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PENN FIBRE PLASTICS, INC. SINCE 1937

2434 Bristol Road
Bensalem, PA 19020
1-800-662-7366
(215) 702-9551
FAX (215) 702-9552
www.pennfibre.com

Technical Article

Thermoforming Nylon And Acetal, It's Easier Than You Think

In 2003 thermoformers were introduced to a new series of forming materials that allow them to participate in growing global market opportunities where they were previously limited by material availability. Leading the charge into these new markets are the first offerings of thermoformable nylons and acetals. As both of these materials have attained mega status in injection molded and fabricated products for decades, their introduction to the economies of thermoforming is being warmly welcomed by thermoformers and their end customers.

Nylons and acetals are found in every marketplace, very often complimenting each other in completed assemblies of finished products. In the automotive market alone, these two materials comprise over 25% of the total plastics in every vehicle. The applications for these materials in other major markets such as aerospace, medical, electronics, and industrial markets, are too numerous to list.

In February of 2003 the first commercial introduction of formable nylons was released by Ensinger/PennFibre under their Pennite® tradename. Pennite Nylons are based upon Durethan resins developed by Bayer AG in Germany. This offering included type 6 and 6/6 formulations in neat and glass filled varieties. Pennite Nylons are impact modified and heat ageing stabilized and provide continuous service temperatures up to 284°F. These features also make Pennite Nylons interesting to fabricators looking for higher performance nylons for demanding applications.

In June of 2003 a release by DuPont™ Engineering Polymers and Ensinger/PennFiber announced the availability of Delrin® Forming Solutions. Delrin FS is the first and only thermoformable acetal on the market. In September a second joint release announced the availability of Zytel® FS as a premium, high performance thermoformable nylon.

All of these new materials are available in both sheet and roll forms. Sheets are available from .010in. to .250in. thick in widths up to 50in. Roll stock is available from .010in. to .125in. thick in standard widths up to 50in. and may be supplied in strips down to as narrow as .250in. As with all of Ensinger/PennFibre's high performance materials, fabric backings are optional.

The development of these materials by the resin manufacturers was a long and capital intensive program. As such, the validation of the formability and processing characteristics of these materials was, and is, a critical component in their introduction. Extruded sheets and coils of these new materials were shipped to Ensinger's global headquarters in Nufringen, Germany and from there were taken to Adolph Illig Maschinenbau GmbH & Co. in Heilbronn, Germany for evaluation. Illig is the premier manufacturer of both roll and sheet fed thermoforming in the European market. Illig performed forming trials on the materials and has been gracious enough to share that information with all interested parties.

Pre-Drying:
Pennite Nylons:
The first step in the process for formable nylons is the drying of the sheet material prior to forming. As with all polyamides, the hygroscopic nature of these materials makes them very susceptible to moisture absorption. Proper pre-drying of nylon sheets prior to thermoforming is a critical element of forming a successful product. The recommendation is that sheets be dried for a 24 hour period at temperatures of 90-100°C in a desiccant style drier. The natural black color and heat stabilizing characteristics of formable nylons allow for these extended drying parameters without surface or color degradation. Failure to adequately dry sheets will result in a moisture release that will cause surface blisters or bubbles to arise on the finished product.

Delrin FS Acetal:
Unlike nylons, acetals by their nature have a very low moisture vapor transmission rate and therefore do not require any drying prior to forming.

Processing:
Pennite Nylons:
The processing trials for these nylon materials were performed on an Illig, model UA 100, forming machine. The tooling utilized for the trials was a Porsche body that is approximately 24" long, 12" wide, and 6" deep. The parameters discussed in this article are relative to .060" (1.5mm) sheet.

The tool temperature for this trial was established at 176°F (80°C). The temperature on the surface of the sheet was read with an IR pyrometer at 482°F (250°C).

The heat settings were established as indicated in the box below:

Delrin FS Acetals:
Once again, the trials were performed by Illig, this time on a model UA-100 4G sheet processing machine. The same Porsche tool as above was utilized, this time with 3mm thick sheet.

The transforming temperature range, read on the surface of the sheet, was between 215°C - 235°C. The upper heat range was set for 700°C and the lower heat was set at 500°C. The heat cycle for the 3mm sheets was 70 seconds. The mold temperature was set at 100°C. There was little sheet sag observed which lead to an even and homogeneous heating of the sheet.

Secondary operations:
As discussed earlier, both nylon and acetal have been long time favorites in the fabrication markets. This is due largely to their unique features and properties but also to the ease of machining the materials by conventional methods. The same conventional methods may be utilized in both of these materials for post forming trimming and drilling requirements.

Shrinkage:
As new products enter the design stage of development, the shrinkage of the material is required for tooling design. Although shrinkage is determined by a combination of factors including the geometry of both the tool and the finished product, as well as processing conditions. The following shrink rates are guidelines for the glass filled Pennite Nylons:

Shrinkage in length (follows sheet orientation) 0.2 - 0.4%

Shrinkage in width (perpendicular to orientation) 1.3 - 2.1%

Although Delrin FS acetal does not display the moisture retention or absorption of nylons there are definite shrink factors to be taken into consideration as well. The following guideline is for unfilled Delrin FS:

Overall shrinkage of 1.6 - 2.3%

Summary:

It is apparent that both of these new families of materials may be formed in conventional methods within existing equipment parameters. At least two dozen thermoformers from around the country have formed these materials with great success in the past few months. Their products have included thin gauge (.010" thin) vacuum formed products as well as heavier (.250" thick) pressure formed products. Even twin sheet applications have been successfully formed for under the hood applications of shrouds and ducts.

These are exciting new materials that offer great opportunity for expansion in the marketplace. And as you can see, they are easier than you would have thought to process.

Further information, including data sheets and a full presentation of Illig's forming guidelines is available upon request from Ensinger/PennFibre from Dave Pincin, the National sales Manager at 800-662-7366 or at penninfo@pennfibre.com.