An Innovative Solution to Fully Automate the Manufacture of Automotive Sound Deadening Parts "Foam & Film" Technology

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ABSTRACT

Until now, one of the major limitations in the polyurethane molding process has been the necessity to interrupt the working sequence between each molding, to remove foam scraps and apply release agent prior to foaming. The introduction of the new Cannon-patented "Foam & Film" technology makes manual intervention unnecessary, removes the one factor that has always been a major weakness when working with polyurethanes in comparison to other injected or extruded plastics.

The main idea behind this new approach consists of thermoforming a thermoplastic or polyurethane film as part of the molding sequence. By using a vacuum effect, this film adheres perfectly and smoothly to the mold cavity, without any creases or wrinkle formation. The mold is equipped with a dedicated frame device, specifically designed to hold the film. A heating system ensures that the film reaches the desired temperature prior to the thermoforming phase and subsequent injection of polyurethane into the mold.

Several industrial applications have been found and a number of fully automated plants currently incorporate this technology. The manufacture of sound deadening parts for the automotive industry represents one of the most exciting applications for this innovative technology.

THE PROBLEM

Mold cleaning is required due to the chemical nature of the polyurethane process. Cannon's objective in developing the Foam & Film technology was to eliminate the tedious, time-consuming manual operations which must be performed on the molds as part of a discontinuous polyurethane foaming process.

The need to properly vent the mold, to avoid air entrapments, often results in a thin flash of polyurethane being formed around the molded part, which needs to be manually removed afterwards via a simple trimming operation. These manual operations involve both cleaning of the mold and spraying of the release agent.

The need to demold parts in the shortest possible time, when the foam is not yet fully polymerized, and due to the thin cross-section of the flash makes them very fragile during the first few minutes following the demold. Often small pieces of flash will break off when the part is extracted, falling back onto the mold. If they are not removed from the mold surface, they could mar the surface of the subsequent parts or they could allow rising foam to leak from the mold if left along the seal.

More extensive cleaning operations, required every few shifts in order to remove deposits of release agent from the mold surface, require production to be stopped. Various technologies have been applied to minimize the required down-time, but so far a valid solution has not been found.

The adhesive force between polyurethane and metal (either aluminium or steel) requires a release agent to be sprayed onto the molds every single cycle (or every few cycles) to enable easy removal of the part. In addition, various internal mold release technologies are available, but they do not apply to all formulations.

As stated previously, these operations take a long time, are expensive and are typically executed manually and it is impossible to have a fully automated line without getting rid of them. To create a fully automated line, we had to eliminate both the need to manually clean the mold and the need to spray release agents on it.

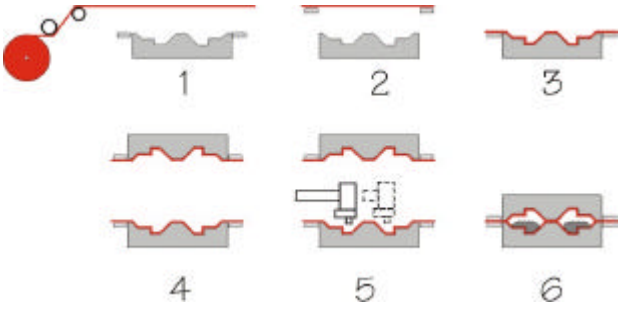

Figure 1. Cannon's "Foam & Film" technology allows the polyurethane process to be fully automated by eliminating the need to clean molds or spray mold release.

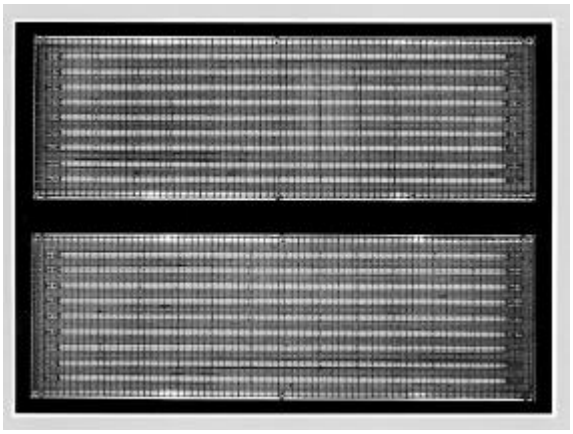

Figure 2. Cannon MVL infrared heaters ensure high efficiency and low thermal inertia.

THE APPROACH TO A SOLUTION

The new approach to polyurethane molding, developed by Cannon, is to introduce a thermoplastic or polyurethane film thermoforming process on one or both halves of the mold as part of the overall sequence. By using a vacuum, this film adheres perfectly and smoothly to the mold cavity, without any creases or wrinkle formation.

The system's key concept is a specially designed and patented frame, integrated into the mold, which is specifically designed to hold the film in position during this thermoforming process. This frame can be either two or three dimensional, to better follow the shape and the cavities of the mold *(see Figure 1)*. The frame receives the film after it is unrolled by pinchers and cut dimensionally. It then moves it in front of an infrared lamp for several seconds to heat it to the required temperature. A control system ensures that the film reaches the desired temperature prior to the thermoforming phase. Special infrared heaters, Cannon's MVL heaters, are used to ensure high efficiency and very low thermal inertia *(see Figure 2)*.

Once the film is heated, the frame moves into the mold where the film, held in place along its four edges, is vacuum-formed onto it. The use of the frame during the vacuum forming prevents the film from folding or wrinkling *(see Figure 3)*.

The Film

There are two different types of Foam & Film processes available, based on the different types of film used: adhesive and releasing.

- In the adhesive type, the film sticks to the part and is unloaded with it, granting an esthetic finish and a waterproof covering.
- The releasing film, on the contrary, remains vacuum-formed to the mold for several shots (5-15, dependent upon the process and the materials utilized) and it is then replaced when it begins to wear.

Obviously, with the adhesive type, the film has a high adhesion coefficient with polyurethane, while in the releasing version the poorer the adhesion, the better. In both cases, the film prevents the mold from ever being put in contact with the polyurethane foam. That is why both cleaning and spraying are no longer necessary and all operations can be automated.

Adhesive Film Solution

Basically, three types of film can be used in the adhesive Foam & Film process *(see Figure 4)*:

- TPU - Thermoplastic Polyurethane
- PE - Polyethylene
- TP - Thermoplastic Film

TPU is a good film for both cold and hot processes, providing good adhesion to the foam and excellent mechanical properties but the cost is high (around 6 cents per square foot). PE film can only be used in cold processes, it requires a special treatment for perfect adhesion and it gives an overall poorer performance but it has the advantage of being very inexpensive. TP film is only suitable for hot processes, it requires no treatment, and it guarantees good adhesion at a low cost (less than 2 cents per square foot).

Figure 3. Cannon's "Foam & Film" technology is incorporated into the mold carrier design.

Figure 4. Parts molded with the adhesive "Foam & Film" technology have a smooth, wrinkle-free surface.

This last type of film is what Cannon have developed in depth, obtaining very good tear and impact resistance, flexibility, elongation and welding ease. This is the solution that has been used for most automated Foam & Film plants supplied so far. Using this film, General Motors makes sound- deadening parts with fully automated equipment that has a productivity of 8000 parts/day, running 24 hours per day with zero (0) operators *(see Figure 5)*.

Releasing Film Solution

The second type of film, the releasing one, sticks to the mold and not to the polyurethane part *(see Figure 6)*. In the releasing Foam & Film technology, there are two main types of film that can be used: PE (Polyethylene) and TP (Thermoplastic film). PE, once again, is very common and inexpensive, but gives a poor release from the foam, which minimizes the benefits of this technology. TP film provides an easy process with good release from the foam for several shots at a very reasonable price.

INDUSTRIAL APPLICATIONS

A good example of such a continuous molding process that incorporates Foam & Film technology is the system that Cannon recently supplied for the production of industrial vehicle carpets. These products are usually made out of a sandwich of two or more layers of different materials. Individually, they provide different features: aesthetics and function (a textile carpet or a synthetic mat), sound-deadening (a layer of polyurethane foam) and protective (a cheap layer to protect the foam from moisture and degradation).

INSOTEC, a technology designed by Cannon for the manufacture of sound-deadening automotive components, offers a variety of manufacturing alternatives that provide significant benefits such as improved quality parts, reduced costs, shorter process times, as well as regular and consistent production cycles *(see Figure 7)*.

These excellent results have recently been improved with the introduction of the new Foam & Film technology. The new technology makes manual intervention unnecessary, removing the one factor which has always been a major weakness with polyurethane processing and added a significant cost to the parts that are perceived to be an economical component of a vehicle.

These components have a surface area of about 32 ft^2 and consist of a surface layer of PVC or thermoplastic elastomer (referred to as the "heavy layer"), an intermediate sound-deadening layer of flexible, medium-to-low density polyurethane foam and a lower thermoplastic film *(see Figure 8)*. The film is designed to prevent the formation of flash during the molding process, eliminate permanent residue usually left in the mold, and to act as a release agent (once the part is in the vehicle, this film inhibits water absorption, a fully automated plants used TPU film, which is very frequent problem with industrial vehicles). In the past, strong mechanically and performs well but is quite expensive. With the new Foam & Film technology, it is possible to replace this polyurethane film with a thinner, less costly thermoplastic one, resulting in high quality production at a lower cost.

The system is composed of two shuttle-bed clamps served by one metering unit, which dispenses the pre-heated heavy layer in the mold. Pre-heating is carried out using a special IR heater (Cannon's MVL) which incorporates easily adjustable, special low thermal-inertia resistances. When a vacuum is applied to the mold, the material adheres to the lower mold half, taking on its shape and embossed design *(see Figure 9)*.

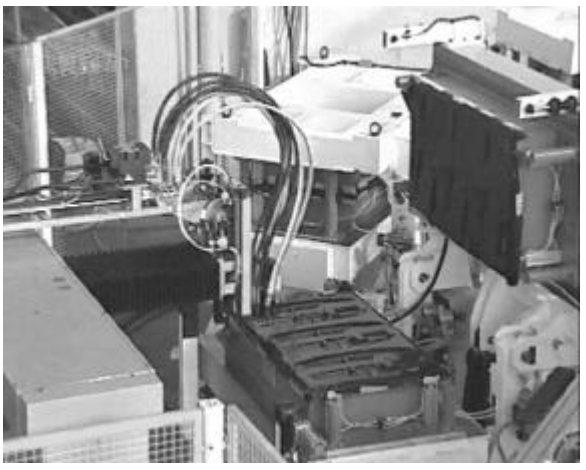

Figure 5. Cannon's "Foam & Film" technology enables General Motors to produce 8000 sound-deadening parts each day with zero (0) operators!

Figure 6. Parts made with releasing "Foam & Film" technology are removed from the mold while the film remains in the mold.

The protective film is automatically unrolled from an overhead source using a vertical traversing frame with pinchers that pulls an appropriate length of film over the frame and cuts it to length. The frame is positioned over the edge of the mold. Another bank of MVL heaters slides laterally in front of the mold and warms the film to the correct forming temperature; a vacuum is applied at the end of the heating phase to conform the film to the mold.

The use of two presses, as opposed to one, means that slack periods are eliminated and use of the cycle time is maximized. While the film and heavy layer are being placed in one of the molds and pre-heated, foaming and polymerization are taking place on the other.

The polyurethane dosing and foaming section of this plant is equipped with CannOxide™ - the Cannon molding technology that allowed CFC blowing agents to be replaced with natural liquid carbon dioxide. This helps reduce the density of the polyurethane considerably and thus saves on material costs.

The overall production time is just two and a half minutes per part. Being a two-station plant, this equipment can produce close to 50 finished parts per hour – without a dedicated operator.

APPLICATIONS

This technology has already been used on turnkey plants for sound insulation parts, carpet back-foaming and seat cushions. No limitations for this technology are foreseen and, actually, Foam & Film can be implemented in almost every kind of polyurethane process needing either release agent or a cover / surface film.

The system requires the presence of an open mold where the film-holding frame can be inserted to position the film prior to the vacuum-forming phase. Obviously, this technology is more easily applied to new equipment and new molds since, most of the time,

Figure 7. Cannon's continuous molding process for the production of industrial vehicle carpets INSOTEC incorporates "Foam & Film" technology to make manual intervention unnecessary.

existing molds must be modified to provide the vacuum and hold the frames. When one surface of the part is covered by an aesthetic or functional layer (carpet, plastics etc.), obviously the film is only applied to the opposing side where the foam would be in contact with the mold.

ADVANTAGES

Foam & Film offers significant benefits, such as quality parts, reduced costs, shorter process times, as well as regular and consistent production cycles.

- operator intervention is no longer required for mold cleaning and application of release agent; consequently this leads to the increased productivity, uniformity and the cycle regularity which come with a completely automatic line -- a fully automated foaming process is now possible.
- polyurethane or thermoplastic film can be used: the latter being thinner and cheaper but giving the same performance.

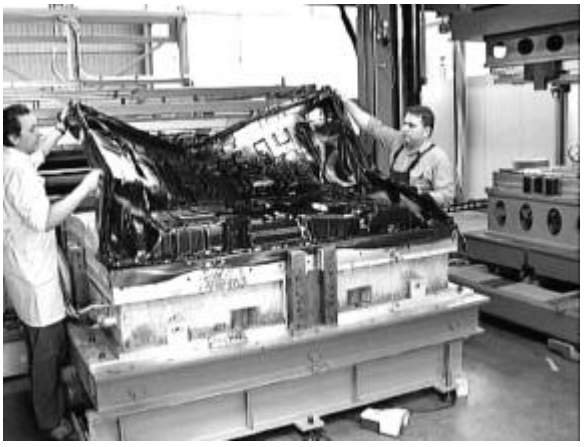

Figure 8. Sound-deadening vehicle flooring consists of a top "heavy layer", an intermediate sound-deadening polyurethane foam layer and a lower protective layer.

Figure 9. When the film is vacuum-formed to the mold, it takes on its shape and its embossed design.

- films which adhere to the product can be used, becoming an integral part of the finished component; this can be a very useful feature for non-aesthetic parts that are to be mounted in hidden positions and will benefit from this extra protection against humidity, oil, aggressive chemicals and foam-ageing agents such as oxygen or other gases.
- films which adhere to the mold can be re-used several times as a substitute for release agent.
- the availability of a wide range of film sizes means no dimensional limitations on the parts to be molded.

To summarize, Cannon's "Foam & Film" Technology:

- automates the production of polyurethane molded parts
- eliminates mold cleaning
- eliminates spraying of release agent, saving its cost plus those of all the relevant dispensing equipment and special fume extraction systems (although regular fume extraction must be maintained for the polyurethane process)
- offers a low operating cost

CONCLUSIONS

Foam & Film technology is not just a film. It is a complete and patented technology that incorporates a film. Cannon's objective is not to sell the film or the technology itself, but to provide a complete turnkey plant. For this reason, information on the type of film to be used is based on the technical specifications and is part of the solution to be supplied.

Trials and part development can be performed in Cannon's development laboratory prior to the purchase of a turnkey plant to ensure the technological and production benefits. Of course, Cannon did not invent polyurethane or the use of film, only a good way to make them work well together!

BIOGRAPHIES

Max Taverna

Max Taverna was born in Buenos Aires, Argentina, in 1949 and has an educational background in industrial chemistry. He worked for Upjohn's Polyurethanes division in Italy for five years and joined Cannon Afros as the European Sales Manager in 1982. Since 1986, he has coordinated the Group's communications activities and currently serves as the Director of Communications.

Jim Riley

Jim Riley has been with Cannon for 13 years and is currently the Sales and Marketing Manager for Cannon Tecnos U.S.A. He has a mechanical engineering degree from Penn State University and a MBA from Carnegie Mellon University.