The Application of Fluid Mixers for Polymerization

A polymer is a large molecule built up by the repetition of simpler chemical units called monomers. In some cases the repetition is linear, forming a long continuous chain. In other cases, the chains are branched and interconnected to form three-dimensional networks.

Polymerization mechanisms: These can be classified into two main groups:

A. Addition polymerization - yields a product where the molecular formula of the repeating unit is the same as that of the monomer. The chain-growth reaction of ethylene monomer to form polyethylene is a classic example.

B. Condensation polymerization - yields a product where the repeating unit contains fewer atoms than the monomer or monomers, and the balance of the atoms form a by-product molecule, or "condensation product." For example, ethylene glycol and acid monomers form polyethylene terephthalate (Mylar), with water as the condensation product

Polymerization methods: There are four common polymerization methods that are used commercially and that require agitation:

A. Bulk polymerization - This method involves no diluents or solvents other than the monomer (or monomers). The polymer is soluble in the monomer. The only additives present are "activators," "initiators," or "chain regulators." Initial viscosities are low but final viscosities are usually 100,000 - 500,000 centipoise. The high final viscosities require the use of close clearance impellers. Since these impellers are not effective at low viscosities, "initiator" or "pre-polymer" reactors with AXF4 impellers are often used to take the reaction to the 10,000 - 30,000 cps range. The "melt" is then transferred to the main "polymerizer" for the balance of the reaction. The difficulty of heat transfer in viscous fluids limits bulk polymerizations

to relatively small tanks. Bulk polymerizations have also been run successfully in continuous reactors using static mixer technology. The plug flow characteristics of these reactors results in a narrower range of molecular weights in the final polymers.

B. Solution Polymerization - This method is similar to bulk polymerization but takes place in a solution of monomer and a non-reacting diluent. The diluent is a solvent for both the monomer and polymer. Heat transfer and viscosity are more easily controlled and the process is really convenient if the polymer solution can be used directly. If the polymer must be separated, as in "rubber crumbing," solvent recovery can be difficult and expensive.

C. Suspension Polymerization - This method again, uses a diluent, normally water, in which both the monomer and polymer are insoluble. Thus, each small, dispersed droplet of monomer is a tiny bulk polymerization, and the final product is a suspension of polymer "beads" or "granules." The continuous water phase keeps the viscosity low and facilitates heat transfer.

D. Emulsion polymerization - Again, the monomer is dispersed in a continuous water phase. Emulsifiers are used to produce the much smaller drop sizes and, a stable latex. Viscosity is low and heat transfer is not a problem. The end products are often used "as is" to formulate paints and coatings.

Agitation Requirements can be summarized as follows:

Polymerization Method	Visc.	HP/1000 Gal. Impellers/	Comments
Bulk	High	15-60	Usually Anchor or helical impellers. 2 stage systems use AXF-4s in first stage
Solution	Medium/High	10-40	Both AXF-4s and close clearance used.
Suspension	Low	5-8	AXF-4s most common.
Emulsion	Low	3-10	AXF-4s most common though some radial impellers also.