylord. Some 25 min later, great results: Granule sizes were good and uniform—just about perfect. Cuts were clean and sharp. Great throughput. Machine came through in great condition.

In went the second batch, and out went the rest of the day. Despite the apparent similarities, these purgings would not process smoothly. The material proved to be stretchy and harder to cut. Friction built up and created heat. Some of the regrind started to soften and melt.

A sticky goo accumulated in the rotor screen. Despite cleaning, inspection, and adjustments, the process took hours.

A little detective work after the test explained the differences and led to a solution: The first batch of purgings, made early in the line setup, contained a higher level of calcium carbonate. The excess of this filler acted to soften and lubricate the shredding process. The second batch of purgings—more representative of the production material—contained far less of the filler, but a similar amount of tackifier, accounting for the friction, melting, and mess.

The eventual solution was a larger, more powerful shredder with a water-cooled cutting chamber. By keeping the rotor cool, this model minimized frictional heat, kept the material cooler and firmer, and enabled the rotor knives to "grip" and slice through it more cleanly. This change did the trick.

Without testing, we would never have guessed the difference. That would have led to a bad surprise!

"I need a new grinder." Finally, I still get a lot of people who call and say, "I need a new grinder. Mine just isn't making it." So, I ask them, "What problems are you having?" The list always includes items like this:

- "Terrible regrind quality."
- "There's so much dust that I can hardly convey the material. The loader filters are constantly blinded and need constant cleaning."
- "I can't get it to grind this part without stalling or jamming up."
- "This grinder can't keep up. I can't get regrind out fast enough."

Fixturing simplifies knife reinstallation and positioning. After placing the knife into the fixture, the user simply turns adjustable bolts on the knives until they reach the proper position, as indicated by a feeler gauge. From there, the "preset" knives can be bolted straight into the granulator. Proper gaps are assured.

Without a "pre-setting" fixture, the "gaps" on sharpened granulator knives must be adjusted on the fly, using a wrench and a feeler gauge, as they are reinstalled into the granulator.

I've been getting this question throughout my career in plastics processing and my response is always the same: "Before you consider a new grinder, do one thing: Open it up, check the knives and sharpen them. Then, check the knife gaps."

I can't tell you the number of times that I have been out to look at a machine whose owners believe is headed for the scrap heap. There are several potential causes for the above problems, but the number-one cause is dull or poorly adjusted knives. I know that on some older granulators, it's hard, and even a little hazardous, to change, sharpen or adjust the knives. But it can be done. Unless you're running abrasive or glass-filled materials, you might be able to get away with as few as two or three sharpenings a year. And, knife sharpening/replacement doesn't involve a lot of downtime—a couple of hours or less, or perhaps a maximum of 4-5 hr on a large machine.

Newer-generation granulators typically have pre-adjustable knives, which can be fixtured and adjusted outside the granulator, making the installation and maintenance of sharp knives a lot easier and, more importantly, safer. For some processors considering an investment in new equipment, that's a key consideration.

So, a final surprise, which to me isn't so surprising: Often, for a particular application, you can fix granulator performance problems by just sharpening the knives and adjusting the gaps. If that doesn't work, then you'll know that a service call—or a new granulator—really is needed.

Like a lot of other plastics processing machinery, size-reduction equipment doesn't get much attention unless there's a problem or an entirely new application challenge. So, when it's time for you to repair or upgrade your size-reduction equipment, do two things with the help of your supplier: First, review its maintenance/repair history and optimize future maintenance (especially knife sharpenings) to maximize equipment life and performance. Second, explore the extensive configurability of new size-reduction equipment, because a carefully chosen configuration can reduce labor inputs and horsepower requirements, eliminate excess noise, save energy, and add valuable flexibility to meet varied application requirements.

ABOUT THE AUTHOR: Dave Miller is general manager of size reduction for the Conair Group. For nearly 35 years, Dave has worked with plastic processors throughout North America to provide granulation and shredding equipment to meet their size-reduction requirements. His work experience includes 31 years with Rapid Granulator, during which he held positions in direct sales, sales management, sales engineering, customer support, training and project management. Contact: *724-584-5580; dmiller@conairgroup.com; conairgroup.com.*

PT Keeping Up With Technology

PRODUCT FOCUS Hot Runners & Tooling

TOOLING

Off-the-Shelf Conformal Cooling Via Standardized Components

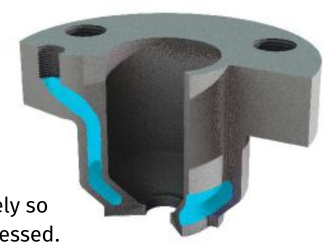
For the past two years, DME, a Milacron brand, has offered custom core and cavity inserts with TruCool conformal cooling, made by the direct metal laser melting 3D printing process. Recently, DME launched standard mold components incorporating conformal cooling technology. DME is starting with standard hot and cold sprue bushings and is working on other components, such as core pins.

David Moore, business development manager for DME, says standardized components with conformal cooling can provide big benefits at lower upfront costs thanks to bulk production. “You don’t have to go through that analysis process; you don’t have to go through a design and trial phase. It gives molders the freedom to add conformal cooling as a standard component instead of a custom-designed solution.”

DME’s entire B Series of cold sprue bushings with 1-in.-diam. shank will be available with conformal cooling. The components still feature the same external geometry, sprue taper and diameter, allowing them to act as a drop-in replacements for their conventional counterparts. The only difference is the addition of two ports for cooling inlet and the outlet. “They’re pretty much plug and play,” Moore says. “You can pull an old one out and put a new one in.” Molders or moldmakers would need to mill a channel in the back of the cavity block to accommodate the bushing’s water circuit. The bushings are currently printed from MS1 maraging steel, with a stainless version coming soon, and DME is also outfitting its A Series of cold sprue bushings, which have a ¾-in. shank, with conformal cooling channels.

For parts where the sprue’s diameter is the thickest section of the component, conformal cooling at the bushing could reduce cycle times that have been extended to compensate for the sprue. Stringing arising from ejecting too soon can also be eliminated, DME says. And since the sprue can be cooled more quickly, if a tool could benefit from a larger sprue—decreasing the amount of pressure needed to fill the mold—it could be used without impacting the process. Decreasing the required injection pressure might enable a mold to be run in a smaller press, Moore notes.

DME is also introducing bushings for hot drops and valve gating that will surround a nozzle tip with conformal cooling for greater control. Bringing cooling very close to the tip for greater control of valve-gate timing and solidification at the nozzle reportedly can help prevent gate blush and splay, as well as stringing. Made from H13 steel, the bushings have a few different options for face design and water-channel connections. The bushing can protrude through for maximum cooling, which would leave a witness mark; or a portion of the face can be milled off entirely so that the bushing is completely recessed.



To accommodate different drop-bore diameters, the center hole is smaller, allowing a molder to machine that opening to match the existing system. “This would work for a variety of different diameters and gating scenarios,” Moore says.

COLORANTS

New System Allows Custom Liquid-Color Matching by Molders

A new liquid-color mixing and dispensing system is designed to permit efficient in-house color matching by injection molders who perform short runs with short lead times and handle dozens of colors. The Pinpoint system was developed by PolyOne in collaboration with 3M. It combines proprietary software and liquid-colorant technology from PolyOne's ColorMatrix Select system with dispensing and dosing equipment from 3M. According to Will Nordloh, general manager of ColorMatrix, "Pinpoint enables short-run injection molders to make a step change in their ability to serve customers by significantly reducing the time needed to design and create colors. The system also helps reduce operating costs by eliminating the need to carry excess or expired colorant inventory."

Pinpoint made its debut at last month's MD&M East show in N.Y.C., where it was showed off by an early adopter of the system, Protolabs, a custom maker of metal and plastic parts for rapid prototyping and on-demand production. Jeff Schipper, the company's director of Special Operations, agrees that Pinpoint is a "game changer" for cosmetic applications such as medical-equipment housings and consumer electronics. He says customers can supply a Pantone color number or a physical sample of a color to be matched. The Pantone number or data from a spectrophotometer scan of the sample is fed into the Pinpoint software to generate a starting recipe of ColorMatrix liquid colors to be blended. (Schipper compared this to blending paints at a hardware store.) Additional data entered into the recipe software includes the plastic resin to be used and any special application data such as suitability for medical use or outdoor UV exposure. The user also indicates whether the recipe should be optimized for closest match or lowest cost. A typical recipe can utilize four or five different base colorants, but can include as many as eight to 10, Schipper says.

The starting recipe is fed into the Pinpoint dispenser. Containers of around 1 qt capacity for single colorants that make up the recipe are connected to a feed tube and locked into the device. The required amount of each colorant is dispensed one at a time into a container for the final color. The amount dispensed is checked gravimetrically by weighing the receiving container. Schipper noted that a barcode scan of each ingredient color is required by the system as a QC check to ensure that only the correct colorants are blended. The completed blend is then placed in a shaker to mix the components. Finally, the container with the blended colors is placed in a Pinpoint metering pump on the injection machine to produce colored parts. The device holds two containers; when one empties, the system automatically switches to the second so the first can be replaced without interrupting production.

Schipper says its Pinpoint system is currently available for 13 resins, including ABS, PC/ABS, PP, HDPE, LDPE and LLDPE. Protolabs can supply a sample color chip to customers within three days of receiving the Pantone number or color sample. Schipper says customers accept the first sample in the "vast majority" of cases so far, though Protolabs offers up to three iterations if necessary. Protolabs guarantees a match within a Delta E of 3, "though we're usually within 1 to 1.5," Schipper says. (He notes that the human eye can detect color differences at a Delta E of a little over 2.) Schipper also notes that Protolabs has used the resulting liquid colorants for molding runs as long as three days without problems. "With development cycles shrinking to meet the market demand for increased customization, this is yet another tool to help our customers accelerate product launches and streamline supply chains," says Joel Matthews, Protolabs global product manager.

Prices of Volume Resins Mostly Flat or Lower

PP, PVC are the exceptions, with prices on 'short-term' upward path.

The second quarter was on track, at press time, to close with prices of nearly all commodity volume resins flat or lower. There were exceptions: PVC suppliers were attempting an increase last month to replace a failed effort; and late-settling May propylene monomer contracts resulted in PP prices moving up, though that spike was expected to be short-lived.

By Lilli Manolis Sherman
Senior Editor

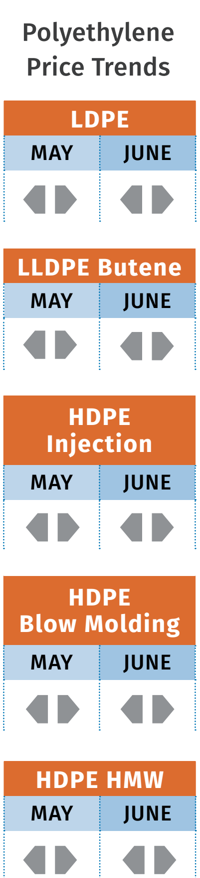
In brief, those are the views of purchasing consultants from Resin Technology, Inc. (RTi), senior editors from *PetroChemWire* (*PCW*), and CEO Michael Greenberg of The Plastics Exchange in Chicago. Here are details:

PE PRICES FLAT-TO-DOWN

Polyethylene prices were flat in May, having risen 3¢/lb in late April. Suppliers appeared to postpone a May 3¢/lb hike as they struggled to justify the earlier increase, according to Mike Burns, RTi's v.p. of PE markets. In fact, the outlook for June and July was for flat to lower prices, according to both Burns and *PCW* senior editor David Barry. "Barring storm-related disruptions or some major global event, we could see more downward pricing impact through the third quarter," said Barry.

Burns emphasized that every price driver was pointing to a flat-to-downward market, ranging from oversupply to lower global feedstock prices. He noted that oil price surges would be the only factor to reverse this trajectory and expected price-increase attempts to dissolve, along with a good chance of the April 3¢ increases fading away. The Plastic Exchange's Greenberg reported, "With additional new capacity slated to come online, some buyers are already hoping for that increase to be peeled back in June, but producers will do their best to hold it and defend their progress."

Greenberg characterized the spot market going into June as plentifully supplied. Spot PE prices were reported to have dropped 1¢/lb, except LDPE film grades and LLDPE injection grades, which were flat.



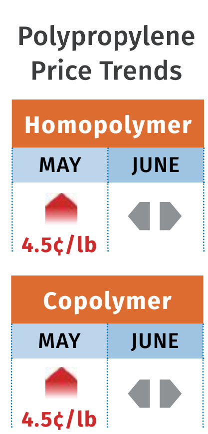
Market Prices Effective Mid-June 2019

Resin Grade	¢/lb
POLYETHYLENE (railcar)	
LDPE, LINER	98-100
LLDPE BUTENE, FILM	81-83
NYMEX 'FINANCIAL' FUTURES	38
JUNE	38
HDPE, G-P INJECTION	103-105
HDPE, BLOW MOLDING	96-98
NYMEX 'FINANCIAL' FUTURES	40
JUNE	40
HDPE, HMW FILM	110-112
POLYPROPYLENE (railcar)	
G-P HOMOPOLYMER, INJECTION	72-74
NYMEX 'FINANCIAL' FUTURES	50.5
JUNE	50.5
IMPACT COPOLYMER	74-76
POLYSTYRENE (railcar)	
G-P CRYSTAL	107-109
HIPS	111-115
PVC RESIN (railcar)	
G-P HOMOPOLYMER	82-84
PIPE GRADE	81-83
PET (truckload)	
U.S. BOTTLE GRADE	60-63

PP PRICES UP

Polypropylene prices increased by 4.5¢/lb in May, in step with propylene monomer contract prices, which settled at 40¢/lb. Projections for June and July were for mostly flat pricing, potentially with slight movement down or up, according to both Scott Newell, RTi's v.p. of PP markets, and *PCW*'s David Barry. Newell and Barry characterize the market as well supplied, owing to slower domestic and export sales, which were offset by some planned and unplanned production outages.

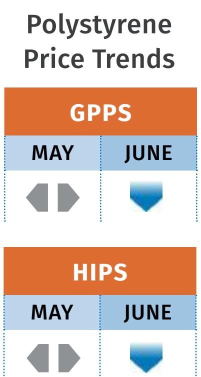
Newell and Barry also ventured that propylene monomer supplies should be in good shape, as maintenance season was coming to an end. Greenberg reported that spot monomer prices had eased by end of May, adding that spot PP prices dropped by 1¢/lb. All three sources do not expect prices of PP, which will continue to follow the monomer, to rally back up



to the high levels of past years. (From October 2018 to April 2019, PP prices dropped by nearly 25¢/lb.) What's more, domestic PP demand has been weak in all major market sectors. Says Newell, "This has switched from a seller's market for the last three years to a buyer's market." Through April, domestic PP demand was down 1.2%, with total demand up 8% due to exports.

PS PRICES FLAT-TO-DOWN

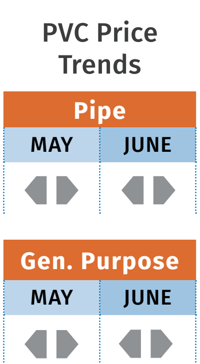
Polystyrene prices remained flat in May and were expected to remain so in June, with a downslide possible in July. This was after PS prices rose 2¢/lb in March and 2-4¢ in April, according to *PCW*'s David Barry and Robin Chesshier, RTi's v.p. of PE, PS and nylon 6 markets. Said Chesshier, "July has more potential for some price relief, as buyers felt that a 4¢/lb price increase was too much. I think they will become more aggressive to get rid of at least the 2¢/lb that suppliers attributed to flooding conditions in the Midwest."



Chesshier noted that by end of April, supply was up 2% while demand was up only 1%, and exports for both monomer and PS were down by 17%. Both she and Barry characterized PS seasonal demand as lackluster, noting that it's not where it typically should be. According to Barry, the implied styrene cost based on a 30/70 formula of spot ethylene/benzene prices was up slightly at 26.1¢/lb as falling ethylene partly offset the benzene uptick.

PVC PRICES FLAT TO UP

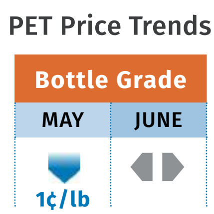
PVC prices dropped 2¢/lb in April, nixing suppliers' February increase, and were flat in May, but new 2¢/lb hikes emerged for June 1, according to Mark Kallman, RTi's v.p. of PVC and engineering resins, and *PCW* senior editor Donna Todd. "There are a lot of balls in the air regarding the success of the new 2¢/lb increase," said Kallman. He cited lower feedstock prices, contrasted by the potential for increased demand following a slowed construction season, along with one major supplier's planned June maintenance shutdown that could tighten supply.



PCW's Todd noted that some buyers contended that the June price hike will not go through—at least fully. *PCW* said that if domestic and offshore demand was as strong as producers contend, they would have been able to achieve more price increases this year. Suppliers have also not shared with resin buyers their profit margins resulting from the 8.75¢/lb decrease in ethylene contract prices, with more declines expected.

PET PRICES DOWN

PET resin prices dropped 1¢/lb at the start of June, with imported PET available in the high 50¢/lb range delivered within 300 miles of ports on the West Coast, East Coast and in the Midwest. Domestic PET was 1-4¢/lb higher (60-63¢/lb range) for railcar business tied to monthly contracts using feedstock costs as the pricing basis.



A surplus of PET imports and globally lower prices for feedstock paraxylene were the major reasons for lower PET prices through much of the second quarter, according to *PCW* senior editor Xavier Cronin. He noted that market sources expect domestic prices to stagnate at current levels through June and possibly into July, despite increasing demand for PET from bottle makers in the high-consumption summer season.

ABS PRICES FLAT

ABS prices remained flat through most of the second quarter and this month was likely to follow suit, said RTi's Kallman. Key drivers include domestic demand that has been flat to down from all key market sectors, and the imports factor. Prices in May stood at very competitive levels due to the escalation of trade conflicts. "Spot ABS import prices are already quite low. Recovery of the domestic ABS market will depend on resolution of the trade war," explained Kallman.

PC PRICES FLAT

Polycarbonate prices were flat through much of the second quarter, according to RTi's Kallman. He ventured that this trajectory would continue, despite some increases in feedstock costs, which have remained well below 2018 levels. Weaker domestic automotive demand and a late start to the construction season signaled some potential for further price concessions.

NYLON 6 AND 66 MOSTLY FLAT

Nylon 6 prices rolled over in April, having remained flat through the first quarter, according to RTi's Chesshier, despite a move by suppliers to raise prices in April. Suppliers announced hikes of 6¢/lb, attributing the move largely to a temporary climb in benzene prices, but there was strong resistance from buyers. This was because benzene prices eased off and resin was in oversupply. A key reason for the latter is relatively weak demand from the automotive sector, which has not rallied all year. Yet another factor was a nearly 17% increase in availability of well-priced European imports.

Nylon 66 prices remained largely flat through the first two months of the second quarter, as they had during the first, following the 2018 increases of 25-40¢/lb that were driven by globally tight supply of nylon 66 intermediates. RTi's Kallman characterizes the market as much more balanced, the result of a 10-month global softening in demand in the automotive sector, coupled by incremental improvements in the supply chain.

Index Expanded Modestly in May

Index pulled to 51 by lower exports and backlogs.

By Michael Guckes
Chief Economist/Director of Analytics

The Gardner Business Index (GBI) for Plastics Processing moderated to 51 in May. Compared with May 2018, the Index is 11.3% lower. (Index values above 50 indicate expansion, a value of 50 represents no change, and values below 50 indicate activity is contracting.) New orders led the Index higher, followed by employment, production and supplier deliveries. The Index was pulled lower by exports and backlogs, but only backlogs actually contracted during the month.

The month's data presented a few indications that the plastics processing industry continues to moderate its growth rate since experiencing in 2018 its best year since Gardner began tracking data in 2011. For the first time since new orders and production spiked in early 2018, the growth of supplier deliveries fell below the growth level of both new orders and production. The implication of this is that the supply chains, which had been racing to respond to the early-2018 surge in new orders, have now fulfilled those upstream needs and are now positioning to maintain healthy inventories.

With this report Gardner Intelligence has refined how the Custom Processors Index is calculated in order to better track this segment of the industry. Employment and supplier deliveries were the top supporting components of the Custom Processors Index. But an unusually steep contraction in backlog activity dragged the Index reading below 50. PT

Michael Guckes is the chief economist/dir. of analytics for Gardner Intelligence, a division of Gardner Business Media, Cincinnati. He has performed economic analysis, modeling, and forecasting work for nearly 20 years among a wide range of industries. He received his BA in political science and economics from Kenyon College and his MBA from Ohio State University. Contact: *(513) 527-8800*; *mguckes@gardnerweb.com*. Learn more about the Plastics Processing Index at *gardnerintelligence.com*.

Gardner Business Index: Plastics Processing

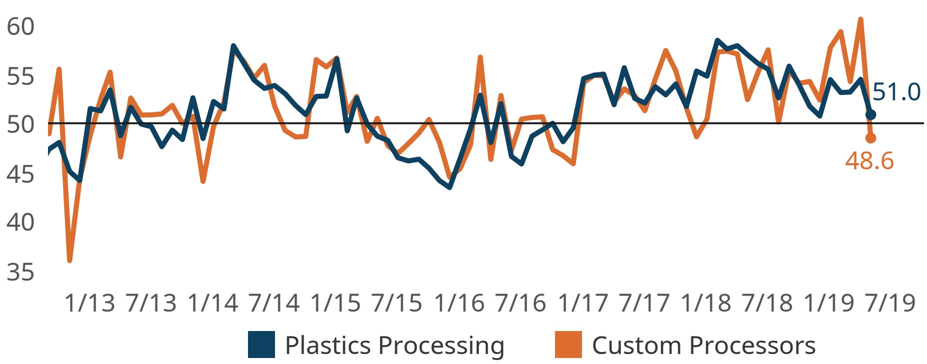


FIG 1

The Plastics Processing Index expanded in May, led by new orders, employment and production. New orders often influence the direction of other index components in later months. An unusually steep contraction in backlogs was the most significant driver of the Custom Processor Index's May reading.

New Order Activity Concentrated Among Larger Firms

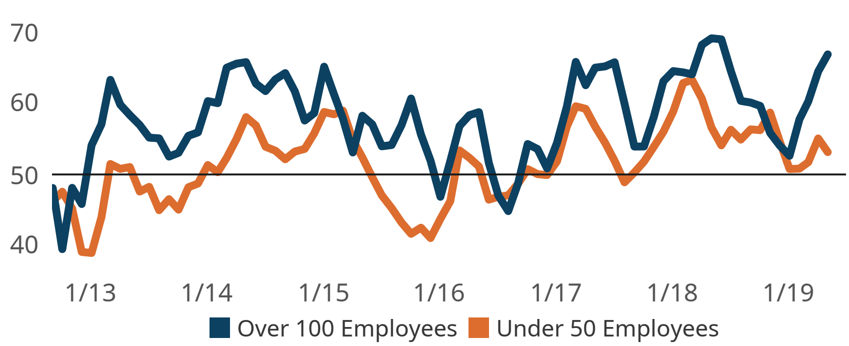


FIG 2

New order's activity was the leading driver of the Plastics Processors Index in April and May. In recent months, larger processors have seen the strongest growth in new orders.

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Monthly Resource Guide

You can get copies of literature from suppliers listed on these pages by sending an e-mail to the address provided at the end of each writeup. Or, where provided, contact the company by phone or fax.

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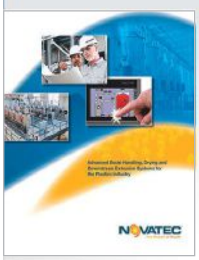

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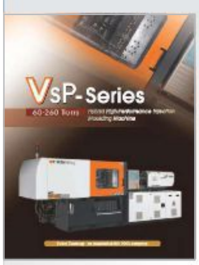

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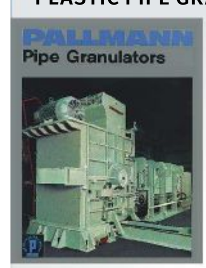

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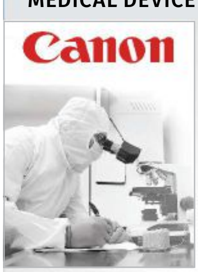

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AARON INDUSTRIES CORP. — LEOMINSTER, MASS.

Molders of Large Totes Save Material & Energy Costs with Recycled PP

Aaron Industries' 100% recycled PP compound fortified with Milliken's specialty modifier boosts MFI and retains strength.

By Lilli Manolis Sherman
Senior Editor

A manufacturer of specialty recycled thermoplastic compounds, Aaron Industries Corp. in Leominster, Mass., is winning praise from customers who make housewares with the recent launch of its Jet-Flo Polypro high-melt-flow compound. Not only does the recycled PP compound promote sustainability, but it allows for molding thinner, lighter parts that require both less material and energy.

The "secret sauce" in this new compound is a DeltaMax Performance Modifier from Milliken & Co.. Spartanburg, S.C., part of a new additive line joining the company's well-known clarifiers and nucleating agents. As previously reported, Milliken describes this family of products as novel reactive extrusion modifiers that maximize PP impact strength and MFI without compromising stiffness (see June '18 feature). These improved properties allow PP to be used in a wider range of applications in more cost-effective ways. In addition to being tailored for use in impact PP copolymers, DeltaMax technology has also proven effective in modifying post-consumer and post-industrial recycled resins. It elevates impact and melt flow to the same level as—or better than—those of virgin resin, a capability that allows compounders and converters to use up to 100% recycled PP without sacrificing performance or processing.

Aaron Industries' 100% recycled PP compound allows molding of large totes that are thinner, lighter and require less material.

Robert Tocci, v.p. of Aaron Industries says the new Jet-Flo Polypro is among the first recycled PP materials to combine two properties that are normally mutually exclusive: extremely high MFI of 50-70 g/10 min and good impact performance (notched Izod of 1.5-2.0 ft-lb/in). High MFI and good toughness suit this compound to economical, highly durable, thin-wall parts, such as housewares. By adding significant value to recycled PP, Aaron Industries is helping to encourage broader use of sustainable alternatives to virgin PP resin.

Novel additive imparts hard-to-get combo of high flow and toughness

According to Tocci, Aaron Industries historically has used peroxide to increase the MFI of its recycled PP, but that method reduces impact strength. This led the company to work with Milliken and its DeltaMax modifiers, which reportedly can increase MFI up to fivefold while maintaining impact strength. The two companies finalized the development of the Jet-Flo compound, which is available as gray and black pellets in eastern parts of the U.S. and Canada.

Notes Tocci, "We started by doing a lot of internal testing as we have a full-scale lab." This followed field testing with two molders of 20-30 gal PP totes. "This DeltaMax modifier has a really high upside. These molders have been transitioning to very-high-melt-flow PP—from 20-30 MFI to 50, 60 and 80 MFI—as they want to produce these totes with thinner walls and save money. This is a very high-volume market, and we couldn't make an entry with a repro compound because we didn't have an additive that would both increase the MFI and maintain impact strength."

Not only does Milliken's DeltaMax enable Aaron's 100% post-industrial recycled PP compounds to achieve the desired blend of MFI and toughness, but a molder making a 20-gal tote reportedly can reduce molding temperatures by 20-30° F and can run bigger molds on a smaller machine. "We've seen cycle-time reduction of 5-15%, depending on molding temperature," says Tocci. The DeltaMax fortified compound allows for more complex and thinner-wall geometries for products ranging from housewares and lawn/garden products to automotive components.

Wittmann Battenfeld

Don't just take our word for it

Left to right: Travis Smith, Molding Process Manager ; John Avery, Senior Product & Manufacturing Engineer ; JP Magat, Product & Manufacturing Engineer

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– John Avery, Senior Product & Manufacturing Engineer, **Stenner Pump Company**

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