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Kneading - Mixing - Drying

LIST Technology
Bulk Polymerization

Improving Performance in Conversion, Temperature Control, and Reaction Rates

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Bulk Polymerization

Polymer Processing in Concentrated Phase.

The LIST Technology KneaderReactor allows polymer processing in concentrated phase, e.g. solvent free bulk polymerization and energy-efficient aqueous bulk polymerization. KneaderReactors can handle both living-chain and free-radical polymerizations. Self-cleaning and surface renewal are critical in bulk (co-) polymerization.

The reactor is based on a horizontal large-volume KneaderReactor with its superior mixing and homogenization performance. Casing, shaft(s) and mixing elements are heated by heat transfer fluids and are dynamically self-cleaning.

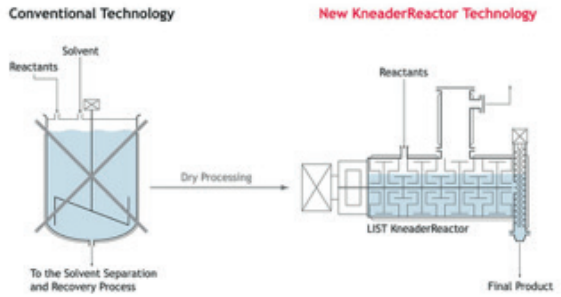


Figure 1: Principle of LIST Technology KneaderReactor to replace conventional technologies.

A Solvent Free Solution For Polymerization In The Concentrated Phase.

For residence times above 5 minutes, the traditional polymerization technologies are the continuous stirred-tank reactor and the tubular loop reactor equipped with static mixers. The tank reactor requires a large amount of solvent to carry out polymerization in the dilute phase. The loop reactor either requires the use of solvent or is limited in conversion due to plugging by increasing viscosity of the polymer [1].

As a consequence, no well-established technology allows polymerization in the concentrated phase with residence times longer than 5 minutes. The absence of solvent implies the ability to handle the high polymer viscosities that characterize nearly complete conversion at the modest temperatures required to avoid product degradation.

LIST Technology Engineers have filled this technology gap.

The LIST Technology KneaderReactor is a novel high-capacity processing solution that improves polymerization performance in terms of conversion, temperature control, and reaction rates.

The LIST Technology KneaderReactor: Self-Cleaning and Effective Surface Renewal.

Central to the versatile KneaderReactor technology are its effective mixing, its ability to handle high viscosities (up to 50,000 Pas) with low shear, the high rates of heat and mass transfer, the residence time distribution that can be adjusted to suit the process and the product and its self-cleaning performance.

The KneaderReactor is a horizontal device based on either one or two rotating shafts fitted with mixing elements. The mixing elements comprise radially mounted plates that can be heated or cooled, with special kneading bars welded to their outer edges.

The reaction volume is typically in a range of 1 – 6 cubic meters, giving production capacities of 10 – 150 kilotons per year per line depending on the residence time. The absence of solvent boosts the reaction rate and hence production capacity.

Self-cleaning and effective surface renewal are the key features of this technology that enhance processing in the concentrated phase. The low rotational speed allows the polymer to be conveyed axially at low shear rates, typically 100 s–1. The product temperature profile is well controlled by heat transfer through large heating and cooling surfaces, by varying the shaft speed, and if necessary through evaporation and reflux of the monomer(s) (evaporative cooling) and by an exact temperature measurement thanks to high mixing intensity

For close control of residence time, the degree of fill or product hold-up is kept constant by adjusting the discharge rate based on measurements of agitator torque, product weight (load cells), or level (radiometric gauge). Discharge is done by a twin-screw conveyor, typically followed by a gear pump to build up pressure for the following process step: devolatilization, chemical modification, filtration, granulation, etc.

The KneaderReactor acts as a series of mixing chambers, each formed by the space between two mixing elements. For a given reaction system, the number of mixing chambers is a design parameter for the KneaderReactor. For living polymerization systems, the number of mixing chambers is kept relatively high so as to form a plug-flow system. Free-radical-based systems are better served by a small number of mixing chambers; this allows back-mixing which rapidly heats the feed up to the temperature at which polymerization begins.

The mixing rotating shafts are supported by bearings at both ends. As a result, there is no metallic contact between the casing and the dynamic kneading elements. This eliminates any chance of metallic contamination in the polymer.

For all grades of polymer, from low to high viscosity, the configuration of the cleaning, mixing and conveying elements forms a single unique geometry. This property simplifies the operation of the KneaderReactor.

LIST Technology *Test Center, Arisdorf, Switzerland*

The PMMA polymerization and co-polymerization of methacrylic derivates are continuously produced in a KneaderReactor at high conversion.

A specifically designed KneaderReactor with well-controlled mixing rapidly brings the monomer up to the right reaction temperature at the feed inlet.

The high conversion rate (close to the equilibrium value), intensive mixing, surface renewal rate of the PMMA mass and product temperature control are all better than what the traditional polymerization technology can achieve.

Bulk copolymerization of adhesives is carried out in a back-mixed KneaderReactor. The cold monomers mix rapidly into the polymer mass, so that they rapidly reach the initiation temperature. As a result, production capacity is boosted and remains independent of surface area. Evaporative cooling controls the highly exothermic reaction. Gel formation is avoided by condensing the evaporated monomer externally.

Monomer conversion of up to 97% is achievable.

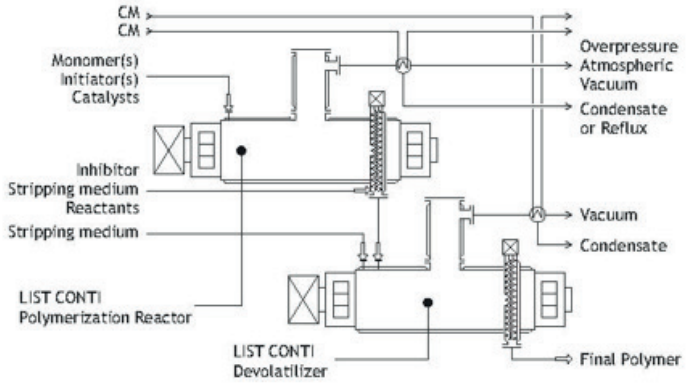
For the production of superabsorbent polymer (SAP), an aqueous and homogenous reactant mixture is initially prepared. Generally, water is the only solvent present in the mixture.

As the polymerization is taking place, the reaction mixture becomes more and more viscous and a gel-like SAP is progressively formed. The self-cleaning mixing elements eliminate dead zones that could lead to thermal degradation.

Surface renewal promotes evaporative cooling, which provides close temperature control of highly exothermic reactions, even at high viscosities and when auto-acceleration is an issue.

The feed to the reactor is a mix of cold or tempered monomer(s) and initiator or catalyst. As it enters the LIST Technology KneaderReactor, the feed stream comes into intimate contact with the existing polymer mass. As it warms up rapidly and initiates reaction, the evaporation allows to safely cool down the heat reaction. Rapid mixing suppresses any tendency to foaming with low-viscosity materials.

As a result, a single line can process large quantities of polymer, giving a sustainable economy of scale.



Process-Flow-Diagram: *High conversion polymerization with the LIST-Technology KneaderReactor process*

Polymers *are used for numerous applications*

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