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Molded Flexible Polyurethane Foam

Flexible polyurethane foam (FPF) is manufactured in two primary ways. In slabstock production, precursor chemicals are poured onto a moving conveyor, and a long rectangular "bun" of foam is produced. The bun is then cut, or fabricated, into sizes and shapes for end products.

Molded Flexible Polyurethane Foam Is Used For Automotive Seating and Trim, Commercial Furniture, Pillows, And Many Specialty Products.

However, if more complicated shapes are required in a finished product, foam molding may be the preferred manufacturing technique. In this process, foam chemicals are poured into a custom-shaped aluminum or resin mold. After the chemicals react, the mold is opened and a FPF product in the shape of that mold is removed. While producing slabstock buns is sometimes compared to baking a loaf of bread, molding is more akin to making a waffle with a waffle iron.

You can read more about slabstock foam manufacturing and fabrication in other InTouch issues, including *Flexible Polyurethane Foam: A Primer* (Vol.1, Number 1), *Foam Fabrication* (Vol. 1, Number 5), and *Foam Density* (Vol. 1, Number 2).

Why Molded Foam?

Molding is employed for shapes that would be difficult to fabricate using conventional machinery. To offset the cost of making the mold, molding is usually reserved for items made in high quantities. Molded FPF components also tend to have higher densities than slabstock foams, and therefore higher costs. The molding process allows such components to be produced without the scrap waste entailed in cutting and slicing a slabstock bun. Finally, the molding process allows for consolidation of foam with other parts (such as a inserting a metal frame into the mold before filling), which can simplify and speed up overall production.

Molded foam products are typically used in:

- Automotive seating and interior trim. These include FPF cushioning, semi-flexible, and integral skin products used in seating, instrument panels, arm rests, console covers, steering wheels, and door panels.
- Institutional furniture for offices, hotels, and similar applications.
- Pillows, particularly ones that provide unique support characteristics.
- Novelty and specialty products, such as foam balls and advertising premiums.
- Impact absorbing foams, for electronic equipment, storage, and sports equipment.

The Molded Foam Manufacturing Process

Molding FPF requires the design and fabrication of an aluminum mold in the precise shape of the finished foam product. A number of identical molds can be built so that components can be produced continuously in a production line process. The molds may be mounted on a circular carousel or track so that different steps of the process can occur simultaneously.

Before the molds are filled with chemicals, a mold release agent is applied to exposed surfaces to allow the part to be removed without tearing or damage. Think of it as applying a non-stick spray to a waffle iron. A variety of release agents are now available. Products with an elastomeric skin (such as a steering wheel) may need a specific release agent so the texture built into the mold is fully defined in the finished product. Release agents may be solvent- or water-based, and many are formulated to reduce or eliminate volatile organic compounds (VOCs) during production.

A carousel of molds for making foam components.

The mold is typically heated, via hot water injection, to manage the exothermic properties of the FPF chemical reaction and to ensure a more uniform finished product. Foam chemicals are injected into the mold (which may be open or closed), where they begin to react. As with the slabstock process, the mixture of polyols, isocyanates, surfactants, catalysts, and other additives is adjusted to determine the properties of the foam produced.

Ventilation and personal protective equipment are used to keep employees safe from emissions during the process. While the chemicals in the first mold react, attention turns to the next empty mold to repeat the process. After the initial chemical reaction is complete, the mold is opened, and the finished component is removed. The process is then repeated.

There are two types of molding processes, hot-cure and cold-cure. In the hot-cure process, the mold may be on a track and moved through an oven to apply extra heat to facilitate the full chemical reaction. The hot-cure process is the older process, and is used mostly for conventional polyurethane foams that require a longer cure time, and is typically toluene diisocyanate (TDI)-based.

The cold-curing, or HR, process was developed for use with high resilience foam chemistries, which cure at lower tem-

peratures. The cold-curing process can be used to produce more premium foams, and offers advantages in faster cycle times, simpler equipment lines, less equipment cost, and lower energy costs because additional applied heat is not necessary.

Molded FPF In Institutional Furniture

While most residential upholstery uses slabstock FPF fabricated to needed dimensions, some long run commercial upholstered products are made with molded foam. This is particularly true for seat and back cushions of office and task chairs, which are commonly marketed based on aesthetics, ergonomic shapes, comfort and reduced pressure points. Office furniture tends to get more use than residential furniture, so durability is also a factor. For some furniture designs, FPF cushions may be molded around the furniture frame to speed up production and reduce upholstering costs.

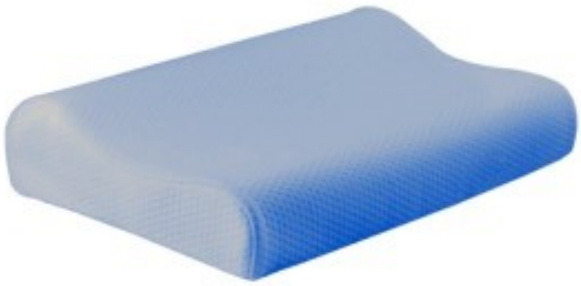
Molded FPF In Vehicle Applications

The largest market for molded FPF is in vehicle seating and trim. The seating system is one of the most costly components in a vehicle. It is a major contributor to both function, comfort, and style. It is the main interface between the driver and the machine, so manufacturers must attend to both ergonomics and aesthetics in designing and engineering.

- Unlike sofas and chairs, which are static, vehicle seating systems must deal with dynamic forces, including vehicle motion and g-forces during acceleration and turning, vibration, and crash safety.
- The seating system is responsible for eliminating transmissivity, the vibration transmitted to occupants through the floor pan by the moving vehicle and variables in the road bed.
- Molded FPF technologies can yield different foam densities and firmnesses in different areas of the cushion. This can provide better durability and comfort characteristics, along with saving weight and cost. Seat cushion inserts position you so you sit comfortably, see the road well, and easily reach controls. Bolsters and wings keep you centered and supported during turns.
- Auto seats are subject to "creep," a settling or compression of cushioning materials over time. Creep can compromise the seat's ability to keep the driver in the "H-Point" for safe operation and unimpared vision. Since molded foam components typically have a higher density than slabstock foam, molded components offer extra support and durability. Performance foam chemistries such as high resilience foam may also be used to combat creep.
- Foam can provide energy absorption to dissipate energy in case of accidents. Both rigid and flexible polyurethane foams are used, and the flexible foam may be slabstock or molded.
- Molded FPF may also be used for components such as steering wheels, where the finished product has an integral skin. FPF with skin provides cushioning for safety, plus gripability and easy cleaning.
- Molded FPF must meet strict OEM specifications, plus MVSS-302 flammability testing, and often comply with low VOC standards.

For more detailed information on FPF in transportation, see InTouch Volume 6, No.1, *Flexible Polyurethane Foam In Transportation*.

Auto/Truck Cushion Components



Molded FPF In Pillows

Molded FPF has seen a growing market in specially designed sleeping pillows. Because foam can be molded into custom shapes, specific designs may be used to provide additional neck support, to hold your head in a steady position during sleep, and provide other therapeutic benefits.

In addition, molded foam inserts are often used in conjunction with fibers or other cushioning materials to provide additional support. Foam inserts may be made from conventional, high resilience, or viscoelastic ("memory") foam, and may be combined with cooling gel inserts to enhance comfort.

Like makers of mattresses and other bedding products, manufacturers of pillows often have their foam certified by the CertiPUR-US® program, an independent organization that tests FPF. Certification means the foam was made without lead, mercury, formaldehyde, and without PBDEs, TDCPP or TCEP flame retardants. CertiPUR-US® foams also emit low levels of volatile organic compounds (VOC's).

Molded FPF In Specialty Applications

Molded foam is used in a variety of specialty applications, including sporting goods, protective gear, novelties, packaging, and other uses where foam in specific shapes is required.

Molded foam sports balls, for example, are softer than leather or rubber ones, so they are easier to grip and catch. They may also be used indoors without as much risk to damaging furnishings.

Advertising novelties and other items can also be made from molded FPF. The versatility of FPF in molded applications means that new uses are limited only by the creator's imagination.

Molded conventional foams and viscoelastic foams are used for protective cases for cell phones, cameras and musical equipment.

Key Foam Properties To Consider When Specifying Molded FPF

Manufacturers of molded FPF may evaluate many properties of the foam when developing a finished product. Here are some of the more important ones:

Density, the measurement of the mass per unit volume, expressed as pounds per cubic foot (pcf) or kilograms per cubic meter (kg/m^3). Density has a direct effect on durability and performance. Molded foam cushions tend to have higher densities than slabstock foam. Learn more about density in InTouch Volume 1, No. 2, *The Importance of Density*.

IFD: Indentation Force Deflection (IFD) is a measurement of foam firmness. Firmness is independent of foam density, although it is often thought that higher density foams are firmer. Learn more in InTouch Vol. 4, No. 3, *How Firmness Affects Flexible Polyurethane Foam Performance.*

Compression Modulus, or Support Factor, the ratio of the difference between an IFD measurement taken at 65% of foam compression and a measurement taken at 25%. The higher the support factor, the better the foam's ability to consistently support weight. Learn more in InTouch Vol. 3, No. 1 *Compression Modulus.*

Flex Fatigue, which determines the foam's ability to retain its original height and firmness properties with use.

For more details on Foam Applications and Foam Testing, PFA offers a series of video training courses, "An Introduction To The Flexible Polyurethane Foam Industry," on the PFA Website, www.pfa.org.

Summary

Molded flexible polyurethane foam (FPF) is used in a number of applications, including transportation, commercial furniture, pillows, and specialty applications like energy absorption, sports equipment, and novelties.

1. Unlike slabstock foam production, where a large bun of foam is produced and then fabricated into finished products, foam molding produces individual items in finished or near-finished form.

2. Foam molding is typically used for products that require unique, complicated shapes. Because of the up-front costs to make the molds, production runs are typically long.

3. Molded foam is used in transportation for seating, interior trim, and energy absorption.

4. Institutional furniture, such as office chairs, often use molded foam cushions to achieve aesthetics, ergonomics, comfort and durability.

5. Molded foam pillows may have specific shapes to provide neck support or other comfort and support benefits. Traditionally shaped pillows may also use molded foam inserts wrapped in fibers.

6. Because foam can be molded into an almost infinite number of shapes, foam molding can be used for sporting equipment, protective cases, novelties, and many other products.

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