SWM
engineered for tomorrow

QUALITY ASSURANCE

BALANCING THREE CRITICAL FACTORS

A global leader in the manufacture of high-performance, thermoplastic polyurethane (TPU) film & sheet, SWM has achieved a reputation for extremely consistent product, chemically and dimensionally, by balancing three critical factors:

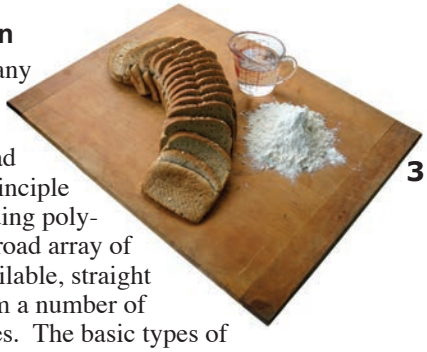
- Recipe control
- Process control
- Exacting adherence to customer specifications

The plastics, quality and manufacturing engineers at SWM all work closely to effectively manage these factors, creating a total, unified process that provides the customer with TPU film products that will meet or exceed the requirements of their final application.

RECIPE CONTROL

Just as today's modern bread recipes are much more than simply flour and water, the formulation for a specific polyurethane film is typically a fixed recipe containing a variety of ingredients. TPU film is rarely extruded solely from just the raw polyurethane resin. The vast majority of applications require a blend, or recipe, comprised of three basic categories of ingredients:

1. Virgin TPU Resin

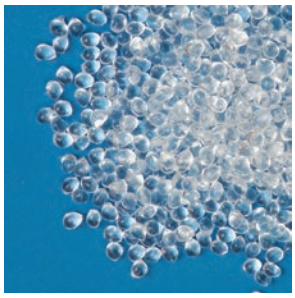


Just as there are many types of flour to use as the primary ingredient in a bread recipe, the same principle is true when extruding polyurethane film. A broad array of TPU resins are available, straight out of the box, from a number of chemical companies. The basic types of polyurethane resin include:

- Aromatic polyester
- Aromatic polyether
- Aromatic polycaprolactone
- Aliphatic polyester
- Aliphatic polyether
- Aliphatic polycaprolactone

These fundamental classes of polyurethane are further subdivided based on variations in physical characteristics, such as hardness, elasticity, tensile properties, tear strength, melt point, lamination temperature range and abrasion resistance, to name just a few. Such property modifications are generally made at the molecular level in conjunction with the resin supplier.

In addition to TPU resins, SWM also has expertise in producing custom engineered film and sheet from a variety of other difficult-to-extrude polymers. Whether the base resin is polyurethane or another specialty material, the same exacting recipe control is necessary to ensure customers the highest quality product, both chemically and dimensionally.



Raw polyurethane resin

2. Chemical Additive Packages

The second category of ingredients included in the typical TPU film recipe are supplementary chemical additives designed to impart specific characteristics to the final film product. These carefully engineered additive packages give the film properties beyond those possible via polymeric modifications to the raw resin, including:

- Color
- Flame resistance
- Ultraviolet (UV) resistance
- Antibacterial (odor) control
- Antibacterial (infection) control
- Antifungal control
- Antistatic control
- Surface slip lubrication
- Antiblock properties

3. Regrind

The use of regrind, or recycled polyurethane film, is environmentally responsible and can also be cost effective, depending on the source, ratio and cleanness of the materials used. SWMc recycles only its own film components, such as edge trim and startup materials. The use of regrind in a given film recipe is carefully controlled and limited to the same resin type, color, and chemistry.

Polyurethane regrind

SWM does not buy regrind on the open market unless specifically instructed to by the customer. This allows absolute control of the "chain of custody" of recycled materials and their chemistry, as well as the ability to dictate the cleanness of the ingredients used in the final film recipe.

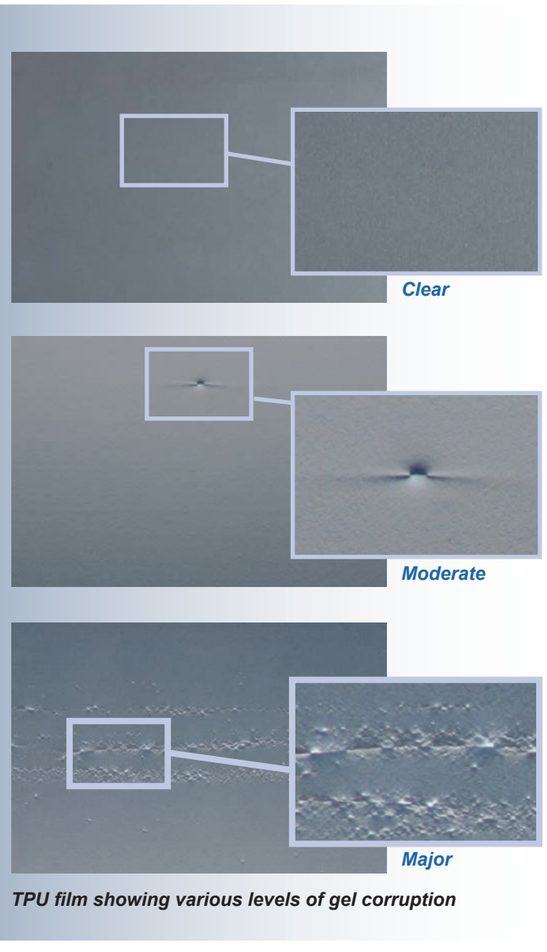
Use of regrind is only feasible if it is compatible with the recipe's virgin materials and can be processed to give uniform film properties. SWM treats regrind as if it is a first-quality raw material having

specifications for both quality and percentage of concentration that must be met before it is allowed in a final recipe.

While it is not SWM policy to reduce cost by use of regrind, the practice, when requested by the customer and properly controlled, can provide certain economies. However, pitfalls of uncontrolled use of regrind can result in several problems with the finished film, including:

- Excessive gel: gel is unmelted raw material that manifests as a cosmetic blemish that will usually not affect performance. Gels can also result from using materials in the recipe that have slightly different chemistry or melt properties. In severe cases, they can appear as larger, solid pieces of material that can cause a tear or void in the film during secondary processing or end use.
- Wide variations in physical properties: use of excessive amounts of regrind, or mismatched materials, can result in variations in mechanical, tensile or elongation properties from one part of the sheet to another. This can affect downstream processability in the customer's fabrication or lamination operations.
- Extrusion processing problems: in addition to physical defects and variations in physical properties in the finished film, improperly matched and proportioned regrind has the potential of creating film extrusion processing problems which can increase manufacturing costs.

Recipe control can be effective only if the mixture of virgin resin, chemical additive packages and any use of regrind is properly formulated and strictly maintained throughout the extrusion process. SWM uses up-front engineering to eliminate mid-run recipe changes needed to fix problems or increase yield. They believe that proper advance design of the film recipe to match exactly the customer's end-use requirements is the very best way to ensure the highest chemical quality of their polyurethane film and sheet.



TPU film showing various levels of gel corruption

PROCESS CONTROL

To control the mechanical consistency and stability of their films, SWM utilizes thoroughly documented manufacturing procedures and equipment to standardize the extrusion process and thereby ensure consistent film quality, lot-to-lot, roll-to-roll. Three essential areas of process control are:

1. Temperature & Pressure

The variables of temperature and pressure affect the extruder's ability to pump the melted resin recipe through the die. This is true whether the process is flat-die, cast-on-carrier or blown film extrusion. These are controlled by screw speed, zone temperatures, die geometry and gap, die temperature and pressure.

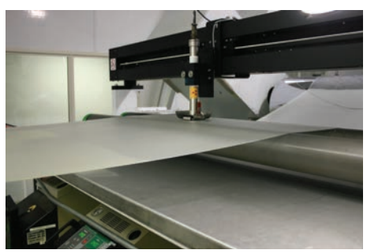
2. Running Speed

The speed at which the extruder operates affects product quality. High quality films take time and energy (heat) to produce. The temptation exists for a film manufacturer to reduce operating costs by running cold and fast for higher yields and faster throughput. However, running film at low temperatures and high speeds can result in poor dimensional stability in the end-use application because the resin will tend to be oriented. Later, when exposed to ambient temperature or secondary processing heat, the polymer will attempt to relax, causing the film to change dimensions. SWM, therefore, establishes and meticulously maintains the optimum temperature and throughput rate for consistent dimensional stability and overall film quality.

3. Measurement

Essential to any effective process control is the ability to measure critical film properties and adjust extrusion operation parameters accordingly to ensure consistently high product quality and adherence to customer specifications. SWM utilizes highly accurate measurement systems to maintain consistent sheet thickness. These systems include microprocessors that continuously record film thickness.

Repeatedly comparing that result against the customer's specification allows the flat-die-extruder operator, when possible, to make needed in-process adjustments in the die gap to thereby maintain the predetermined gauge standard.



Digital in-line gauge measuring system for maintaining thickeness control on SWM flat-die extruders.

While SWM uses sophisticated measurement systems on both its flat-die and blown-film extruders to track any gauge variation, in-process adjustment of the die is possible only on flat-die extruders. This capability allows the operator to correct any variations in thickness as soon as they are detected, yielding a flat roll put-up. Conversely, while SWM measures bubble thickness during blown-film extrusion, in-process adjustments are not possible because this process utilizes a rotating circular die. Should a variation in film gauge occur, however, the rotation of the die will spread the disparity across the entire width of the finished sheet, resulting in the flattest possible roll put-up. (See diagrams below comparing distribution of gauge variations between flat-die and blown-film extrusion.)

ADHERENCE TO CUSTOMER STANDARDS

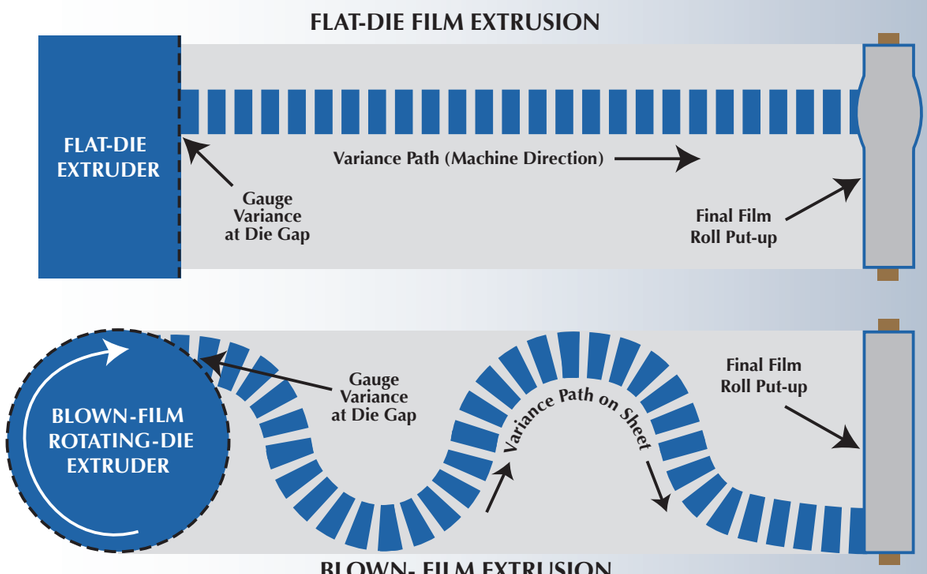
The third area to which SWM is committed is the strict adherence to customer specifications. The company philosophy is that, once agreed upon, the customer's requirements are the benchmark against which all resulting film is measured. Changes to SWM's standard operating conditions or procedures, be they alterations to either the engineered recipe or process parameters, is considered a variation from specification and may result in a re-evaluation by the company's quality team, possible re-engineering or, as deemed necessary, approval of the customer. The objective is to provide the customer with the exact film required for his application.

OTHER SWM QUALITY EFFORTS

The three areas discussed above should be standard operating procedure for any quality-oriented manufacturer of polyurethane film and sheet. However, there is more that can be done to ensure the highest possible quality product, and SWM continues to make the necessary investments in equipment and people to do just that. The company's three most recent advances include:

1. Installation of Laboratory Extrusion Lines

SWM has made significant investment in quality and R&D capability with the installation of blown-film and flat-die laboratory test lines. Similar in function to full-sized extrusion lines, these lab lines allow SWM to run smaller test batches prior to committing customers to the expense of a full production run. They also avoid interruption of commercial production for trial runs on the full-size lines. Additionally, they are used to generate short-run film concept samples for customers, testing the processability and physical characteristics of new film formulations, and performing preliminary tests of new product offerings from resin suppliers. All of which will result in faster, lower-cost scale-up of commercial projects, as well as maintaince of the highest possible quality standards.



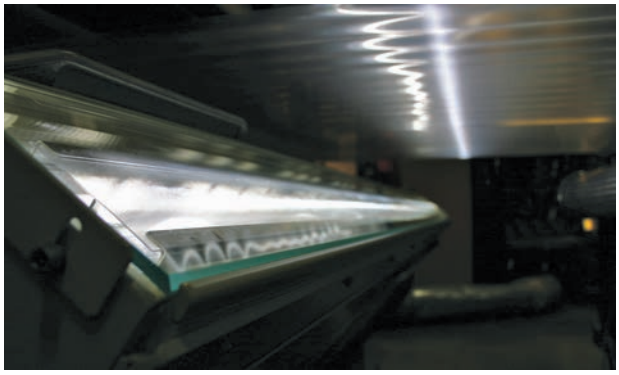
The diagrams at left compare the difference in gauge variation coming off flat and circular dies, and how, if left uncorrected, can effect final film roll put-up. However, gauge variations in flat-die-extruded film can be corrected in-process by the machine operator adjusting the die gap; gauge variation in blown film cannot be corrected in-process, although it is typically spread evenly across the width of the roll by the rotation of the circular die.

2. Installation of New Camera Inspection System

This inspection system is capable of detecting and documenting pin holes, voids, gels, wrinkles, streaks and dark or light contaminants as small as 0.3 mm. It is used to inspect films produced by standard flat-die extrusion methods. The system provides the machine operator with not only 100 percent real-time inspection status and control, but also the capability to generate complete roll-by-roll documentation of any potential defects and their location. It is designed to ensure SWM customers receive the most consistent and highest quality films possible.

3. Installation of Hard-Walled Clean Rooms

In 2008 SWM expanded its extrusion operation with the addition of a third, 100,000 square foot facility that also serves as the company's world headquarters. This



state-of-the-art operation has eight flat-die extrusion lines installed in an 8,000 square foot hard-walled white room, with each line housed its own Class-7 soft-walled clean room.

SWM is the primary supplier of optical-grade interlayer films to the global security-glass industry. In addition to selected general TPU film products, all of SWM's aliphatic, optical-grade, interlayer films are produced in clean-room environments, assuring customers the cleanest films in the industry.

A RECOGNIZED LEADER IN THE SPECIALTY FILMS INDUSTRY

SWM is a global supplier of custom-engineered, high-performance, polyurethane film and sheet for a wide variety of critical applications in thicknesses ranging from 0.2 to 125 mils, and in widths up to 86 inches. In addition to flat die, cast-on-carrier and blown film extrusion technologies, the company also has expertise in extrusion coating and multi-layer constructions.

Successful uses of SWM films include: optical-grade interlayer films for the security-glass industry; performance apparel applications where waterproof-breathable protection and maximum comfort are required; medical applications, such as elastic tapes, wound dressings, hospital mattresses and covers, transdermal patches, and wheel chair cushions; automotive applications, including weatherable films for paint protection, and barrier films for headliners and foamed-in-place seating, head rests and arm rests; graphic printing films and protective overlaminate facestock for exterior applications such as advertising graphics and automotive wraps. Other common uses include bladders, hydration packs, inserts, sock liners and mid-sole materials for athletic applications, keyboard covers, industrial bellows and headset ear cushions.

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SWM INTL
53 Silvio O. Conte Drive
Greenfield, Massachusetts 01301 USA
tel: (413)772-2564 fax: (413)772-2565
e-mail: ams@swmintl.com web: www.swmintl.com