Volume 6, Number 2, December 1997

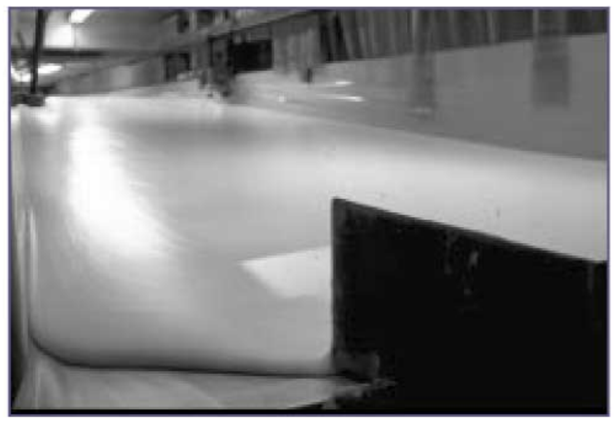
IN•TOUCH®

INFORMATION ON FLEXIBLE POLYURETHANE FOAM

IN • TOUCH® is a regular publication of the Polyurethane Foam Association (PFA). It covers topics of interest to users of flexible polyurethane foam and is designed as a quick reference for background information on key issues. To get more detailed information about a particular topic, consult a PFA member.

Polyurethane Foam and the Environment: A Progress Report

This edition of IN•TOUCH comprises a progress report on environmental issues impacting the flexible polyurethane foam industry.



When the United Nations issued the Montreal Protocol in 1987, producers of flexible polyurethane foam (FPF) in the United States responded immediately. The Montreal Protocol mandated that industries eliminate chlorofluorocarbons (CFCs), which some scientists believe deplete the earth's ozone layer, from manufacturing processes. Members of the PFA assumed a proactive role and began to seek alternatives to CFCs at once. CFCs were used extensively as auxiliary blowing agents (ABAs), which make it possible to produce either softer or lower density foams used in the manufacture of upholstered furniture and bedding.

The foam industry's preemptive actions resulted in swift, dramatic reductions of CFCs. The Montreal Protocol called for the elimination of CFCs by the year 2000. By 1992, well ahead of the required schedule, PFA members representing the majority of the FPF industry had achieved a 98 percent reduction of CFCs by initiating the use of alternative foam chemistries and mechanical equipment.

Extensive research and development of alternative production methods allowed the foam industry to meet its commitment to the environment and to fulfill its responsibility to customers. The reduction of CFCs was achieved without a disruption in supply or compromise of product quality.

Methylene chloride is now a prime target for reduction technologies. In addition to the EPA's call to limit emissions of the chemical, OSHA has imposed a tight cap on allowable limits within plants. New technologies spearhead industry's moves to stay ahead of compliance requirements as EPA and OSHA establish and publish their definitive guidelines.

Methylene chloride has been widely used to produce lower-density, softer foams that could not be poured with the normal polymer reaction because the formulation would become too hot. Methylene chloride is also economical, as are other chlorinated solvents. Acetone works well, but requires careful handling due to flammability.

Research to develop production methods without the use of ABAs while maintaining quality standards has resulted in five primary alternative technologies. They are:

- Alternative Blowing Agents
- Chemical Additives
- Forced Foam Cooling
- Controlled Pressure Foaming
- Carbon Dioxide Systems

This special edition of IN•TOUCH, a progress report on environmental issues impacting FPF, examines these five options for reducing hazardous air pollutants (HAPs) and outlines major advantages and disadvantages of each.

Chemical Solutions for Reducing ABAs

Use of alternative ABAs and chemical additives are two technologies that allow the production of softer, less dense foam while sharply reducing or eliminating traditional ABAs.

Alternative Agents for Blowing

Methylene chloride was already in widespread use as an ABA when the Montreal Protocol, eliminating the use of CFCs, was agreed upon. The FPF industry moved almost completely to methylene chloride as an ABA, thus eliminating the use of CFCs. Subsequently both the EPA and OSHA have established limitations on methylene chloride emissions into the air and in the plant environment, which will greatly reduce its use in the 1998 to 2000 time span.

Acetone is another ABA with some distinct advantages. Acetone usage, via a licensed process, has little impact on the environment. The use of acetone requires only minimal formulation changes. Special precautions for acetone usage are based upon its flammability characteristics and include spark-proof and explosion-proof handling equipment.

There are currently no economically viable alternative agents for blowing FPF other than those already mentioned. Chemical Additives Chemical additives fall into either the category of softening agents or stabilizing agents. The softening agents act to alter the morphology of the foaming polymer by interfering with the hard domain. Thus higher water foams can be made which have lower density characteristics without the attendant hardness increase often noted with these high water foams.

The stabilizing agents permit the possibility of making low index (< 100) FPF. The reduction of TDI index below 100 in FPF manufacture is a mechanism to produce foams with softer characteristics than would otherwise result from the water level employed in the formulations. The stabilizing agent can also be used to help produce FPF with the same firmness as would be produced at a higher index, but at a lower density.

There may be cases where graft or polymer polyols may be needed to allow reaching higher IFD (harder) FPF without exceeding exotherm limits due to high water usage levels. Conversely the extremely low IFD (softer) FPF may still require some modest use of ABAs to achieve the target level. The use of both softening and stabilizing agents provide a chemical means to achieve many desired properties in FPF. ABAs can be greatly reduced, and in some grades eliminated, using these agents. But chemical additives may be costly, so a careful balance of the economics of the chemical approach with the economics of manufacture and the physical properties of the FPF must be made.

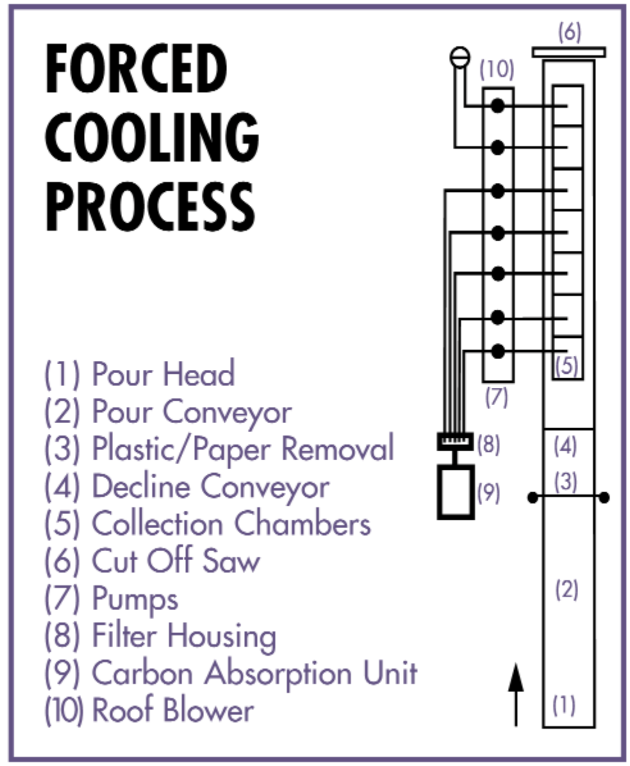
Mechanical Methods for Curbing the Use of ABAs

Forced cooling, also called vacuum cooling, is one method. There is a generic version and at least three patented versions of this process. The other mechanical approach is controlled pressure foaming or variable pressure foaming. There are at least two patented versions of this process.

The Forced Cooling Process

The forced cooling or vacuum cooling process permits the use of high water levels in FPF formulations to achieve low density. The high exotherm developed from the use of high water levels is dissipated before it can cause internal scorch or autoignition of the FPF. The use of air as the cooling medium is relatively simplistic. The flow of the air through the FPF must be uniform to ensure that no “hot spots” remain in the center of the bun.

Care must be taken with regard to making certain that back up systems are in place in case a power outage or mechanical failure interrupts the cooling process. Timing is also important so that critical physical properties are developed in the FPF and to prevent autoignition. The basic process consists of a series of vacuum plates beneath or a vacuum chamber surrounding the FPF bun that pulls air through it. Hot gases emanating as reaction products, as well as small amounts of volatile impurities or unreacted products, are removed and the FPF is cooled to safe temperatures as the air is drawn through the FPF. Exhaust gases can be treated to remove volatiles before the cooling air stream is discharged into the atmosphere.



Uniformity of physical properties throughout the block is one of the highly desirable advantages of forced air foam cooling.

The reduction of some physical properties in low-density, hard foam may limit the use of all-water in some applications. The use of some chemical additives or small amounts of conventional ABAs can restore the diminished properties. Experience with the process indicates that formulations and plant equipment can readily be adapted to forced cooling.

An unquestioned advantage of forced foam cooling is that total elimination of ABAs is achievable. The concept is not new, but the motivation for its use has changed. The process has been considered because of its potential for reducing space requirements for curing and storage of FPF. Now, concerns for the environment inside and outside the plant have spurred research and development. Forced cooling can be used with most other chemical and mechanical methods.

Controlled Pressure Foaming

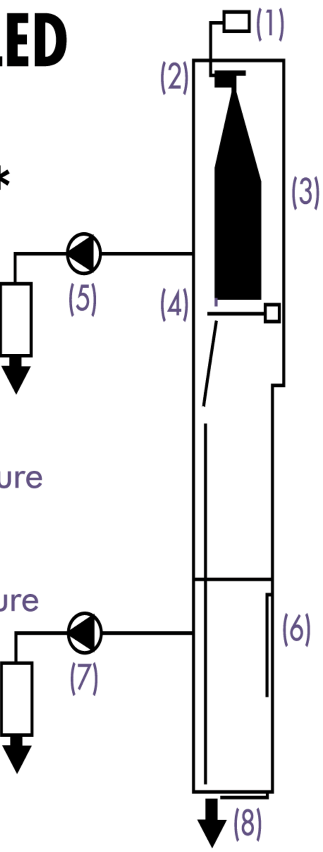
Controlled pressure or variable pressure foaming is achieved in a totally enclosed chamber either on a batch basis or a continuous basis. This sealed environment prevents the escape of emissions into the plant environment while the emissions to the atmosphere can be carefully controlled and easily absorbed or scrubbed. Reduction of pressure in the chamber permits the FPF to rise higher for a given amount of water contained in the formulation. Thus lower density FPF is readily achieved without the use of ABAs.

Another aspect of controlled pressure foaming is improved quality control. Atmospheric factors such as heat and humidity that affect the mix in more traditional processes do not come into play in the air-tight chamber.

Pouring controlled pressures below and above atmospheric pressure allows the production of existing foams and the introduction of new lower density softer foams as well as higher density firmer foams.

The controlled pressure foaming technology is relatively new, so there is a lot to learn to take full advantage of the process. However, once a formulation is determined to be a match for the variable pressure method, the foam can be produced over and over again with minimal variation. Conversion of existing FPF production equipment to controlled pressure foaming is not an option. New equipment is required. The cost of a single continuous-operation system is in the multi-millions. Batch systems are limited in production output but are less costly.

CONTROLLED PRESSURE FOAMING*



(1) Mix Head
(2) Trough
(3) Process Enclosure
(4) Cut Off
(5) Fan A
(6) Airlock Enclosure
(7) Fan B
(8) Racks

*Continuous process

CO_2 Foaming: An Attractive Choice for the Industry

The manufacture of FPF involves simultaneous chemical reactions :

Polyol + TDI Polymer

Water + TDI CO_2 + Polyurea Polymer

The CO_2 gas formed via chemical reaction provides the main foaming action to produce FPF.

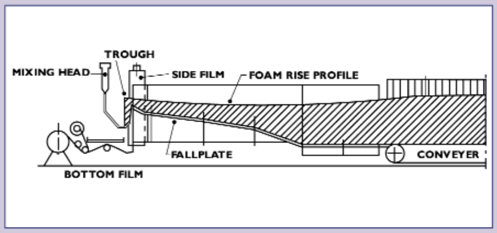
Technology has been developed to use additional externally supplied CO_2 in liquid form as an ABA by way of a frothing technique to manufacture FPF. This "physical" use of CO_2 is a unique solution to the ABA problem.

One of the reasons for the swift rise in this technology's popularity is safety. Liquid CO_2 is not toxic or flammable. Its environmental compatibility is another attraction. The use of CO_2 recovered from other industries does not create new CO_2. Converting to the CO_2 process requires a significant capital investment, and cost may be affected by the necessity to use more silicone surfactants and amine catalysts in the mix.

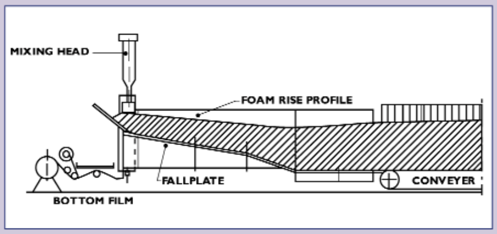
Basically, the current CO_2 foaming technology differs from conventional processes in five ways:

- Reactants are mixed under high pressure with liquid CO_2.
- Mixed material passes through a pressure drop zone/lay-down device.
- Specialized raw materials may be needed to achieve optimum results.
- The system froths components with CO_2 prior to reaction.
- Material is released onto the conveyor as a froth.

Although the polyurethane foam industry has recognized CO_2 for many years as a viable blowing agent, liquid CO_2 was not more widely used because it turns to gas at room temperature, which can cause defects in the foam being produced. This difficulty in controlling the cell structure prompted both suppliers and foam manufacturers to conduct extensive research to identify the additives and equipment to prevent defects and to facilitate production of foams to meet quality standards and customer specifications.



FOAMING WITH AND WITHOUT ABAs



FOAMING WITH LIQUID CO_2

The altered role of silicone surfactants underscores an important point. Pioneers of the process emphasize that, as with every emerging technology, there is a learning curve. Companies that wish to capitalize on the advantages of CO2 processing must be prepared to invest the time and resources to engineer formulations that work with the equipment to produce exactly the grade of foam required for specific applications. On the plus side, foamers should keep in mind that it is economically feasible to make most foam grades without ABAs. Also, the CO2 process produces low-density foams with much less concern about the high exotherms that result from foams blown with all water.

Many industry members concur that the CO2 process is an attractive, viable alternative for eliminating the ABAs that some scientists believe may be hazardous to employees and the environment. This conviction is leading to ongoing research and development to further refine processes for the production of FPF.

GLOSSARY

FPF

—flexible polyurethane foam

Auxiliary Blowing Agents (ABAs)

—Low temperature boiling chemicals used to generate gases to aid in the blowing of FPF during the production process.

Hazardous Air Pollutants (HAPs)

—The Clean Air Act lists 189 HAPs. Two have been identified as used in the manufacture of FPF.

Methylene Chloride

—A HAP ABA targeted by the EPA for emission reductions by the year 2000. OSHA is reducing allowed amounts in the plant environment.

Forced Foam Cooling

—A mechanical technology for FPF production that uses air cooling rather than ABAs to reduce exotherms in production of high water formulations.

Controlled Pressure Foaming

—A new technology that produces FPF in an enclosed chamber without the use of ABAs and still achieves low density and soft foam.

CO_2 Foaming

—The use of liquid CO2 to froth FPF chemicals prior to their normal reaction in the manufacturing process.

Summary

- 1. Taking a proactive role to protect the environment, the FPF industry phased out the use of CFCs well before the deadline set in the Montreal Protocol.
- 2. The FPF industry is technology-driven and has continuously confronted and solved problems it has faced relating to the manufacture and use of its products.
- 3. Extensive research and development is resulting in new systems and processes to sharply reduce or eliminate ABAs.
- 4. New processes focus on producing FPF that meets quality standards and customer specifications as well as environmental mandates.
- 5. Foam producers are currently relying on chemical processes, mechanical means, and external CO_2 to come into compliance with the Clean Air Act and continue to provide FPF that satisfies the needs of the marketplace.
- 6. Chemical approaches include some ABAs, acetone, and additives that make it possible to achieve low-density and soft foam.
- 7. The mechanical processes are forced foam cooling and controlled pressure foaming. Both of these processes support FPF production without the use of ABAs. Additionally, the mechanical processes provide the opportunity for controlling the release of volatiles into the environment.
- 8. CO_2 foaming is becoming a viable, attractive option for the industry as research and refinements result in formulations and equipment that facilitate cost-effective production of most foam grades without the use of ABAs.
- 9. The FPF industry continues to demonstrate its responsibility to the planet in another important way. Scrap and recovered materials are recycled into useful consumer products, such as bonded carpet cushion, rather than being dumped into landfills as waste.

This information is provided as a service of the Polyurethane Foam Association to improve the understanding of key issues that affect flexible polyurethane foam cushioning. To learn more about specific foams, contact your foam supplier.

Subscription Prices: PFA Members, $20/year; nonmembers, $60/year. Add $15 for subscriptions outside the continental USA.

A complete library of PFA IN•TOUCH issues can be found on the Internet World Wide Web at http://www.pfa.org.

FOAM℠

Form Equals Function

Polyurethane Foam Association

P.O. Box 1459, Wayne, NJ 07474-1459, (201) 633-9044

http://www.pfa.org