A Cool Mix

Combining Intensive Static Mixing with Effective Heat Exchange

Static mixers are compact, but they cannot lower the melt temperature. Combining a static mixer with a powerful cooler in a single unit opens up new possibilities in process engineering.

Static mixers have long been used to homogenize polymer melts and other viscous liquids. Such devices can still mix efficiently even when the installation lengths are short (**Fig. 1**). Not only do they ensure intimate mixing of different substances and additives, but their special transverse bars also smooth out the flow velocity and melt temperature across the mixer's entire cross-section. These are ideal prerequisites for downstream process steps, e.g. those involving shaping dies.

Although static mixers thermally homogenize the melt, they do not specifically adjust the melt temperature. Consequently, it is only possible to equalize the temperature resulting from the upstream processing section, e.g. an extruder. Moreover, the temperature level rises on account of the pressure drop in the static mixer and the higher back pressure which, in the case of an extruder, generates more heat of friction. In many cases, however, temperature rises are detrimental to the process and are undesirable. Elevated temperatures can lead, for example, to a loss of quality which can only be compensated for by reducing output. Experience shows that cooling the mixer casing fails to lower the melt temperature effectively because the surface area available for heat exchange is insufficient.

Fig. 1. Compact mixing: Promix Static Mixer SMB Plus (© Promix)

Cooling of viscous liquids such as polymer melts is complicated by the fact that the resultant rise in melt viscosity causes it to adhere to the cooling surface. The outcome is a build-up of undesirable deposits which greatly diminish the extent of heat exchange and, in extreme cases, essentially prevent it. A countermeasure for this problem is to employ a very large heat exchange area and to operate the cooler with very small temperature differences, but that would require the use of very large coolers with a very wide residence time distribution, an uneven flow rate and poor self-cleaning. In addition, coolers of such installed length would frequently be unavailable and very expensive. Cooling tubes with attached fins or designed so as to have a type of mixer structure mark an improvement, but fail to resolve the basic problem and are therefore always a compromise solution.

Operating Principle Behind the Cooling Mixer

The P1 cooling mixer technology from Promix Solutions AG, Winterthur, Switzerland, is the first combination of a highly efficient static mixer and a high-performance cooler without the need for compromises. The heat transfer fluid, preferably oil or water, is passed through hollow channels in a mixer structure (**Fig. 2**). This design ensures that the boundary layers at the cooling surface are continually renewed and generates extremely high heat transfer rates. While transfer rates vary with the process conditions, values ranging from 200 to over 400 W/m²/K are possible. Because the boundary layers are continually renewed, the cooling mixer is not prone to deposits or freezing. Even very high driving temperature differences can generate a high cooling effect. By way of example, **Figure 3** shows the cooling down of a PET melt near the solidification point of 237 °C with driving oil temperatures of up to 180 °C. Since the P1 works simultaneously as a static mixer, the unit achieves a narrow residence time distribution that is not feasible with a conventional cooler.

Tests have shown that a cooling mixer charged with red-pigmented polypropylene and then with colorless polypropylene is more than 99 % self-cleaning within three residence times and 100 % self-cleaning within 5–6. The direct attachment of the bars to the casing, moreover, confers very high strength. Such cooling mixers can easily withstand pressure drops of up to 150 bar. »

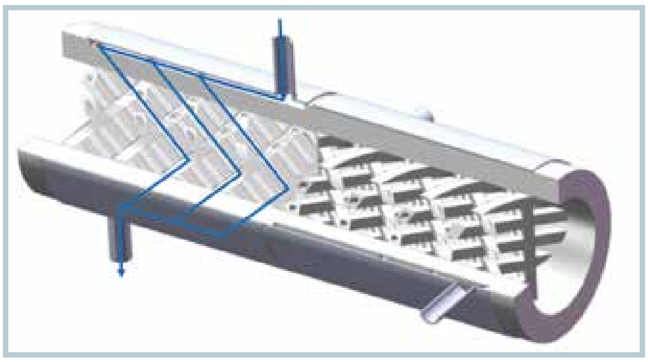

Fig. 2. Cooling mixer: The cooling fluid is fed along short paths through the hollow channels, which simultaneously provide mechanical mixing (© Promix)

Fields of Application

The patented cooling mixer technology is now finding use in a wide range of applications, with more expected to be added. Important fields of application are:

- **Processes that require precise temperature control and a highly homogeneous melt:** Many extrusion processes, for example, require precise temperature control; inconsistent or excessively high melt temperatures lead to quality problems. The use of a cooling mixer in such processes makes for constant temperatures, irrespective of extrusion conditions and raw material quality. At the same time, the melt is further homogenized and mixed, which helps to boost its product quality. Typical benefits are increased throughput in extrusion lines and improved product quality in compounding, granulation and fiber spinning processes.
- **Cooling of residence-time-critical melts:** Processes which require cooling of melts or other viscous liquids and which suffer from problems relating to residence time, deposits, product decomposition and self-cleaning (e.g. during color changes) (**Fig. 4**).
- **Cooling of melts close to the solidification point:** In the past, the problem of freezing meant that a reliable process for cooling melts very close to the solidification point was unavailable. However, this is crucial in the manufacture of expanded products and especially in the manufacture of lightweight foams such as XPS, XPE and XPET. The enhanced melt strength at lower temperatures forms the basis for producing fine-cell, highly homogeneous foams of low density (**Fig. 5**).

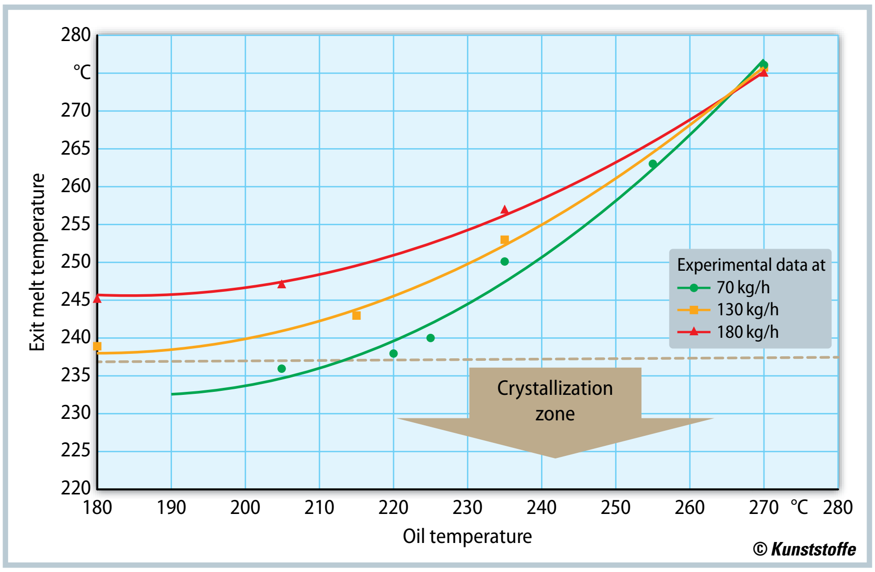

Fig. 3. No freezing: The cooling of PET melt near the solidification point proceeds smoothly at different melt throughputs and oil temperatures (source: Promix)

Fig. 4. Higher extrusion throughput: Production of PET/PS packaging film (© Promix)

- **Plug-flow reactions:** A very narrow residence time distribution coupled with precise temperature control is by definition the ideal condition for plug-flow reactions such as polymerization.

Outlook

P1 cooling mixer technology combines intensive static mixing and efficient heat exchange for the first time. The device has the potential to redefine engineering processes and product quality, and thus constitutes an interesting topic for exploring and testing further application possibilities. ■

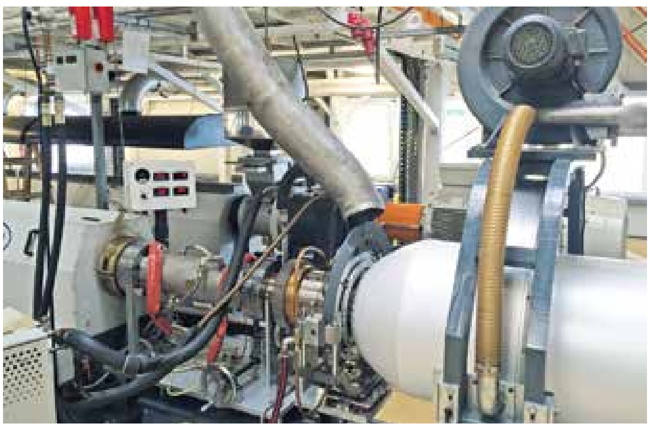

Fig. 5. Even lighter lightweight foam: A P1 cooling mixer integrated into the production of PS lightweight foam film improves cell structure and lowers the density (© Promix)

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