WINTER 2014
VOLUME 39, ISSUE 1

A Message From the Chair

I am delighted to be serving as the Extrusion Division chair this year.

There are many exciting changes that are currently taking place in the Extrusion Division; we have established two new scholarships for our students as a way to encourage them to enter the plastics field: the Russ Gould and the Ed Steward scholarships.

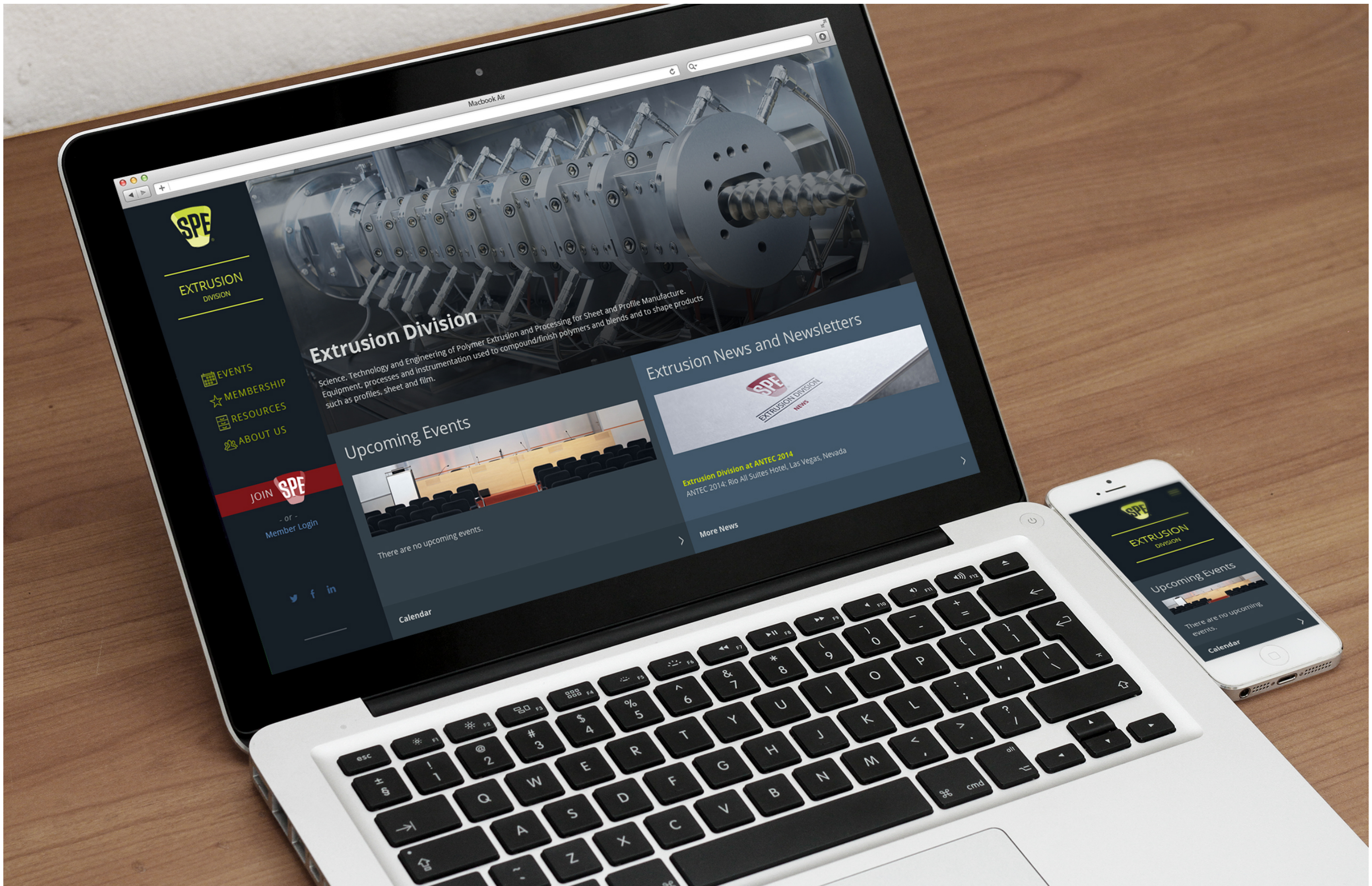
Both Russ and Ed were long-standing members of the Extrusion Division, and made significant contributions to the plastics industry. We would also like to acknowledge the contribution of the Steward family and American Kuhne for their help in establishing the Ed Steward Scholarship. Combined with the existing Lew Erwin scholarships, the extrusion division now offers three levels of scholarships available to all students, from first year freshmen to grad students.

We are also actively encouraging young professionals (YPs) to get involved in the board, so that the extrusion division can be more relevant to the needs of the YPs and to help them accelerate their careers. We have an initiative to elect two YPs onto the board every year for the next three years. They will form their own YP committee to discuss what is relevant to them. They will then report to the board with ideas and programs to be implemented.

It is our goal to continue to improve communication to all of our members and increase membership enrollment. SPE recently revamped our website both at the National and the Divisional level. If you have not had a chance to do so, please go to www.4spe.org to visit our new website. The Extrusion Division is also on LinkedIn, Facebook and Twitter, so follow us on all of the social media websites!

Finally, the board welcomes three new members this year, Chad Brown from Merck, Monika Gneuss from Gneuss and Kevin Slusarz from American Kuhne. We look forward to working with them.

Karen Xiao, Ph.D.
SPE Extrusion Division Chair, 2014-2015
Email: Karen.xiao@celgard.com



Check Out the New SPE Extrusion Division Website

extrusion.4spe.org

Extrusion Expert, SPE Fellow Frank Nissel Dies

Frank Nissel, whose name and Welex brand are synonymous with plastics sheet extrusion worldwide, passed away in late August after a brief illness. He was 88. Nissel co-founded Welex in 1966 and retired in 2010. Welex is now part of Graham Engineering Corporation and remains the global standard in sheet extrusion systems.

In a career that began in 1946, Nissel was responsible for technical innovations that have made sheet extrusion among the most precisely controlled plastics processes. He was awarded patents in the US and 13 foreign countries and authored more than 50 technical articles and papers for innovations in extrusion and coextrusion processing, barrier packaging, die design, and calendering.

A long-time member of the Extrusion Division, Nissel received the SPE Extrusion Division Distinguished Service Award in 1992, became an SPE Fellow in 1993, and in 1995 received the SPE International Award in Business Management. He was inducted into the Plastics Hall of Fame in 2000.

Nissel was an internationally-minded business leader who spoke five languages. His collaboration on coextrusion with leading packaging producers in Europe and Japan led to its prevalence in those markets and ultimately to the US, where, in the mid-1970s, production of the now famous 4-layer, 2-color party cup began using Welex equipment. Similarly, collaboration in Japan with a pioneering EVOH barrier packaging producer resulted in innovations that made their way to the US in the early 1980s, when the first successful barrier container was produced.

Born in Germany in 1926, Nissel left with his family for Egypt during the Hitler era. In Egypt he was educated at the American University in Cairo. He went on to earn his MSc in chemical engineering at Virginia Tech in 1946 and began his plastics career at Bakelite Corporation (Union Carbide) in vinyl calendering development. In 1956 he left Union Carbide to help found Prodex Corporation and, when it was sold in 1966, formed Welex with the late Jack Hendrickson.

“We are saddened by Frank’s passing and, along with the industry, are grateful for his many contributions,” said Graham Engineering Corp. president and CEO David Schroeder. “He was part of the industry’s greatest generation, and his legacy lives on in Welex solutions installed in more than 3,000 customer locations in 69 countries. Today the extrusion systems that Frank Nissel pioneered are manufacturing high quality plastic sheet for products used everywhere, by everyone, every day.”

Extrusion Division Establishes Scholarship for Ed Steward, Russ Gould

The Extrusion Division announced recently the establishment of two new scholarships for student seeks to pursue advanced education in polymers.

The Ed Steward Ed Steward Scholarship will be awarded to students selected by the SPE Extrusion Division's Scholarship Review Panel. The Division will award scholarships as follows: Once each academic year, the Extrusion Division of SPE will have a goal to award at least one $2,500 scholarship to a student meeting the scholarship's criteria listed below:

- Applicant must be or become a SPE Student Member and be active in the local Student Chapter if their university or college has such a chapter.
- Applicant must be attending (or high school senior applying to attend) a U.S. or Canadian college or university.
- Applicant must be an undergraduate student enrolled in, or high school senior applying to, an associate degree or technical degree program, who is committed to becoming a "hands-on" workers in the plastics industry – i.e. students who are dedicated to careers as plastics technicians or engineers.

Preference will be given to:

- Students pursuing a career in plastic or rubber extrusion processing.
- Students of exceptional merit enrolled at a university or college who are focusing on polymers or Plastics Engineering
- Students pursuing an associates or bachelor's degree in Mechanical, Chemical, or Manufacturing Engineering and focusing on a career in manufacturing involving plastics.
- High school seniors or students in their first year in an engineering program at a college or university;
- Students with an academic record indicating a 3.0 grade point average or higher who are in good academic standing;

Students who are awarded the Ed Steward scholarship are to submit a testimonial report back to the SPE Extrusion Division as to the benefit that they were given by receiving the scholarship from the Extrusion Division.

Ed Steward (photo, previous page) was a long-time member of the SPE Extrusion Division whose screw designs are still operating at plastics plants around the world. After a long-stint at Davis-Standard, Steward joined with Bill Kramer to co-found American Kuhne Corp., Ashaway, R.I., which is now part of Graham Engineering Corp. Ed passed away in 2011.

The scholarship will be funded by contributions from of $1200 from the Steward family; $1800 from SPE Extrusion Division; and $6000 from American Kuhne.

The Russell J. Gould Scholarship, meantime, will also be awarded to students selected by the SPE Extrusion Division's Scholarship Review Panel. The Division will award scholarships as follows:

Once each academic year, the Extrusion Division of SPE will have a goal to award at least one $2,500 scholarship to a student meeting the scholarship's criteria. The conditions are as follows:

- The applicant must be or become a SPE Student Member and be active in the local Student Chapter if their university or college has such a chapter.
- The applicant must be US or Canadian citizen;

Preference will be given to:

- Students pursuing a career in plastics, rubber or polymer processing.
- Students of exceptional merit enrolled at a university or college who are focusing on polymers or Plastics Engineering
- Students pursuing an associates or bachelor's degree in Polymer, Materials Science or Plastics Engineering and focusing a career in manufacturing.
- Students in their second or third year in their degree program at a college or university;
- Students with an academic record indicating a 3.0 grade point average or higher who are in good academic standing.
- Students who are awarded the Russell J. Gould scholarship are to submit a testimonial report back to the SPE Extrusion Division as to the benefit that they were given by receiving the scholarship from the Extrusion Division.

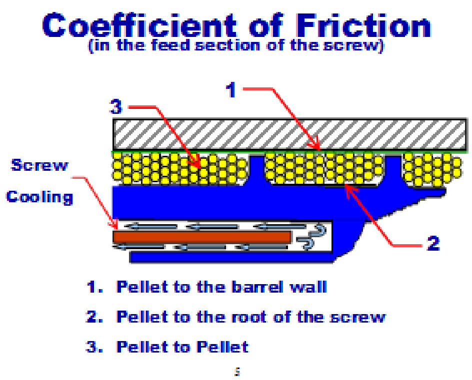
Russ died last December. A long-time member of the Extrusion Division Board and editor of this newsletter, he was an internationally known inventor and consultant and won engineering awards for his distinguished work in the plastics industry. ■

ANTEC CALL FOR PAPERS

ANTEC 2015 will be co-located with NPE2015 in Orlando, Florida, March 23-25. Click here for information on submitting a paper.

Tech Tips: The How's and Why's of Extruder Screw Cooling

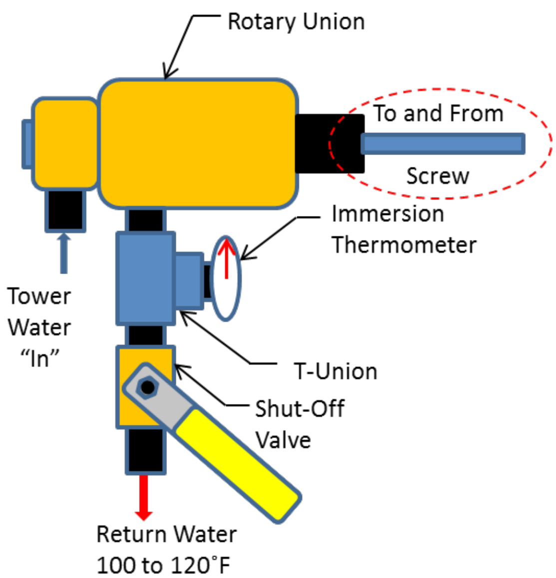
By Tim Womer



There are basically distinct three coefficients of friction (above) that take place in the feed section of the screw: between the barrel and the pellet; between pellet to pellet; and between the root of the screw and the plastic pellet.

Always install screw cooling on the feed section core of the screw. In most cases, screw cooling will be a benefit to the process. It will give the operator another "zone" of control on the extruder. The main theory of "solids conveying" is that the resin must "stick to the barrel" and "slip on the screw." By cooling the root of the screw, it will reduce the coefficient of friction between the steel of the screw and the plastic pellet.

Processing will also be enhanced by installing a rotary union to an extruder screw.



One advantage of using screw cooling is when regrind is part of the feedstock recipe because there are always traces of "fines" in the regrind. These fine particles will always melt quicker than pellets and pellet-size regrind particles. Therefore, the fine particles will stick to the root of the screw in the feed section. This resin will eventually degrade and break loose and ultimately exit through the die and find its way into the final product being made.

Circulating 100F to 120F water through the feed section of the screw will control the temperature of the steel in the feed section of the screw and reduce the possibility of the fines building up on the root in this area.

Another advantage of using screw cooling is to increase the throughput rate of the extruder. For resins that have poor coefficients of friction in the solid phase, such as polypropylene and polyamides, by increasing the first barrel temperature zone and keeping the root of the screw cooled at 100F to 120F, the differential of the COF between the pellet/barrel and pellet/screw can be maximized. Thus, solids conveying will be maximized.

The easiest way to maintain 100F to 120F on the screw is to simply use tower water and control the flow so that the return water out of the screw is maintained. In order to do this, all that needs to be done is to install a shut-off valve and immersion thermometer on the return side of the rotary union as shown above. Therefore, by spending about $500 for a rotary union, an immersion thermometer, and the necessary plumbing components, many of the feeding problems may be resolved. ■

Tim Womer is a recognized authority in plastics processing and machinery with a career spanning more than 35 years. He has designed thousands of screws for all types of single-screw plasticating. He now runs his own consulting company, TWWomer & Associates LLC. He was inducted in the Plastics Hall of Fame in 2012.

Contact: (724) 355-3311; tim@twwomer.com; twwomer.com.

INVEST IN YOUR FUTURE: JOIN THE SPE

Whether you're a plastics scientist or engineer, a business owner, marketing/sales expert, or any other professional in plastics, SPE membership can help you advance your knowledge and your career. The information you need to increase efficiency and productivity, develop your career, and add to your company's bottom line is literally right at your fingertips.

SPE's support of the development of plastics professionals begins at the moment they enter the industry as a student. Undergraduate and graduate students in plastics related fields of study can learn, study and build their professional networks.

The Society offers three levels of membership:

Student: SPE is the perfect place to build your foundation in the plastics industry! SPE's support of the development of plastics professionals begins the moment they enter the industry as a student. Undergraduate and graduate students in plastics related fields of study can learn, study and build their professional networks. A Student Member should be a regularly enrolled, full-time student in a course of study for a future in the plastics industry. Student Members receive full Professional Membership Benefits. Cost: $31/year.

Young Professional: Launch your career with SPE learning, networking, and career-building resources! The Young Professional should be under 30 years of age, but not a Student Member. Young Professional Members receive a discounted rate. In order to qualify, for this rate, member's birth date must be furnished. Young Professional Members receive full Professional Membership benefits. Cost: $99/year.

Professional: SPE is the "go to" plastics industry resource for technical and business professionals looking to broaden their knowledge, and stand out in the field!

A Professional Member should have a professional or academic interest in plastics engineering, technology or science, or in the management of such activities. Cost: $144/year.

Emeritus Member: A member of the Society who has accumulated at least 20 years of membership, and (1) who is either retired from active professional activity and is over 62 years of age, or (2) is over 70 years of age, is eligible for Emeritus member type. Emeritus Member receives a discounted rate. In order to qualify for this rate, a member's birth date must be furnished.

Learn more about member benefits and join here.

Extrusion Division Honors Five At ANTEC '14

The SPE's Extrusion Division doled out five awards during its Antec 2014 reception, which was held in Las Vegas. Dr. Mark Spalding, a member of the Divison Board of Directors and Fellow, Materials and Parts Processing, Dow Chemical Co., Midland, Mich., was master of ceremonies for the event. Awards were presented to the following:

Distinguished Achievement Award: Ed Steward. The SPE Distinguished Service Award recognizes contributions to the Society that exhibit such exceptional devotion of time, effort, thought, and action as to set them apart from other contributions. Recipients of this award automatically become Distinguished Members.

The Extrusion Division's 2014 recipient was Ed Steward. Steward was co-founder of American Kuhne and VP of process technology when he passed away in 2011. Prior to that he Davis-Standard for 24 years, leaving as its chief process engineer. His responsibilities included screw design and application engineering along with processing related tasks that ensured extrusion systems would meet the designated performance goals.

Steward was a member of the Society of Plastics Engineers (SPE) since 1973 and was recognized as an SPE Fellow in May 2006. In May 2004 he also received the Bruce Maddock Award from the SPE Extrusion Division in recognition of his contributions to single-screw extrusion.

His long-time friend and business partner Bill Kramer (pictured top left with Mark Spalding) accepted the award on his behalf.

The Heinz Hermann Twin-Screw Extrusion Award: Paul Squires. Recipients of this award are to have contributed significantly to the advancement of twin-screw extrusion technology. This can be accomplished through experimental or theoretical achievements that provide an understanding to the fundamentals of processing material in the extruder. These experiments could include (but not limited to) work relating to solids conveying, melting, mixing, devolatilization, and pumping functions of twin screw extrusion.

Dr. Squires was one the DuPont "Dream Team" extrusion researchers in the 1950s. His research in the 1950s was focused on the fundamental operation of the metering section of the screw and the mathematical models required to predict flows. Extrusion

Division board member Dr. Eldridge Mount accepted the award from Coperion K-Tron's Dr. Paul Andersen (previous page, l-r). Coperion K-Tron sponsors this award.

The Heinz List Award: Anthony C. Neubauer. This award is presented to an individual that has contributed an outstanding achievement in the area of polymer devolatilization, drying, evaporation, or reactive polymerization technologies. The award honors the pioneering contributions and innovations that were made by Heinz List during his long career.

Neubauer (pictured at the podium) invented, tested, developed, and implemented multiple technologies to improve the melt strength of high molecular weight and high strength blown film and pipe polyethylene (PE) products through reactive processing while at Dow Chemical Co. He was involved in crosslinking technologies (oxygen and azide coupling chemistries) improve the bubble stability of high density PE blown film products to acceptable levels while maintaining acceptable solid state strength (dart drop), and improve the sag resistance (i.e., melt strength increase) of thick walled pipe products, without the formation of gels. These technologies enabled annual sales of over 450 million lb of patent protected high-value UNIPOL PE products.

The Jack Barney Award: Wayne Gifford. The Jack Barney Award was initiated by the late Frank Nissel of Welex to honor Jack Barney, the founder of Extrusion Dies Inc. The award is to be presented to persons who have made a significant contribution to the development of the flat sheet industry. Their contributions can be technical or commercial, but should have value to the industry as a whole.

The 2014 winner, Wayne Gifford, is the president and owner for Dieflow, a die design and design software provider. Wayne (pictured at the podium) was a member of the Extrusion Division Board for 15 years and a frequent presenter at ANTEC.

Bruce Maddock Award: Dr. John Vlachopoulos. The Extrusion Board accepted administration of the Bruce Maddock Award Gloucester Engineering Co., with Dow providing the honorarium. Award recipients are to have contributed significantly to the advancement of single screw extrusion technology or associated processing technology by providing experimental achievements and understanding to the fundamentals of the process. Single-screw processing technologies include but are not limited to solids conveying, melting, mixing, and pumping functions. Associated processing technologies include but are not limited to feed systems, filtration systems, gear pumps, coextrusion, and die systems.

Dr. Vlachopoulos has developed technologies and has advanced the fundamental knowledge of just about every polymer processing operation including plasticating extrusion, extrudate swell, melt fracture, die flows, coextrusion, blown film, rheology, and model development. His research and model development led to formation of the company Polydynamics Inc., licensing software to about 500 corporations in 27 countries. Dr. Vlachopoulos is a Professor Emeritus in the Department of Chemical Engineering at McMaster University. ■

Extrusion Technology Update

Devolatilization via Twin Screw Extrusion: Theory, Tips and Test Results

By Charlie Martin, Leistritz

In a twin screw extruder (TSE), the mixing/blending of polymers/additives and devolatilization are mass-transfer operations dependent upon shear/energy that is being imparted into the materials being processed by rotating screws. Devolatilization (DV) refers to the removal of unreacted monomer, solvent, water and other undesirable materials from the process melt stream. There are many devices that perform DV, including extruders. Almost always, the TSE includes the provision for devolatilization; sometimes as a critical factor in the process, and sometimes as an after-thought.

Factors that effect devolatilization efficiencies, in any device, include:

1. Residence time under the vent or vents- longer is better but…

- Oxygen, shear, time and temperature may contribute to degradation and side reactions (understand kinetics of degradation)

2. Surface area of the melt - higher is better

- Rolling pools and film effects

- Function of screw geometry and operating parameters

3. Surface renewal- higher is better

- Renewed surfaces come from rolling pools and partially filled screw channels

4. Bubbles are key: nucleation, growth and rupture

- Stripping agents can be injected to facilitate bubbles

5. Vacuum level applied to vent zone(s) – it can make a big difference

- Low viscosity material may require decreased vacuum levels

Materials are metered into the twin screw extruder and the screws rpm is independent and set to optimize processing efficiencies. Melt pools are bounded by screw flights and barrel walls, which makes extrusion, by definition a "small mass" continuous process that results in a high surface area of the polymer melt. Rotating screws result in rolling pools and thin films, both of which improve DV.

Process control parameters include screw speed (rpm), feed rate, barrel/die temperatures, and vacuum level. Typical readouts include melt pressure, melt temperature, motor amperage, and in-line optical sensors. Depending on how the TSE is configured and operated, residence times can be as short as 5 seconds, as long as 10 minutes, and are typically in the 20 second to 2 minute range.

Starve feeding refers to the extruder being fed at a rate less than the forwarding efficiency of the screws. The independence of feed rate from screws rpm facilitates control of surface area generation, residence time, and mixing (to eliminate gradients); and is what makes the TSE an effective tool for stripping volatiles from polymer melts.

Click here to read this paper or download it in its entirety.

Extrusion Technology Update

Drying and Crystallizing Systems for Reclaim Extrusion

By Jeff Courter, ACS-Walton/Stout

Many reclaim lines require moisture removal from the regrind material, and a PET reclaim extrusion line will not operate properly if the drying and crystallizing system cannot supply the material into the feed throat at the desired moisture content, temperature and intrinsic viscosity (I.V.). A proper drying and crystallizing system can be the difference between quality product and junk, so it is worthwhile to consider some features of the new equipment for your system:

- Correct sizing and proper operation
- New filter systems for increased performance
- High-efficiency motors
- New user-friendly PLC-based control systems
- Heat recovery systems
- Gas-fired options
- Integration with extruder control system
- The following equipment is crucial to any reclaim extrusion line:
- Hot air dryer (material dependent)
- Crystallizer (material dependent)
- Dust collection system
- Dryer and hopper sized for the application
- Loading system

A properly configured crystallizing and drying system will help produce your product with higher quality, improved efficiency and lower cost if they are reviewed and specified in advance.

Click here to read this paper or download it in its entirety.

Extrusion Technology Update

A Mechanism for Solid-Bed Breakup In Single Screw Extruders: Solid-Bed Shape Change

By Gregory A. Campbell, Clarkson University/Castle Associates, Mark A. Spalding, The Dow Chemical Company

It is well known that solid bed breakup in plasticating single-screw extruders can lead to defects in the downstream product, reduced rates, and process instabilities. After a review of the mechanism of solid bed melting an enhanced discussion will be presented regarding a new concept for solid bed break up.

The literature generally attributes this breakup to pressure gradients emanating from the beginning of the metering section of the screw. In a previous paper a new mechanism was proposed that was developed as a result of the physics of the melting mechanism and fluid flows associated with screw rotation physics.

During the discussion after the presentation of this new mechanism at ANTEC 2013, questions were raised as to the assumptions made regarding the shape change of the solid bed during melting which the authors proposed was a result of the flow that occurs as a result of the new mechanism. In this paper more data will be presented that will help define this new concept.
Solid bed breakup is a process that occurs in almost all plasticating single-screw extruders, and in most cases the process is undesirable since it can lead to solid polymer fragments in the extrudate, process instabilities due to solids plugging mixers, and thermal gradients. Solid fragments in the extrudate will almost always cause defects in the finished product. For example, a lab extruder was operated with a mixture of 100 parts of white tinted acrylonitile-butadiene-styrene (ABS) terpolymer pellets with 1 part of black tinted ABS pellets. If the extruder operates properly without solid bed breakup, the extrudates are tinted black and are relatively uniform in color, as indicated by the cross sections shown in Figure 1 at screw speeds less than about 70 rpm. At higher screw speeds, the solid bed broke up and caused solid polymer fragments to flow downstream and into the extrudate, as indicated by the white tinted fragments at screw speeds greater than 80 rpm.

Solid bed breakup can be observed by performing a Maddock solidification experiment. Here the black tinted areas show regions in the screw channels that were molten at the moment of stopping screw rotation and solidifying the resin. Areas that were tinted white show regions that contain resin in the solid form. Solid bed breakup is evident in these cross sectional photographs since there are regions were the molten resin is essentially across the entire channel and solids are evident in downstream cross sections. These types of views are typical in almost all published Maddock solidification experiments.

Click here to read this paper or download it in its entirety.

Extrusion Division Goes Global

Over the spring the Extrusion Division was involved in two successful conferences. Board members Dr. Costas Gogas, Dr. Maria Noriega and Charlie Martin (photo top left) participated in a twin-screw seminar held in Medellin, Columbia May 29-30 at the ICIPC (Research institute for Plastics and Rubber).

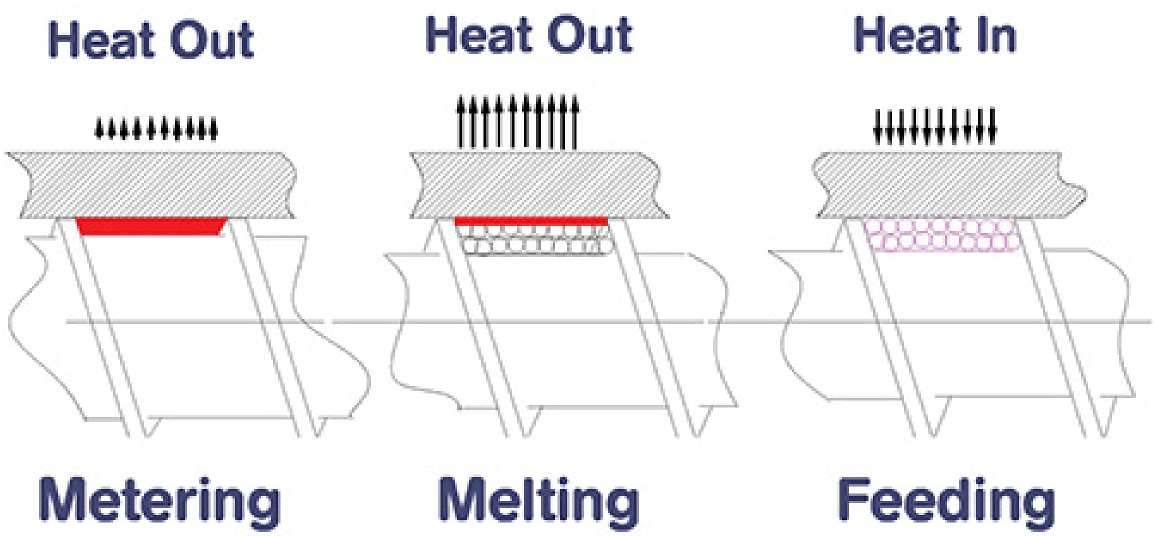
Two months later, Extrusion Board members Dr. Noriega (top right), Martin, Olivier Catherine, Steve Schick and Dr. Jaime Gomez participated in the fourth annual Plastic Extrusion Week 2014, July 16-19 in Bangkok, Thailand.

THE SPE EXTRUSION DIVISION

SPE

"The objective of the Extrusion Division shall be to promote the scientific and engineering education and knowledge relating to the extrusion of plastics."

Telltale Temperatures



Generally, the first section of an extruder absorbs heat from the barrel; the middle or melting zones add heat to the barrel; and the last zones stay fairly neutral, adding some heat to the barrel.

Sometimes you might be called on to troubleshoot an extrusion operation without being able to physically inspect the screw to note its design. In these cases, you'll need to get a "feel" for the design by combining all the normally measured external parameters (output, motor load, melt temperature, stability, etc.) along with the heat flow in and out of the barrel. Since most of the energy going into the polymer comes from the screw rotating in the barrel, you can get some insight about the screw design without any dimensions on smooth-bore extruders.

Energy enters the polymer as heat in two ways: viscous dissipation or shear stress of the polymer as it sticks to the barrel and is being sheared by the rotating screw; and heat conducted into the polymer from the heated barrel. This conducted heat can be significant in small extruders (less than 3 in. diam.), less so in larger ones. In larger extruders, the heat-transfer distance increases because the flight channels get deeper with screw size, resulting in an exponential increase in mass flow vs. surface area. Consequently, heating-cooling observations are useful indicators of screw design mainly in larger extruders.
In general, the first section absorbs heat from the barrel; the middle or melting zones add heat to the barrel; and the last zones stay relatively neutral (with some heat added to the barrel).

The magnitude of the heat transfers is not uniform and depends on polymer properties and screw speed. I recently observed three extruders (4.5, 5 and 6 in.) processing the same polymer with no screw-design information. All but one showed similar heat flow in each section. The odd one was generating excessive heat into the barrel across its entire length despite having proportionally similar specific output and discharge pressure relative to the others. I figured the screw was designed with some type of flow restriction. Sure enough, several weeks later the screw was pulled, revealing an extremely restrictive, labyrinth-type mixing device near the discharge.
Since each polymer requires different barrel-temperature profiles for processing, you'll need to use a zone setting suitable for each polymer and situation. A test setting 10° F below the exiting melt temperature gives good results without upsetting performance for all but zone 1, which can be set 30° F below the exit melt temperature. During an evaluation, these zone settings can usually be applied one at a time with no disruption of production.

Since heat only flows from a hotter to a colder area, when the barrel temperature rises above the test temperature (calls for cooling) it means the temperature of the polymer at the barrel wall is hotter than the test temperature. When the barrel temperature drops (calls for heat) it means the melt temperature is lower than the test setting near the barrel wall. This can be determined by watching each zone individually and observing how much time the zone is heating or cooling when set at the test temperature. Since heat flow is not instantaneous, time must be allowed for the zone to stabilize. The larger the extruder, the longer the time frame.

How do you use this information? A well-designed screw should generally absorb heat in the first zones where the polymer is cold and melting has either not started or has just begun. So if you set zone 1 at the test temperature, you'll likely need electrical energy to maintain that temperature. If that's not the case, the feed section may be too shallow, the conveying angle too low due to polymer properties, or the extruder output is limited further downstream, restricting the feed rate.

If the barrel heaters in zone 1 cannot maintain the temperature at the test setting, the overall output of the screw may be too great, which would be confirmed by issues with melt quality.

In the melting section, typically starting in zone 2 or 3, a lot of energy should be going into the polymer as the channel depth decreases. Those zones are likely to override the test setting and call for cooling because the viscous dissipation or shear stress in that area tends to be very high. The melt film experiences very high shear rates, is very thin, and typically is hotter than the final melt temperature. The adjacent barrel is a good heat conductor, while the polymer beneath the melt film is a poor heat conductor. Hence, heat moves into the barrel instead of into the unmelted polymer.

In fact, if the melting zones do not maintain the test setting without added heating, the melting section is probably either under-designed or worn, resulting in poor melt quality. With many non-barrier designs this deficiency is offset by placing a dispersive mixer such as the Maddock type near the discharge. Since these are very high-shear-stress devices, they will add a lot of heat to the barrel and typically cause the last zone to significantly override the test setting. A similar override can occur in a compression or barrier section when it does not have sufficient melting area and plugs with solids. That would be expected in the mid-section of the screw.

As it enters the metering section, the polymer is sufficiently fluid that it should not exceed the test temperature by more than 10° F. If substantial override occurs, there must be a downstream restriction such as the dispersive mixer noted above or substantial screw/barrel wear in that area.

Such an analysis is easier when you can run a side-by-side comparison of more than one extruder running the same polymer. Coupled with knowledge of the polymer characteristics, a preliminary assessment of the screw design and condition is possible without actually reviewing the screw. ■

Note: This article was originally published in the January 2014 issue of *Plastics Technology* Magazine. Click here for more Extrusion Know How columns.

About the Author

Jim Frankland is a mechanical engineer who has been involved in all types of extrusion processing for more than 40 years. He is now president of Frankland Plastics Consulting, LLC.

Contact: jim.frankland@comcast.net or (724) –651-9196

Extrusion Division Board of Directors