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# HEATING AND COOLING OF PLASTIC POLYMERS

Plastic polymers are all around us in the products we use every single day. Manufactured (or synthetic) polymers were introduced into the market in the 1800s and have significantly contributed to our quality of life. Many products we rely on every day would not be possible without plastics, and those that were possible have been vastly improved with plastics. For example, strong, lightweight plastics have made cars and airplanes lighter, reducing the amount of energy needed to operate them, thereby lowering emissions.

Plastic polymers are an important part of our daily lives, and for manufacturers it's important to preserve the quality of the polymers they produce. Heating, cooling, and drying plastic polymers can be a resource intensive process using traditional processes, but newer thermal technologies allow manufacturers to increase their efficiencies and limit their impact on the environment.

## What are plastic polymers?

Plastics are synthetic materials, meaning simply that they are manufactured using natural building blocks, rather than being found in nature. Synthetic polymers such as nylon, polyester and polyethylene all contain organic compounds ("organic" meaning that their molecular structure contains carbon). Synthetic polymers are found in a wide range of consumer goods, with applications such as adhesives, coatings, foams, packaging, textiles, industrial fibers, electronics, biomedical devices, optical devices and automotive parts.

There are eight common types of synthetic organic polymers commonly found in consumer products, including both low and high density polyethylene (ldpe and hdpe), polypropylene (pp), polyvinyl chloride (pvc), polystyrene (ps), nylon and teflon.

Polymers are substances containing many molecular units (monomers), which can be bonded together to form a chain-like structure with other identical molecules. Proteins, nucleic acids, carbohydrates and rubber are natural polymers, containing a chain of thousands of identical monomers.

## How is plastic made?

The production of plastic begins with crude oil, which is separated into fractions of differing mixtures of hydrocarbon chains, varying in size and structure. These hydrocarbon chains are used to produce synthetic polymers through the processes of polymerization and polycondensation.

- **Polymerization:** a chemical reaction between monomers to form a polymer chain. Common monomers such as ethylene and propylene are often linked together in this process to create polyethylene and polypropylene.
- **Polycondensation:** the formation of a polymer chain by removing water to link the molecules together.

Converting the polymer chains produced in polymerization or polycondesnation into finished products can be done through a number of different processes:

- **Extrusion:** polymer granules, pellets or powders are fed through a cylindrical, heated chamber called an extruder. With the extruder the plastic is melted and forced out a die-shaped opening to form the final product. The final product is then cooled.
- **Injection molding:** using extruder technology, the molten plastic is ejected at a high pressure into a cold, closed mold. When the plastic cools, the mold is opened to reveal the final product. This process is typical for butter tubs, yogurt containers, bottle caps and toys.

## The importance of drying polymers

Some polymers, such as polycarbonate, nylon and pet are hygroscopic, meaning that they attract moisture from the surrounding air. Excess moisture can cause splaying or streaking in the finished product. It can also cause hydrolysis, which breaks the covalent bonds within the polymer chain, reducing the molecular weight of the polymer. To ensure the highest quality final product, it is important to dry hygroscopic polymers.

## Drying polymers

There are a variety of traditional processes used to dry polymers:

- Dehumidifying dryers eliminate moisture from the plastic prior to processing by using a hygroscopic substance known as a desiccant. Air that has been heated to a specific temperature is forced through the desiccant bed, removing moisture from the air. The dry air is then fed into a drying hopper containing the plastic that needs dried. The hot, dry air draws moisture out of the material within the hopper. The now moisture-saturated air leaves the dryer hopper and is fed back through the desiccant bed, again removing the moisture from the air before it is fed back into the hopper and the process begins again.
- Rotary drums allow for a constant dew point suitable for the material that needs to be processed. This technology uses a rotating wheel with a desiccant agent to dry the service material. Rotary drums can be 40% more efficient than dehumidifying dryers.
- Low pressure dryers or vacuum dryers eliminate moisture without the help of a desiccant. The vacuum lowers the boiling point of the water, rapidly extracting the moisture from the heated material. As the vacuum can dry materials in 1/6 the time of a desiccant dryer, the risk of material degradation is lowered because the material is not exposed to prolonged drying times.
- Indirect heat exchangers utilize hot water, air or steam to indirectly heat the polymers by conduction. A small amount of cross flow air can also be incorporated to carry away moisture. The heated medium does not directly contact the polymer, but is transferred indirectly through walls of the heat exchanger. Thermal heat transfer is the mechanism used to raise the product temperature to eliminate moisture.

## Heating and cooling polymers

Sometimes polymer materials are kept in storage prior to processing, where temperatures of the material are subjected to fluctuation temperatures due to ambient weather conditions. Temperature changes can lead to increased moisture content, slower processing times or increased percentage of rejected product. Temperature control helps ensure product quality and consistent production capacities.

A highly efficient solution to control polymer temperatures prior to processing is the use of an indirect heat exchanger. This new technology allows for accurate control of the polymer temperature regardless of ambient conditions and variable input temperatures. The polymer material is fed vertically, down between a series of hollow, stainless steel plates. As the material flows down, hot or cooling water flows countercurrent within the plates, heating or cooling the passing material via conduction. The product is fully protected within the unit resulting in zero degradation. The controlled mass flow rate guarantees consistent capacity output. No air is used in this process, reducing energy consumption and virtually eliminating emissions. The indirect heat exchanger results in a final product with an accurate and stable output temperature that is ready for processing.

The indirect heat exchanger can also be an efficient and beneficial drying solution in cases where only residual moisture needs to be removed from polymer pellets. This technology uses heated water or steam for indirect heat transfer and incorporates a small quantity of cross flow air to remove moisture from the pellets as they move through the unit. The cross flow air is a mechanism to carry moisture away, not a direct drying method. The pellets achieve drying through conduction. In comparison to traditional technologies, such as the drum dryer, which uses a large quantity of hot air to direct dry the product, this solution separates the heat transfer and moisture removal components, significantly reducing energy consumption.

In all plastic production processes, the first step is ensuring the quality of the initial polymer materials, by means of controlling the material temperature and moisture content. This can be achieved through traditional technologies such as dyers, drums and vacuums or through innovative new technologies such as indirect heat exchangers.

To learn more about indirect heat exchangers and how they can work for your polymer processes, visit: www.Solexthermal.Com/heat-exchanger-applications-and-industries/polymers/