**Energy efficient bulk polymerization**

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**Highlights**

* Solvent free Polymerization
* Devolatilization to 300 ppm
* Process Simulation

1. **Introduction**

The goal of most polymerization processes is to create a high molecular weight material with a specific structure. However, these polymerization processes are often highly exothermic and the final polymer is very viscous. The conventional production process for polymers requires large volumes of excess solvent and / or monomer to absorb the heat of reaction and to dilute the polymer to a low viscosity that can be processed. The LIST Kneader are able process extremely viscous materials, while adding or removing large amounts of heat, and this makes them an ideal alternative to the conventional processes.

A typical process using LIST Kneader consists of two stages. The first stage LIST Kneader is used to polymerize the monomers and catalyst in a highly concentrated, solvent-free phase. Conversion rates of 90% to 99% can be easily reached. In the second stage Kneader, the polymer is directly devolatilized to a residual monomer content of 1000 ppm or lower.

Especially in exothermic bulk (co)- polymerization processes, the large heat exchange surface of LIST Kneader in combination with evaporative cooling helps to precisely control the product temperature. The unique geometry of the mixing elements provides constant surface renewal which optimizes the heat transfer while minimizing product accumulation and dead zones. High quality polymer can be produced with low remaining monomer without solvent.

**2. Methods**

During the polymerization, conventional stirred-tank reactors require solvents to transfer heat and facilitate mixing of the viscous mass. After polymerization, solvents – whose concentrations can reach 90% – must be removed. Additionally, the conversion rate is limited [1].

The Kneader however, is designed to operate without or with little solvent, reaching a polymer concentration between 40 and 99%. In the case of polymerization without solvent, the conversion rate can exceed 99%. The polymer mass can then be directly devolatilized, to 100 – 500 ppm or lower.

**3. Results and discussion**

The technology is suitable for solvent-free living and free-radical polymerization with a polydispersity index less than 2. The unique design of the kneader provides constant surface renewal that improves heat transfer, allows excellent temperature control, and minimizes the diffusion and mass transfer limitations – particularly effective for exothermic bulk the polymerizations. The conversion rate in the polymerization step is up to 98,5% and monomer content in the final product after the devolatilization reaches 100 to 500 ppm. For the devolatilization a simulation program is used to scale the industrial process units.



**Figure 1.** Energy consumption for the production of a meth acrylic polymer in bulk compared to suspension prcessing

The process intensification leads to savings in the entire process chain. Compared to the suspension polymerization, in bulk in total up to 65% of energy can be saved.

**4. Conclusions**

Due to this process intensification, process steps can be eliminated and the recovery step can be simplified. The result is a recreated or new process solution leading to the savings of raw material, operational costs, with improved product qualities and with a much smaller carbon footprint.

**References**

1. Zahev Todmor, Costas G. PRINCIPLES OF POLYMER PROCESSING, Viley.com, ISBN 0-471-36770-3 pp 620-624