MODELING A FLUIDIZED-BED REACTOR FOR THE CATALYTIC POLYMERIZATION OF ETHYLENE: PARTICLE SIZE DISTRIBUTION EFFECTS

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Abstract— **Particle size distributions in the output stream of commercial, fluidized-bed reactors for ethylene polymerization are analyzed using a mathematical model. The impact on the overall reactor performance of the universe of sizes for the particles in the bed, with only a fraction of them being extracted in the product flow, is studied. For the output stream, product size distribution is modeled using both triangular and generalized gamma functions. Extraction system parameters are employed to model the particle quantity and sizes. The importance of the proper modeling of the extraction system is shown through the analysis of the effects several output schemes have on the particle size distribution inside the fluidized-bed. Some of the main reactor variables, such as yield and temperature, are studied for several distributions. Operating variables, such as catalyst feed rate, are varied according to the reactor capacity in a typical, 12 meter bed, 130,000 ton/year reactor. Predictions indicate higher output rates for higher catalyst loads, as expected. A shift towards smaller particle sizes in the product and in the bed is observed when increasing catalyst load. Bed fluidization and heat exchange conditions are shown as affected by size distributions. Results show that it is appropriate to include both product and bed particle diameter distribution when studying the reactor performance.**

Keyword -- **mathematical-model, fluidized-bed, size-distribution, polyethylene, polymerization.**

I. INTRODUCTION

When modeling a polymerization system for the continuous production of polyethylene using a low pressure, catalytic, fluidized-bed reactor of the Union Carbide UNIPOL type (Rhee and Simpson, 1986; Karol *et al.*, 1979; Karol *et al.*, 1981) the particle size distribution is an important issue. A fluidized bed polymerizer contains solid support-catalyst-polymer particles reacting in a bed through which a continuous flow of a gaseous stream composed of monomers and other species is passed. This stream must be maintained at a rate high enough to keep the particle bed in a particular type of suspension referred to as fluidized. The gas leaving the top of the reactor is used as the energy carrier to convey the heat of polymerization out of the reactor. The gas is circulated through gas-liquid, tube-and-shell heat exchangers where it is cooled, to be later recompressed and recycled to the reaction vessel.

The reaction zone is this fluidized particle bed containing a very small fraction of recently added catalyst particles and a large set of growing support-catalyst-polymer particles. Their sizes, which depend on their residence time in the bed, range from the initial support-catalyst particle diameter all the way to the largest particle in the bed, composed mostly of polymer and close to exiting the reactor. The gas flow rate must exceed the minimum fluidization velocity required for the largest particles in the bed. However, gas velocity must be lower than that able to drag the smallest particles with the exiting stream. To achieve this flow regime, high recycle ratios are used, typically of the order of 50. The highly exothermic polymerization reaction is the factor determining the overall, per-pass conversion, generally as low as 2%. The fluidized bed can be visualized as a highly mixed dense phase of particles each of which is moving because of the gas percolation effect. The pressure drop across the reaction zone is equal to, or slightly higher than the weight of the particles divided by the cross sectional area.

Catalyst particles are fed continuously to the reactor zone using an inert gas stream to carry them. The injection point is usually located slightly above the gas distribution plate at the bottom of the reaction vessel, at a height where good mixing conditions exist. Since the catalyst particles are the smallest in the reactor, they are immediately driven upwards. However, while they are being pushed up by the gas flow they are simultaneously increasing their size due to the polymerization. By the time they reach the upper limit of the reaction zone, their terminal velocity is higher than the superficial gas velocity. Thus, particles are kept outside the size range subject to drag and expulsion and become part of the highly mixed fluidized bed.

Product discharge is performed in an discontinuous fashion using a double hatch air-lock system set with tanks and valves as detailed by Aronson (1983). During product discharge, some gas is temporarily taken out of the reactor, and later returned through a recycle. Basically, product extraction is achieved using two separa-