

# Elastomer efficiency

**Andreas Diener and Ronald Oertel** highlight how direct devolatilisation of an elastomer solution can save time and money



**ELASTOMERS** are synthesised either by solution or emulsion polymerisation. After the polymerisation step, the polymer is separated from the solvent or from the emulsifying agents. This separation typically involves several process steps, including coagulation, stripping, various mechanical separation stages and finally drying. As well as being complicated and time consuming, the process consumes a lot of energy, produces waste solvents that need to be incinerated, and requires plenty of specialised equipment which in turn takes up a lot of space.

But there is an alternative. The so-called "direct devolatilisation process of elastomers contained in polymer solutions", jointly developed by the Swiss processing specialist List AG and the elastomers producer Dow Olefinverbund, promises an end to the disadvantages of solution polymerisation processes.

Figure 1 illustrates how much simpler direct devolatilisation is compared with conventional technologies.

## direct devolatilisation in solution

Most elastomers are produced using the solution polymerisation processes with solvents of aliphatic or aromatic hydrocarbons. Conventional processes need a water-based coagulant to separate the elastomers from the solvent. The solvent is then separated out by steam stripping and the elastomer from this water phase by mechanical and thermal process steps. The new process solution does not require water coagulation, steam stripping and mechanical separation, but separates the solvent directly from the elastomers while simultaneously recovering the solvent. Elastomers made this way have exactly the same

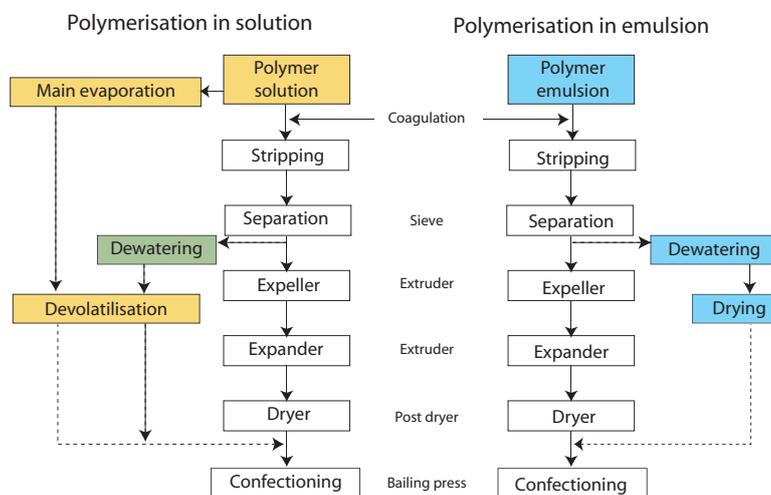


Figure 1: Block diagrams of existing technologies and the simplification introduced with the new process solutions for the separation of elastomers from solvents and emulsifying agents

properties and fulfill the same product quality specifications as elastomers produced via the conventional route.

The direct devolatilisation process is based on two steps: firstly, the continuous main evaporation of the solvent and unreacted monomer; secondly the continuous final devolatilisation of the elastomer.

The process can separate the solvent and non-converted monomer to the expected residual content, which is usually less than 100 ppm. The main evaporation takes place under vacuum while the elastomer solution is kept at the pasty/viscous phase. The energy input happens mainly mechanically. The polymer solution temperature is controlled by evaporative cooling.

Care should be taken not to let the elastomers overheat or potentially self-ignite during devolatilisation. Therefore the final devolatilisation also takes place under vacuum and during the process development it was found that overheating can be avoided by transforming the elastomers into a

crumbly form.

Figure 2 shows a simplified process diagram of the direct devolatilisation process.

## direct dewatering and drying of slurries

Some elastomers are still manufactured by the emulsion polymerisation process. The emulsifying agents are mostly water-based products. After polymerisation, the elastomers are coagulated and separated from the agents in a series of mechanical separation steps before being dried. This technology has reached its limits when processing new elastomer grades because of higher adhesiveness; the direct dewatering and drying process is able to overcome this disadvantage. Direct dewatering and drying simplifies the process and cuts down on energy use and contaminated air, without altering the properties or final product quality specifications of the elastomer.

After coagulation, the elastomer slurry is mechanically dewatered using a

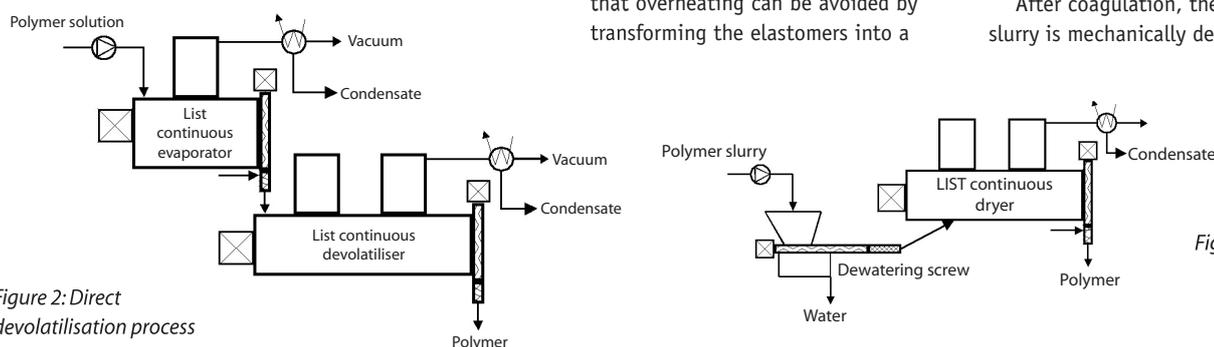


Figure 2: Direct devolatilisation process

Figure 3: The direct dewatering and drying process

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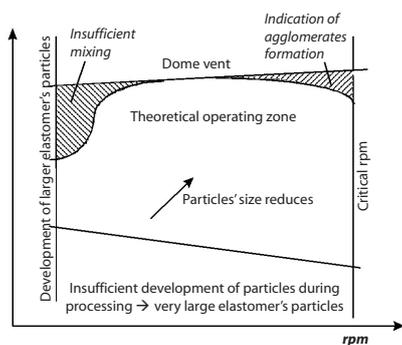


Figure 4: Operating zone of the finishing process with crumb elastomers

new specialised low-shear dewatering screw which dewateres the elastomer slurry with the least possible work, and feeds direct into a vacuum drier, similar to the final devolatiliser. The initial moisture content after mechanical dewatering is in the range 8–20% by weight. The processes, both of which are continuous, can separate the water to the expected residual content, which is usually less than 0.5% by weight.

The conditions of the drying step prevent overheating and self-ignition with transforming the elastomers into a crumbly form during the drying step and operates under vacuum in a complete closed system.

## controlled finishing

As stated, overheating and self-ignition during the final devolatilisation and drying processes can be prevented by appropriate treatment of the elastomers – ie carrying out the finishing processes with the elastomers in crumbly form, without the need to use sweep media such as hot air or nitrogen to lower the partial pressure or remove the residue by concentration differences with a large inert gas stream.

List and Dow Olefinverbund have developed a specialised polymer finishing process which turns the elastomer mass into suitable crumbs for this process. When operated

at a specific fill level and speed of revolutions it transforms the elastomer's mass into particulate crumbs and preserves them until the finishing process is complete.

The operating range of this finishing step is shown in Figure 3, and depends on the elastomer type and the processing capacity. The List devolatiliser was designed for this elastomer finishing to produce crumbs, keep them in a fluidised bed and realise the best gas exchange between the solvent in the elastomer crumbs and the gas phase until the expected final volatile content is reached. The mechanical energy input drops down to 1/10th of the energy needed for during the main evaporation and protect the elastomer against overheating.

The final devolatilisation process is a diffusion-controlled operation. The driving force for this process is the difference of volatile concentration between the gas phase and the elastomers' phase. This diffusion step is a time-relating process step and takes 0.5 h. The size of the crumbs is its limiting factor, and can be adapted during the design of the devolatiliser; with process parameters such as vacuum level, this technology can be optimised further.

Figure 5 shows an elastomer at the end of its finishing process. The elastomer is free of volatiles and its colour is clear white, as a first visual quality control. The perfect self-cleaning of the metallic surfaces is necessary to produce a product of consistently high quality and low volatile content.

## process efficiency

The process efficiency is judged according to the amount of thermal energy and cooling water it consumes, how much space is needed for the installation, environmental considerations, especially the amount of water effluent produced, and

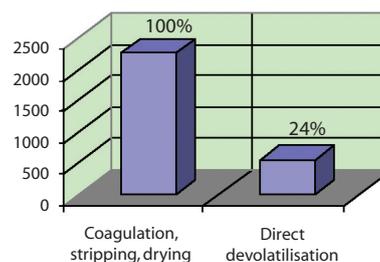


Figure 6: Comparison of the energy consumption between elastomer treatment technologies

investment and operating costs. To keep the comparison simple, the accumulation of energy and the energy losses are not considered.

The direct devolatilisation process consumes only as much energy as is needed to evaporate the solvent. No mechanical and thermal energy is spent on coagulation, stripping and mechanical water separation. Less energy is used to condense only the solvent, and the cost of coagulating agents and separating water and solvent is removed altogether.

Compared with the existing technology, direct devolatilisation greatly simplifies the process, achieves a water-free separation, eliminates the need for solvent/water separation, prevents water effluent and its subsequent treatment, and causes no air contamination.

The initial investment for the direct devolatilisation process is around the same as for existing technology. However, the investment costs are recovered much quicker due to the lower operating costs (energy, space requirements for the installation, wastewater and off-gas treatment, personnel) of the new technology versus existing.

Figure 6 illustrates the differences in energy consumption between the technologies, using the example of a plant in Western Europe.

## process development and validation

Direct devolatilisation, direct dewatering and drying were jointly developed with Dow Olefinverbund in Schkopau, Germany – one of Europe's largest elastomer producers. The parameters of the processes were first investigated in the laboratory and pilot-scale units, after which the processes were implemented on a large-scale pilot plant. That plant is installed at the pilot plant centre of Fraunhofer Gesellschaft in Schkopau. Fraunhofer Gesellschaft is an independent German research and development institute.



(Left) Figure 5: Elastomer at the end of its finishing process

The Pilot Plant Centre for Polymer Synthesis and Processing in Schkopau is competently equipped with List's specialised polymer-processing technology. Beyond the implementation of the processes described above, the plant can perform the latest polymerisation, polycondensation and reactive compounding processes. A comparative advantage of Fraunhofer Gesellschaft is that the institute provides the necessary analytical laboratories and units for application testing. This facility also allows the immediate analysis of sample products.

The installed List processing technology is designed for continuous and batch operation, and the testing capacities range from 3–50 kg/h of final product.

The pilot plant allows List and Dow Olefinverbund to validate process development done in the R&D laboratories to a continuous large-scale pilot process, and gather experience of the process operation at the larger scale. It also allows the production of samples for application tests, validation of time-extensive processes and product stability, comparison of different processing technologies, not to mention training personnel.

Figure 7 shows the Pilot Plant Centre of Fraunhofer Gesellschaft in

Schkopau and Figure 8 the specialised LIST pilot-scale polymer-finisher during construction.

### benefits and risks

#### direct devolatilisation

The main benefit of the direct devolatilisation is the absence of water, which in turn translates into lower energy consumption for evaporation, cooling, and water/solvent separation, as well as much more compact units.

For some years, large production size plants for direct devolatilisation of special elastomer grades have been successfully operated. With this new development, temperature-sensitive elastomers can also be treated in a more efficient water-free process.

Beyond the main economical benefit, an important point is that this process is completely closed, and consequently no air and water contamination takes place.

One possible shortcoming is that impurities in the traditional process that would have been removed during the steam-stripping stage may remain in the elastomer's mass. This disadvantage could be resolved by using clean monomers, and catalysts and/or initiators that evaporate during the devolatilisation of the solvent, or do not influence the elastomer's quality when contained in



(Above) Figure 7: Pilot plant centre

(Below) Figure 8: Specialised LIST pilot scale polymer-finisher



the final product.

#### direct dewatering and drying

The major benefit of the direct dewatering and drying process is its ability to successfully process new elastomer grades that could only be difficult to process with the existing technology because of higher adhesiveness, and its reduced energy consumption and no air contamination because of a complete closed system.

With new technologies, benefits and risks co-exist. The risks are reduced as the new technologies are taken up by industry and implemented in full-scale plants as it is with other elastomer grades.

This development for temperature-sensitive elastomer grades needs further implementation and approval to get the first production size line on stream.

With increasing energy costs and environmental acceptance, big players will be forced to think about new processes and more efficient environmentally-friendly technologies such as that described here. **tce**

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### other solutions for polymer industries

LIST has developed a wide range of innovative reactors and processes for the polymers industry in recent years, specialising in polymerisation and polycondensation reactions and special compounding, blending and grafting of polymers.

#### bulk and solution polymerisation

Kneader reactors allow high monomer conversion rates in continuous bulk or solution (co-)polymerisation reactions, both above and below the glass transition temperature of the polymer. The heat of reaction combined with the Trommsdorff's effect can be controlled through the combined action of the evaporative cooling, the surface renewal and the self-cleaning conditions. The formation of gel due to high temperature is avoided.

Continuous polymerisation in a kneader reactor results in an end polymer mass with at least 80% polymer content; in some cases polymer concentrations close to 100% have been reached. This makes the technology attractive to conventional processes that otherwise would only reach a polymer concentration of 10–20%, because it removes the need to separately remove solvents and water. The highly-concentrated polymer mass can be directly devolatilised, which reduces the remaining volatile content of the polymer to 200–500 ppm or lower if it is necessary.

The technology can be applied to all (co-)polymerisations or polycondensations within the viscosity range. This includes redox/radical/ionic/Ziegler-Natta/Metallocene initiated systems, such as SAP (co-polymers of acrylates and/or acrylamides or PAN), flocculants, PMMA, POM, PBI, LCP, PLA, HMM, SPS, poly(aspartic acid), poly(succinimide), cross-linking of poly(allylamine), cross-linkable (co-)polymers (PB, BR, butyl rubber, poly(isoprene), PDMS, and other comparable products).