PROCESSING EXPANDABLE POLYSTYRENE IN A PLOW MIXER

Mixing expandable polystyrene (polystyrene beads) with additives gives the polystyrene beads particular characteristics that are useful to a wide variety of industries. However, the additives mixed with the polystyrene beads are often needed in very small quantities. This article describes a plow-type mixer and how the mixer is used to process polystyrene beads and additives.

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Expanded polystyrene (polystyrene foam) is a lightweight, robust, closed-cell bulk material created from *expandable polystyrene* (polystyrene beads). The resulting hard foam product (also called *EPS*) is used in industries that range from construction and building to packaging and sporting goods. Depending on the intended purpose, polystyrene foam may need special characteristics such as antistatic or flame-retardant properties or to be a specific color. These characteristics can be achieved by introducing additives, from one to multiple different additives, often in very small quantities, to the polystyrene beads before they are expanded. A horizontal plow-type mixer, as shown in Figure 1, has proved to be ideal for this complex process engineering task.

Polystyrene foam was invented nearly 70 years ago. BASF Group first presented the material in 1952 under the brand name "Styropor" at the plastics fair in Düsseldorf, Germany. Today, polystyrene foam is used throughout the world. In 2018, 10.3 million tons of the material were produced.[1] According to current market studies, the global demand for polystyrene beads is expected to increase in years ahead.[2]

Polystyrene foam is manufactured using a polymerization process that involves turning liquid-form styrene monomer into polymers, referred to in this article as polystyrene beads. The blowing agent pentane is added during the polymerization process, and this pre-foam step results in the polystyrene beads, as shown in Figure 2, which can then be turned into foam. After polymerization, the beads are fractioned to achieve a uniform bead size. The fractioned pentane-filled beads are then put into a customer-specific mold where they'll be transformed into polystyrene foam by applying pressure and water vapor at a temperature of around 212°F (100°C). During this process, the blowing agent evaporates and the compact polystyrene beads expand up to 50 times their original volume, at which point they're considered polystyrene foam. The polystyrene beads can be manufactured into panels, as shown in Figure 3, blocks, and more complex shapes based on the customer's needs.

FIGURE 1

Plow mixers for continuous operation can be specially designed for high throughput rates.

FIGURE 2

Polystyrene beads need to be fractioned before being combined with additives.

FIGURE 3

Polystyrene beads can be molded into many different shapes depending on the customer's needs.

Understanding polystyrene beads

There are good reasons for the high level of demand for polystyrene beads. The small beads may consist of 98 percent air, but they're highly functional. Once polystyrene beads are turned into polystyrene foam, the air in the polystyrene foam keeps the material's thermal conductivity to a minimum, which in turn makes the foam an ideal insulating material. Polystyrene foam is also characterized by its light weight, highly compressive strength, and shock-absorbing properties. In addition, this cost-effective material can be processed in a number of ways. Polystyrene beads can be pressed into various shapes and then simply sawn, milled, or cut to size.

These characteristics make polystyrene foam suitable for a wide variety of applications. In the construction industry, polystyrene foam is used to insulate buildings from cold, heat, and noise and helps to increase the buildings' energy efficiency. The construction industry is the largest consumer of polystyrene foam in North America.[3] But polystyrene foam is also an essential material in the packaging industry. Boxes made of polystyrene foam are perfect for transporting temperature- or pressure-sensitive foods. And, thanks to this material, electric appliances, such as computers and refrigerators, reach customers undamaged.

Processing polystyrene beads

Polystyrene beads can be made into many different forms, and additives mixed in with the beads during processing dictate the possibilities. After polymerization and fractioning, the polystyrene beads are mixed with additives that give the beads themselves or the final polystyrene foam product specific properties. These can include achieving special bead flow characteristics during processing, creating flame-retardant properties, attaining a specific color, or producing antistatic characteristics. To achieve the desired material or product attribute, the beads are coated with additives after fractioning, as shown in Figure 4. To coat the beads, a horizontal plow mixer can be used. While other mixer types, such as a paddle blender, ribbon blender, or tumble mixer, can be used, they may not be able to achieve the same homogenous mixture that a horizontal plow mixer will, as this mixer type processes the material on the basis of a mechanically generated fluidized bed.

A plow mixer, which is also used in the pharmaceutical, food, and cosmetic industries, features an arrangement of plow-like shovels on a horizontal shaft. The shovels and shaft rotate in a cylindrical mixing vessel that's also positioned horizontally. In every mixer, the shovels' size, number, position, shape, and circumferential speed are carefully coordinated to create a three-dimensional movement in the material during the mixing process. This means that the shovels continuously mix the materials to prevent dead spots or areas of low material movement from forming.

Processing the polystyrene beads presents particular challenges. Only very small additive quantities, less than 1 percent, in fine powder or liquid form are introduced to the polystyrene beads. Nevertheless, achieving a homogeneous mixture and a consistently high-quality material is essential.

Another process engineering problem is the use of pentane as a blowing agent in the production process. Firstly, the gas atmosphere during the system's design and construction requires adherence to the National Fire Protection Association's *NFPA 70: National Fire Code*.

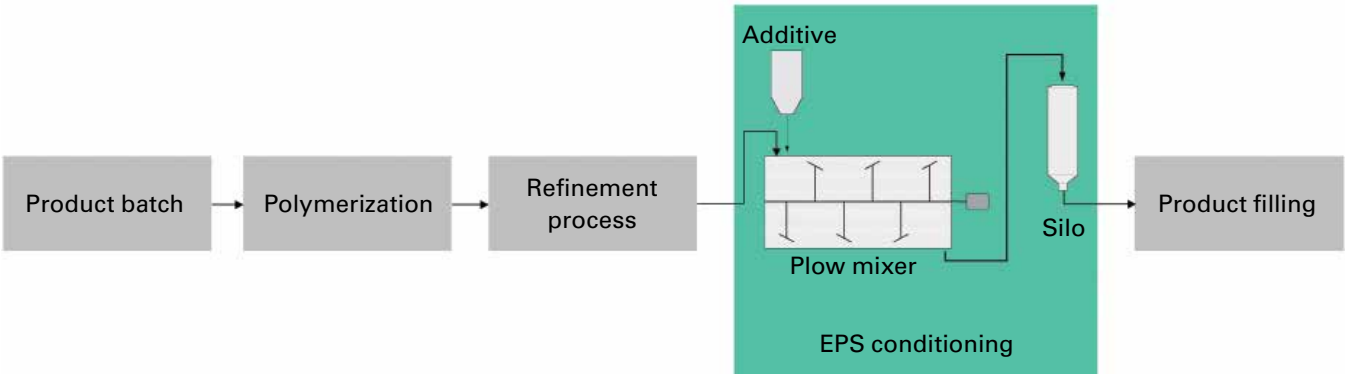
Secondly, the mixing process, which is intensive but causes no harm to the material, must be performed without any energy imparted on the material. Even temperatures above 104°F (40°C) can result in the blowing agent expanding the beads, which must be avoided while the beads are in the mixer due to the mixer's design.

Mixing polystyrene beads and additives

Plow mixers can process polystyrene beads in batches or continuously. The powdered, liquid, or powdered-and-liquid additives can be introduced into the moving material in several different locations in the mixer. In both batch and continuous processing, tools with a specific design ensure that even the smooth surfaces of the polystyrene beads come into full contact with the additives. This cylindrical-based mixing process achieves excellent material adhesion with help from

FIGURE 4

The production of expandable polystyrene



the shovels and horizontal nature of the drum and shaft. In this position, the materials are mixed together in such a way that they transform from a loose material bed to a mechanically generated fluidized bed. This makes achieving extremely uniform additive distribution possible even if the additives make up less than 1 percent of the total mixture. At the same time, the mixing process is very rapid, so high throughput rates with low retention times and short cycle times are achieved, which ensures that polystyrene foam production is cost-effective.

The mixing process, as shown in Figure 5, can be performed in a batch mixer and a continuous mixer under inert conditions or with suitable measures to ensure the required level of explosion protection. Be sure that the mixer you choose has the necessary certificates for operation in gas and dust atmospheres and is approved for operation in potentially explosive atmospheres.

Achieving the ideal results

The use of plow mixing equipment prevents the risk of costly interruptions to production, particularly in the field of bulk plastics, for example, caused by inconsistent material properties or fluctuations in quality. The use of plow batch mixers for processing polystyrene beads allows for a high level of flexibility, which is particularly helpful when formulations are changed frequently.

Many plow mixers for continuous operation are especially designed for high throughput rates. These rates can vary depending on the retention time, filling level, and material properties. The continuous three-dimensional movement of mixture components in plow mixers ensures the consistent separation of the particles in the fluidized bed. This makes adding liquids and coating the particles in a continuous process very easy. The process can be performed at filling levels between 20 and 50 percent without any impact on the mixing quality. The mixing units can be set to constantly backmix the material during retention times. This guarantees that the mixture keeps moving at all times until the material is transported through the discharge opening for further processing. The discharge opening size, which can be regulated using an adjustable weir, has a significant effect on the retention time. This reliably compensates for any fluctuations in the dosing process caused by the system.

If your application involves processing polystyrene beads with additives, a plow mixer is often the ideal mixer to use. However, be sure to talk to a plow mixer supplier first to ensure that all your material needs are addressed. Asking the right questions to verify that the mixer you're interested in is suitable for your application and environmental concerns is essential. **PBE**

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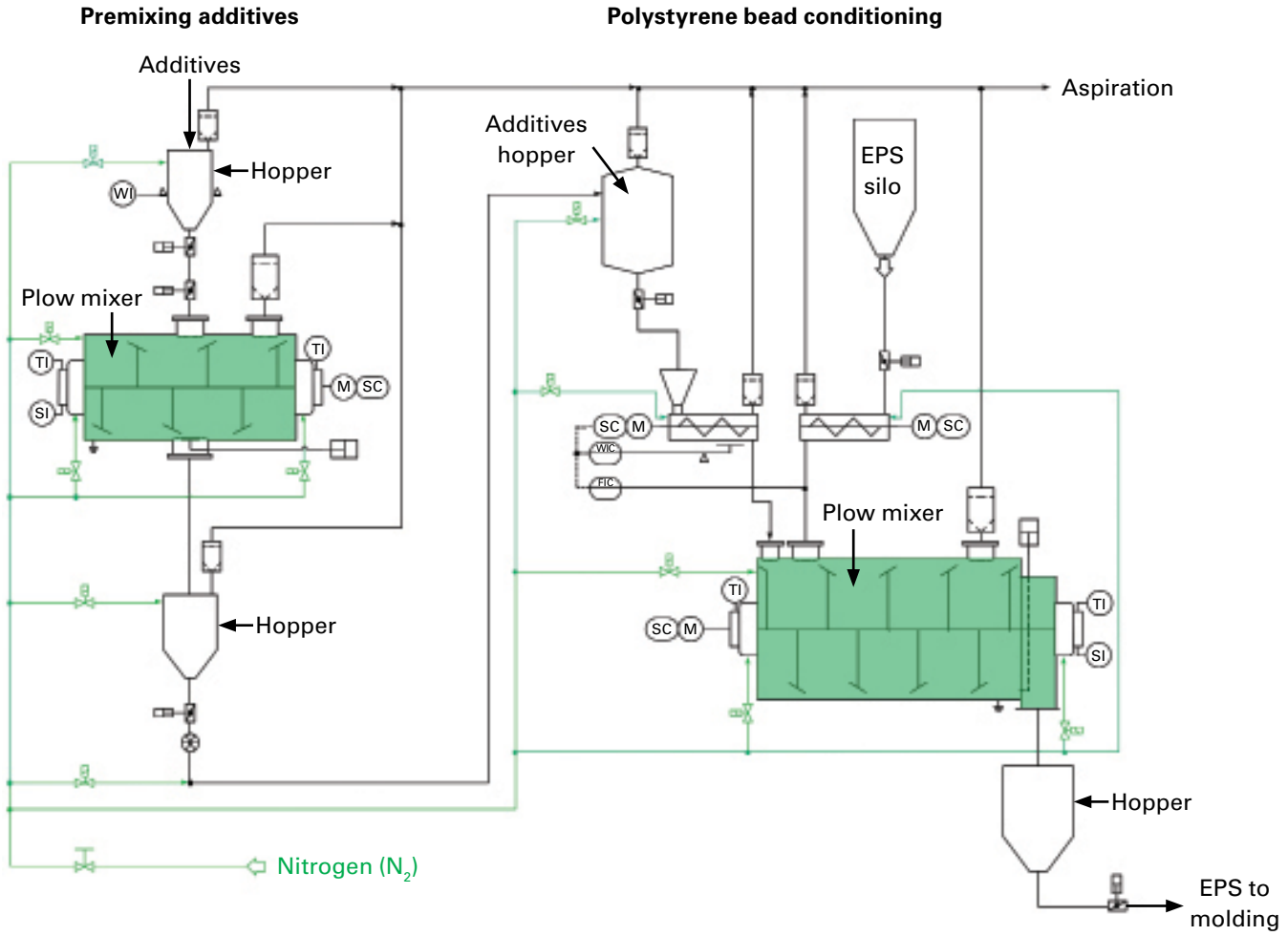
FIGURE 5

A plow mixer can be used to premix the additives in a batch process while another plow mixer can be used to coat the polystyrene beads with the mixed additives in a continuous process.



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