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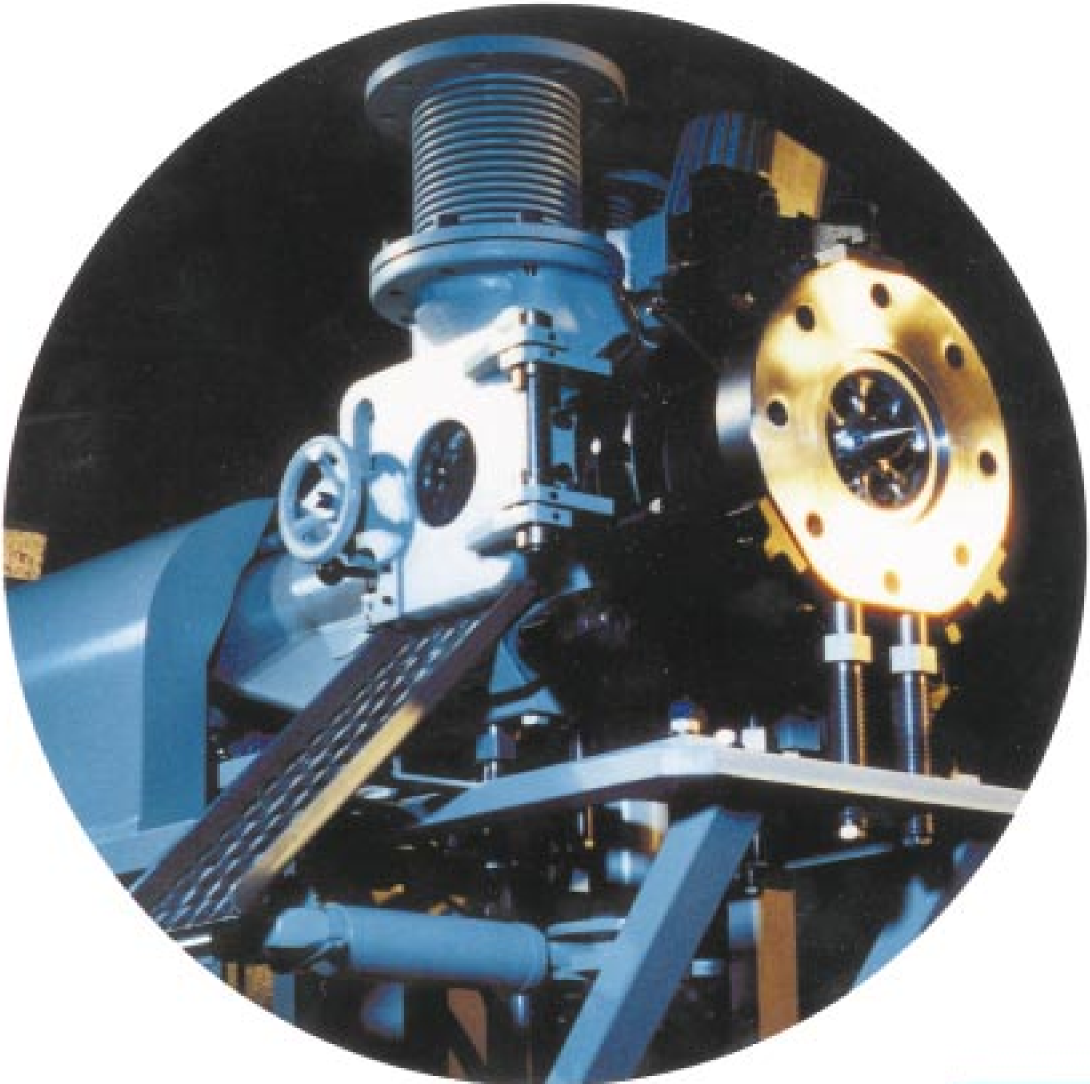
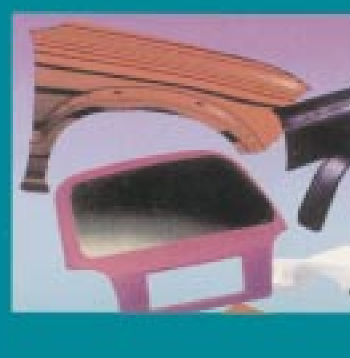


PROCESSING AIDS

Internal lubricants: process additives yield profits and productivity



Internal lubricants: process additives yield profits and productivity

Nancy Teufel of Axel Plastics Research Laboratories discusses how the use of an internal lubricant in injection moulding applications should be considered not only when problems occur in processing, but to realize significant gains in productivity.

Many injection moulders consider the addition of a processing additive/internal lubricant only when they are confronted with parts that are difficult to release from moulds. Using an internal lubricant outside of this condition is frequently regarded as an unnecessary expense. Resin and colour compounders, on the other hand, are more familiar with some of the primary benefits of these materials: their effect on lowering resin viscosity through increased melt flow and their contribution to improved dispersion and wetting of reinforcement, filler and colour. As a group, compounders are more inclined to incorporate internal lubricants when resin processing parameters can not be met, or if a customer makes a specific formulation request. What is less evident about the internal lubricants is that their usage can greatly enhance quality, productivity, and ultimately profits, by making it possible to produce more parts and better parts in less time. A better understanding of internal lubricants should encourage both moulders and compounders to consider the real value of these materials in thermoplastic processing.

How internal lubricants work?

Internal lubricants are frequently described in terms of internal and external functionality (see figure 1). That is to say, they can exert a lubricating effect on the polymer chains that will decrease melt viscosity and enhance polymer flow. The ability to do this is representative of the lubricant's functional compatibility, or capacity to solubilize the resin to which it is added. Internal lubricants can also provide slip, or release, between the resin and the mould surface. External functionality, or mould release occurs when these additives are incompatible and are forced to the surface of the part during the moulding cycle, lubricating the interface between the part and the mould. While materials like these may also modify resin viscosity, they usually do so at the cost of delayed fusion of the polymer and can significantly alter physical properties.

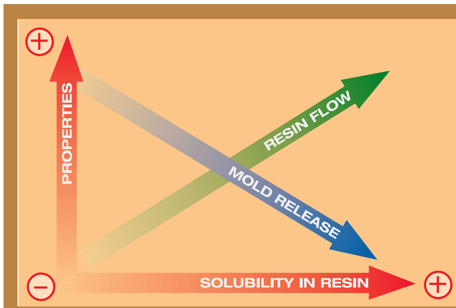


Figure 2: Functionality as a factor of solubility in resin.

In order to achieve both internal and external functionality, internal lubricants must achieve a balance in solubility and in-solubility, as this affects internal and external processing properties inversely (see figure 2). Accordingly, all internal lubricants are not created equal. Solubility in resin, melting point of the additive and rate of migration, are just some of the factors that can impact performance. A better understanding can be gained by looking at the generic chemicals that are commonly used as internal lubricants.

Chemical composition/ functionality

Commodity lubricants are single purpose additives that generally offer narrow functionality and can have positive and negative effects on the polymer. By contrast, proprietary lubricants are custom formulated to be multi-functional and to have a more

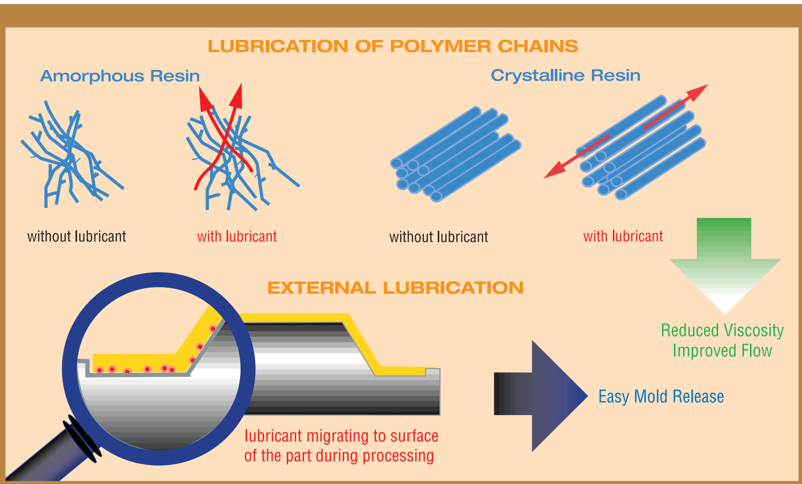


Figure 1: Internal and external functionality.

synergistic effect on the polymer. In both case, internal lubricants are comprised or formulated from some basic chemical groups. These include:

Trial testing of various additive formulations can be critical to improving productivity. Internal lubricants are available in many forms, including low viscosity liquids, powders and pellets, with formulated products providing more choices than generic chemicals.

Metallic stearates

Metallic stearates are probably some of the most widely used internal lubricants because they are inexpensive and modify melt viscosity without delaying fusion. Stearates and their complexes are generally supplied as fine powders that can present a dust hazard or nuisance in processing. In addition, stearates tend to exude from the polymer matrix often resulting in unsightly residue on the surface of moulded parts. Their use can, therefore, contribute to conditions that impair secondary processes like, printing, painting, bonding, or plating.

Hydrocarbons

This group of lubricants includes mineral oils, paraffin and microcrystalline waxes and partially oxidized polyethylenes. These are non-polar materials that are inert and lack internal functionality. Resin incompatibility allows hydrocarbon additives to function well as external lubricants but it also means that the surface of moulded parts can be easily contaminated by these additives. This is particularly true when simple waxes rather than low molecular weight polyethylenes are employed.

Fatty acids and alcohols

Fatty acids or alcohols are frequently employed when clarity or discoloration of resin is a consideration. Discoloration is frequently the result of resin scorching when high temperatures are needed to achieve adequate flow. Fatty acids and alcohols can offer good internal lubrication, permitting faster homogeneity and better flow at lower processing temperatures and decreased injection pressures. Another asset of these materials is the anti-static or slip properties that they can impart to moulded parts. While this can improve the performance of plastic parts that require low surface friction, like tight tolerance assemblies, attention to loading levels is required, because too high an addition may decrease the physical properties of the resin.

Esters

Esters utilized as plastic processing additives include materials like vegetable oils, carnuba wax and glycerol monostearate. Within this family, higher molecular weight materials are used for their internal functionality, while lower molecular weight esters provide external lubrication. Lower molecular weight esters can be expected to have lower heat stability than their higher molecular weight relatives. They can also plasticize or delay polymer fusion, resulting in parts with poorer physical properties.

Amides

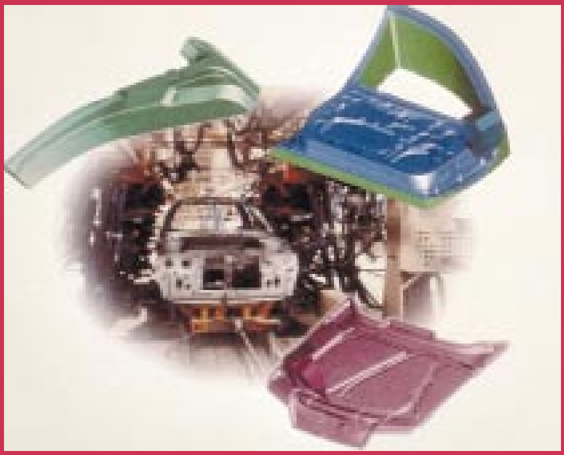
Oleamides, erucamides and bis-stearamides are highly valued for their multi-purpose functionality – providing both internal and external lubrication and imparting good anti-static properties with few harmful effects. Amides or amide based lubricants can be a good choice for processing applications where the objectives include both flow improvement and good mould release.

Polymerics

Polymers like nylon or PTFE can also be used as internal lubricants. While these materials are quite expensive in contrast to some of the other additives, they are also far less volatile, making them suitable for high temperature processing resins. Use of materials in this category can assure limited migration of lubricant from moulded parts, even when they are subjected to service at elevated temperature. The self-lubricating qualities of some of these materials also make them particularly valuable when moulding parts that require good abrasion resistance.

Internal lubricants in practice

After reviewing the many chemical families that can be used as internal lubricants it should be evident that there is no one best additive. The ideal formulation will be a material or formulation of materials, which maximizes processability without adversely effecting the resin. This is the goal of



All types of consumer and industrial products benefit from internal lubricants or process aid additives that help to lower the process temperature and reduce cycle time while maintaining or improving end-product quality.

Table 1: Effect of internal lubricant on the injection moulding of an electrical housing and cap

Shot Size: 9oz. (245.5 gms)
Resin: Borealis PP #RD36P with 10 wt.% talc

Open/close (s)	Injection (s)	Cooling (s)	Holding (s)	Cycle (s)	Improvement (%)
15	6	41	25	87	Control
15	6	31	25	77	11.5
15	6	26	20	67	23.0
15	6	26	15	62	28.7
15	6	26	10	57	34.5

proprietary lubricant formulations. While these materials cost more than generic chemicals, they can take a lot of the guesswork, or legwork, out of determining the best lubricant to use. In addition, these specially formulated additives are generally effective at very low loading levels. In fact, one of the greatest misconceptions about internal lubricants is that the more you use the better the results. Nothing could be further from the truth. The question of how much lubricant is required to optimize performance should always be determined by pre-production trials, however, it is reasonable to say that the additive range is 0.1 - 2% based on weight. Moulders who wish to forego compounding and simply blend a lubricant in their resin prior to injection should realize that loading levels at the high end of this range will generally result in screw slippage. Then again, excellent processing should be possible at a 0.25 – 0.5% loading, and this will pose no problem to injection.

Internal lubricants are available in many forms, including low viscosity liquids, powders and pellets, with formulated products providing more choices than generic chemicals. While compounders may be capable of incorporating any of these, moulders may not. Specially formulated additives can be an important convenience in this regard, particularly pelleted additives. Pellets can be simply dry blended, gravitational or volumetrically mixed, or fed at the throat of moulding machines, making it possible to avoid the expense of compounding. This can be extremely important in low volume part production. In situations where compounding is not undertaken, special care must be taken. Powdered or pelleted internal lubricants may melt at low temperatures. While this may not diminish their effectiveness it can be a messy problem if additives that melt at low temperatures are incorporated prior to drying the resin. Therefore, if drying resin is essential, special consideration should be given to this matter. Generally lubricants are not hygroscopic so they can be added after drying without any problems. However, if there is a reluctance to do this, then it may be necessary to reduce drying temperatures, select a different lubricant or resort to compounding.

Case History

A manufacturer of small consumer appliances conducted an evaluation of an internal lubricant in the production of an electrical housing and cap. The objective of the trial was to reduce cycle time without impairing the physical properties of the moulded resin.

The two-part housing and a cap were moulded in a pigmented polypropylene copolymer. Dimensional stability of the parts was critical, requiring a perfect vapor-proof closure by the cap, while still permitting easy removal by the consumer.

Four test cycles were run, and six shots were produced from each. During each cycle the moulding temp and cooling temperatures were adjusted in the hope of determining the optimum cycle improvement that was possible. All of the test cycles used resin that contained 0.5% of a proprietary lubricant formulation. The results from these test runs, see table 1, were compared to a control part that was moulded without the addition of a lubricant. The parts moulded with lubricant were also evaluated for physical properties, and all met, or surpassed, the values of the control part.

The trial concluded that an 8% reduction in processing temperature and a 34.5% reduction in cycle time was possible with the addition of an internal lubricant.

Processabilty and profitability

It is certainly easy to identify the need and benefit of employing internal lubricants when mould cavities fail to fill consistently, or parts release with such difficulty that they require spraying mould release every five or ten shots. Dire circumstances, like having to mould a lower shrinkage resin than a mould was designed for, will certainly promote an enthusiasm for process additives in even the most skeptical mind. What is more often overlooked, is the real economic value that these additives can contribute to manufacturing. Many gains derive from the improvement that internal lubricants can offer in melt flow. For instance, it is not unreasonable to assume that a polycarbonate with a melt flow of 15 can be increased to 19 or better, without any adverse impact on Izod strength. A good internal lubricant can, in fact, relieve stress in moulded parts by improving flow, resulting in parts with good physical properties, strong knit lines and no unattractive flow marks. This means fewer rejects and part failures. Similarly, the ability to inject resin at lower temperatures and to easily fill cavities contributes to quicker cycle times and shorter cooling before ejection (see box). This can easily amount to a 25% increase in productivity.

Conclusion

Although injection moulders may often consider that use of an internal lubricant is not required for a process, particularly if there are no major problems, significant gains in productivity may be being missed. The most expensive product on the market may only add marginally to the resin cost, but increased productivity will more than compensate for that. ◆