Degasification of Polymer in the Vacuum Evaporator

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Polymerization – a chemical reaction by which many like molecules combine to form a chain – is of great technical importance by the manufacture of numerous plastics. Sulzer Chemtech offers an economic and reliable process, which is also employed now in the manufacture of polycarbonate for the respectively required degasification.

Medicinal packings, yoghurt tubs, interior linings of refrigerators, plastic lenses for spectacles (Fig. 1), compact discs, automobile parts or drinking cups are just a few of the numerous products that are made of polycarbonate or polystyrene. Polymeric plastics are the raw material for innumerable articles that are required daily and therefore produced industrially in large quantities.

Low Residual Monomer Content

Whereas an initiation reaction causes the monomers to grow and form long molecular chains during the course of manufacture, a chain-terminating reaction ends it. As a

1 The plastic lenses of spectacles are frequently made of polycarbonate. The cost-effective and highly efficient Devoli degasification technique can thus be applied for the manufacture of this polymer.

result, a proportion of the non-bonded monomers is left behind, which impairs the quality of the end product and therefore has to be kept as low as possible. In the majority of cases, the product of the polymerization has the following composition:

- Polymer (desired product)
- Admixtures of unbonded monomer
- Oligomer from only a few bonded molecules
- Solvent
- Other impurities

The proportion of undesired substances is mostly highly volatile, but firstly by temperatures at which the quality of the polymer would be greatly impaired. To remove the undesired proportions of the highly viscous polymer melts, Sulzer Chemtech has developed the devolatilization process "Devoli", with which an end product with an extremely low content of residual monomer and solvent can be attained. In addition, the energy requirement of the Sulzer process is much less than that of competitive methods. Furthermore, the gentle handling of the process contributes appreciably to the retention of the original polymer quality.

Devolatilization by Means of Static Installations

In the main, the devolatilization process is based on a vacuum evaporation in static installations. Depending on the residual monomer content after the polymerization and the desired characteristics of the product, Sulzer Chemtech can supply single- or multi-stage degasification units.

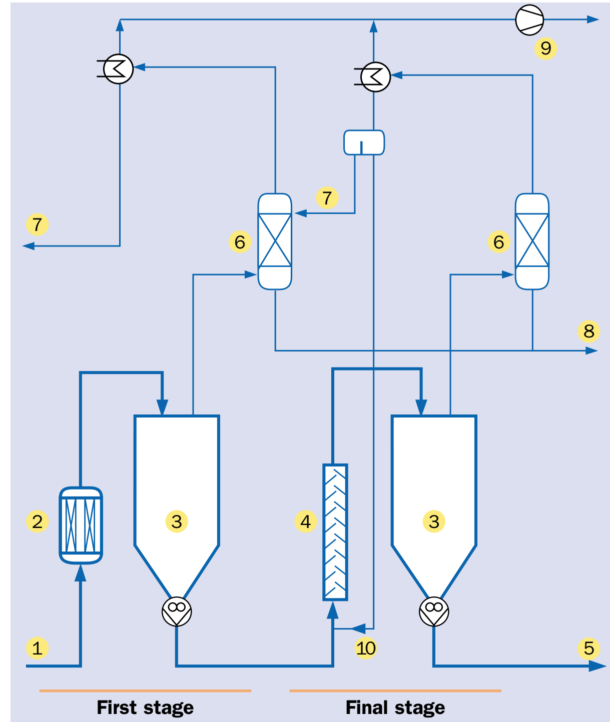
The first stage of a Devoli process comprises a static mixer/heat exchanger and an expansion vessel for the vacuum degasification. The heat exchanger with integrated mixing elements (Fig. 2) provides for a rapid and uniform heating of the polymer, which is supplied from the reaction stage. Local overheating, which could destroy the polymer chains, is thus avoided. The simultaneous mixing and heating reduces the residence time of the polymer and also prevents undesired heat reactions.

The actual separation of the material by means of degasification takes place in the downstream ex-

2 The heat transfer in this heat exchanger with SMXL mixer internals is four to eight times greater than in a normal pipe. The detrimental temperature differences in the polymer melts are leveled out quicker.

3 The installations for the evaporation degasification hardly require any moving mechanical parts, e.g. centrifugal pumps. This enhances the availability of the installations and keeps the maintenance costs at a low level.

1. Polymer with residual monomer and other pollutants
2. Static mixer/heat exchanger
3. Devolatilization vessel
4. Static mixer
5. Degassed polymer melts
6. Rectification column
7. Monomer + solvent for recycling
8. Oligomer
9. Vacuum pump
10. Stripping agent



pansion vessel (Fig. 3). With the so-called flash evaporation, the polymer is expanded abruptly, which causes the highly volatile part – consisting of monomer, oligomer and solvent – to evaporate. The solvent and monomer are separated from this vapor in a rectification column and returned to the reaction again, while the oligomer is of no further use.

If there is call for a polymer with exceptional purity – which is necessary in the case of polystyrene for foodstuff packings – the residual monomer content of the end product can be reduced to less than 100 ppm (especially through the use of stripping agents, such as CO_2, water or nitrogen) in further stages.

Low Costs

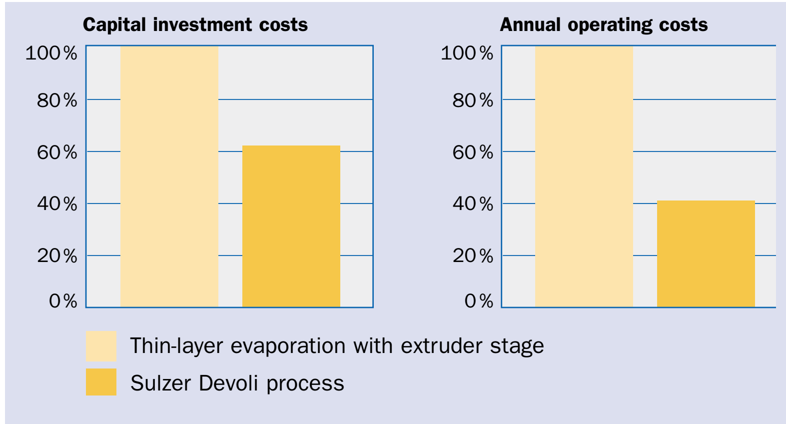
The process developed by Sulzer Chemtech is clearly superior to other possible alternative technologies in many aspects. The capital investment and operating costs are less than those for competitive systems, a fact which is confirmed by a case study for a model installation with a production capacity of 25 000 tons per year (Fig. 4).

The vacuum degasification also offers major advantages from the technical standpoint, because most polymers can be purified with this method. Since the employment of centrifugal pumps is largely dispensed with, the polymer is only subject to low shear forces during the degasification process. The residence times are also short and extend over a narrow spectrum, and so it can be ensured that there will be no change in the product characteristics. This is an important advantage especially by the manufacture of elastomers.

The characteristics of the Sulzer process especially with regard to the two important criteria – energy consumption and the exploitation of raw material – are also convincing. The efficient heating of the polymer in the mixer/heat exchanger and the small number of pumps that require motive energy reduce the energy consumption of the complete system. If water is used as a stripping agent, the process can be operated as a closed cycle, and there is no need for an external waste-water treatment plant.

Many Years' Experience

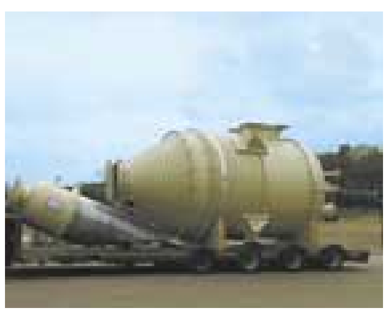
The realization of the simple principle in a large-scale, complex chemical plant is by no means commonplace and necessitates a wealth of know-how and experience. With its knowledge of the mixer technology, Sulzer Chemtech has been able to turn a simple idea into a successful process. The key components of the system are the mixer/heat exchanger, the expansion vessel and the static mixer. These components are manufactured by Sulzer and adapted to the specific substance characteristics of the product material by means of their respective internals. In particular, the use of stripping agents places very stringent requirements on the constructor. Conclusive laboratory tests also contribute to the manufacture of polymers of top quality and purity.



4 In comparison with a two-stage, thin-layer evaporation extruder stage (production capacity 25 000 t/year), the Sulzer concept for polymer devolatilization requires only 60% of the capital investment and 40% of the operating costs.

Polycarbonate Devolatilization in Iran

The Devoli process from Sulzer Chemtech has been successfully employed for the manufacture of polystyrene with a quality suitable for foodstuffs for many years. The technology has now found a further field of application on its way to industrial application, namely the manufacture of polycarbonate. The engineers from Sulzer Chemtech have designed the devolatilization section of a polycarbonate installation for the Iranian Khouzestan Petrochemical Company. From 2003 onwards, the colorless plastic will be produced on an industrial scale in the “Bandar Iman Petrochemical Zone” in the southwest of Iran. The original intention was to employ conventional degasification technology at this plant. Following the recommendations made by experts from Sulzer Chemtech, it was decided to reconsider the possibility of employing vacuum degasification. The advantages of this process were so evident that the planning had to be revised accordingly. Sulzer was awarded the contract for the planning, engineering, and supply of the units for the removal of monomer and solvent from the polycarbonate. The process parameters were adapted to the customer’s requirements in a pilot plant, so that there would be no unexpected complications when the plant is put into operation.



5 Expansion vessel of a Sulzer Devoli plant on its way to a customer.

Apart from being employed for the manufacture of polystyrene, various Devoli plants from Sulzer have been operating for many years, and now, with the production of polycarbonate (Fig. 5), the experts from Sulzer Chemtech see even greater potential for the process with other polymers. Polyethylene, polyvinyl acetate, or elastomers are just a few of the products that could be degassed with Devoli. As a part of conversion projects, existing plants can be re-vamped for the application of this energy-efficient and economical technology. ◀

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