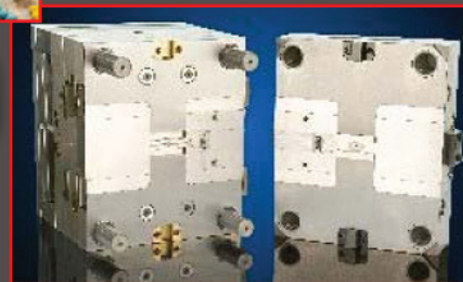
Fall 2014 | No. 97



MOLDING VIEWS

Brought to you by the Injection Molding Division of the Society of Plastics Engineers

Chair's Message

Dear Members,

With the Internet and social media, professionals in every industry are utilizing these tools for communication, training, and networking. Those of us that work in the injection molding world are no different. Therefore, the Injection Molding Division launched a 3-part webinar series in October and November in order to provide training in part design, gate and runner design, and simulation. A new website (www.injectionmolding.org) was also launched in 2014 with the intent of providing access to upcoming conferences and events, current and past newsletters, and other resources such as relevant books, articles, and troubleshooting videos.

It is through these types of avenues the IMD is reaching out to its members in order to provide more value and advance the industry. Further opportunities for industry training will be avail-

In This Issue:

Letter from the Chair 1
Industry Events 3
Webinar Listings 4
Ask the Expert: Injection Molding 6
Tech Tips: Understanding the Gravity of the Situation 9

This Month's Features:

Swith over to Consistent Quality 13
| *Mark Rosen, Corex Design Group Inc.*

IMD Best Paper: 20
Vapor-Foamed Injection Molding of Polycarbonate Using Sodium Chloride and Active Carbon as Nucleating Agents

Additive Manufacturing (AM), Creating New Tradespace for Plastics 30
| *Jack Dispenza, Design Results, LLC*

IMD Board Minutes 36
IMD Leadership 39
IMD New Members 40
Membership Application 43
Industry News 45
Publisher's Message/Sponsors 48

Chair's Message Continued

available at the Annual Technical (ANTEC) Conference, held in Orlando, FL from March 23-25. In addition to the technical presentations covering cutting-edge research in the areas of plastics materials and processing, the IMD will also be hosting a one-day tutorial session, aimed at the industry practitioner, and consisting of tutorials on part design, screw design, process setup/optimization, and other relevant topics. Look for the schedule to be published on www.4spe.org, www.injectionmolding.org, and also in your e-mail. The IMD is hoping its members find value in these types of applied training opportunities, and we look forward to seeing everyone in Orlando, FL in March 2015!

Best Regards,
Adam Kramschuster
Chair, IMD Board of Directors

Industry Events Calendar

Click the show links for more information on these events!

November 2014

19-20:
Expoplast 2014

Palais des congrès de Montréal
www.4spe.org

euromold.
World Fair for Moldmaking and Tooling, Design and Application Development

25-28:
EuroMold 2014

Frankfurt/Main, Germany
www.euromold.com

January 2015

14:
Single-Screw Extruder Analysis and Troubleshooting
Charlotte, NC
www.4spe.org

February 2015

SPE INTERNATIONAL POLYOLEFINS CONFERENCE | SPE South Texas Section
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23-25:
2015 SPE International Polyolefins Conference
Houston, TX
www.4spe.org

23-25:
SPE ACE Conference 2015
Houston, TX
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March2015

ANTEC® Orlando

Orlando, FL
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Webinars

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Five Ways TPEs Can Help Pharmaceutical Device Manufacturers Meet the Impending Capacity Crunch

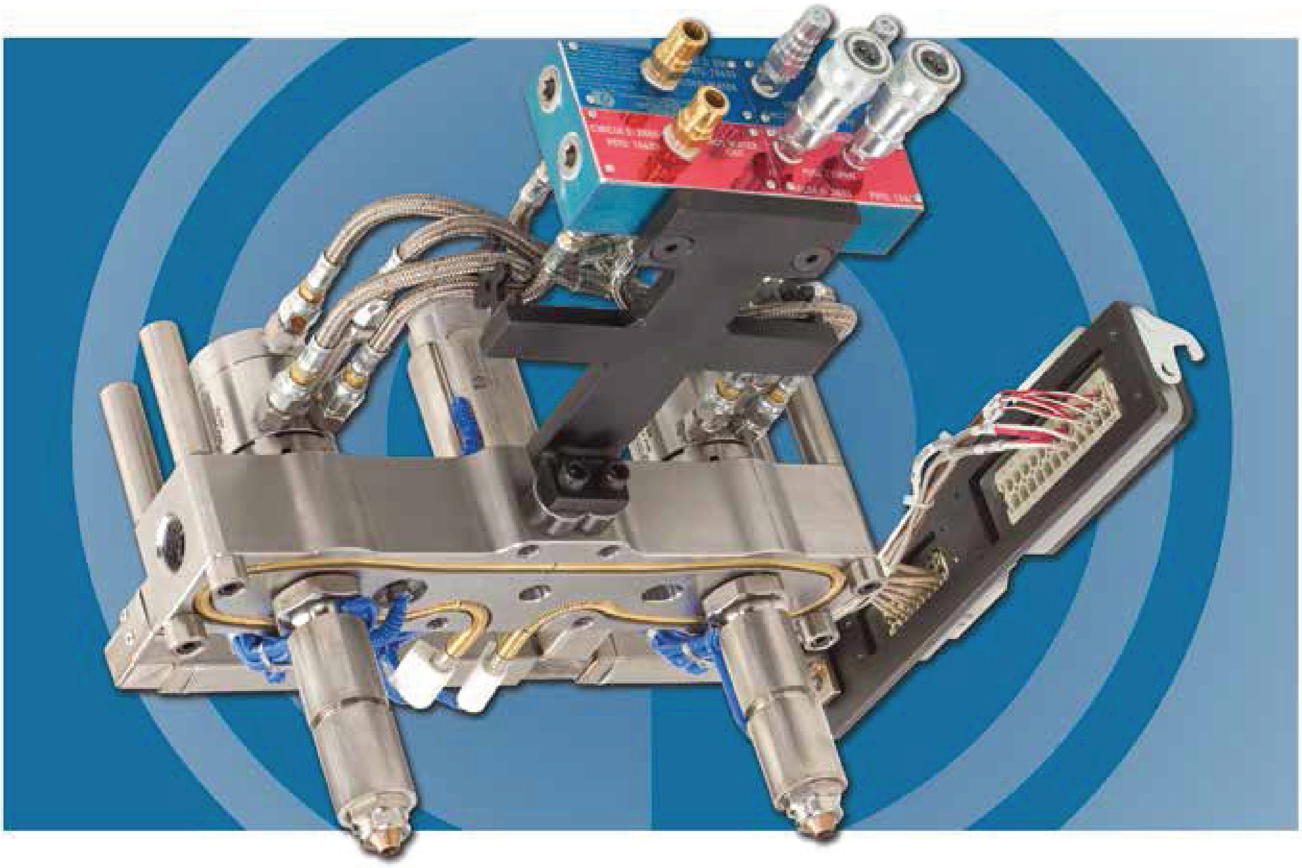
Injection Molding Troubleshooting: Flash & Burn Marks

Injection Molding Troubleshooting: Short Shots & Weldlines

Maximizing Regrind Quality for your Granulation Processer

How PolyJet 3D Printing is Revolutionizing Injection Molding

Dry Ice in the Plastics & Rubber Industry: Cut Costs, Improve Productivity and Quality



WHO'S BRINGING NEW LEVELS OF PERFORMANCE TO COMPACT HOT RUNNER/MANIFOLD SYSTEMS?

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The Best Surface for Leveling An Injection Molding Machine

Bob Dealey, owner and president of Dealey's Mold Engineering, Inc. answers your questions about injection molding.

Bob has over 30 years of experience in plastics injection-molding design, tooling, and processing.

You can reach Bob by e-mailing molddoctor@ dealeyme.com

Q: What is the best surface to use when leveling an injection molding machine; the tie bars or the machine ways? Then, what sequence or order is the best?

A: The quick response is to follow the instructions and guide lines provided by your injection molding machine manufacturer. I believe the first priority in the operation of an injection molding is that the machine platens are in alignment, both when the machine is closing and then upon clamp up. By leveling the machine with the clamp function as the first priority, the machine should be level in theory to support the other functions.

Personally, I prefer using the machine tie bars (assuming it isn't a vertical or tie bar less machine). I believe it is easier and more accurate to position a precision level on or across the tie bars then the ways.

Generally, the first step is to evenly distribute the weight of the injection molding machine on each of the machine pads or mounts. One company that I worked at actually had a scale where the weight could be checked. Most companies are not equipped with a scale. Then one method is to torque all machine pads to the same amount, and in theory the machine weight should be equally distributed to all the pads. Never assume that the floor is level and use the same amount of bolt turns to distribute the weight.

Place the level across the bottom tie pars as close to the stationary platen as possible and adjust all the pads on the side that is low, by an amount necessary to level the machine from front to back. To do this you need a long precision level, a long precision bar, or if not available a neon light tube is a viable option.

Then, place the level along the length of the bottom tie bar on the operator or control side of the machine. Adjust the pads on either the front or back of the

Ask the Experts: Bob Dealey Continued

machine on each side, to raise the low end of the machine to achieve the proper level. Keep in mind that that the leveling on the length of the machine could and probably will affect the machine level in the cross direction.

Always go back and double check the level in both directions. This is always a tedious but important task. It is typically not a quick or easy operation.

Using the machine ways for leveling, while not wrong, typically is more difficult to insure the level resting flat and/or square to each other. However, in theory a machine leveled using the tie bars, should be level when measured on the ways. If the level is off by a mere fraction there is something with the alignment that requires a greater in depth investigation and correction. Leveling alone will not overcome that issue.

As always, we invite input from other our readers and those who have experiences leveling injection molding machines.

Bob Dealey
MoldDoctor@dealyME.com

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Understanding the Gravity of the Situation

If you work in the injection molding industry long enough, at some point in your career you will be sure to hear someone say “turn the mold 90 degrees (or 180 degrees) to see if the problem changes”. And when asked why on earth would that person suggest such a thing, the answer usually is “because gravity is pulling the plastic down to the bottom of the mold”. At this point everyone gets a good laugh and makes fun of the person who suggested such an absurd solution. But are plastic materials immune to Isaac Newton’s Law of Universal Gravitation? No... Then why is it considered absurd to think that gravity could not influence the filling of a plastic part made by the injection molding process?

Figure 1

Photo courtesy of Purgex.

The simple answer is that gravity always acts on the material but its influence is heavily influenced by wall thickness. A majority of plastic parts are considered “thin walled”. In this situation, the relatively thin walled channels, high viscosity fluid and high pressure-driven flow assures that the plastic is nearly always in intimate contact with the cavity walls. This intimate contact causes the polymer to freeze/stick to the cavity walls. Couple that with the fact that the molding process is done under very high speeds and pressures, we simply don’t expect to see much influence, or at least any measurable amount of influence, of the gravitational pull on the majority of molded parts.

But there are molders who make plastic parts that have thick wall sections. And depending on the wall thickness, the material being molded, the process conditions, the cavity orientation, gate location, and a few other factors, gravity may finally have a chance to work its magic on our plastic parts. Afterall, if there is nothing for the plastic to stick to as it comes out of the gate then the plastic will fall to the bottom of the cavity. As an example, simply observe what happens when you purge out the barrel of a molding machine. There is nothing for the material to stick to outside of the nozzle, so gravity takes over (**Figure 1**).

Technology Tips: Understanding the Gravity of the Situation Continued

That is an extreme case, so let's take a look inside a few injection molds to make this more relevant. The first example will be the mold that John Beaumont built to first study the effect of shear on filling variations. The cavities were designed to be "purge pockets" (**Figure 2**) with a thickness of 19mm (.750"). As shown in **Figure 3**, it was observed that the plastic flowed to the bottom of the cavities but not the top (note the relative location of the plastic versus the gate, which was centered per **Figure 2**). This was due to the thickness of the purge pockets and the fact that the plastic had little to stick to as it came out of the gate.

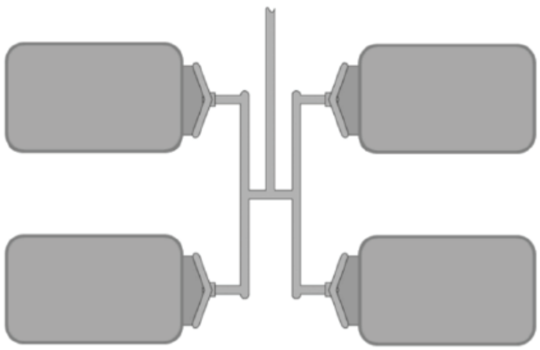


Figure 2

Figure 3

The second example comes from a mold producing thick walled screw driver handles. The short shot in **Figure 4A** shows how gravity is pulling the plastic to the bottom of the bottom four cavities, thus causing a cosmetic defect for those four cavities. The top four cavities are filling as expected with no cosmetic defects present. This filling pattern was also observed in a filling simulation which was setup to represent a short shot of this mold **(Figure 4B**).

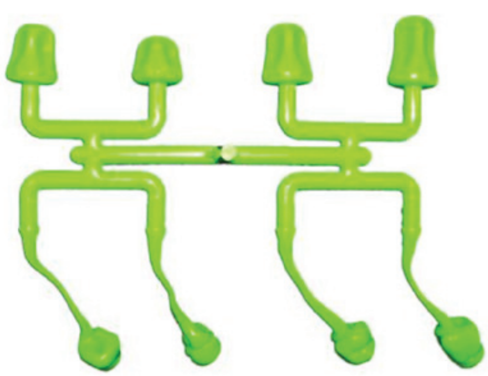


Figure 4A

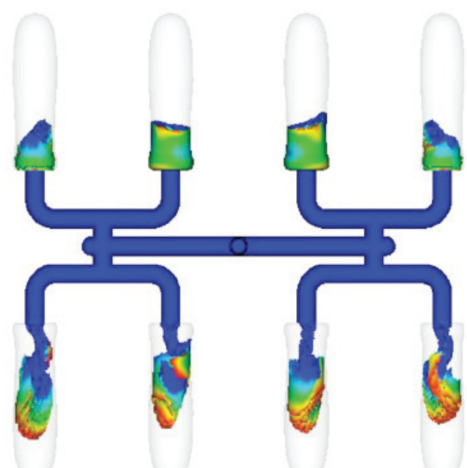


Figure 4B

Technology Tips: Understanding the Gravity of the Situation Continued

The mold was then turned 90 degrees and, after the laughter turned to amazement, the problem went away. **Figure 5A** shows the results (molding black handles instead of green). However, gravity's influence did not completely go away. **Figure 5B** shows how the material is still biasing the bottom half of the cavity. But regardless the filling was much improved and the cosmetic defect was resolved with the new mold orientation. **Figure 5C** shows the simulation output with the new orientation.

Figure 5A

Figure 5B

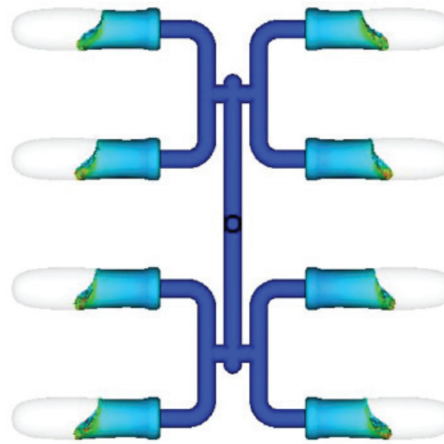
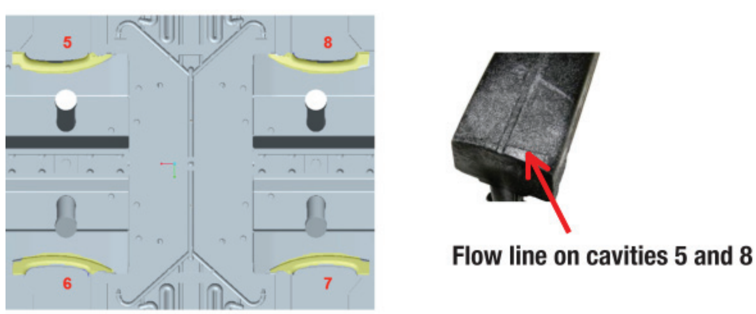


Figure 5C

Just to be clear again...gravity will have very little influence over the majority of injection molded plastic parts and its effect can be ignored. However, under the right conditions, gravity can certainly alter the filling of a mold and the resultant part quality. A mold designer for thick walled parts may want to keep this in mind as the cavity orientations are determined. Otherwise, the molder may unnecessarily find themselves chasing their tail.

Quiz: The 4-cavity mold shown in **Figure 6** produced thick-walled gas-assist molded automotive handles oriented as highlighted. The mold uses a cold runner with one gate per part. The bottom two cavities, 6 and 7, produced acceptable parts. The top two cavities, 5 and 8, produced unacceptable parts due to a visible flow-line on one end of the part. How would you expect the filling pattern to vary between the top and bottom cavities relative to the part shape, and what would you suggest to resolve/avoid the problem?

Figure 6



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Dipl.-Ing. Josef Giessauf, ENGEL AUSTRIA GmbH in Schwertberg/AUSTRIA
Prof. Dr.-Ing. Georg Steinbichler, ENGEL AUSTRIA GmbH in Schwertberg/Austria and Director of the Institute of Polymer Injection Molding and Process Automation at the Johannes Kepler University, Linz, Austria

Switch over to Consistent Quality

Although modern electric injection units can be shown to execute movements with the highest levels of repeatability, consistent molded part quality is still, in practice, often unachievable. The most important factors influencing this have been found to be variations in the quantity of melt and melt viscosity. A new process control method picks up these variations during the injection phase and equalizes them within the same shot.

How stable is the cushion on machine X? How strongly does the peak value of the injection pressure vary on machine Y? Injection molding machine manufacturers are often confronted by questions like these. Since these parameters are, for the most part, dependent less on the machine itself but rather on the process as a whole (material, mold, drying, process settings, etc.) it is very difficult to provide a blanket answer to such questions. It is important, therefore, to first look in more detail at why repeatable movements in the injection molding machine do not necessarily lead to consistent molded part quality.

Precise Movements are not a Guarantee of Quality...

For the analysis, an LCD frame was manufactured in polypropylene on an all-electric e-mac 200/50 from ENGEL AUSTRIA GmbH. In order to be able to look, in isolation, at the variations in the filling phase, short shots were produced without holding pressure. Screw movement was stopped at a defined switchover position representing a fill level of about 95%. In doing this, the smoothing effect of the holding phase was removed and deviations in injection could be directly assessed on the basis of the fill level and the weight of the molded part.

External inductive position transducers recorded variations in the start and end positions. The encoders integrated into the drives ensured a high level of positional accuracy so that the start position of the screw was repeatable to within ±10µm and the end position to within ±3µm. For the 25mm diameter screw these values equate to a maximum variation in volume of $0.012 cm^3$, which for polypropylene is equal to a weight variation of 0.009g.

Feature: Switch over to Consistent Quality Continued

However, the shot weight variations actually measured during testing were 0.11g, which is twelve times as much as could be explained by the tiny variations in the position of the screw (**Figure 1**). Why then does the amount of material vary despite the high precision of the movements?

… Because Melt Quantity and Viscosity Vary

Initial suspicions centered on the closing behavior of the non-return valve. Yet, in many cases this is found to be no more than prejudice. Detailed investigations have shown another important effect: at the end of decompression after plasticizing, polymer melt continues to flow from the screw channels into the space in front of the screw with lower pressure level. Due to slightly different boundary conditions (material homogeneity, melt temperature, viscosity, etc.) the quantity of polymer melt flow changes — this effect can be clearly observed in the molded parts.

Finally, whether variations in the quantity of melt are caused by continuing polymer flow or by leakage losses during the closing of the non-return valve, the effect is the same in both cases: during injection the curve of specific injection pressure is shifted (**Figure 2A**). The different filling levels lead to different pressure values at the switchover point.

A second significant reason for the process variations are changes in polymer viscosity that are mostly based on batch or moisture variations. Fundamentally the pressure required to fill the mold is proportional to melt viscosity. If the viscosity increases then the pressure during injection rises more steeply (**Figure 2B**).

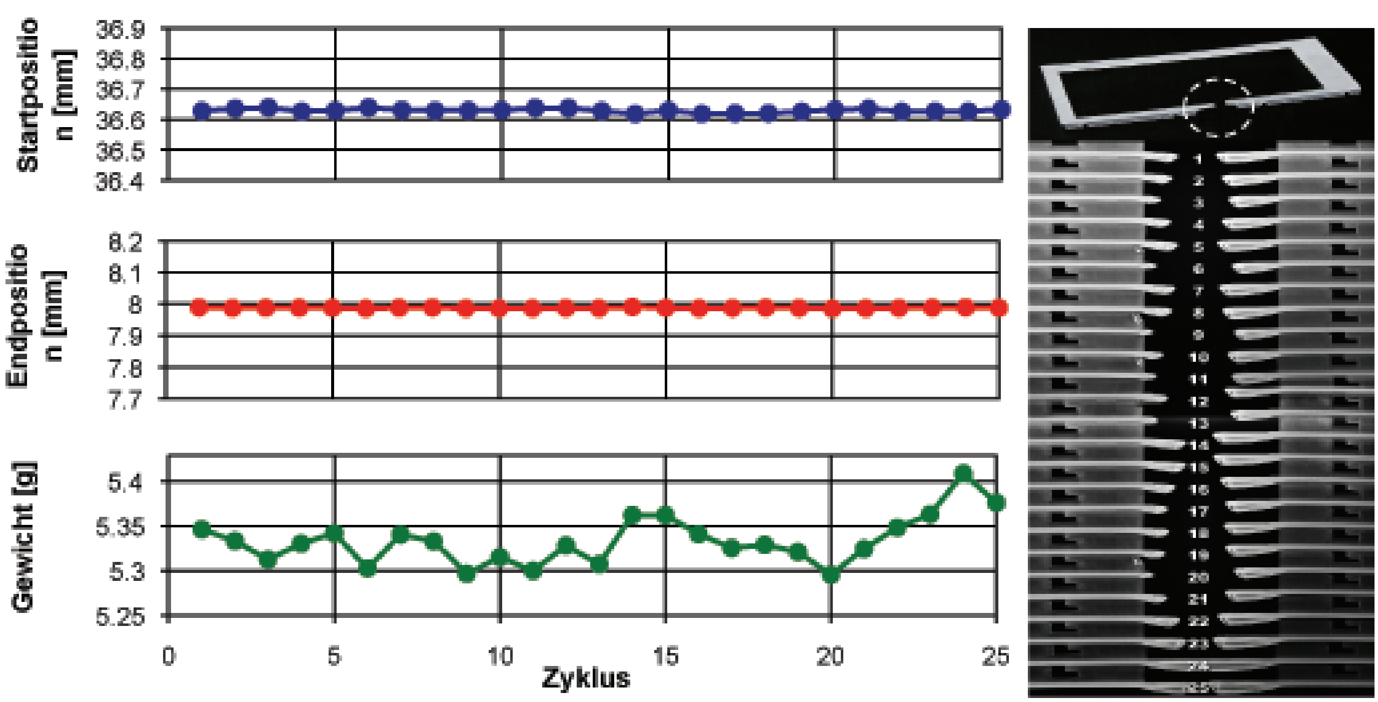


Figure 1

Feature: Switch over to Consistent Quality Continued

Type of Switchover: The Agony of Choice

With position dependent switchover, the process is fairly sensitive to variations in melt quantity. Switchover at a fixed point is, strictly speaking, only optimal for constant material quantity, for example, if exactly the same amount of polymer melt continues to flow and no leakage occurs during closure of the non-return valve. Unfortunately, this is rarely the case in practice. Pressure dependent switchover can provide a quick fix. If the pressure rises earlier due to a higher amount of melt, the set switchover pressure will be reached earlier. In this way, variations in fill level can be avoided.

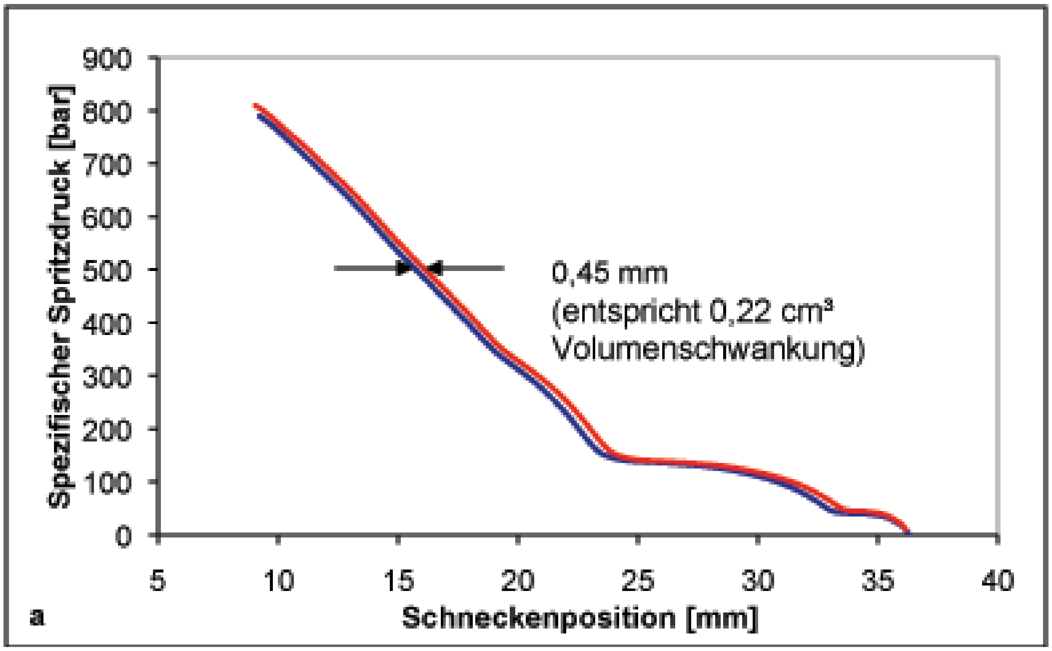


Figure 2A

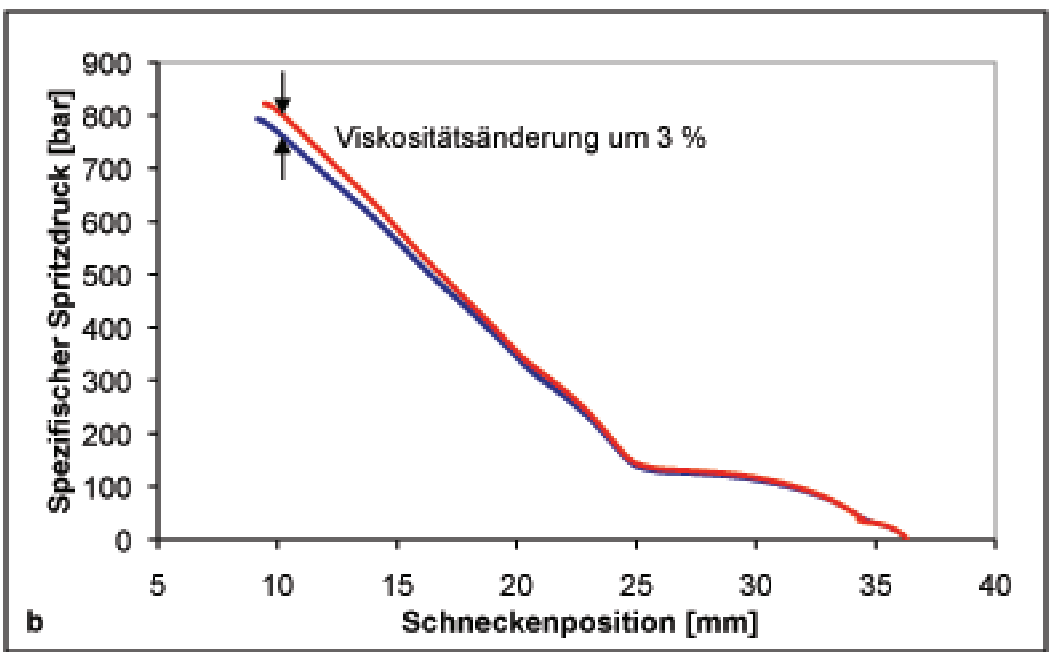


Figure 2B

Feature: Switch over to Consistent Quality Continued

However this only delivers satisfactory results as long as melt viscosity remains constant. With increasing viscosity the set switchover pressure will be reached too early, and, as the melt front will not have reached the desired filling level yet — variations in the molded part occur. This means that where variations in viscosity are the principle problem, position dependent switchover is the preferred choice. Independent of the pressure profile a constant quantity of melt would be injected — at least in theory — if it were not for the previously mentioned variations in the amount of material.

Time for an interim conclusion: if variations only occur in the melt quantity then pressure dependent switchover is the best option. If it is only the melt viscosity that varies then position dependent switchover works better. The dilemma for the injection molder is this: under real production conditions both types of variation occur at the same time. Regardless of which switchover type is chosen, sooner or later it is almost certainly the wrong one.

A Different Way to Switchover with Automatic Compensation

Is it better to switch on pressure or position? This has been one of the eternal questions for injection molders. Actually, what they really want to do is to switchover at a particular filling level in the cavity. It is precisely that – and quite a bit more – that is possible using iQ weight control, a process control method developed and registered for patent by ENGEL.

The software that is integrated into the CC 200 control system of the ENGEL injection molding machine analyzes the injection pressure as a function of screw position, in real time during the injection phase, and compares this to a reference cycle. The algorithm differentiates between three types of variation:

- a shift of the pressure curve in the x-direction (**Figure 2A**),
- changes in the slope of the pressure rise (**Figure 2B**)
- and variations that cannot be explained by either of the first two criteria.

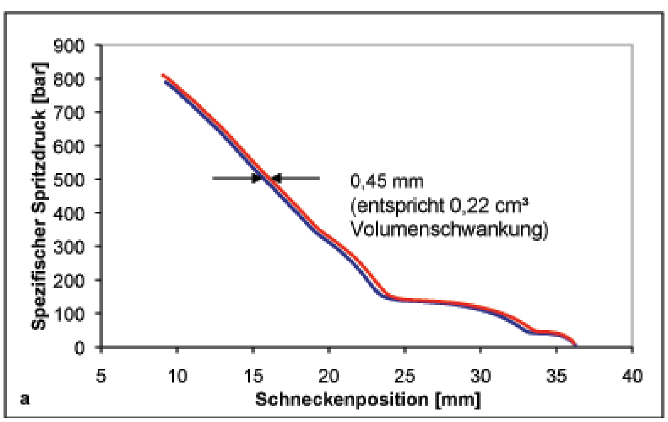


Figure 2 A

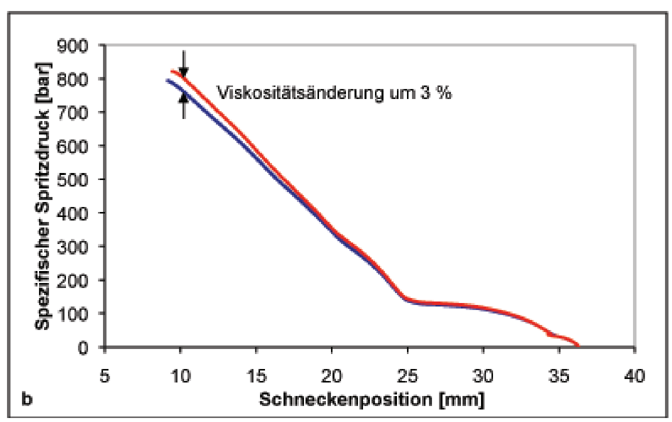


Figure 2 B

Feature: Switch over to Consistent Quality Continued

Based on these variations three meaningful new process parameters are created:

- **Injection Volume:** this is the measure of material actually injected after taking melt quantity variations into account.
- **Viscosity Change:** this reflects changes in the melt viscosity as a result of batch, moisture or temperature variations.
- **Compliance of the Pressure Curve:** this parameter shows whether the pressure curve has changed fundamentally in comparison to the reference cycle (examples: cold slugs, blocked cavity/cavities, etc.).

The parameters can be used to provide comprehensive monitoring of the injection process and to compensate for the variations that were detected. Regardless of whether position or pressure dependent switchover was selected, the injection speed profile and switchover point are altered during the injection process so that the changeover to holding pressure takes place at the same filling level and volume flow as in the reference cycle. The initial conditions for the holding phase then only show minimal variation and the repeatability of the process and part weight is clearly improved.

If the iQ weight control system is activated during, for example, the production of the previously mentioned LCD frame, this results in the position and weight values shown in **Figure 3**. Since the end position of the screw is now actively changed it obviously varies more in comparison to the trials without process control (**Figure 1, page 14**). In this case, the high precision of the screw positioning system is absolutely necessary in order to exactly execute the desired compensation through a deliberate change in the switchover point. The results speak for themselves: The range of variation in the part weight is reduced from 0.113g to 0.016g.

Better Reproducibility even with Special Processing Technologies

Even when the LCD frame is completely filled the potential of this new method can still be seen. It is of particular interest for components with a high flow path to wall thickness ratio (for the LCD frame this is significantly more than 200). In such cases the filling phase is principally responsible for determining molded part properties and the holding phase can only compensate to a limited degree. When processing POM the conditions are even more difficult than for PP. Filling the mold required an injection pressure of more than 2,000 bar.

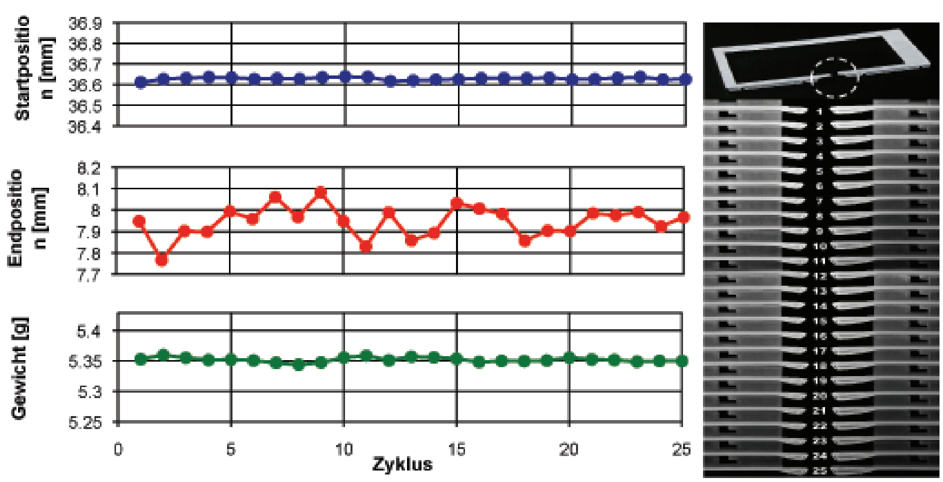
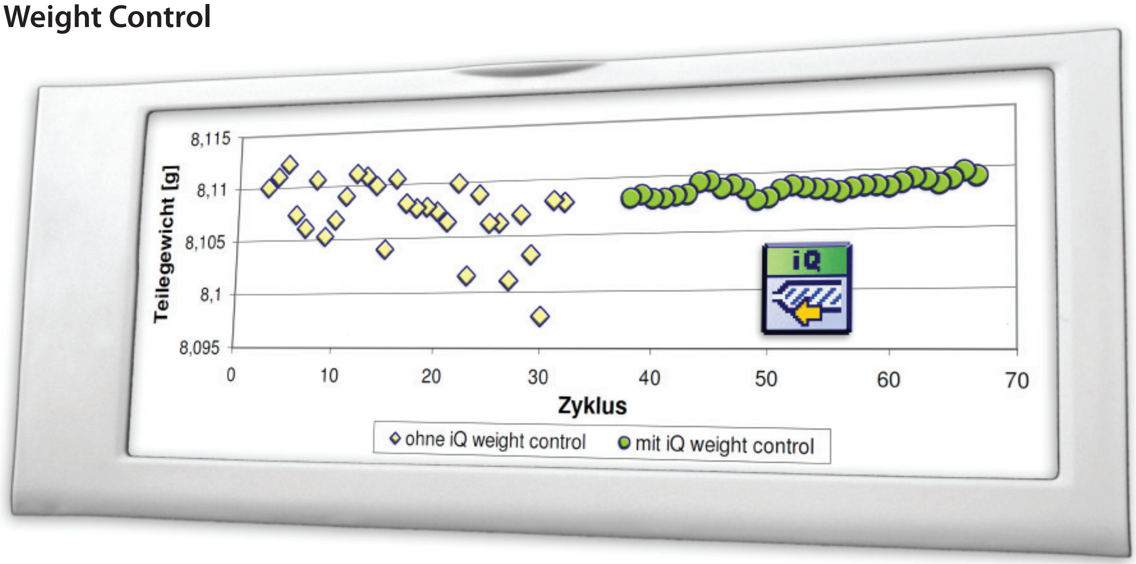


Figure 3

Feature: Switch over to Consistent Quality Continued

IQ Weight Control



Even without process control the range of variation was comparatively small at 0.014g (0.177%). However, with the new software this could be reduced to a remarkable 0.002g (0.025%) which is an improvement of 86% (Shown above).

There are even some special processes where a holding pressure is not used or kept very short, for which the example of partial filling without holding pressure can have real relevance. These include, for example, physical foaming (MuCell® from Trexel), injection compression molding, and gas-assist or water injection technology.

FCI Austria GmbH, Mattighofen/Austria, is one of the first companies to test iQ weight control under industrial conditions. Connector housings with 30% glass fiber content were manufactured using physical foaming on a tie bar-less hybrid ENGEL e-victory 310/90 in a 2- cavity mold. The MuCell process is able to work without holding pressure since the foaming of the material compensates for shrinkage. At the end of the filling phase the shut-off nozzle is closed and therefore the part weight is determined by the injection process alone. In this case, the process control reduces weight variation by 67% (**Figure 4**).

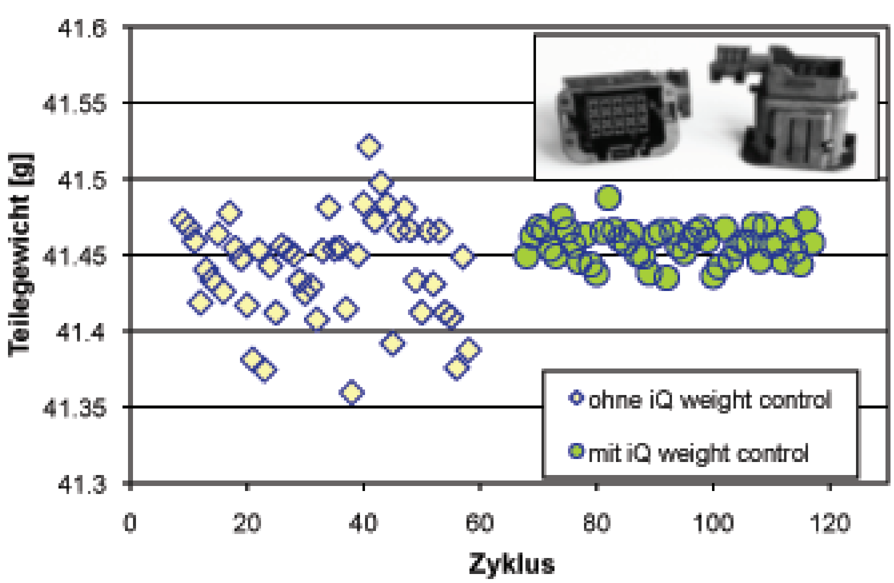


Figure 4

Feature: Switch over to Consistent Quality Continued

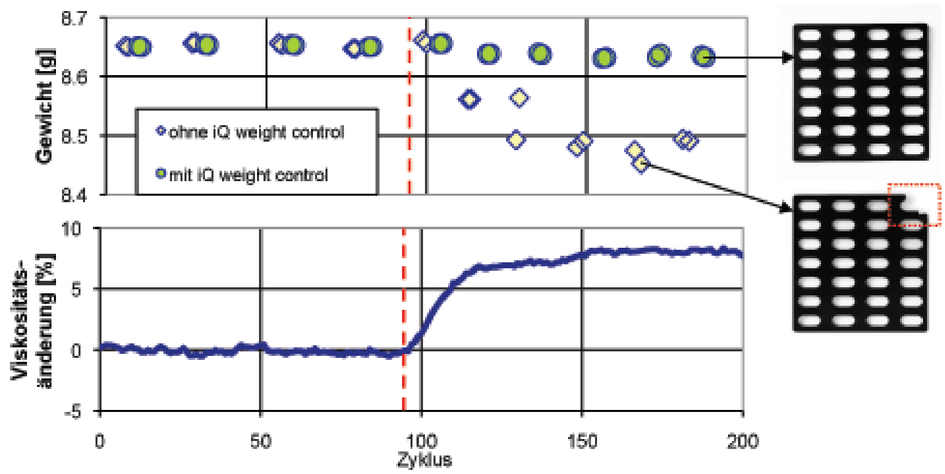


Figure 5

The change in flow behavior caused by incorporating a gas like nitrogen in the polymer melt during foam injection molding can also be quantified by iQ weight control. In the given example the viscosity decreased by about 7%.

With polymers that require intensive pre-drying, the viscosity can vary over long periods of time due to variations in moisture content. Data from the production of a keyboard from polyamide shows how the change from a 9:1 mixture of dried and undried material to 100% dried leads to an increase in viscosity of about 8% (**Figure 5**). Without the control system short shots were produced after the moisture change while with iQ weight control the part weight remained stable at the same level.

Conclusion

Precise movements by the machine are necessary, but not in themselves sufficient for consistent product quality. The widely used monitoring of screw positions is only able to deliver a limited assessment of part quality. For example, a varying material cushion can just as easily mean that variations during the injection phase were compensated during the holding phase.

As a result, the process control system iQ weight control takes a new approach: essential process parameters are derived from the screw position and injection pressure curves. This takes a step away from monitoring purely machine based variables and towards the actual process and the associated part quality.

Based on the process-oriented parameters, the new system can automatically compensate for short and long term quality deviations resulting in a sustained improvement in repeatability. Frequent adjustments to process parameters due to changes in environmental and material conditions belong in the past. Highly automated functionality also ensures ease of use.

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IMD Best Paper

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Vapor-Foamed Injection Molding of Polycarbonate Using Sodium Chloride and Active Carbon as Nucleating Agents

This paper presents a new process for producing vapor-foamed polycarbonate (PC) parts using water vapor as the physical blowing agent and two kinds of nucleating agents, namely, sodium chloride (NaCl) particles and active carbon (AC) powder. The effects of these two nucleating agents on the surface roughness, mechanical properties, and microstructure of solid and foamed parts were characterized. The results were compared with microcellular injection molded parts using supercritical fluid (SCF) nitrogen as the physical blowing agent without a nucleating agent. The water vapor-foamed PC parts with NaCl as the nucleating agent had a smooth surface comparable to that of solid injection molded parts. Foamed PC parts with AC had desirable specific mechanical properties as well as an advantageous average weight reduction of 16.4 wt%. AC powder, serving as nucleating agents, water carrier, and reinforcing fillers, positively improved the microcellular structure and mechanical properties of vapor-foamed PC parts. Based on infrared spectrometry (IR) and gel permeation chromatography (GPC) results, the melt compounding processing to incorporate the nucleating agent and the vapor-foaming process caused minor thermal degradation and hydrolytic degradation, respectively. Without the nucleating agent, vapor-foamed PC parts exhibited much larger and fewer bubbles within the molded parts.

Introduction

Microcellular injection molding is capable of fabricating lightweight, dimensionally stable plastic parts while using less material and energy. This process blends supercritical fluids (SCF; usually nitrogen or carbon dioxide) with polymer melts in the injection molding machine barrel to create a single-phase polymer/gas solution that subsequently foams during the injection molding stage to produce lightweight, microcellular injection molded parts [1-4]. Accordingly, this technology enables an injection molding process with lower processing temperatures and pressures, leading to a reduction in the clamp tonnage requirement, cycle time, and energy consumption [5, 6]. In addition, the uniform packing resulting from cell growth throughout the entire part leads to reduced residual stress and improved dimensional stability [7, 8].

Water can be used as either a chemical blowing agent or a physical blowing agent. Water has been widely employed as a chemical blowing agent to produce rigid polyurethane foams, in which water reacts with diisocyanate, thus resulting in reaction products of gaseous carbon dioxide and polyurea [9, 10]. On the other hand, water is also capable of acting as a physical blowing agent for rigid polyurethane foams that contain a small amount of water in bamboo residues [11, 12]. In poly-styrene foam production, water expandable polystyrene (WEPS) beads containing small water droplets as the blowing agent expand when heated above the glass transition temperature. Those tiny water droplets are encapsulated in beads via suspension polymerization of styrene monomers in an emulsion [13, 14].

In the present study, an alternative microcellular injection molding technique is investigated by employing water vapor as the physical blowing agent, which has potential benefits to reduce equipment cost without dedicated SCF generation and injection systems. Two kinds of nucleating agents along reinforcement fillers (i.e.: NaCl particles and AC powder) were employed to produce vapor-foamed PC parts. The effects of the nucleating agent, which also served as a reinforcement filler, on the surface roughness, mechanical properties, and microstructure of solid and foamed parts were characterized and compared.

Experiments

Melt Processing

Polycarbonate (PC, Lexan 141), which had a melt flow rate of 10.5 g/10 min, was obtained in pellet form from SABIC Holding Europe BV. Hi-grade evaporated salt (NaCl) was obtained from Cargill Salt and had an original size range of 200 to 600 μm. Active carbon powder of non-uniform shape and an average diameter less than 25 μm (Hardwood Powdered Activated Charcoal of Food Grade; cf. **Figure 1**) was obtained from the Multavita Company. Tensile test bars (ASTM D638-03, Type I) of solid and foamed PC were injection molded via an Arburg Allrounder 320S injection molding machine with processing parameters listed in **Table 1**.

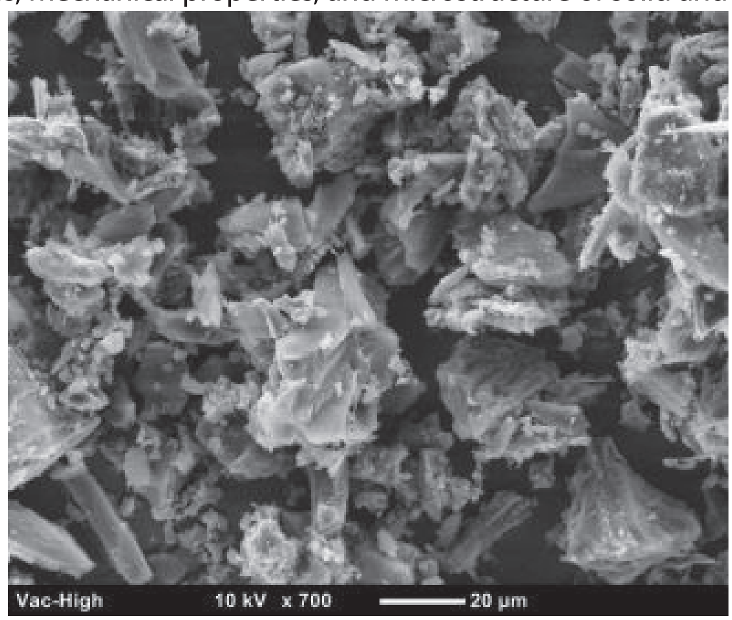

Figure 1: The active carbon as nucleating agents. Scale bar is 20 μm.

Table 1: Injection molding parameters.

Samples	Shot Volume (cm^3)	Back Pressure (MPa)	Packing Time (s)	NaCl or AC (wt %)	Nitrogen or Water (wt %)	Average Part Weight (g)	Average Weight Reducti on (%)
PC-S	20.5	1.0	4.3	N/A	N/A	9.40±0.01	N/A
PC-N	19.5	5.5	0	N/A	0.22	8.54±0.11	-9.1%
PC-NaCl-W	19.5	5.5	0	0.5	1.98	8.81±0.21	-6.3%
PC-AC-W	19.5	5.5	0	0.5	0.76	7.86±0.16	-16.4%

S, N, and W denote solid, nitrogen, and water, respectively.

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A commercially available microcellular injection molding process (MuCell) was employed to fabricate microcellular injection molded PC-N tensile test bars as reference, with N denoting SCF nitrogen. Two procedures were employed to fabricate water-foamed, microcellular injection molded PC-NaCl-W [15] and PC-AC-W using recrystallized NaCl and AC as nucleating agents, respectively. Water was employed as a physical blowing agent to fabricate vapor-foamed PC-AC-W parts using the same injection molding machine. PC-AC (0.5 wt %) solid batch pellets were compounded via twin-screw extruder since AC could not be dissolved in water as a salt. To enhance the ability of PC-AC pellets to absorb water, solid pellets were immersed in an ultrasonic tank for 6 hours, which is different from directly adding a salt solution to the PC melt through the barrel. Prior to the microcellular injection molding process, the wet pellets were dried at ambient temperature.

Testing Techniques

Fourier transform infrared (FTIR) spectra were recorded on a Bruker Tensor 27 FT-IR spectrometer at a resolution of 1cm^{-1}, in the frequency range from 4000 cm^{-1} to 600 cm-^{1}. Gel permeation Chromatography (GPC) was employed to measure the molecular weight distribution of polycarbonate solid and foamed parts. Weight average molecular weights and polydispersity indices were calculated from a calibration curve using linear PMMA.

Two-dimensional surface roughness (2D-SR) measurements were taken via a surface roughness analyzer (Surfan Alyzer 4000). The measured length traversed 2.5 mm in the melt flow direction (cf. **Figure 2**) on the sample surface at a fixed rate of 0.25 mm/s. An optical microscope (Olympus) with a magnification of 100 was used to examine the three-dimensional surface roughness (3D-SR).

The cell morphologies (porous microstructures) were observed by a scanning electron microscope (SEM; Model LEO 1530, JEOL, Japan), operated at an accelerating voltage of 3 kV. The as-molded samples were then cryogenically fractured at three locations on the tensile bar with liquid nitrogen, as shown in **Figure 2**.

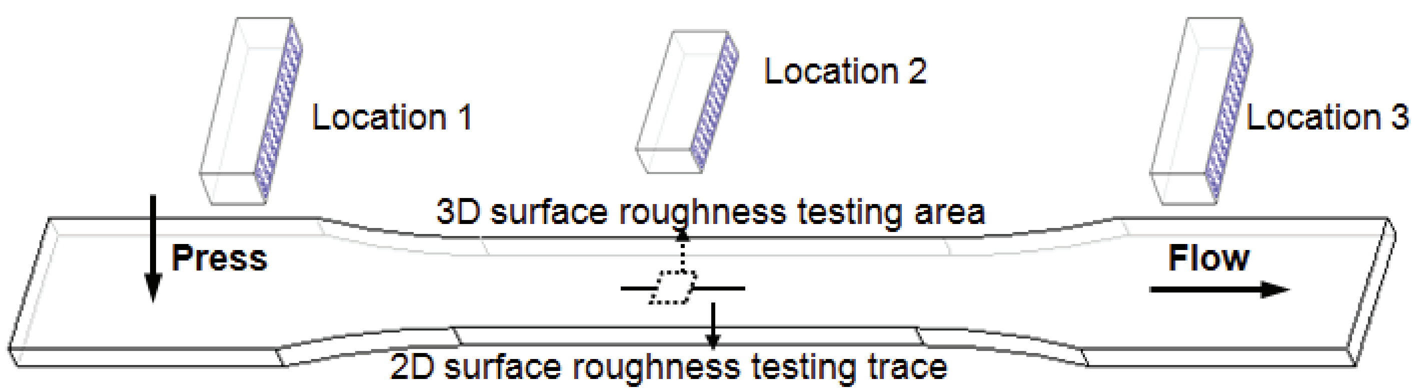

Figure 2: Schematic of 2D surface roughness trace, 3D surface testing area, and the SEM imaging locations.

Results and Discussion

Analysis of Degraded Polycarbonate

High temperature and moisture are two potential causes of PC thermal or hydrolytic degradation. To check the degradation caused by melt processing and the vapor foaming process, infrared spectrometry (IR) was tried in an attempt to locate peaks which might be associated with degradation, and gel permeation chromatography (GPC) was employed to determine the average molecular weight and polydispersity due to degradation.

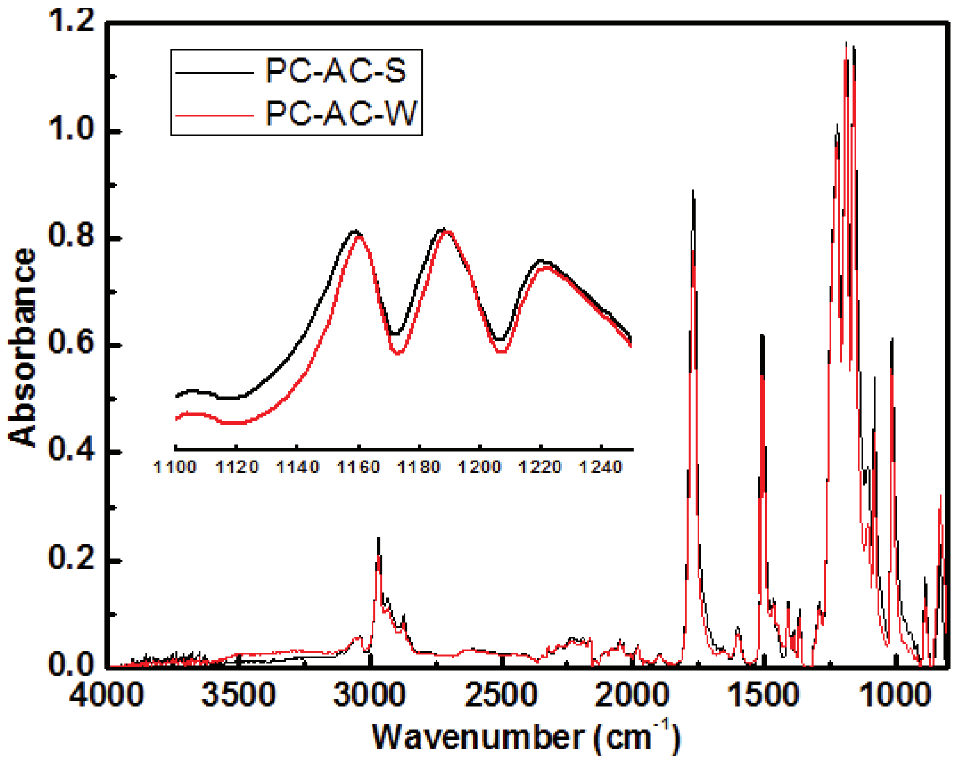

Figure 3: FTIR spectra of solid PC-AC-S and vapor foamed PC-AC-W parts, and inert: enlarged region from 1100-1250 cm^{-1}.

Figure 3 shows the FTIR spectra of solid PC-AC-S and vapor-foamed PC-AC-W parts. After the vapor-foamed injection molding procedure, the degradation of PC was characterized by a decrease in the IR absorption band at 1100 to 1250 cm^{-1}, with the largest shifts involving the broad C-O stretching at 1220cm^{-1}, the carbonate C-O stretching at 1188 cm^{-1}, and the carbonate C-O stretching at 1160 cm^{-1}. The thermal melting procedure was expected to change the rotation of various PC single bands, but the shift in the stretching bands of C-O and C-H3 resulted from PC degradation instead. A broad peak at 3400cm-1 was observed on PC-AC-W as a result of the formation of hydroxyl groups, thereby suggesting the hydrolysis of the carbonate bonds.

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The molecular weight and distribution are critical parameters in evaluating the degradation of a polymer (cf. **Table 2**). Small reductions in the Mw and Mn, as well as a broadened molecular weight distribution, indicate degradation resulting from the melting processing.

Samples	Mw (g mol^{-1})	Mn (g mol^{-1})	PD
PC-S	32,947	19,611	1.68
PC-AC-W	30,577	17,472	1.75

Table2: Mw of solid and vapor-foamed PC parts

Surface Roughness

The arithmetic 2D-SR averaged is plotted in **Figure 4**, while the 3D optical micrographs are shown in **Figure 5**. It is evident that solid PC-S exhibited the lowest surface roughness while PC-NaCl-W has a surface roughness comparable to that of PC-S. PC-AC-S and PC-AC-W samples showed relatively rough surfaces due to the appearance of AC on the parts' surfaces. In comparison with typical solid or vapor-foamed counterparts, PC-N parts foamed using SCF nitrogen as the blowing agent possessed a rougher surface due to their characteristic swirling patterns. This suggests that using water vapor as a blowing agent had a positive effect on the surface finish of the foamed parts.

The rougher surface characteristics of microcellular injection molded PC-N parts are mainly attributed to gas escaping from the PC/nitrogen solution and nucleated cells (bubbles) at the melt front and being trapped, collapsed, and stretched at the interface between the part and the mold.

In comparisons with PC-N, PC-NaCl-W has a smoother surface quality. The vapor foaming mechanism is different than that of the SCF foaming process since the water and PC melt cannot quickly form a single-phase solution like PC/nitrogen in the barrel due to water's low solubility and long absorption time in PC. In this study, distilled water, or a water/salt solution, is dispensed into the machine barrel through the hopper, unlike SCF nitrogen which was injected into the mixing zone of the machine barrel. The initial water temperature and pressure in the barrel are not high enough for water to convert to the supercritical state. When a PC/water mixture is injected into the mold cavity, a sudden pressure drop will allow the small water vapor droplets to turn into expanding vapor bubbles in the PC matrix. In the meantime, tiny salt particles recrystallized from the water/salt solution will act as cell nucleating agents, thus greatly reducing the cell size and increasing the cell density in the foamed PC-NaCl-W parts.

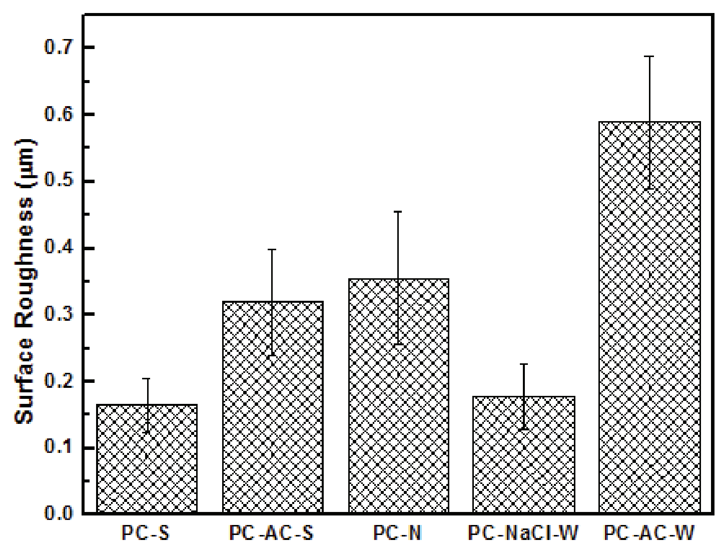

Figure 4: 2D surface roughness of tensile bars. S, N, and W denote solid, nitrogen and water vapor, respectively.

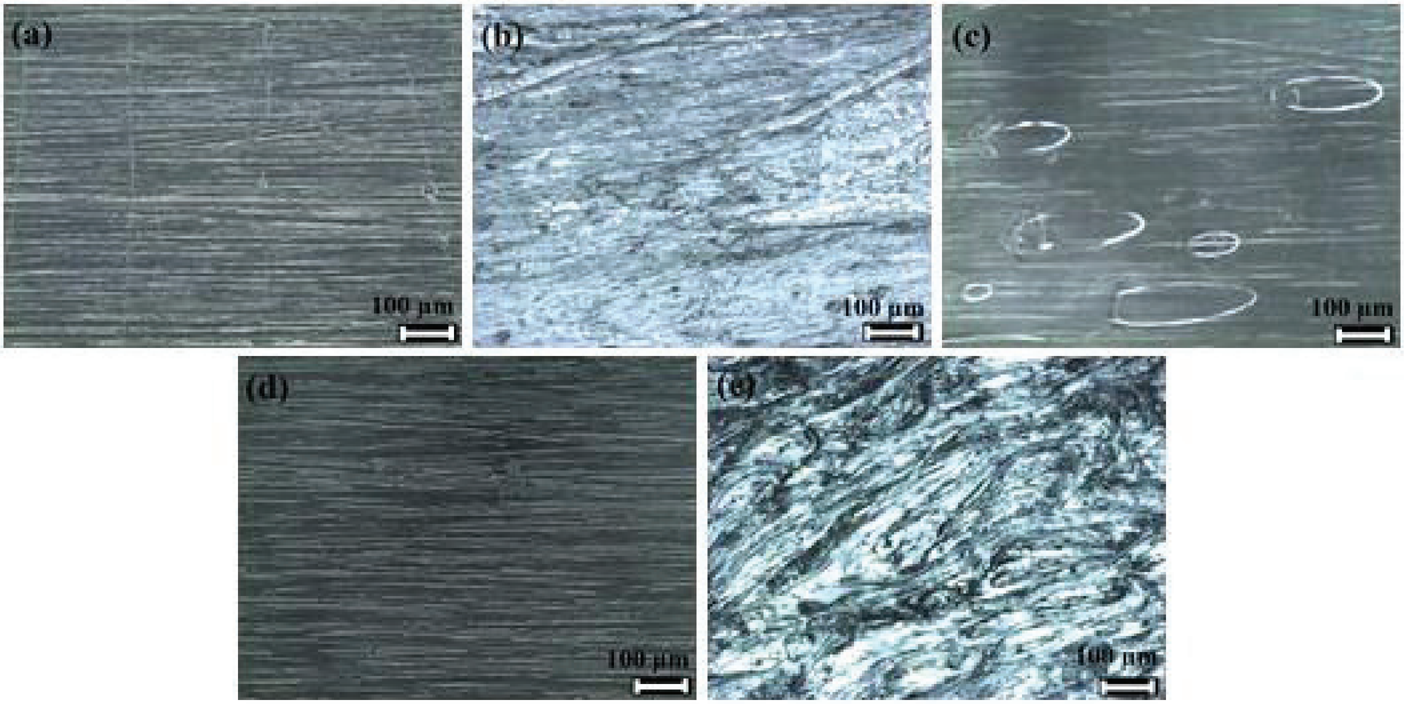

Figure 5: 3D surface images: (a) PC-S, (b) PC-AC-S, (c) PC-N, (d) PC-NaCl-W, and (e) PC-AC-W. The scale bar denotes 100μm.

Unlike SCF nitrogen or carbon dioxide, water does not dissolve into or emerge from the polymer melt easily or quickly, which results in a slower cell nucleation rate and thus reduced cells at the melt front. Even when cells are formed at the advancing melt front as driven by the expanding water vapor in the polymer melt and some vapor diffuses out of the PC/water mixture to be captured at the mold interface, a vapor-liquid phase change helps to reduce the surface roughness. As the vapor filled cells contact the mold wall (85 °C), the sudden temperature drop forces the vapor to condense into liquid. Such a phase change induces a large volume contraction in the cells, compared to cells filled with nitrogen that stay in gaseous form, thereby minimizing any visible surface defects.

Active carbon has a lower density, smaller size, and higher surface area-per-volume ratio (cf. **Figure 1**) in comparison with recrystallized salt crystals, even though they have the same weight content of 0.5 wt%. The surface quality of both solid PC-AC-S and foamed PC-AC-W parts are unsmooth, and the AC particles appear on the surface of the parts as shown in Figures 4 (b) and (e). The AC particles on the surface reduce the PC-AC-S surface quality and simultaneously increase the friction of the part–mold interface when melt filling the mold cavity. Further studies are needed to investigate the effects of AC ratios and water absorption content on the surface roughness to help determine the optimal compositions and processing conditions.

Tensile Properties

The representative stress–strain curves of solid and foamed parts (PC-N, PC-NaCl-W, and PC-AC-W) are featured in **Figure 6** and **Table 3**. As expected, solid injection molded PC-S parts have a higher Young's modulus and ultimate strength than foamed tensile test bars. Apparently, the cells within the foamed part negatively

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affect the ultimate strength and strain-at-break as they reduce the effective cross sectional area or serve as stress concentration points. Broadly speaking, foamed parts of PC-NaCl-N and PC-AC-W have similar values to that of PC-N, with some specimens outperforming PC-N due to the nucleation agents that act as reinforcements.

In comparison with solid and other foamed parts, foamed PC-AC-W parts have a higher specific Young's modulus and a specific strength due to the addition of AC powder. In the foamed components, AC and NaCl serve not only as nucleating agents, but also as rigid reinforcing fillers. Hence, AC powder can enhance the mechanical properties of solid and foamed PC parts. At the same weight concentration, AC has more particles due to its low density and comparable size in comparison with recrystallized NaCl crystals (10 to 20 µm). Hydrophobic AC powder is capable of achiev-

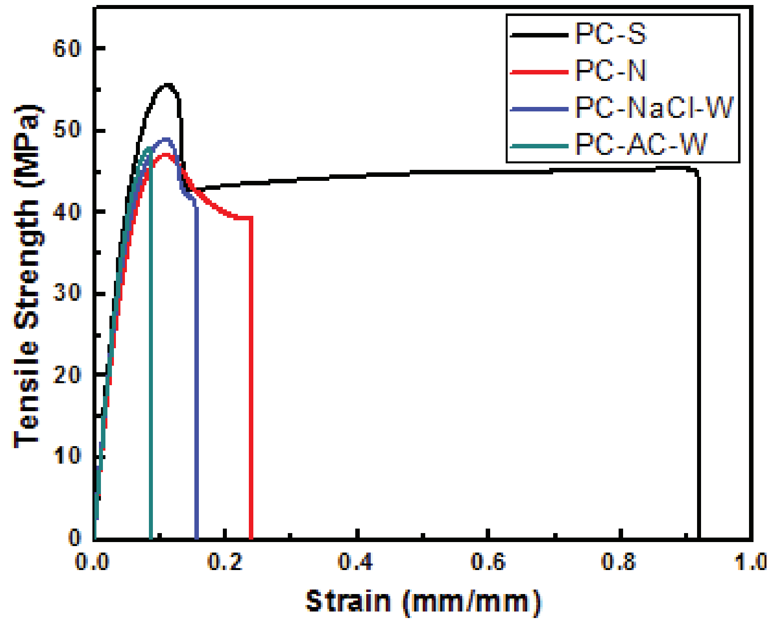

Figure 6: The mechanical properties of solid and foam injection molded tensile bars. S, N, and W refer to solid, nitrogen, and water, respectively.

Table 3: Average tensile properties of solid and foamed PC parts with NaCl and AC as the nucleating agents.

Samples	Young's Modulus (MPa)	Specific Young's Modulus (MPa m^3/kg)	Ultimate Strength (MPa)	Specific Ultimate Strength (MPa m^3/kg)	Strain at Break (mm/mm)
PC-S	8.12E+02	7.21E-01	5.55E+01	4.93E-02	9.20E-01
PC-N	6.37E+02	6.23E-01	4.71E+01	4.61E-02	2.40E-01
PC-NaCl-W	6.95E+02	6.59E-01	4.90E+01	4.65E-02	1.60E-01
PC-AC-W	7.53E+02	8.00E-01	4.79E+01	5.09E-02	9.00E-02

ing a uniform dispersion in the PC matrix via twin-screw extruder compounding, and this uninform dispersion improves the mechanical properties of PC-AC-W. Furthermore, even though the tiny AC particles adversely affected the surface quality of foamed parts, they effectively enhanced mechanical properties. The next section will present the cellular microstructure and multi-layered structure of the tensile test bars, which will influence the mechanical properties of the foamed parts.

Morphology of the Fractured Surface and Microcells

To investigate the effects of blowing agents (SCF nitrogen and water vapor) and nucleating agents (AC and NaCl) on the microstructure of foamed PC samples, cryogenically fractured surfaces were examined at three different locations (cf. **Figure 2**). As shown in **Figures 7–9**, all foamed parts exhibited a multi-layer structure. The skin layers possessed a higher density resulting from fewer cells, whereas the core layer contained most of the cells. **Figure 7** presents the microstructure of cells of PC-N parts foamed using SCF nitrogen as the blowing agent. The average cell size and cell density of microcellular injection molded parts in the core region at the three test locations are plotted in **Figure 10**.

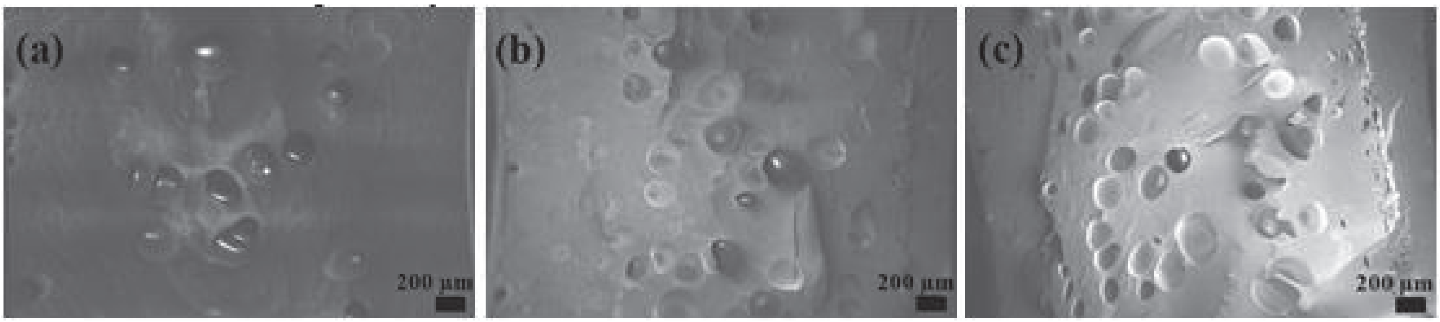

Figure 7: SEM images of fractured PC-N. Images (a), (b), (c) denote samples along the melt flow direction. The black scale bar refers to 200 μm.

Figures 8 (a) through (c) show the evolution of cell size along the flow direction of the foamed PC-NaCl-W tensile test bar. It can be seen that the cell size increased from near the gate **(Figure 8 (a)**) to the middle of the part (**Figure 8 (b)**), and stayed at approximately the same size toward the end of the part as shown in **Figure 8 (c)**. The smaller cell size near the gate was due to the high melt pressure. In addition, recrystallized salt crystals were found on the inside cell walls (cf. **Figure 8 (d)**), suggesting that they served as nucleating agents. The sizes of the salt crystals shown in **Figure 8 (d)** ranged from 10 to 20 μm and were almost 30 times smaller than their original size (200 to 600 μm). It should be noted that nucleating agents are critical for the water foaming process to generate tiny and non-uniform voids in the PC matrix.

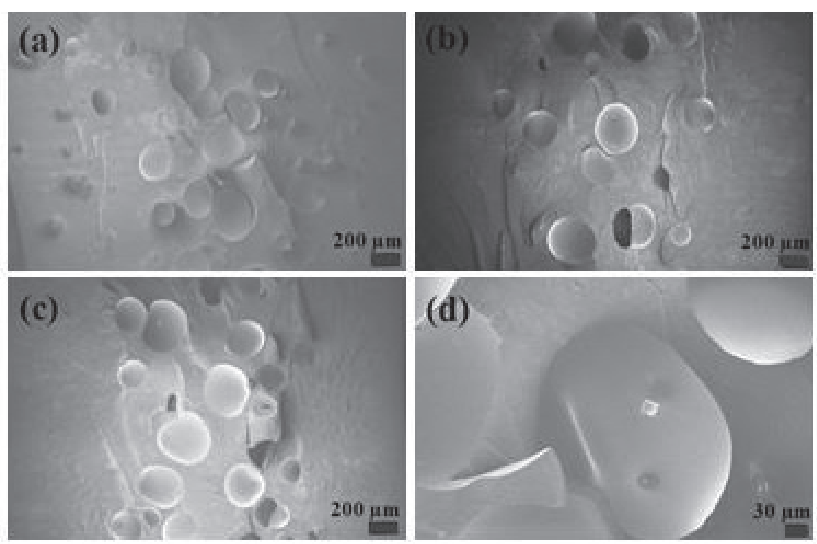

Figure 8: SEM images of fractured PC-Salt-W using water vapor as the blowing agent and recrystallized salt crystals as the nucleation agent. Images (a), (b), (c) denote samples along the melt flow direction. The black scale bar refers to 200 μm. Image (g) shows recrystallized salt crystals (10-20 μm). The black bar refers to 30 μm.

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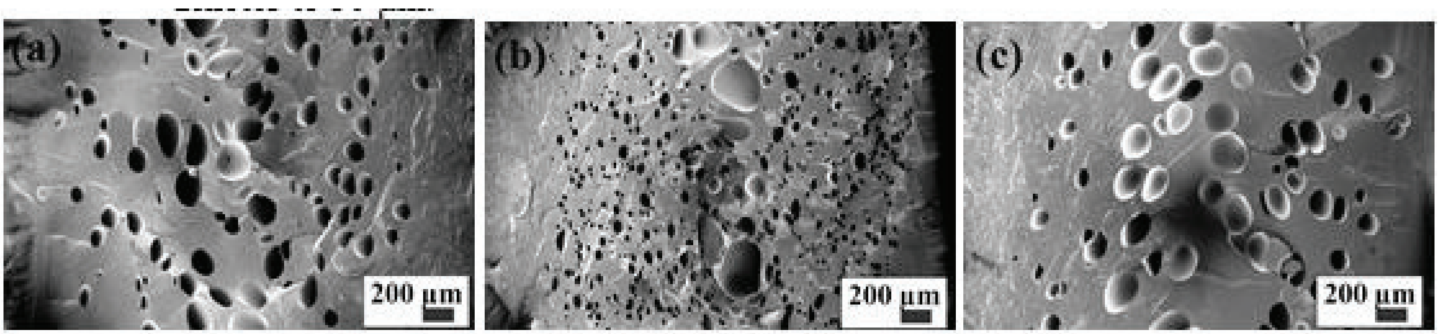

Figure 9: SEM images of fractured PC-AC-W using water vapor as the blowing agent and AC as nucleating agents. Images (a), (b), (c) denote samples along the melt flow direction. The black scale bar refers to 200 μm.

Figure 9 presents the fractured PC-AC-W parts. Vapor-foamed PC-AC-W parts possessed smaller voids than that of PC-N and PC-NaCl-W parts at various counter locations along flow direction. The smaller cell sizes were attributed to high amounts of AC powder serving as nucleating agents. When cell nucleation and cell growth were triggered by vapor expanding after PC/AC or PC/NaCl was injected into the mold cavities, the higher density of the nucleating agents resulted in smaller cell sizes and higher cell densities. Taking the tensile bar profile (cf. **Figure 2**) into consideration, location 2 exhibited a tapered cross-section area that signified that the expanding vapor had a relatively small space in which to expand compared to counter locations 1 and 3. At the mold cavity filling stage, where the advancing melt front experienced the lowest melt pressure (atmospheric pressure), a relatively large number of bubbles formed and were subsequently pushed toward the mold surface by the outward fountain-flow phenomenon. As a result, the voids at location 3 were the largest, while those at location 2 were much smaller. The tiny, uniform cell structures at location 2 helped to retain the mechanical properties of foamed parts.

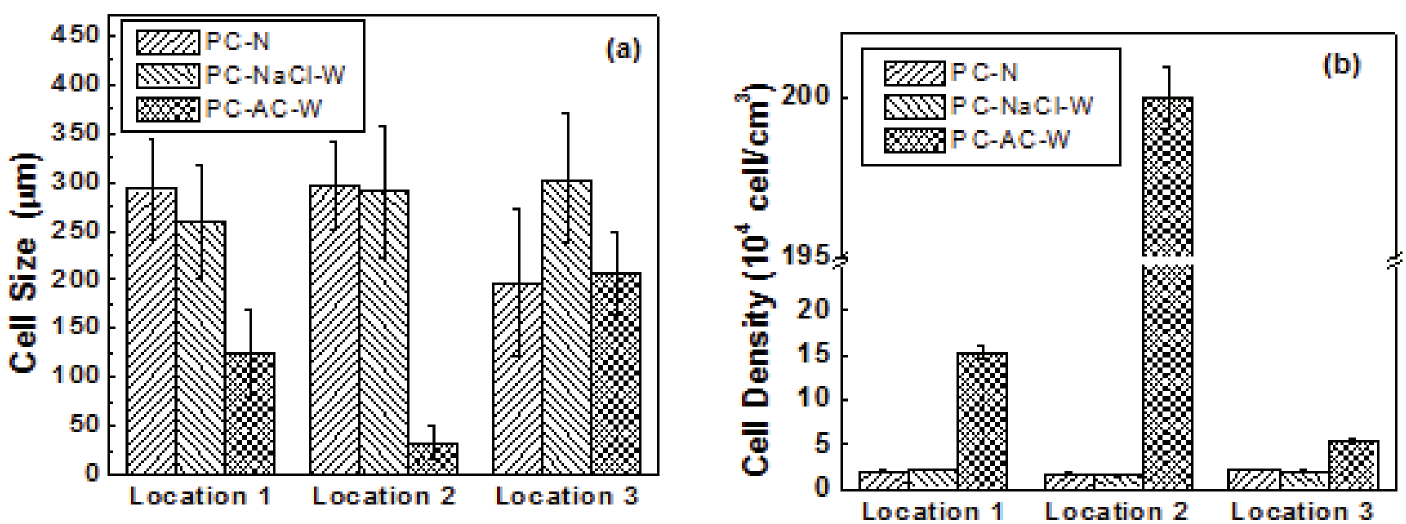

Figure 10: Representative values of (a) the average cell size, and (b) the cell density of foamed PC samples.

Conclusions

This paper introduces an alternative vapor-foamed injection molding process to fabricate PC foamed parts using water as the blowing agent and investigates the effects of two nucleating agents on the surface roughness, mechanical properties, and microstructures of foamed parts. The setup of the vapor-foaming process based on conventional injection molding is much simpler and more cost-effective than commercial microcellular injection molding systems. PC-N with SCF nitrogen as the blowing agent employs thermal instability triggered by a pressure and temperature drop, while PC-NaCl-W and PC-AC-W make use of the expansion of water vapor at low pressure in the mold cavity. PC-NaCl-W foamed parts with recrystallized salt crystals as nucleating agents yielded surface qualities comparable to that of solid PC parts. On the other hand, PC-AC-W possessed the highest specific mechanical properties (i.e., specific Young's modulus and ultimate strength), since AC particles serve as nucleating agents as well as reinforcing fillers. PC-AC-W foamed parts had smaller cell sizes and higher cell densities than their PC-NaCl-W counterparts owing to AC's low density and larger surface area-per-volume ratio. Weight reductions of 15% were achieved by adjusting processing conditions. High temperature and moisture likely caused some PC chain degradations, although the Mw and Mw polydispersity indicated acceptable amounts of degradation which is comparable to that caused by typical melt processing procedures. Furthermore, PC-AC-W and PC-NaCl-W vapor-foamed parts had better mechanical properties than PC-N parts foamed with SCF nitrogen due to enhancement of AC powder and NaCl particles.

Acknowledgements

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Keywords: microcellular injection molding, water vapor foaming, composites, sodium chloride, active carbon

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Additive Manufacturing (AM), Creating New Tradespace for Plastics

Reshaping Manufacturing

Manufacturing has certainly changed in the last hundred years. From craftsmen's hand built products, to automation, to high speed molding, manufacturing continues to reinvent itself. Reshaping manufacturing is continuous and advancements happen daily. Where do we see exceptional innovation today? Additive Manufacturing (AM).

AM builds three dimensional parts by layers using a variety of processes and materials. The most popular AM processes include SLA/stereolithography (vat polymerization of photopolymers), FDM/fused deposition modeling (thermoplastic monofilaments extruded through a nozzle), SLS/selective layer sintering (fusing thermoplastic powder by laser) and material or poly-jetting (polymer droplets placed by print heads). The aforementioned SLA, FDM and SLS processes account for the majority of AM today. Other processes include binder jetting (an inkjet print head moves across a powder bed placing binder material) and laminated object

Feature: AM, Creating New Tradespace for Plastics Continued

manufacturing or sheet lamination (cut sheets, bonded layer by layer to form a part). Also some manufacturers are using LMD/laser metal deposition (focused thermal energy to fuse metal material) and directed energy deposition (metal powder feed) to produce mold tools and factory aids.

AM's High Innovation Quotient

I am very fortunate to work with a number of AM developers and users on fascinating applications. I am always amazed at the creativity I see during business travels and at the various trade shows. In Europe, Formula One race car builders are printing half-scale models of the cars for wind tunnel testing. Once the half scale parts show balanced aerodynamics, full size spoilers, air dams and body components are produced. In China's Guangdong province, known to produce a large percentage of the world's recreational shoes, 3D'ers started printing not only approval models but patterns used for cast tooling as well. Visiting MIT, I viewed research on 4D printed models that have moveable features and using geometric code transform into other shapes. There were even functional models that performed self assembly! Using printed thermoplastic parts, a small exoskeleton was created to help a young girl with underdeveloped muscles play and hug. Microlattice materials, or open-cellular architectures, are being printed at high-speeds to provide rigid, lightweight structures that offer impact protection. The open cell structure of these parts allow for embedded sensors, fluid movement and air flow. There are too many cool projects to list here.

AM Markets – From Medtech to 'Prosumers'

A number of segments, especially medical, have made AM the method of producing their products. Hearing aids that fit the individual patient's ear(s) for example are not made from machined steel molds, they are printed. Using a scan of the ear or a physical pattern, a digital file is created and sent to a stereolithography (SLA) machine to expose photopolymer with lasers, layer by layer, to create the unique device housing. Over 10,000,000 devices are in circulation today due to the high-accuracy, micron level 3D builds. Dental aligners are another example of printing thousands of parts a day, each part with unique geometry. The metal wire aligners can now be replaced with printed, clear plastic aligner trays. The largest firm in the aligner business produces over 40,000 piece parts a day running a few dozen SLA machines continuously.

Target markets span most industries including automotive (17%), medical (14%), consumer products (18%), aerospace (12%) and industrial parts (19%) according to Deloitte[1]. There is a significant rate of change with production or end use parts growing from 19% a few years back to over 29% today. Production parts are increasing in giftware, home furnishings, jewelry and shoe segments in addition to medtech and industrial applications. Many consumer product applications warrant improvements in polymer powders, thermoplastic filaments and photopolymers before we see product surviving long term end use conditions. Tooling for all the industries is also progressing as a number of limitations in conventional manufacturing are not common to additive manufacturing. In AM there is little waste, much lower capex and less complicated facilities and operations. The consumer and 'prosumer' markets are taking advantage of the ease of entry to manufacturing.

New Tradespace – Advanced Polymers

In a perfect world, machine builders and polymer science houses would be working together to solve the myriad of process and material issues effecting additive manufacturing methods. Putting the hype aside as well as the media love fest with 3Dp, all AM builds need improvements in material physical and mechanical properties. This is especially true for photopolymers (SLA) exposed by lasers and thermoplastic monofilaments (FDM) placed by hot nozzles. In addition, AM powders (SLS) also need higher 'as sintered' strength and

Feature: AM, Creating New Tradespace for Plastics Continued

less waste. Service providers are always working with the customers to establish a 'fit' of materials that may come close to meeting end-use requirements. There is no perfect system and there are known limitations to polymers developed for any of today's AM processes. Since AM usually builds by layers, we also need to concentrate on the bonds between each layer and often the resulting porosity. The new tradespace is simply advanced materials. There are many material technology gaps for each AM process. FDM materials for example have poor Z strength, being weaker along the build axis or poor layer to layer adhesion. Resulting layer lines or textures are quite pronounced on FDM parts, making FDM parts unacceptable for some aesthetic applications. SLA photopolymers are somewhat brittle resins and even after post curing, most parts cannot survive a severe drop. Higher elasticity and impact strength would enable many more consumer product applications where toughness is needed. SLS powders create a fairly durable part but the rough surfaces, like sandpaper, are difficult to finish. Polyjet models are beautiful to look at but are not durable enough for simulated use testing. The newer machines may build faster and more accurate but the thermoplastics, thermoset resins and photosensitive materials need to improve before additive manufacturing will fit all production or end-use requirements. Opportunities abound for the thermoplastic and thermoset suppliers that have an open ear to the machine builders and market segments with specialized needs.

The Key Players

The big players in AM are 3D Systems (nyse: DDD), supplier of SLA machines and SLS machines and Stratasys (nyse: SSYS), leading supplier of FDM machines (commercial and personal) and polymer jetting systems. EOS is another important supplier of SLS machines and competitor to 3DS. 3DS is 13th on Forbes 100 Most Innovative Growth Companies and finished last year with an incredible $513M in revenue[2]. Stratasys finished 2013 with an impressive $486M[3]. The big players are battling for position with acquisitions in addition to new machines and materials. 3D Systems has purchased a number of software firms, robot companies, scanner producers, other 3Dp machine builders and major service providers. 3D Systems also runs their own service provider network called Quick Parts. Stratasys merged with Objet in late 2012 to offer inkjet-based polymer part creation in addition to FDM. In August of 2013, Stratasys and MakerBot completed their merger adding desktop systems to the Stratasys commercial and production machine line-up. Stratasys also has their own service provider called Red Eye to deliver quick piece parts to customers. M&A activity is fierce and you would need to watch the technology news feeds daily to stay on top of the action. Adding to the big AM players are countless groups introducing new machines and technology through funding vehicles such as KickStarter, Fundable and other crowdfunding. As patents held by the big players expire, many new builders will enter the AM space.

Interesting Game Changers

What may be next? There are some emerging technologies that are sure to upend the AM industry. Arburg recently provided information on the soon to be released Arburg Plastic Freeformer (AKF). This machine is loaded with standard thermoplastic pellets and utilizes a fixed nozzle. The plastic part is printed on three axis and with a component carrier five axis. Single parts can be economically built in the thermoplastic the user requires. Autodesk, one of the top 3D modeling software suppliers, announced a lower-end or consumer printer called 'Spark'. Autodesk created an open 3D printing platform from part visualization to physical printing control. Design of the printer, based on SLA / stereolithography, will be made available to developers and machine builders to enhance capabilities. Autodesk states one of the limitations is material science or chemistry and will encourage the AM community to develop materials of their own for the printer. We will

Feature: AM, Creating New Tradespace for Plastics Continued

see if this system will become an accepted operating system. Relative to machines, Hurco filed a patent for a hybrid CNC/3Dp machine that combines their CNC or subtractive capabilities to printing or additive capabilities. Matsuura is another company combining CNC with AM of metal parts. The hybrid machines will provide customers with large robust platforms, precision control and one machine for all types of model, tools and end-use parts. Organovo is making steady progress on 'bioprinting', the deposition of living cells or bio ink on hydrogels. Today they supply tissues for testing and are working on parts or patches for implant and repair. In the future, they expect to print lobes or pieces of organs. The robots that provide the machine functions, either for large parts or small bioprints are rapidly advancing as well. Robots span from simple open source (RepRap) Cartesian models, to delta bots, SCARA arms and octopods to name a few.

3D Printing's Fast Evolution to AM

It took twenty years for 3D printing to become a billion dollar industry; it doubled in the previous five years and will double again by 2015 according to Wohlers Associates[4], experts on the 3Dp / AM markets. Deloitte[5] analysis shows the 2013 AM market to be 3.1 billion up at least 35% over 2012. Exponential market growth is expected to continue into 2020 when the AM industry may exceed $12 billion [6, 7] (some research groups project higher market growth). Lux Research predicts AM markets will easily quadruple by 2025. Interestingly, Gartner Research reports show enterprise printing machines (sub-$100,000.) grew 49% last year. They predict that enterprise-class 3D printers will be available for under a few thousand dollars in 2016 and "there may be no limit to what could feasibly be 3D printed"[8]. Manufacturers of personal 3D printers also had double digit growth which is expected to continue with the popularity of printers in education, hacker spaces and a variety of special interest and user groups. Early 3D printing was costly and limited to commercial or enterprise prototyping but today the technology is within easy reach of anyone. New and varied polymer applications will arise for all sizes of businesses, 'prosumer' groups, artists or makers, design offices, schools and even the average consumer using a table top printer in the home.

Industries such as aerospace, automotive, consumer products, defense, industrial parts, medical, dental and sports equipment are all stakeholders and embracing the AM capabilities. Shops called fab labs, hacker spaces and maker groups are springing up all over the world and using all types of AM systems. We need to take another look at our strategies and business plans as thermoplastics will benefit from the numerous emerging technologies and the rate of acceleration. Raw material houses, polymer scientists, compounders, extruders, grinders, additive suppliers, distributors and service bureaus need to advance AM from a materials perspective, the new tradespace. We are living in the future and additive manufacturing is key to growth.

References

ASTM International provides a recognized description of additive manufacturing as: "A process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive methodologies." Additive manufacturing builds parts utilizing a three-dimensional (3D) computer-aided design (CAD) file or scanned image (point cloud file) converted into surfaces (triangles, polygons) and saved as a standard tessellation language (.STL). The .stl file is then sliced into layers which serve as instructions for the AM device.

1. Cotteleer, Mark. "The 3D Opportunity Webinar", Deloitte University Press, August 2014
2. 3D Systems Q4 and Full Year 2013 Conference Call and Webcast, February 28, 2014
3. Stratasys Reports Record Fourth Quarter and Fiscal Year 2013 Financial Results, Investor Call, March 3, 2014
4. McCue, T.J. "3D Printing Stock Bubble? $10.8 Billion by 2021", Forbes, December30, 2013
5. Cotteleer, Mark. "The 3D Opportunity Webinar", Deloitte University Press, August 2014

Feature: AM, Creating New Tradespace for Plastics Continued

6. Goldsberry, Clare. "3D/Additive Manufacturing Boom Continues", Plastics Today, May 2, 2014

7. Industrial Laser Solutions Editors. "3D market poised to reach $12B in 2025, says Lux Research", May 5, 2014

8. Gorton, Richard. "Will 3D Printers Rise to Rule the Manufacturing and Consumer Worlds?", Gartner Blog Network, August 5, 2013

About the Author: Jack Dispenza

Jack is a Fellow in the Society of Plastics Engineers (SPE), member of their New Technology Forum and serves on the Injection Molding Division Board of Directors. Jack is Consultant and Founding Engineer of Design Results, LLC in Long Valley, NJ. Design Results is a full service product realization consultancy focused on plastics, composites and additive manufacturing. jackdispenza@gmail.com, Design Results, LLC, 908 876-5774

IMD Board of Directors Meeting

September 19, 2014

Teleconference

Submitted by Srikanth Pilla, Secretary

Welcome

The Chair Adam Kramschuster called the meeting to order at 9:05pm PST. He welcomed all attendees to the meeting.

Roll Call

Present were: Adam Kramschuster (Chair), Susan Montgomery, Jim Wenskus, Peter Grelle, Hoa Pham, Jeremy Dworshak, Srikanth Pilla, Raymond McKee, Rick Puglielli, David Okonski, Brad Johnson, Kishor Mehta, Tom Turng, Erik Foltz, Lee Filbert

Guests were: James Di Vita, Jon Ratzlaff, Kathy Schacht, Barbara Spain

Absent were: Nick Fountas, David Kusuma, Mike Uhrain, Jack Dispenza

This constituted quorum.

Approval of April 28, 2014 Meeting Minutes

Motion: Pilla moved that the April 28, 2014 meeting minutes be approved, as written and distributed. Adam seconded the motion and carried.

Financial Report – Jim Wenskus, Treasurer

- Jim presented the financials from July 1, 2013 to June 30, 2014. Balance sheets were shared.
- A motion was moved by Susan to donate $1000 to the next generation advisory board to help fund plastics race and it will count as miscellaneous in our budget. Adam seconded it and the motion carried and approved.
- Jim has moved a motion to increase miscellaneous to $2000. Susan seconded it and the motion carried and approved.
- The budget for fiscal year July 1, 2014 to August 31, 2014 was also presented. Pete made the budget call and Hoa seconded the motion and carried.

HSM and Fellows Nomination Report – Tom Turng

- Tom nominated Jack Dispenza for the Honored Service Member (HSM) award. All unanimously supported the nomination.
- Board members are requested to nominate new members for fellow and HSM awards.

IMD Board of Directors Meeting Continued

Pinncale Award – David Okonski

- David is currently working on the application for the pinnacle award. Erik, Tom, Pete and Susan are willing to help if needed.

Technical Director's Report – Peter Grelle

ANTEC 2015

- ANTEC paper review is scheduled for 15th October 2014 at the University of Wisconsin-Stout. The paper review committee is comprised of Adam Kramschuster (2014 TPC), Jeremy Dworshak (2016 TPC), Raymond McKee (2015 TPC) and Pete Grelle (IMD Technical Director).

MMD/IMD Minitec

- Pete proposed a MiniTec in collaboration with the Mold Making and Mold Design (MMMD) division during the 4th quarter of 2015.

Injection Molding Webinar

- 1st IMD webinar series was proposed to schedule in Oct/Nov. The speakers are:

Title	Speaker
Moldflow Simulation-What Information Do you Get?	Matt Jaworski
Gate/Runner Design	Erik Foltz
IM Part Design Basics	TBD

There was a discussion on whether to have free option or non-split option for the webinar series. Pete made a motion to have a non-split option. Since this deemed expensive, Hoa suggested a counter proposal other than the above two but there is a concern of the timing since the webinars need to be organized in Oct/Nov. Finally, Jeremy proposed and made a motion to have $10 for SPE-IMD members and $30 for non-members and non-IMD members. Hoa seconded and the motion carried.

Councillor's Report – Susan Montgomery

- IMD members were made aware of 'The Chain', SPE's professional e-network that is scheduled for a soft launch in Oct.
- Adam has volunteered to participate in the soft launch. Barbara will forward a link to all the IMD members to participate in the soft launch. Login is through SPE membership.
- A microsite was proposed for IMD website, as a subset of SPE main website. A member of the board can be trained on the CMS software to manage the microsite. However, there is a one-time fees of $5000 for this training.

IMD Board of Directors Meeting Continued

ANTEC Technical Program Committee Report – Ray and Jeremy

- A full day tutorial session was planned for ANTEC 2015 with the following potential speakers: Umberto Catignani, Michael Durina, Jeff Jansen, David Hoffman, John Bozelli, Mike Sepe, John Beaumont
- Sponsorships are currently solicited for ANTEC 2015 reception. Interested parties can contact Jeremy at jdworshak@steinwall.com.

IMD Membership Committee – Adam/Nick

Nick sent the updates from IMD membership committee. There was an increase in the enrollment of members. Since April 2014, there were 116 new members with 68% from USA out of a total of 3195 total members. However, there were also a total of 613 lapsed members.

Communications Report – Adam Kramschuster

- Rick Puglielli is currently serving as the Communications Chair. Adam is still managing the webpage, Jeremy will manage Facebook and Hoa will manage LinkedIn.
- Members were invited to manage the IMD Facebook page. Interested members can contact Adam.
- The Communications Excellence Award is due November 30th, 2014.

Upcoming newsletter deadlines:

Spring (March 2015):

- February 10 for content, ads, and payments

Summer (July 2015):

- June 10 for content, ads, and payments

Fall (November 2015)

- October 10 for content, ads, and payments

Nominations Committee – Hoa Pham

Hoa will email the Board about the general and officer ballots for 2015.

New Business and Other Topics – All

None

Next Meeting

Adam will run a Doodle poll to schedule the next meeting in January in order to leave enough time for planning for the March ANTEC conference.

Adjournment

Motion: Jeremy moved to adjourn the meeting. Erik seconded. The meeting was adjourned at 11:45am EST.

Submitted by Srikanth Pilla
November 03, 2014

IMD Leadership

DIVISION OFFICERS

IMD Chair
Adam Kramschuster
University of Wisconsin-Stout
kramschustera@uwstout.edu

Chair-Elect
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Treasurer
Jim Wenskus
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Technical Director
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Past Chair
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The Madison Group
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Councilor, 2011 - 2014
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Priamus System Technologies
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TPC ANTEC 2015
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TPC ANTEC 2016
Education Committee Chair
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TPC ANTEC 2018
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TPC ANTEC 2019
2013 China TOPCON Chair
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TPC ANTEC 2020
David Okonski
General Motors R&D Center
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Membership Chair
Nick Fountas
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Engineer-Of-The-Year Award
HSM & Fellows
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Plascon Associates, Inc
ksmehta100@gmail.com

Reception Committee Chair
Jack Dispenza
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Awards Chair
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turng@engr.wisc.edu

Assistant Treasurer
Nominations Committee/Chair
Historian
Hoa Pham
Avery Dennison
hp0802@live.com

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EMERITUS

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Dosscor@GMAIL.com

Larry Schmidt
LR Schmidt Associates
schmidtlra@aol.com

IMD New Members

The Injection Molding Division Welcomes 103 New Members...

Erika Albury
Gary Arinder
Marco Arras
Flent Ballantyne
Jeff Barnett
Ronald Beitler
Smita Birkar
James Bourne
Andrew Boyd
Bryan Brightman
Carl Brown
Dennis Brown
Matt Brown
Christian Cassel
Thomas Catinat
Maggie Chau
Mark Costain
William Cypert
Joe Davis
Marc-Claudel Deluy
Renee Desbles
Tom Downs
Kevin Dyer
David Erculiani
Martyn Faville
Scott Fraser
Matthieu Germain
Joseph Giamo
Jinsu Gim
Stephan Gnatiuk
Chris Goetz
Christopher Greene
Robert Hale
Seongryeol Han
Kim Hanes
Tom Hansen
Joshua Hautamaki
Bernd Henkelmann
Ruben Hernandez
Heath Holste
Marc Hutto
Josh Jia
Damon Johnston
Evan Knapp
Michael Koss
Indika Kulatunga
Howard Kunz
Sanjay Kuttappa
Jaime Lafita
Scott Large
Hui Li
Adam Loch
Johnny Lu
Dan Manning
Stan Martin
Steven Matthews
Sharon McCord
Michelle McManus
Patrick McNutt
Vahid Mortazavian
Victor Naegelin
David Naughton
Dylan Nixon
Craig Olroyd
Justin Olsson
Craig Ozols
Jacob Pathuis
Sofie Peeters
Jim Peplinski
Raquel Perez
Anita Quillen
Mauro Cesar Rabuski Garcia
Thomas Reffle
Syed Rehmathullah
Antonio Righez Mesquita
Dave Sander
Michael Sarver
Terrence Saul
Christopher Schneider
Maxime Schunder
Keith Scutter
Todd Sholtis
Vishal Singh
Edward Smith
Jeremy Smith
Aaron Spalding
Roy Spatz
Ronald Springer
Wipoo Sriseubsai
Oliver Stauffer
Con Stavropoulos
Paul Stidworthy
Brian Summerkamp
Shih-Po Sun
Scott Sutherland
Dana Thompson
Daryl Thompson
Shannon Vaughn
Rubal Verma
Alan Walker
Maria Wang
Roy Woodley

IMD New Members Continued

...from 16 countries:

Australia
Brazil
Canada
China
France
Germany
Hong Kong
India
New Zealand
South Korea
Spain
Sri Lanka
Taiwan
Thailand
United Kingdom
U.S.A.

...representing more than 87 organizations including:

Advanced Plastiform Inc.
Ajou U.
Aladdin Temp-Rite
Alco Plastics
Ambrit Engineering Corp.
Americhem
Amsted Rail
AST Technology UK Ltd.
Autodesk
Barr Inc.
Basell Australia
Becton Dickinson
Bemis Manufacturing
Berry Plastics
Callaway Golf
CalsonicKansei N.A.
CE Engineering
Celanese
Clariant
CoreTech System (Moldex3D) Co. Ltd.
Corma Inc.
Custom Service Plastics
Kongju National U.
Diversified Engineering & Plastics Inc.
DME Co.
Elgin Molded
EMS-Chemie
EMS-Grivory
ETS
Eve Hook Fall Protection
Evenflo Company Inc.
Executool Precision Tooling
Generation Four LLC
Global Precision Industries Inc.
Hennepin Technical College
Hochschule Darmstadt
Icon Plastics Pty. Ltd.
Innovative Design
International Contract Molding
InterPRO
ISPA
ITW
Kellen
King Mongkut's Institute of Tech. Ladkrabang
Kraft Foods Group
Lacks Trim Systems
LORD Corporation
McCord Executive Search
MGS Manufacturing Group
Milacron Inc.
Milliken Chemical
Mission Plastics Inc.
MRIGlobalPlastics
Nanosyntex, Inc.
National Plastics Color
New Berlin Plastics
Nextool Canada Limited
NIT Hamirpur

IMD New Members Continued

Nypla Industrial
Olsen Tool & Plastics
Orel Corporation (PVT) Ltd.
Osterman & Company Inc.
Outerspace Design
Oxylane
Parker-Hannifin
Parmalat Australia Pty. Ltd.
Penn State Erie
Pikes Peak Plastics
Poly
Polymer Resources Ltd
PolymerWarehouse LLC
PTI Inspection Systems
RGI
Serigraph
Shure Inc.
Styron LLC
Teleflex Medical
Theranos
TMaG
U. Mass. - Lowell
Underground Devices
United Solar Ovonics
Visy
Walter Pack S.L.
Weili Plastics Machinery (HK) Ltd.
Xiamen U. of Technology
YESCO Electronics LLC

Molding Views has many opportunities to help promote your ideas, programs, company and more. We have more to offer in editorial opportunities for companies to share their product/services.

Reach the Injection Molding Community by sending in your submission for the next issue! For information on contributing papers or sponsorships e-mail **Heidi Jensen at PublisherIMDNewsletter@gmail.com**

Membership Application

SOCIETY OF PLASTICS ENGINEERS MEMBERSHIP APPLICATION

13 Church Hill Road, Newtown, CT. 06470 USA
Tel: +1 203-775-0471 Fax: +1 203-775-8490
membership@4spe.org www.4spe.org

European Member Bureau
Tel: +44 7500 829007
speeurope@4spe.org www.speeurope.org

Applicant Information: (please print)

My Primary Address is home_____ or business_____ (check one)

Name ________________ ______ __________________________
First MI Last

Organization Name_______________________________________

Address ____

Address ____

Address ____

City______________________State_________________________

Zip/Postal Code_____________ Country______________

Phone Number________________________ Home___ Work____ Cell___

Job Title____

Email(Required Field)____

Alternate Email ____

Date of Birth___________________ Graduation Date*________________

Gender: Male _____Female_____ *Required for Student Membership

Membership Types (please check one)

_____ **Student $31** _____**Young Professional $99** _____**Professional $144(**includes $15 new member initiation fee)
Choose up to 2 Member Groups on the back of this application.

_____**Professional +2 Additional Member Groups** $**164** Choose up to 4 Additional Member Groups on the back of this application.

_____**Professional +4 Additional Member Groups $184** Choose up to 6 Additional Member Groups on the back of this application.

Payment Information: PAYMENT MUST ACCOMPANY APPLICATION-NO PURCHASE ORDERS ACCEPTED

Amount_____________ Check Number__________________ Cash ________________

Credit Card Information (Check One) American Express_______ Visa_______ MasterCard________

Credit Card Number____ Exp. Date__________ Security Code________

Name On Credit Card____ Amount____________

By signing below I agree to be governed by the Bylaws of the Society and to promote the objectives of the Society. I certify that the statements made in the application are correct and I authorize SPE and its affiliates to use my phone, fax, address and email to contact me.

Signature____ Date________________

Recommended by______________________________ ID#________________________

The SPE Online Membership Directory is included with membership. Your information will be automatically included.
______ Exclude my email from the Online Membership Directory.
______ Exclude all my information from the Online Membership Directory.
______ Exclude my address from 3rd party mailings.

Dues include a 1year subscription to *Plastics Engineering* magazine-$38.00 value (non-deductible). SPE membership is valid for twelve months from the date your membership is processed.

Member Groups

Technical Area of Interests(Divisions)

A Technical Area of Interest gives you access to up-to-the-minute, specialized, technical information and an international community of colleagues in your area of interest. It enhances your membership by providing more targeted, practical advice, from proven experts and professionals currently working in your field.

Please circle choice(s) below:

None

Additives & Colors Europe - D45
Automotive - D31
Blow Molding - D30
Color & Appearance - D21
Composites - D39
Decorating & Assembly - D34
Electrical & Electronic - D24
Engineering Properties & Structure - D26
European Medical Polymers - D46
Extrusion - D22
Flexible Packaging - D44
Injection Molding - D23
Medical Plastics Technical Area of Interest - D36
Mold Making & Mold Design - D35
Plastics Environmental - D40
Polymer Analysis - D33
Polymer Modifiers & Additives - D38
Product Design & Development - D41
Rotational Molding - D42
Thermoforming - D25
European Thermoforming - D43
Thermoplastic Materials & Foams - D29
Thermoset - D28
Vinyl Plastics - D27

Geographic Locations(Sections)

A Geographic Location connects you to your local plastics colleagues and your local industry. Please circle choice(s) below:

None
Alabama-Georgia-Southern
Arkansas
Australia - New Zealand
Benelux
Brazil
California - Golden Gate
California - Southern California
Caribbean
Carolinas
Central Europe
Colorado - Rocky Mountain
Connecticut
Eastern New England
Florida - Central Florida
Florida - South Florida
France
Hong Kong
Illinois-Chicago
India
Indiana-Central Indiana
Iowa
Israel
Italy
Japan
Kansas City
Korea
Louisiana-Gulf South Central
Maryland-Baltimore-Washington
Mass-New Hampshire-Pioneer Valley
Mexico-Centro
Michiana
Michigan-Detroit
Michigan-Mid Michigan
Michigan-Western Michigan
Middle East
Mississippi
Missouri
Nebraska
New Jersey - Palisades-New Jersey
New York
New York-Binghamton-Scranton
New York-Rochester
New York Mid-Hudson
North Carolina-Piedmont Coastal
Ohio-Akron
Ohio-Cleveland
Ohio-Miami Valley
Ohio-Toledo
Ohio-Firelands
Oklahoma
Ontario
Oregon-Columbia River
Pennsylvania-Lehigh Valley
Pennsylvania-Northwestern Pennsylvania
Pennsylvania-Philadelphia
Pennsylvania-Pittsburgh
Pennsylvania-Susquehanna
Portugal
Quebec
Southeastern New England
Spain
Taiwan
Tennessee-Smoky Mountain
Tennessee-Tennessee Valley
Texas-Central Texas
Texas-Lower Rio Grande Valley
Texas-North Texas
Texas-South Texas
Turkey
United Kingdom & Ireland
Upper Midwest
Utah-Great Salt Lake
Virginia
Washington-Pacific Northwest
West Virginia Southeastern Ohio
Western New England
Wisconsin-Milwaukee

Special Interest Groups(SIGs)

Special Interest Groups are where like-minded Plastics professionals come together to explore the emerging science, technologies and practices that will shape the plastics industry. There is no charge for membership. Choose as many as you would like. Please circle choice(s) below:

Advanced Energy Storage – SIG 024
Alloys and Blends – SIG 010
Applied Rheology – SIG 013
Bioplastics – SIG 028
Composites Europe – SIG 026
Extrusion Europe – SIG 025
Failure Analysis and Prevention – SIG 002
Joining of Plastics and Composites – SIG 012
Marketing & Management Division – SIG 029
Nano/Micro Molding – SIG 023
Non-Halogen Flame Retardant Tech-SIG 030
Plastic Pipe and Fittings – SIG 021
Plastics Educators – SIG 018
Plastics in Building and Construction – SIG 027
Process Monitoring and Control – SIG 016
Quality and Continuous Improvement – SIG 005
Radiation Processing of Polymers – SIG 019
Rapid Design, Engineering and Mold Making – SIG 020
Thermoplastic Elastomers - SIG 006

Advanced CVe Monitor and CVe Live from AST Technology

AST Technology announces the release of its new CVe Monitor, bringing many new features to this second generation device that takes monitoring mold activity to another level.

The CVe now provides more options and versatility with the following notable upgrades:

- For retrofitting: Users can install on an existing mold and input previous cycle counts that appear on the display and in reports.
- PM Alerts: New alert modes to notify users when PMs are due, flashing on the display a message that maintenance is overdue.
- Removal Monitoring: When the CVe Monitor is removed from the tool for any reason (i.e. cleaning) pins on the back of the device will record it as an event.
- Three mounting options: Mount CVe at the parting line, below the parting line using an internal extension rod, or on the mold's surface using an external mounting block.
- Flash drive on CVe doubled from 2GB to 4GB for increased file storage.
- OnDemand software upgraded to enable use of new CVe functions in 10 languages.

CVe Live®: Monitor Molds in Real-Time

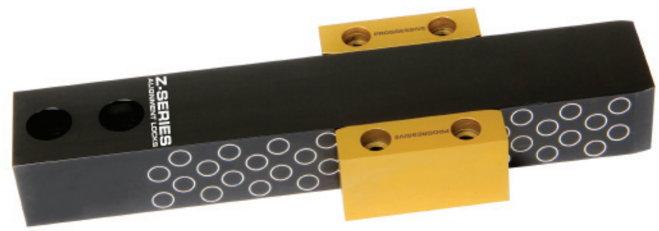
CVe Live, a hardware/cloud platform, provides OEMs and molders with secure access to up-to-the-minute mold activity reports from the CVe Monitor via Press Modules and Gateway hardware.

Features Include:

- A dashboard that gives information at a glance and allows one to drill into specifics on each tool.
- Administration and security levels are controlled by the user, and access can be given to subcontractors to upload information or to initialize the CVe Monitors to begin submitting data.
- Radio Frequency (RF) antennas are interference-free in typical molding environments.
- Secure website for data collection, reporting, and file storage.

For more information about the CVe Monitor System, CVe Live or OnDemand software, please visit www.CVeMonitor.com.

Progressive Components Expands Z-Series Line With the Addition of New Bar Locks



Progressive Components announces its new Z-Series Bar Locks, giving mold designers a standard "off-the-shelf" solution for alignment of large molds and multi-plate sequencing tools. Z-Series Bar Locks deliver the maximum amount of guidance and support for the minimum amount of machining required.

Bar Locks provide long-term precision registration of plates, and for long-lasting durability and wear resistance, they feature Z-Series proprietary treatments, engagement ramp geometry and particle rings on the guiding surfaces.

"Z-Series Bar Locks are ideal for use in molds where longer and more robust alignment is required," explained Ken Rumore, Senior Design Engineer. "This includes molds for parts that have very tall cores that engage quickly. Bar Locks are ideally suited for large automotive molds, stack molds, three plate molds, and stripper plate molds."

Other notable features include:

- Bar Locks can be configured many ways and parts can be ordered individually to suit the specific application.
- Bar Locks are available in 4 standard widths and lengths up to 16" long
- Bar Locks allow alignment to take place before tall cores engage at mold close, versus leader pins, which do not provide the same precision to accurately align the mold halves and prevent damage to cores and shutoffs.
- Custom Bar Locks are available upon request.

For more information visit www.procomps.com/z-series.

MoldTrax Gets Bigger, Faster and Stronger With the Release of MT6

MoldTrax, the industry's leading software designed specifically for tracking the performance and maintenance of molds and dies, releases MoldTrax 6 (MT6).

New features include:

- "Inventory Monitoring" that allows the user to quickly see how many parts are left in stock. The simplest inventory system anyone will ever use!
- A MoldTrax exclusive: A "Hot Runner Specs" tab has been added to the popular TechTips section gives users quicker access to manifold maintenance and repair instructions, images and specifications of the system. Categorizing this technical data saves search time and improves repair accuracy
- A "Maintenance Alert" report making it possible for the user to see what PM's are coming due (Yellow), overdue (Red) or OK (Green) on molds currently in production

- A MoldTrax Performance Dashboard is now available from the main screen that shows the current ratio of Scheduled vs. Un-Scheduled mold stops as well as the number of molds currently in production and their PM status (based on cycles run)
- All screens have been enlarged and many fields include Zoom windows with rich (customizable) text. Choose between full or ¾ screen sizes
- Two new FastTrax Reports include Inventory Tracking and Maintenance Alerts.

"MoldTrax was born on the bench out of a need for repair technicians to be quickly brought up to speed on specific mold and product issues so they can maximize the time they spend with molds," explains MoldTrax founder and ToolingDocs Operations Manager Steve Johnson.

"All molding companies, both custom and proprietary, save money through better targeting of mold and production defects," Johnson states. "Using this database will change one's shop culture from firefighting to preventive by providing users with more complete and accurate data that can be used to make more informed decisions."

Download a free demo system to try by visiting www.moldtrax.com or www.toolingdocs.com.

Contact ToolingDocs at 419 281-0790 or email info@toolingdocs.com for more information.

Trexel's MuCell Technology gives New Balance Running Shoes Premium Energy Return for the Highest Performance

Trexel has helped New Balance achieve greater performance by incorporating Mucell technology in the development of their running shoe components. The current molding program for mid sole and heel components is incorporated into the production of over 1+ million pairs of running shoes a year. The running shoe designs utilize 3 different forefront parts – in 23 sizes along with 2 heel parts in 6 different sizes, all molded with MuCell.

"MuCell processing technology has allowed us to customize our designs to offer premium cushioning with a reduced amount of material. We have found the durability of these components exceeds standard foam running shoe applications – offering a longer wearing shoe with more rebound and energy return to our customers," said Katherine Petrecca, Strategic Business Unit Manager for New Balance. "This technology is currently incorporated into New Balance running shoes – including our offering for ultra (long distance) runners and we are also looking at other lines that can take advantage of the technology."

About Trexel and the MuCell® Process

The MuCell® Microcellular Foam technology from Trexel Inc. is a complete process and equipment technology that enables the production of high quality plastic parts with significantly enhanced dimensional stability, lower weight/material and reduced cycle time. MuCell® technology involves the introduction of precisely metered quantities of atmospheric gases (nitrogen or carbon dioxide) in the plasticizing unit of an injection molding machine to create a microcellular material structure in the end product. The creation of these microcellular structures brings a wide array of benefits including an increased part quality along with reduced production costs.

Trexel, Inc. has led the development of the MuCell® Microcellular foaming technology and has pioneered many plastic processing solutions. Process deployment, as well as equipment, is supported by teams of highly qualified engineers through Trexel subsidiaries in North America, Europe, and Asia. www.trexel.com.

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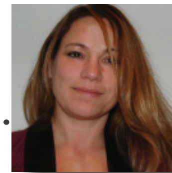

Hello everyone!

I hope you enjoyed this edition for Molding Views. If you haven't already noticed, SPE has revamped it's web site. You will see an easier navigation, new professional contact groups, news from all divisions, event updates and more. Also check out the Injection Molding Division page, http://injectionmolding.org which has live webinars coming up!

Spring shows such as ANTEC 2015 are already gearing up for a your arrival. Make sure you mark your calendar and stay in touch with the upcoming sessions and events. You can follow ANTEC highlights as well as other 2015 shows at the SPE web site.

Thank you to all the members who submitted articles this month and to all our sponsors in showing support in SPE. If you have an article or technical paper, please send those in for the next issue. Submissions for the newsletter are accepted throughout the year.

Have a wonderful holiday and see you in the spring!

Thank you all, stay in touch!

Heidi Jensen PublisherIMDNewsletter@gmail.com

A big thank you to the authors and sponsors who supported this month's issue.

ANTEC 2015 .... **8**

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