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PLASTIC TIMES

Telangana And Andhra Plastics Manufacturers Association

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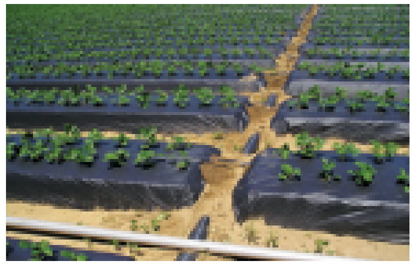
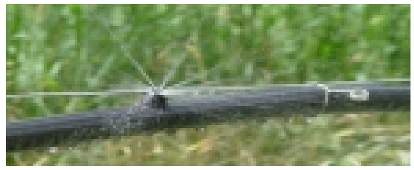
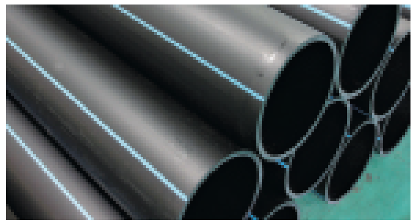

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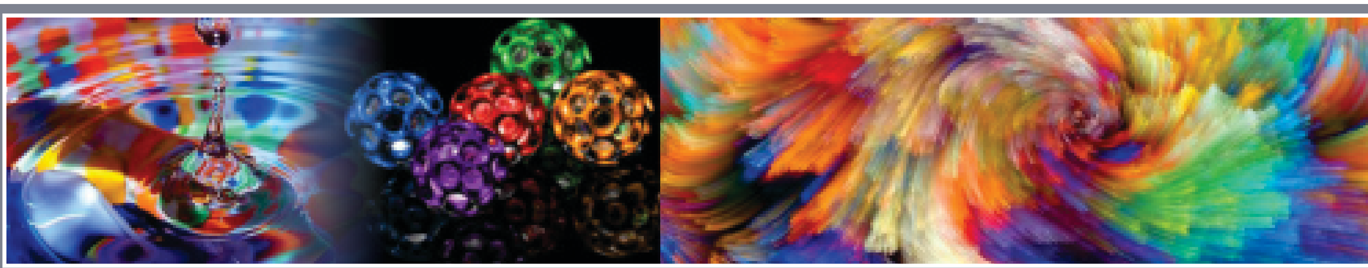

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Jan. - Feb., 2017

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President Writes...

Dear Members,

It has been our continuous effort to find innovative ways to serve the members of TAAPMA. One such initiative is organizing the 2nd Edition of TAAPMA POLYMER CONFERENCE 2017. The first Edition was organized by TAAPMA on the 22nd of January 2016. It was a huge success and the positive feedback received from members has encouraged us to organize the Second Edition.

TAAPMA POLYMER CONFERENCE 2017 is being organized at HICC on the 28th of April, 2017. It is a full day Conference and papers on current topics like new innovations in technology dominating the Plastic Industry are being presented by experts of international fame. The Conference will give an opportunity to interact and Network with delegates from all over the country and as well as international delegates.

We will be circulating the Brochure of the TAAPMA CONFERENCE 2017 containing the details of the Topics, names of the speakers and the registration fees once it is ready.

Since there are limited seats, we request members to register at the earliest and avail this opportunity to enhance their knowledge and awareness which will be useful in facing challenges while running their business.

It has been observed that many members are due for payment of subscriptions. Reminders are being sent repeatedly through SMS, Whattsapp and Emails. We humbly request members to clear all their dues for continued service. Your cooperation is highly solicited.

We are in the process of creating a Whattsapp group for TAAPMA members for better communication. Interested members are requested to share their Whattsapp no. so that the no. can be included in this group.

We wish you all the Best in all your endeavors.

Thank You
Venu Gopal Jasti
President, TAAPMA

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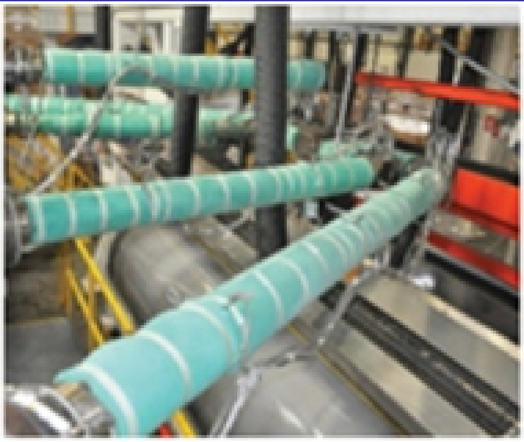
TAAPMA ACTIVITIES

Team TAAPMA in action at PLASTIVISION - 2017, Mumbai
for promotion of IPLEX'18

TAAPMA ACTIVITIES

Is Head Pressure Sapping Your Extruder's Strength ?

A redesign of all of the flow paths between the end of the barrel and die may be in order.



Design of melt pipes and other components between the barrel and die is critical to controlling head pressure

Every extrusion operation has head pressure, unless material is just being dumped out the end of the barrel onto the floor. Head pressure has positive and negative effects on extruder performance. In most cases the effects are negative. Most operators (and even technicians) assume it's a condition beyond their control—something you have to deal with, so work around it.

Head pressure occurs due to the flow resistance of the die and the piping that connects the die to the end of the barrel. But it can be minimized by proper design. Using a melt pump almost entirely offsets the head-pressure effects and is the best solution in many cases. However, melt pumps may not be cost effective where there are highly corrosive or abrasive conditions and on small to very small extruders, where the pump's cost can approach half that of the extruder. In those cases, control of head pressure is in the design of the flow piping after the end of the barrel.

Although it's not simple to make changes in the flow piping, it certainly should not be ignored, as proper design can provide a day-in/day-out benefit that will add up to a significant cost savings over time. The die itself may not be the easiest part to redesign for pressure drop, as it has characteristics designed into it to shape the extruded part that often cannot be changed without altering the product's shape.

All the other parts of the flow path between the end of the barrel and the die should be considered for their effects on head pressure. The calculations are relatively simple, and there is a great deal of information on the internet about piping flow for viscous fluids. Piping includes screen changers, static mixers, valves, and simple piping. I have seen some very poor designs, particularly where processors tried to cobble together flow paths out of whatever available parts they had around. Even some new equipment has not nearly optimized the flow path for pressure drop. Then the processor wonders why he/she has high pressures, polymer degradation, high melt temperatures, low output, and lack of thermal homogeneity.

Head pressure reduces the output of the screw and raises the power requirement and melt temperature, just like on any pump. Output is a pretty straightforward measurement, and the improvement possible with lower head pressure can be easily calculated. The effect of increasing melt temperature from head pressure is more subtle, but just as many extrusion operations are cooling limited as output limited. For example, on a 1-in. extruder running a 5-MFR PP, the effect of each 1000 psi of head pressure could be a 7-10 F increase in melt temperature and a reduction in output of 3-7%. On a 4.5-in. extruder the effect could be 15-20 F with a reduction in output of 5-10%, depending on the screw design.

The shorter and more direct the polymer flow is from the barrel to the die, the more easily the head pressure can be controlled. However, care must also be taken even in a straight flow path to balance the pressure loss through the pipes while maintaining sufficient velocity in the pipe to keep the walls clean. Flow piping often is been designed only in terms of pressure loss, making the flow path too large, causing stagnant flow at the walls, resulting in polymer degradation and loss of temperature homogeneity.

Tech - Talk

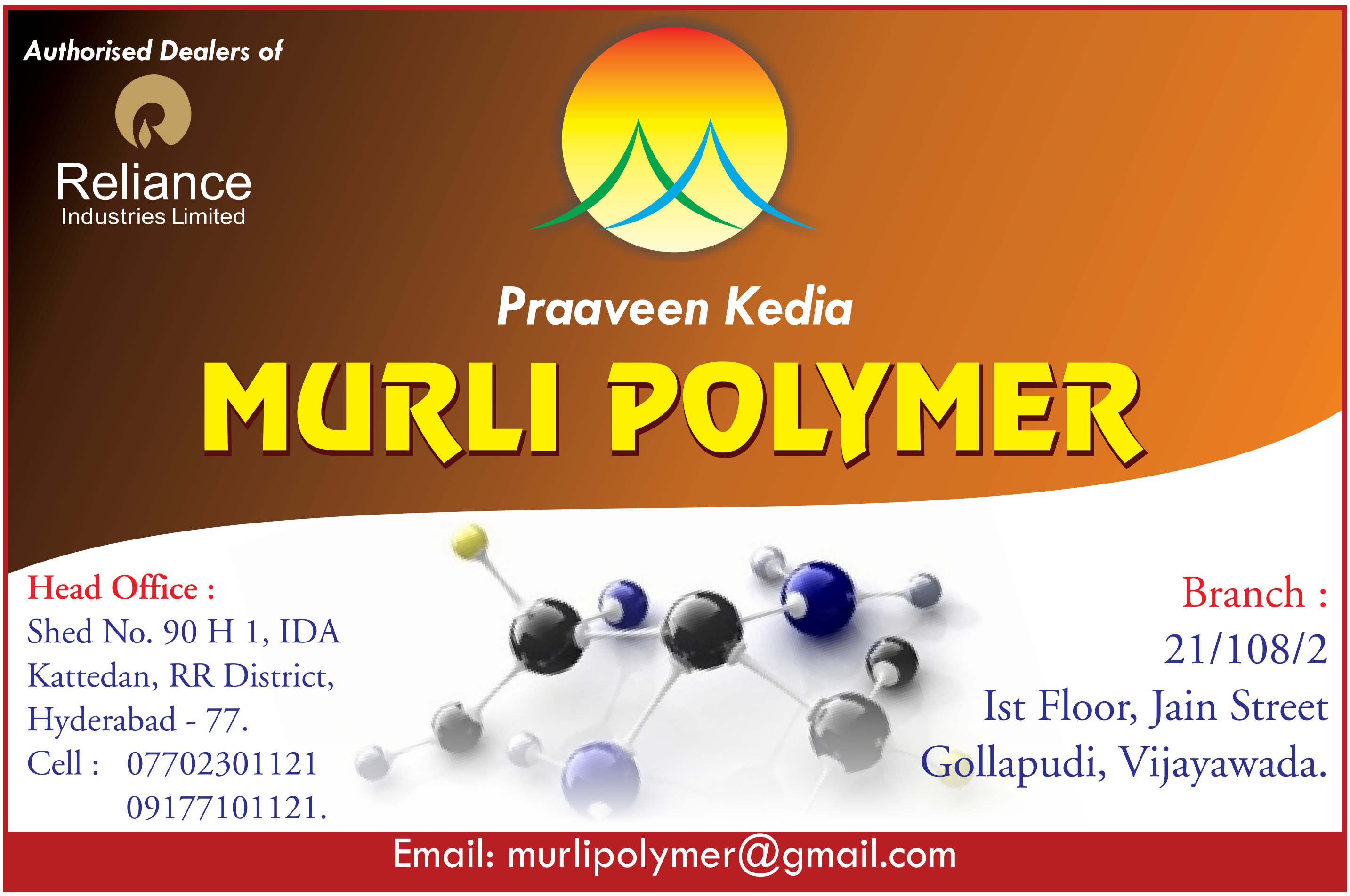
In coextrusion lines, piping can become very complicated, requiring various bends to allow for working space around the extruders and still mate with the feedblock. Bends do two things: They result in added head pressure and they further aggravate loss of temperature homogeneity. A short 90° elbow 1 D long can be equivalent to 20 D of straight pipe, while a 2 D long elbow reduces that to about 12 D. Two short 45° elbows are equivalent to about 16 D each—or worse than one 90° elbow.

As polymer flows around a bend it slows on the outside of the bend and accelerates on the inside, causing temperature variations to develop in the melt stream. In severe cases, stagnation can develop on the outside of the bend.

Abrupt changes in pipe size are also an issue, and the best result is usually achieved when the converging or diverging angle is approximately 60° included. Converging pipe sizes (i.e., going from larger to smaller diameter) result in large pressure drops, depending on the ratio of sizes; and diverging pipe sizes (going from smaller to larger diameter) cause stagnation at the entrance to the larger diameter.

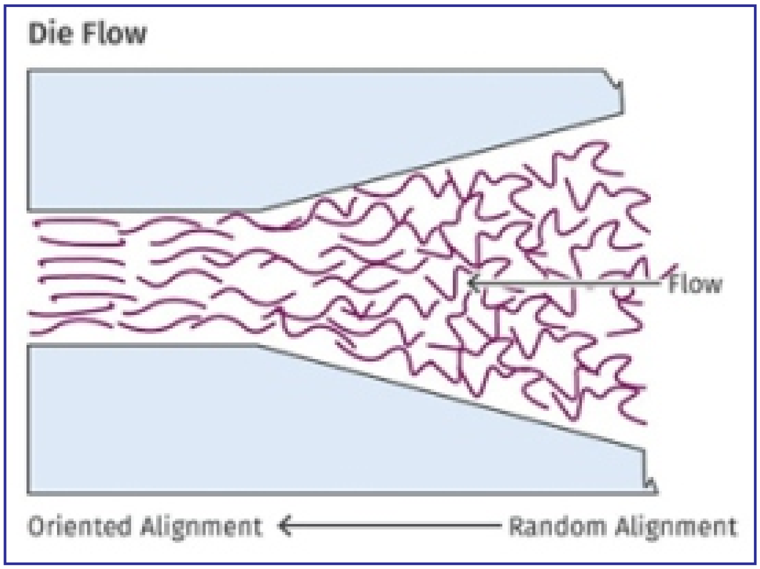
Head-pressure control is just another aspect of extrusion technology where efficiency can be improved and costs can be squeezed out with attention to detail. Remember, flow pipes should be as short and straight as possible, with a minimum of size changes. When size changes are required, a converging or diverging angle is important. Proper design of elbows is very critical and they should be eliminated whenever possible. Don't allow conservation of floor space to result in a complicated piping arrangement that will add cost in every minute of operation.

Source: Plastic Technology



Orientation: The Good and the Bad

Depending on what you are trying to accomplish, molecular orientation can have a positive or negative impact on your part. Here's how to control it.



Molecular orientation occurs when melted polymer is sheared or stretched. If cooled quickly, this orientation is largely retained until the extrudate is reheated to a temperature that allows the molecular chains to move to their relaxed state.

Orientation can be beneficial or troublesome. It can be desirable when it is deliberately added to the extrudate. For example, it provides property improvements such as unidirectional strength in fibers, hoop strength in oriented extrusion blow molded bottles, and tear strength in oriented films. But in many extruded parts orientation can cause post-extrusion problems from non-uniform shrinkage and warpage.

Orientation occurs in every extrusion process due to the inherent strain applied to the long-chain molecules as the polymer is shaped and flows through the die. Some orientation through the die is unavoidable, and the magnitude depends on output rate for a given die design. A secondary annealing process is about the only way to reduce all orientation in extruded parts.

Polymer orientation can be measured for transparent polymers in the amorphous state by birefringence, and in both the amorphous and semi-crystalline state by infrared spectroscopy. The simple field test for orientation, often referred to as the "Chrysler test," calls for cutting samples of the extruded part, accurately measuring them, and then subjecting them to heat for a few minutes at a temperature near the processing temperature. After that, the samples are cooled and measured again to determine the shrinkage and/or change in shape. The amount of dimensional change indicates the comparative degree of orientation in that area or direction.

In profiles with simple shapes, unbalanced orientation across the extruded cross-section can be reduced by optimizing the die-gap exit to be as dimensionally close to the final shape of the profile as possible to minimize exit velocity differences. In the case of flat sheet, for example, the die-exit gap should be as uniform as possible across the width.

A correctly designed die-flow geometry will result in the same velocity exiting the die across its full width. That's not possible if the die slit is pinched down or opened up somewhere to balance the flow rate. The same is true of annular dies where the die gap has to be adjusted out of concentricity because of unbalanced flow to the die exit. This unbalanced flow of annular shapes occurs frequently in crosshead designs and blow molding dies. More complex extruded shapes with varying cross-sections can result in non-uniform velocity across the profile, resulting in unbalanced orientation that's very difficult to eliminate, requiring post-extrusion heat treating to stabilize the shape.

Changes can be made in the die design to balance the velocity and the resulting orientation across the cross-section as the polymer passes through the die-gap exit. The more non-uniform and complicated the geometry, the more difficult this design work becomes. It used to be done by the "cut-and-try" method but is now executed mostly by computer simulation along with practical experience.

Commonly Extruded Polymers and Their Glass-Transition Temperatures

Polymer	Tg, °F
PP	32
ABS	221
Nylon 66	158
PLA	145
PET	158
PMMA	117
LDPE	-193
PVdF	-31
PS	203
Nylon 6	158
HDPE	-110

Source: Wikipedia

That said, much of the undesirable orientation occurs after the extrudate exits the die and is stretched between the die exit and the hauloff. At this point the polymer is going through the temperature range where orientation effects are at their maximum, with immediate cooling locking in the orientation. This can be avoided simply by minimizing drawdown or neck-in as the extrudate leaves the die. This means setting a die gap as close to the finished product dimensions as possible, with precise takeaway velocity to minimize any stretching by pullers or rolls until the polymer sets up. Precise speed control of the downstream pulling/cooling equipment is the key to minimizing machine-direction orientation.

This portion of the orientation is within the control of the operator and does not need special expertise. Excessive drawdown after the die exit is mostly due to operators' lack of knowledge of the effects and their reluctance to reset all the operating conditions for every profile change.

I have seen operators make several thicknesses of sheet, film, pipe, etc. from the same die gap using drawdown as an adjustment. By the same token, I have seen those same parts distort or even crack from exposure just to sunlight when placed under mild strain due to excessive orientation caused by drawdown.

The tendency for polymers to experience post-extrusion warpage and distortion from orientation is related to their glass-transition temperatures (Tg). Glass transition is the temperature at which the polymer changes from a rubbery consistency to a rigid structure. Molecular chain movement is greatly restricted below the Tg, so that any orientation largely remains in place. Once the Tg temperature is reached, the molecules have sufficient freedom of movement to reorder themselves into their more relaxed configuration to relieve the orientation. The level of temperature above the Tg largely determines the rate at which the relaxed state is reached.

The accompanying table lists commonly extruded polymers and their Tg. It shows whether orientation is expected to be a problem, depending on the service temperature expected for the part. On this list there are four polymers whose Tg is at or below the freezing point of water, meaning they will relax their orientation even at room temperature. Others with higher Tg will retain much of their orientation without appreciable shrinkage or distortion until raised to their Tg. However, almost all have a Tg below the temperature of boiling water.

Source: Plastic Technology

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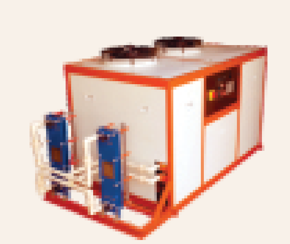

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How to Adjust for Shrinkage and Orientation

Polymers shrink and orient. Sometimes orientation is unbalanced, resulting in misshaped parts. But there are steps beyond tweaking the die that can mitigate these effects.

Issues such as flat sheet shrinking in the middle and profiles distroting are caused by unbalanced orientation with post processing shrinkage.

Polymers shrink, and extrusion processors have to compensate for that effect to meet the dimensional and geometrical requirements of their parts. While it's true that most materials shrink, polymers tend to shrink a lot more. They shrink due to the normal thermal expansion/contraction caused by heat, of course.

But they also have a second shrinkage stage, one that's particularly pronounced in some semi-crystalline materials (and to a less extent in amorphous polymers). Semi-crystalline polymers shrink at a rate that can be six times higher than amorphous polymers. In their relaxed state, semi-crystalline polymers are structurally aligned for the most part, whereas the orientation of amorphous polymers is always completely random.

When melted, all polymers are in a random state. When cooled below their crystallization temperature, the ordered structure of the crystalline polymers starts to form. Amorphous polymers have a natural random chain orientation and require less realignment to reach their relaxed state when cooled after melting. Crystalline polymers, on the other hand, have to realign considerably to achieve their reorganization and packing for a relaxed structure. As a result, crystalline polymers shrink more as they reorient to their relaxed state. This is also accounts for the small change in density for amorphous polymers from the melt to the solid state, while crystalline polymers have a much greater density change.

Typical Glass-Transition Values

Polymer	Tg, C
Nylon 6	47
Nylon 66	70
PE	-80
Polyvinylidene fluoride	-35
PP (atactic)	-20
Polyvinyl fluoride	-20
PP (isotactic)	0
Poly-3-hydroxybutyrate	15
Polyvinyl acetate	30
Polychlorotrifluoroethylene	45
Polylactic acid	60-65
PET	70
PVC	80
Polyvinyl alcohol	85
PS	95
Polymethyl methacrylate	105
ABS	105
Polytetrafluoroethylene	115
PC	145
Polysulfone	185

Source: Wikipedia

If this shrinkage effect accounted for all the dimensional changes that take place during extrusion cooling, processors would have a relatively straightforward means to adjust for the dimensional change in their parts. During processing, however, polymers in the melt condition are subjected to flow-induced stress orientation and mechanical stretching in the melted to semi-solid state as they are cooled. This results in the molecular structure becoming oriented proportional to the stress.

If cooled quickly by quenching, the polymers tend to retain some of the oriented structure; the mobility of the polymer chains gets “frozen in.” But when subjected to heat afterward, all polymers will eventually return to their relaxed state, even if that takes years if kept at a temperature low enough to reduce molecular mobility. That explains why extruded parts may not distort for long periods of time, but when subjected to an unusually high temperature will distort substantially.

The more the polymer molecules are oriented, the more shrinkage will ultimately occur in that direction. Imagine a rubber sheet being stretched in just one direction. The difference in transverse and machine direction shrinkage is a visible indicator of how much unbalanced orientation is in the extruded part. This can be determined by cutting coupons, heating them and measuring the relative shrinkage. Because of this unbalanced stress it's not unusual to see pipe that cracks in the sunshine, flat sheet that takes on a corrugated shape, lids that become oval and will not fit the cups, and profiles that bend and twist. All are due to unbalanced orientation with post-processing shrinkage.

Orientation is seldom uniform across the part cross-section due to varying drawdown, shear stress, and cooling rates across the part.

It's impossible to eliminate all orientation in an extruded part without some sort of secondary annealing process that allows for complete relaxation of the polymer. The usual goal is to minimize the variation so a usable extruded part can be made without additional steps. See the accompanying illustration for some examples of unbalanced orientation.

In the case of the sheet, the middle had higher flow stress or orientation through the die because the die was pinched down more in the center than the edges. With uniform cooling across the sheet, the result is more residual orientation in the center than the edges, causing the sheet to shrink more in the middle. This results in both edges wrinkling up to match the length of the middle portion.

A similar situation exists in the profile. The thinner cross-section sees more flow-induced stress in the die and drawdown because of the narrower opening, resulting in more orientation in that section. Assuming uniform quench cooling, the thinner cross-section shrinks more than the less oriented circular section. This causes the part to distort as it seeks its relaxed state.

Processors sometimes do not recognize the effects of unbalanced orientation and how to combat it. As a result, they tend to make die adjustments with little success. Relaxation cannot occur below the glass-transition temperature (Tg), but many of the most useful semi-crystalline polymers have glass-transition temperatures well below room temperature (see table) so they continue to relax (shrink) indefinitely until they reach their equilibrium structure. With highly oriented parts, the unbalanced shrinkage can be as much as 50%, making for some severe distortion or even cracking to relieve the stress.

The biggest problem is that this distortion might not show up for several days, weeks, or even months, if the part was quenched quickly and is kept cool after processing.

Changing the part geometry is usually not an option to resolve the unbalanced orientation, so the operating conditions must be changed. In most cases, simply reducing the cooling rate and reducing the drawdown will alleviate much of the unbalance. For more difficult situations, zoned cooling, additional heating in the highly oriented sections, interruptions in the cooling phase to allow thermal homogenization, and, finally, secondary annealing steps may be required.

Source: Plastic Technology

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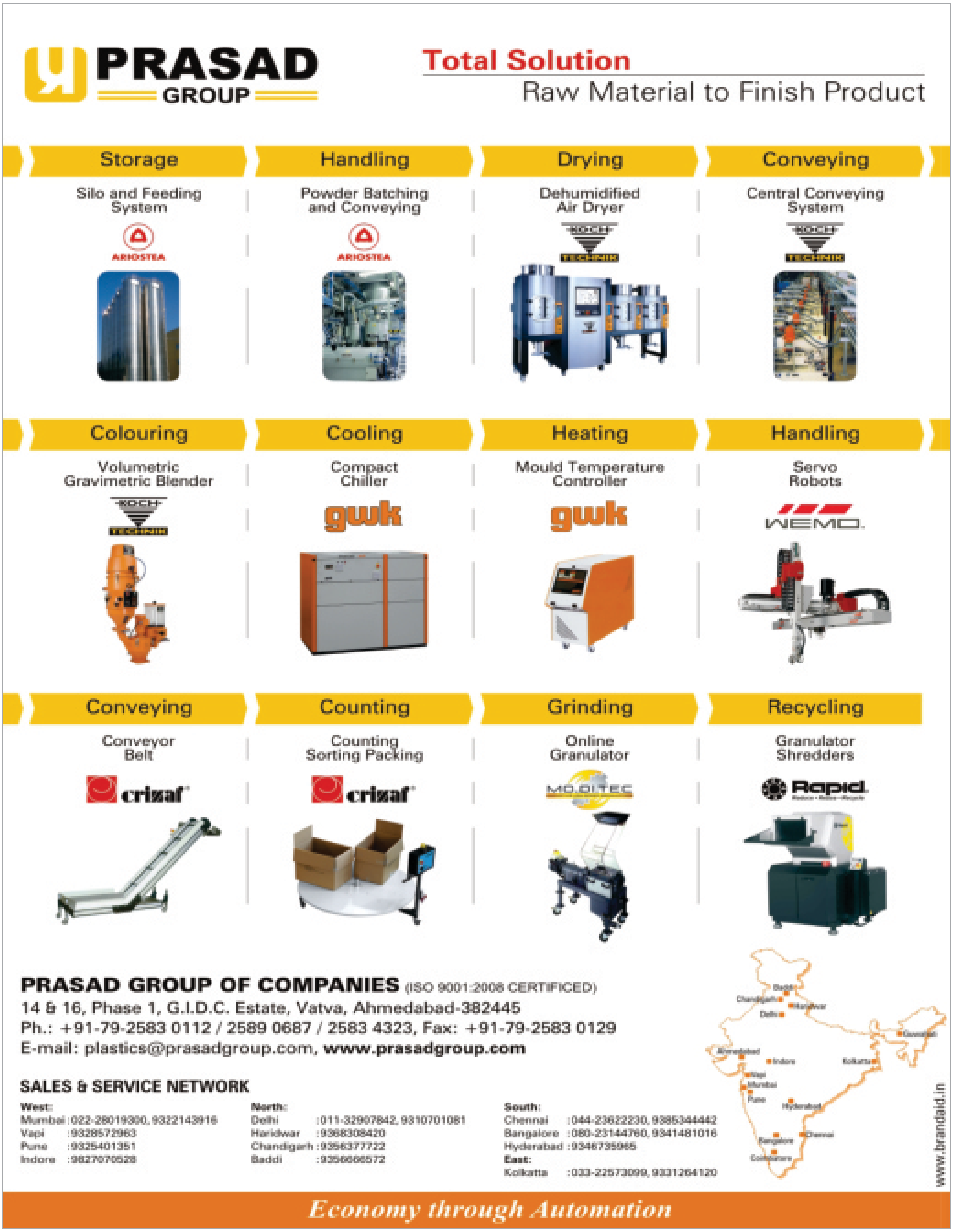
	**TIRUPATI PLASTICS** 15-1-561,Siddambar Bazaar, Hyderabad-500012	**Ajay Agarwal** *(Proprietor)*	9885298491	Manufacturing of Reprocessed Granules.
	**SOWBHAGYA PLASTICS PVT LTD** Sy.No 123, Pollam Industrial Estate Jeedimettla Village, Qutubullapur Mandal, Hyderabad 500055	**V.Nageswara Rao** *Managing Director*	9246217648	Manufacturer of Pvc Pipes & Fittings



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APPLICATION FOR MEMBERSHIP

The Secretary

Dear Sir,

Date:

I / we request you to enroll my / our concern as a member of the Association. Our details are as under :

Manufacturers ☐ Large Scale ☐ Medium ☐ Small Scale ☐ Traders ☐

Name of the Firm:
(USE CAPITAL LETTERS)

Constitution of Firm:

Proprietor ☐ Partnership ☐ Pvt. Ltd. ☐ Ltd. ☐ Others ☐

Name of Proprietor/Partners/Directors

1. ______________ 2. ______________ 3. ______________

Address for Communication:

Off :

TeleFax :

Email :

Factory Address:

Line of Activity

MACHINERY / AUXILIARY EQPTS. / MOULDS / RAW MATERIAL / PRODUCT-Specify

Name of the Authorised Representative	Designation	Cell No.

LIFE MEMBERSHIP FEE Rs. ______ Cash / Cheque / DD ______

Annual Subscription Rs. ______ Dated ______

Admission Fee Rs. ______ Drawn on ______

Environment Fund Rs. ______ Branch ______

Service Tax @15% Rs. ______

TOTAL Rs. ______

Proposer **Seconder** **Signature & Co. Stamp of the Applicant**

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Accepted in Working Committee Meeting held on date______________ Membership No. ________________

Treasurer **Secretary** **President** **Membership Chairman**

FEE DETAILS

LARGE & MEDIUM SCALE UNITS, Affiliate Members & OTHERS: - Agents / stockists / importers / exporters of plastics raw material Plant and Machinery and finished / semi-finished plastic goods and Manufacturers of plastic moulds / dies / tools and other allied Equipments / accessories and all medium and large scale industries	**Rs.2,500/-**
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Admission Fee	**Rs. 500 /-**
Environmental Contribution	**Rs. 200 /-** (Minimum)

LIFE MEMBERSHIP

LARGE & MEDIUM SCALE UNITS, Affiliate Members & OTHERS	**Rs. 25,000/-**
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Admission Fee	**Rs. 1000/-**
Environmental Contribution	**Rs. 1000/-** (Minimum)

+Service Tax @15%

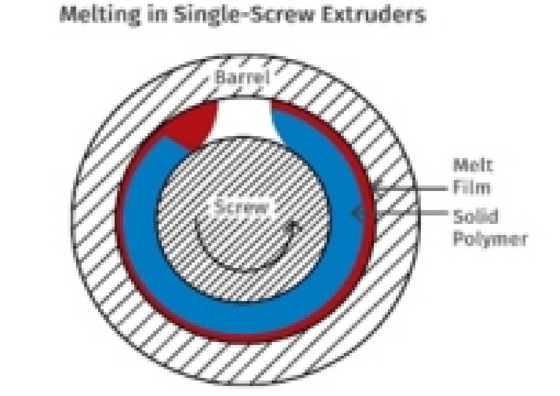
Enclosures:

1. Passport size photograph (s) of the representative(s)
2. Valid MSME / SSI registration certificate
3. VAT registration copy
4. Partnership Deed / Memorandum of Association of Company

Tech - Talk

Extruding Very High-Flow Polymers

Screw designs not suited to process lower-viscosity materials will result in poor melt quality and lower outputs.



In a single-screw extruder, melting occurs primarily as a result of viscous dissipation (or shearing) of the polymer. Unmelted polymer gets dragged against the barrel wall by the rotation of the screw, developing shear stress in the solid resin. This heats it up and melting begins.

There are two main things to consider when processing very high-melt-flow polymers—the increased difficulty of melting them and the magnified effect of head pressure. We will discuss about melting.

When the melt flow is very high, that means the melt viscosity is very low. The screw design usually has to be changed to accommodate that difference. Melting in a single-screw extruder occurs primarily as a result of viscous dissipation (or shearing) of the polymer (see illustration). In both a conventional flighted screw or a barrier screw, the melting principle is essentially the same. The unmelted polymer gets dragged against the barrel wall by the rotation of the screw, developing shear stress in the solid resin. This heats it up to begin melting. Continued melting is facilitated by the compression or declining channel depth of the screw, which brings the solids nearer the barrel wall to create a renewed region of viscous polymer, where shear changes the mechanical or rotational energy into heat in the polymer.

There are many other interactions going on in the screw channel simultaneously, but let's keep things simple and stay with the basic melting process. Once melting starts, there is always a film of melted polymer against the barrel wall. All of the shearing force or drive torque must then be transferred through that melt film. The less viscous the film, the lower the resistance to screw rotation, and the lower the power entering the system from the drive. The result is that it is harder to transfer the energy necessary to raise high-melt-flow polymers to their processing temperature. Yet high-flow resins require a similar, if not identical, amount of energy per pound to reach their processing temperature—the same as low-flow polymers, in fact, since their specific heat is largely unrelated to the melt flow rate (MFR).

The solid polymer turns with the screw just like a stripped wood screw. Think of a solid cylinder comprised of the screw and the solid polymer turning inside a hollow cylinder with a viscous film between. That should make it clear that much of the force or torque required to rotate the screw, regardless of its design, is dependent on the resistance of the melt film. As the viscosity of the film decreases, it becomes easier to rotate the screw. The easier it is to rotate the screw, the less power it takes to do the rotation and the less power is going into the polymer. In fact, for a given screw design, the only variable to energy input from the drive is the viscosity of the film along the barrel if conducted heat in/out through the barrel is eliminated from consideration.

To compensate for the lowered viscosity in the film, the screws need to have lower specific output (output/screw revolution-hour). This allows for more energy per unit of output to enter the system as the specific output is reduced to compensate for the reduced viscosity. Other changes in the screw design can also be beneficial, such as longer screws, more aggressive compression, and high-shear mixing sections.

The fact that all the energy entering the system from the drive must pass through the melt film is a concept that is not generally understood by many operators, who unfortunately still believe the heat transfer is primarily from the barrel heaters.

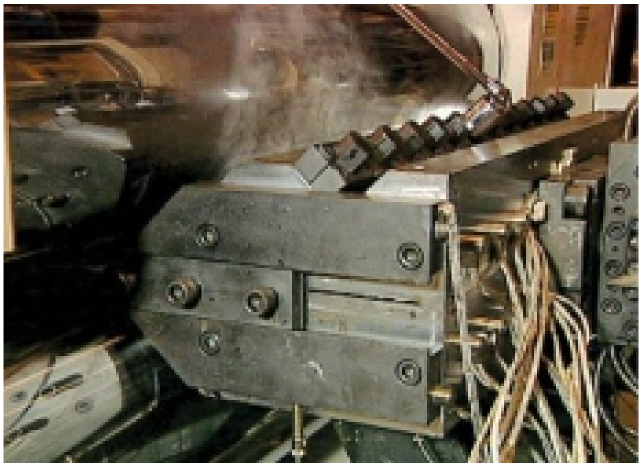
For very small screws (smaller than 2 inch diam.), conductedheat from thebarrel shouldbe a consideration, but as screws increase in size it shrinks to a minor effect. For example, a typical 4.5-inch, 30:1 L/D extruder with a 250-hp (or 186-kW) drive would be equipped with 70-85 kW of barrel heating. If all the heaters were on all the time and normal heat-transfer efficiency prevailed, the heaters would only account for 20-30% of the energy available from the 250-hp drive.

When planning to process very high-flow polymers, be sure to review the screw design. If it's not suited to the lower viscosity, it can produce poor melt quality and reduced outputs. Don't expect the same level of performance from your low-melt-flow screws just because it's the same polymer type.

Source: Plastic Technology

A Better Way to Balance Die Flow

Use temperature adjustments before making any mechanical tweaks.



When getting ready for startup, set the die gaps even or concentric, and use temperature to get as close as possible to correct part-weight distribution. Then adjust bolts (as shown above) and other mechanical devices for final tweaking, rather than the other way around

If an extrusion die is properly designed to meet a specific condition of output and polymer properties, then it should need very little adjustment to shape an extrudate to the desired form when operated under those conditions.

Die design is basically a procedure where the internal die configuration is shaped to deliver polymer from the entrance to the exit with the same pressure drop. That provides a balanced flow where all of the polymer is exiting at the same velocity and closely duplicates the shape of the die orifice. That task is complicated by the fact that polymers exhibit different degrees of non-Newtonian (shear-thinning) behavior when exposed to different shear rates in the die's varying cross-section.

Additionally, temperature has a strong effect on die flow. With polymers having a strong non-Newtonian nature, just changing the output can unbalance the die flow. This makes for a complicated analysis that can be simplified somewhat by assuming that the process in the die is isothermal, so that only shear thinning must be considered. This leads to a potential variation in die flow for many designs, since the conditions in the die are seldom truly isothermal. As a result, a die is a surprisingly specific apparatus that works best at one set of conditions.

In order to give the die a range of operating conditions, mechanical adjustments are often present to adjust the flow. In practice, these mechanical adjustments are often used to correct for a thermal imbalance. Consequently, extrusion dies can often be adjusted thermally with better results than with the mechanical adjustments. Poor understanding of the need for thermal uniformity leads to use of the mechanical adjustments to correct for thermal imbalance, resulting in even more distorted die flow. In actual operation, part thickness control—not equal velocity—is the criteria for die-flow adjustment. The weight distribution of the final part may be corrected with mechanical adjustments, but the resulting unbalanced flow can affect part performance.

For example, having to make an annular die non-concentric to equalize the desired distribution suggests there is a flow issue. Correcting the weight by adjusting off-center will cause the flow to vary in velocity around the circumference as it exits the orifice. It is obvious that when you are attempting to extrude the same volume through a smaller opening of the die the velocity has to increase. This results in an uneven extrusion that may have ripples where the highest velocity occurs.

Even if these issues are corrected by some downstream tooling or mold, the higher velocity portion will have more orientation in the extrusion direction and less in the cross-machine direction. With rapid cooling, this orientation will be temporarily “locked” into the part as stress. As the polymer seeks its natural molecular orientation after processing, this stress is relieved and causes higher shrinkage in the areas with higher orientation. This can cause distortion or even cracking of the part, as well as weakness once the relaxation is completed. By using heat to balance the flow, the original die geometry is maintained. This corrects differences in pressure drop that lead to varying velocity exiting the die.

When the exit velocity is balanced, the subsequent stress and shrinkage are more uniform. Crystalline polymers can shrink as much as 20% as they cool and seek their natural molecular orientation. Amorphous polymers generally shrink substantially less primarily because there is little molecular reorientation. Consequently, thermal die balancing provides more benefits to the properties of the final part (sheet, pipe, tube, film) with crystalline polymers, but the flow improvements are just as pronounced with amorphous polymers.

One of the problems in pursuing thermal die-flow balancing is that many dies are not properly set up for temperature balancing in the first place, leaving mechanical balancing as the only option. Inherent thermal variation can be caused by simple choice of die-temperature settings, insufficient number of temperature zones, or poor distribution of the heating in the die body.

For example, I have seen large-diameter dies with heater bands around the entire outer circumference. This permits no thermal adjustment around the circumference, forcing the operator into using the mechanical adjustments to hold gauge. Wrinkling of a section of the tube-like extrudate due to the velocity difference when exiting the die may result because of a non-concentric gap. The same is true in a slit die. Here, center flow often predominates because of heat losses at the ends of the die. Often, there is no separate heat control at the die ends, or the thermocouples are located too far from the ends.

A suggested procedure for initial die setup is to set the die gaps even and/or concentric, and use temperature to get as close as possible to correct part-weight distribution. Only then use mechanical adjustments to make the final tweaking, rather than the other way around. You will be using the die design as intended and will have a much more sensitive adjustment to make mechanically. If the die cannot be thermally adjusted to very close to the desired slit or annulus shape, either the heating is not designed properly or the die is unsuited to the polymer.

Source: Plastic Technology

UnderstandingDesign of Cooling Channels for Moulds and Cooling Lines with Cooling Tower for Injection moulding shop.

Introduction

Injection moulding process is cyclic in characteristic. Cooling time is about 50 to 75% of the total cycle time. Therefore, optimising cooling time for best performance is very important from quality and productivity point of view.

Cooling time is proportional to square of wall thickness. Therefore part design should ensure more or less uniform wall thickness through out the part.

Part design should also ensure that the melt flow is uniform in all direction from the gate and melt should reach the boundary of the part more or less at the same time.

Cooling channel design - location and size and type - should ensure that melt freezes uniformly inside the mould. Cooling channel design can be perfected with the help of MOLDFLOW analysis.

It is necessary to understand Heat Exchange and Cooling Channel design in the mould.

Heat Exchange in mould

During every injection moulding cycle following heat transfers take place:

- from the hot melt to mould steel (heat input to the mould) and
- frommould steel to coolant flowing through cooling channel of the mould. (heat removal from the mould)

If heat input is more than heat removal, then the mould temperature would keep on increasing from cycle to cycle. Therefore moulding quality would not be constant from cycle to cycle. The moulding quality would be erratic- i.e. varying from cycle to cycle. Therefore, there is a need to balance between the heat input and heat removal in the mould after the desired mould surface temperature is reached. In other words, removal of heat by circulating coolant through the mould cooling channel would arrest the rise of mould temperature above the desired value. In practice, it may not be possible maintain constant mould temperature with respect to time. However, the mould temperature would fluctuate between two values around the desired value.

During injection moulding cycle heat flow takes place from polymer melt to mould steel by

- effective thermal difusivity of polymer melt and
- conduction.

This heat is to be removed by circulating cooling fluid through the cooling channels in core as well as cavity during cooling period in order to maintain the desired temperature. Uneven temperature of the mould surface results (uneven shrinkage) in parts with moulded-in stresses, warped sections, sink marks, poor surface appearance and varying part dimensions from cycle to cycle and even cavity to cavity.

Cooling Channel Design for Mould- Design tips

Moulds are usually built with cooling channels. These channels are usually connected in series with one inlet and one outlet for water flow. The water flow rate may not be enough for turbulent flow because the water pump capacity itself may not be adequate. This obviously leads to random temperature variation on the mould surface. With the result, uncontrolled temperature drift, varying part dimensions and irregular warped surface appears on mouldings.

The mould designer should take care of following points:

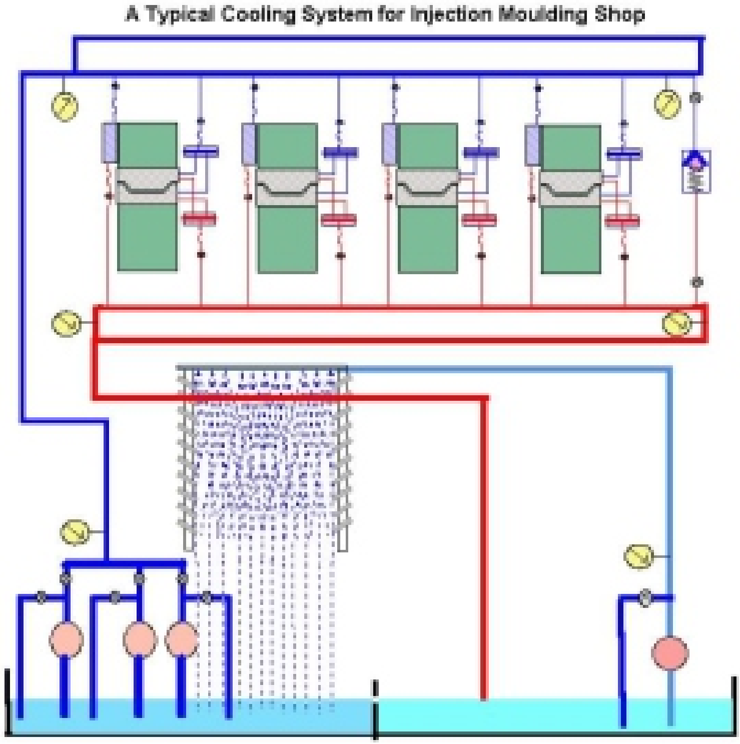
- Thermal conductivity of mould steel influences the rate of heat transfer though mould steel to cooling channel.
- Pure Ethylene glycol can be used as Primary fluid transfer medium in closed loop cooling system. Ethylene glycol does not produce rust and mineral deposits in cooling channels. Mixture of water and Ethylene

glycol can also be used for circulation through the cooling channel.

- Cooling channel diameter should be more for thicker wall thickness:
- For wall thickness upto 2mm, channel diameter should be 8 - 10 mm.,
- For wall thickness upto 4 mm, channel diameter should be 10 - 12 mm.,
- For wall thickness upto 6 mm, channel diameter should be 10 - 16 mm.
- Cooling channels should be as close as possible to the mould cavity / core surfaces. The distance of cooling channel from mould surface should be permissible by the strength of mould steel against possible failure under clamp and injection forces. It could be 1.2 to 2 times diameter of cooling channel.
- Cooling system of the mould should have adequate number of cooling channels of suitable size at equal distance from each other and from cavity walls. The center distance between adjacent channel can be 1.7 to 2 times diameter of the channel. This is also governed by the strength of mould steel.
- The difference between the inlet and outlet water temperature should be less than 2 to 5 degrees C. However, for precision moulding, it should be 1 degree C or even 0.5 degree C.
- Cooling circuits should be positioned symmetrically around the cavity. There can be sufficient number of independent circuits to ensure uniform temperature along the mould surface.
- The coolant flow rate should be sufficient to provide turbulent flow in the channel.
- There should be no dead ends in the cooling channels. It could provide opportunity for air trap.
- Many a times it is difficult to accommodate cooling channels in the smaller cores or cores with difficult geometry. In such case the core should be made of Beryllium copper which has high thermal conductivity. These core inserts should be located near the cooling channel.
- The seals of coolant system should not leak inspite of application of frequent clamping force and mould expansion / contraction due to thermal cycle during moulding. The O-ring should be positioned so that there is no chance of them being damaged or improperly seated during mould assembly. Seal and O-ring grove should be machined to closely match the contour of the seal. It should ensure that seal is slightly compressed when the mould is assembled.
- Mould temperature above 90 degree C normally requires oil as the heating medium. Heat transfer coefficient of oil is lower than that of water.
- There is enough scope for confusion while giving water connection to mould when there are more number of cooling circuits particularly on bigger moulds. A sketch indicating cooling circuits should be available during mould set up.
- Hot runner mould should be provided with compression resistant insulating plate between back plate and machine platen. This is to prevent the heat flow from mould to machine platen, which can create an unbalanced heat flow in the mould. With out insulating plate machine platen will act like a big heat sink, there by destabilising the possible balance between heat given to the mould by the hot melt, and heat taken away by circulating water through mould.
- The cooling channel layout is suitable when the isothermal i.e. the equi-potential lines, are at a constant distance from surface of the mouldings. This ensures that heat flow density is same everywhere.
- Provision for thermocouple fixing should be available at specific one or two places in core as well as cavity tomonitor the temperature of mould.
- Use efficient sealing methods and materials to eliminate cooling leaks.
- Poor mould surface temperature control can cause following quality problems: Axial eccentricity, Radial eccentricity, Angular deviation, Warpage, Surface defects, Flow lines,
- The mould has to be heated or cooled depending on the temperature outside mould surface and that of environment. If heat loss through the mould faces is more than the heat to be removed from moulding,

then mould has to be heated to compensate the excess loss of heat. This heating is only a protection for shielding the cooling area against the outside influence. The heat exchange takes place during cooling time. The design of cooling system has to depend on that section of part, which requires longest cooling time to reach demoulding temperature.

For Water Pump, Cooling Lines And Cooling Tower



Cooling Channel layout depends on :

- part geometry,
- number of cavities,
- ejector and cam systems,
- part quality,
- dimensional precision,
- part surface appearance,
- polymer etc.

The sizing of cooling channels is dependent on the rate of cooling and temperature control needed for controlling part quality. CAE software like MOLDFLOW or C-Mold can be used to determine the optimised dimension of cooling channel and distance from mould surface, distance between cooling channel, flow rate.

Typical Cooling lines with Cooling Tower for Injection Moulding Shop.

The figure shows number of pumps (each with bypass lines) connected in parallel supplying water through supply line. Two pumps are for main operation. Where as middle pump can be stand by pump. When ever there is problem on any one operational pump, it can be taken up for repair after the standby pump is put on operation. This ensures uninterrupted water supply for moulding shop.

Water reservoir is partitioned to separate cold and warm water. Water from cold reservoir is pumped to process and returns warm to warm part of reservoir. Warm water is again pumped by a separate pump- of same flow rate but lower head- to cooling tower and returns to cold part of reservoir. The partition will have interconnecting hole at suitable height to avoid overflow on account of any unbalance in water transfer. This is shown in separate figure to avoid over crowding of lines.

Each pump should be connected the pump manifold or main line or supply line through flexible connection. This can save time when pump requires to be removes off line for repairs or maintenance.

Pressure at pump side should be between 5 and 6 bar. Pressure loss across mould is about 2 to 3 bar. This pressure loss represents the productive use of power in cooling the mould and heat exchanger of machine.

The supply line as well as return line have additional pressure equalizing line. Supply line with pressure equalizing line forms main supply ring and similarly return line with equalizer line forms main return line ring. Pressure equalizer lines ensure uniform pressure at each supply terminal (inlet valve) on machine as well as mould. In the absence of equalizer lines on supply as well as return line, the inlet pressure would be different at different machine and mould. Highest at the first machine from pump and lowest at the last machine

Any other pressure loss in the system is waste. Therefore, adequate size of pipe should be used for supply and return lines. Pressure equalizer lines should also have same size as that of supply line. Return line and its equalizer line pipes can be of larger size than supply lines as there should not be any pressure loss on return line and equalizer line.

End of supply line and end of return line is connected through pressure differential valve. This valve automatically ensures pressure loss across mould is 2 to 3 bar. In case this valve is not available then, a gate valve should be used. But this requires adjustment of flow when ever there is a mould change.

Connections to mould as well as machine terminals should be through separate gate valve. Connections to Heat exchanger should be through flexible hose pipe. This saves time during regular preventive clean up of heat exchanger. Select correct pipe for heat exchanger as specified by the machine manufacturer.

A manifold with adequate number of connections for in and out of mould should be connected to the terminal inlet valve for mould. It should be noted that there should be no reduction of water passage area from manifold to cooling channel of mould. Normally hose fittings have smaller cross section area inside thereby throttling the flow. This can prevent turbulent flow. In other words, the water passage for 10 mm channel should have hose fitting with minimum internal diameter of 10 mm. Any thing less will not give turbulence. Turbulence is required for efficient heat exchange resulting in power saving. Therefore ensure that mould should have larger pipe fitting to accommodate this point of view.

Please note that at 3 bar pressure loss across the mould;

- 6 mm channel requires 6.5 lpm to generate turbulent flow,
- 10-12 mm channel requires 12-20 lpm.

Smaller the diameter of channels higher the pressure drop across. Higher the channel diameter lower the pressure drop across. Therefore, it is better to have all the channels of same diameter through out the mould. If there are different diameters for channels, then the smaller diameter will have larger pressure drop and hence it will have turbulent flow of water, but larger diameter channels will not have turbulent flow. To achieve turbulence in larger diameter channels the flow rate is required to be increased.

Tips for Design of cooling lines and cooling tower.

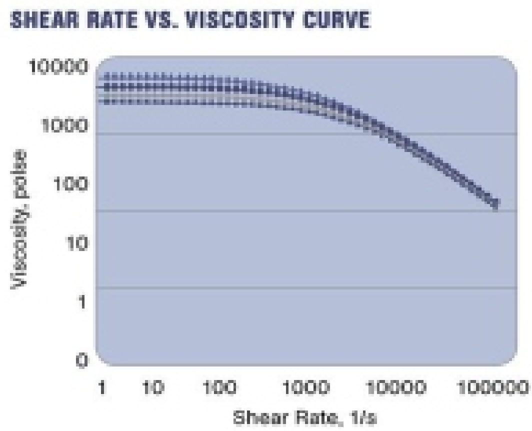
1 Compute total requirement of flow rate and pressure for pump selection.
2. Decide the pump / pumps from manufacturers catalogues.
3 Decide reservoir size which should be more than 30 min flow.
4. Decide pipe diameter recommended for the pump and select supply line and return line diameters.
5. Measure the lengths of each line and prepare Bill of Materials.

Include valves and pressure gauges, hose pipes etc.

Source : pitfallsinmolding.com

Effect of the Screw Flight On Melt Temperature, Energy Use

So-called rules of thumb regarding the design of flight clearance and width do not consider the temperature effect, both from the point of view of melt temperature and energy efficiency.



A typical shear rate/viscosity curve shows a ratio in viscosity between the screw channel and the flight clearance of about 3.5:1 based on the calculated shear rates, with resulting viscosities being 3500 poise and 1000 poise for the channel and clearance, respectively. The greater the ratio or the greater the slope of the curve, the less effect that viscous dissipation will have in the clearance. (Source: Beaumont Technologies Inc., in Plastics Technology, August 2013)

Most discussion of screw design is centered on the channel depths, or whether the screw has a barrier section, wave section, mixer, and so forth. You seldom hear much about the effect of the flight on the design. Out of convenience, flight width and clearance are usually chosen as approximately 10% of the screw diameter for the width and 0.1% of the diameter for the radial flight clearance. Screws smaller than 2 in. or larger than 10 in. may not follow that practice.

In general, the rule of thumb makes for an effective area for support of the screw in the barrel, a mechanically rugged flight, and sufficient pressure drop between channels to minimize backflow of melt as pressure develops. However, this generalization does not consider the temperature effect, both from the point of view of melt temperature and energy efficiency.

The shear of the polymer in the flight clearance can add significantly to the melt temperature and energy efficiency. The shear rate is described as $\ddot{Y}=D\pi N/h$, where D is the diameter, N is the rev/sec, and h is the channel depth or flight clearance. For example, a 2.5-in. screw turning at 100 rpm (1.67 rps) with a channel depth of 0.100 in. and a flight clearance of 0.003 in. would have a shear rate of 131 sec-1 in the channel and 4372 sec-1 in the flight clearance.

The shear rate/viscosity curve in accompanying graph shows a ratio in viscosity between the channel and the clearance of about 3.5:1 based on the calculated shear rates, with resulting viscosities being 3500 poise and 1000 poise for the channel and flight clearance, respectively.

The greater the ratio or the greater the slope of the curve, the less effect that viscous dissipation will have in the clearance. The viscosity-thinning effect or the slope of the curve is typically described by the power law coefficient. This coefficient can range from 0.2 to 0.8 for common polymers, as shown in the accompanying table. The lower the number,the more non-Newtonian the polymer and the more shear thinning will occur.

Because there is a relatively small amount of polymer in the flight clearance compared with the channel, the overall temperature rise due to the clearance is usually less than 20% of the total viscous dissipation for polymers having a power law coefficient less than 0.35. However, with long L/D screws, that can easily be exceeded. With polymers having a greater power law coefficient the viscous dissipation in the flight clearance becomes a significant design criterion and cannot be ignored.

POWER LAW COEFFICIENTS FOR COMMONLY EXTRUDED POLYMERS

Polymer	PS	PVC	PMMA	SAN	ABS	PC	LDPE	LLDPE
(n)	0.30	0.30	0.25	0.30	0.25	0.70	0.35	0.60
Polymer	HDPE	PP	PA-6	PA-6.6	PET	PBT	PVF2	FEP
(n)	0.50	0.35	0.70	0.75	0.60	0.60	0.38	0.60

Source: Chris Rauwendaal, Polymer Extrusion, Hanser Publications, 1986

Of course there are exceptions, even for polymers having a low power law coefficient, such as cooling screws, ultra-sensitive polymers, multiple-flighted screws, and mixing elements. Mixing elements in particular can have large areas with narrow clearances to the barrel that generate high levels of viscous dissipation. Regardless, recognition of the viscous dissipation effects in the flight clearance or mixing sections should be a part of all screw designs. Noted extrusion researchers Drs. Zehev Tadmor and Imrich Klein, in their book Engineering Principles of Plasticating Extrusion, have characterized the percentage of energy entering the extruder over the flight clearance as: (μf /μ) (H/W) (e/ δf), where: μ is viscosity in the channel; μf is viscosity in the clearance; H is channel depth; W is channel width; e is flight width; and δf is screw/barrel radial clearance.

This expression multiplies the ratio of the viscosity in the channel and flight clearance times the ratio of the depth to the width of each. This relationship takes into account the shear-thinning characteristics and depth-to-area relationship in the channel and clearance.

In addition to this relationship, the flight helix angle has a strong effect on the viscous dissipation in the clearance, primarily because it changes the channel width. Having shear rate/viscosity curves is essential for this analysis and many other aspects of screw design.

What does this mean to screw performance? Using the above analysis, it can be seen that the ratio of the flight width to the flight clearance is important; and from the chart it's very important to know what the shear-thinning characteristics of the polymer are as depicted by the power law coefficient. The narrower the flights and wider the clearance, the less shear heating by viscous dissipation occurs over the flight. The lower the power law coefficient, the less the shear heating over the flight contributes to the overall energy going into the polymer.

For optimum screw performance with respect to energy going into the polymer, the flight width should be the minimum and the flight clearance the maximum for polymers having a higher power law coefficient.

This also relates to energy efficiency, since the shearing of the polymer in the flight clearance causes a rapid increase in its temperature. Although that polymer gets quickly mixed with the polymer in the channel, reducing its temperature and preventing degradation, it still adds to the overall melt temperature. Even though the polymer in the clearance gets quickly cooled as it exits the clearance, the temperature in the clearance is more or less permanent as the screw rotates.

The high temperature in the clearance transfers significant amounts of heat to the adjacent barrel, as it is much more (200 times) thermally conductive than the surrounding polymer. This causes barrel override and energy loss to the barrel cooling system, reducing power efficiency.

Naturally there are constraints to arbitrarily changing the flight width and clearance, but understanding and examining the effect can resolve many processing problems.

Source: Plastic Technology

Extruding with Fillers

You can use the reference point from processing unfilled polymer to determine whether you can run filled resin on your current system.

Fillers change the specific output of a compound, and calculations must be done to be sure not to overload the extruder drive.

Fillers are added to polymers to accomplish many different property changes and improvements. They can alter physical properties, reduce costs, trim weight, change the electrical conductivity, and enhance thermal properties, just to name a few. In almost every case they also have an effect on processing behavior during extrusion.

Questions are often asked whether filled polymers can be processed on a specific extrusion system. This question can be answered for inert fillers, which do not chemically change or go into solution after mixing. But finding the answer requires a reference point with the unfilled polymer.

Most inert fillers have a higher specific gravity than polymers, which increases the compounded specific gravity (S.G.). Since the extruder screw is a volumetric device, a compound with higher S.G. will typically increase the specific output (lb/hr-rpm) proportional to the density. This might be expected to result in drive overload at higher filler loadings.

To evaluate this possibility, some simple calculations will provide guidance. The accompanying table gives some of the required data for such a calculation. Notice that the fillers all have a higher specific gravity and lower specific heat (the amount of energy required to raise the temperature of a particular substance by a specified amount) than the polymers. For example, the compounded specific gravity of 40% calcium carbonate (CaCO3) filled PP can be computed by the "formula for mixtures" as follows:

1/[(% Polymer/S.G. Polymer) + (% filler/S.G. Filler)] = S.G. Mixture

EXAMPLE ONE

Average S.G. of mixture:

1/[(0.60/0.72) + (0.40/2.71)] = 1.019

S.G.

(**Note:** the polymer melt density is used in this calculation.)

Tech - Talk

In this case, the extruder specific output in pounds will increase by more than 40% (1.019/0.72 = 1.415) with the 40% filled polymer because CaCO3 has three times the S.G. of PP and the screw has a relatively fixed volumetric output per rpm.

We can also use the same formula for mixtures to obtain a very good estimate of the average specific heat of a mixture that is not alloyed.

EXAMPLE TWO

Average specific heat of mixture:

1/[(0.60/0.5) + (0.40/0.1994)] = 0.312 (BTU/lb-°F).

Since about 90% of the drive power requirement on a single screw goes to raising the temperature of the polymer from solid to melt, we can ratio the drive load requirements for similar filled and unfilled polymers. The ratio of the power requirement for the neat PP and the mixture can be approximated at the same melt temperature by multiplying the S.G. by the specific heat for each, since the volume of output is approximately the same:

Neat PP: 0.72 × 0.5 = 0.36 Mixture:

1.019 × 0.312 = 0.318 Ratio: 0.318/0.36 = 0.883 (Ratio of drive load)

This indicates a decrease in power requirement for the filled PP of 11% versus the neat PP. This indicates a decrease in power requirement for the filled PP of 11% versus the neat PP. This means the filled PP would have a lower motor load with 40% CaCO3 and require no changes in either the specific output of the screw or in the torque capacity. But if you processed nylon 6 with 40% CaCO3, the drive load would be almost exactly the same as with neat nylon 6, so it's a combination of all the variables that determines the load.

Because this is a simplified calculation, several variables can affect its accuracy, the primary one being the change in viscosity with theaddition of 40% CaCO3.

Inert fillers almost always increase the viscosity, which increases the pressure drop through the tooling and can decrease output. However, the increased head pressure also increases the melt temperature, so the overall effect on power requirement often follows the calculation closely. Keep in mind that PP with 40% CaCO3 by weight is only about 15% filler by volume, so the mixture is still 85% PP by volume. Also, inert fillers do not normally change the shear sensitivity in the processing shear-rate range, so the die flow with the filled polymer would not be expected to change significantly.

Polymer & Filler	Specific Gravity (Solid)	Specific Gravity (Melt)	Specific Heat (BTU/lb-°F)
Polypropylene	0.92	0.72	0.5
Nylon 6	1.14	0.932	0.406
$CaCO_3$	2.71		0.18
Mica	2.88		0.12
Clay	2.50		0.22
Talc	2.75		0.208
Barium Sulfate	4.49		0.113

When considering processing of filled polymers, a quick estimate can save a lot of difficulty and predict possible equipment changes.

Source : *Plastic Technology*

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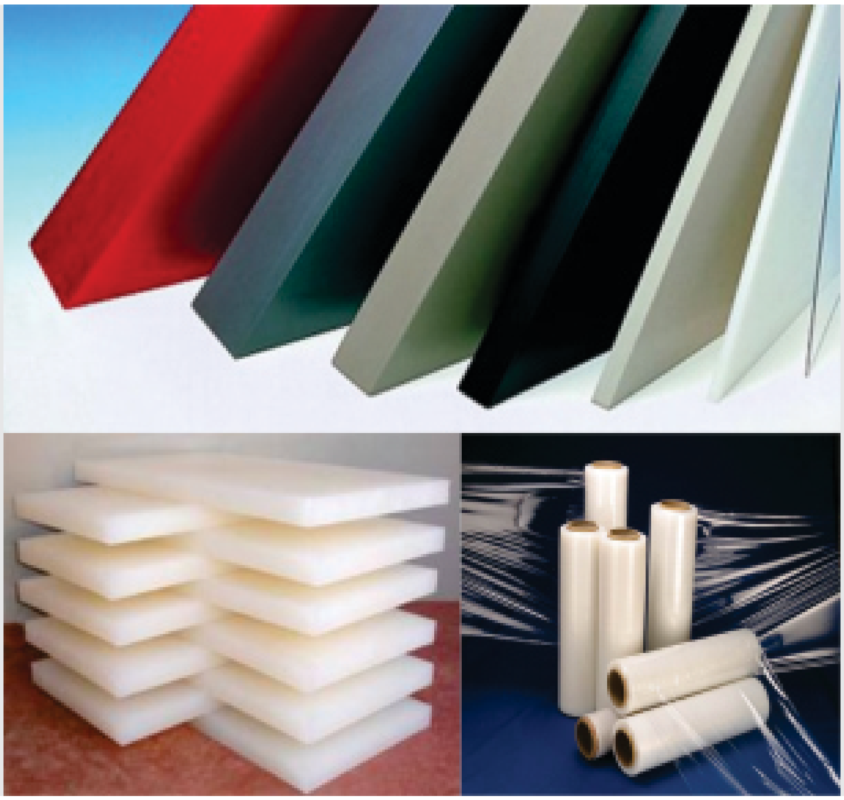

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New composite pipe designed for extreme subsea oil and gas operations

Source : compositesworld.com

To reduce exploration and production costs and risks in subsea oil and gas systems, Magma Global Limited has developed new flexible m-pipe technology. The company states that the latest lightweight continuous pipe is both the largest and longest VICTREX PEEK-based structure ever made. It can be deployed to depths of 10,000 feet and handle pressures of up to 15 ksi (103MPa). The composite pipe combines VICTREX PEEK, high-grade carbon fiber and S-2 glass fibers to form a reliable subsea intervention line that meets the demand for a hydraulic pumping system that can handle high pressures and high flow rates.

“Thanks to partnering with Victrex Plc, we have been able to successfully develop our 10,000 foot solution for hydraulic pumping and light well intervention in the Gulf of Mexico. VICTREX PEEK polymer's high performance, and their material and processing expertise, has supported the new record-breaking flexible and spoolable m-pipe for the oil and gas industry,” said Charles Tavner, commercial director at Magma.

Magma is offering its m-pipe and integrated deployment package as a vessel back-deck system for rapid hydraulic light well intervention. The Magma deployment system has a modular reeler with m-pipe intervention line pipe handling system, built-in tensioner, level wind, controls cabin, hydraulic power unit, installation platform and winch, for rapid pipe deployment and retrieval. The m-pipe is a composite material based on VICTREX PEEK polymer, carbon and glass fibers that delivers low fatigue, improved buoyancy in fluids and high resistance to corrosion compared to steel pipe.

“In oil and gas exploration the continuous need to extend scope and efficiency motivates us to develop reliable solutions further. In close collaboration with customers we consequently contribute to solve the toughest challenges,” said Tom Swanson, energy director at Victrex.

“VICTREX PEEK-based m-pipe and deployment system offers regular, reliable low-cost hydraulic well intervention, and can be rented as a complete deployment package from Magma, on either a short-term campaign or annual contract basis. The m-pipe reduces the cost of intervention at a time when the oil and gas industry is extremely challenged on operational costs, and is also striving to achieve efficiency and reliability. The Magma system is designed to minimize mobilization time and maximize vessel utilization by reducing hydraulic pumping time, reducing intervention costs by up to 30%,” says Tavner.

Magma's 'integrated package' approach provides the ability to intervene in subsea completions continuously and efficiently, to maximize their ongoing productivity. The Magma system and high performance m-pipe allows for flexible high pressure and high-flow-rate pumping of intervention fluids into subsea wells from small vessels.

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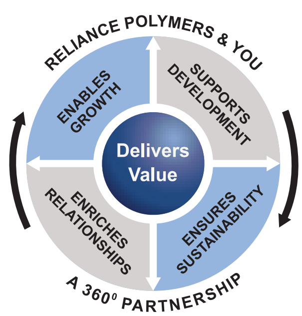

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