Optimization of Slurry Loop Reactors by Understanding the Complex Mesoscale Behaviors of swelling particles

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Highlights

- Four flow regimes of swelling particles can be identified in an elevated temperatures liquid-solid fluidized bed.
- A swelling-dependent two-fluid model was developed and applied for reactor optimization.
- An optimization scheme of the reactor structure with dual pump and dual cycle was proposed for reducing the volume of blockages induced by particle swelling

1. Introduction

Slurry loop reactors have been extensively used in chemical industry, for example, ethylene copolymerization. A classical engineering problem is the timely removal of reaction heat which would otherwise cause particle swelling and aggregation, and thus reactor fouling, operation instability, or even blockage, imposing a high safety risk in production[1]. Lack of knowledge on the mesoscale information of particle swelling and aggregation poses great challenge on the prediction of the macroscale behavior[2].

2. Methods

This work conducts an experimental study on the fluidization of polyethylene particles in an elevated-temperature liquid-solid fluidized bed. The measurement of pressure drop under different temperatures is used to study the effect of temperature on fluidization regimes. And then we develop a swelling-dependent two-fluid model, the CFD with Eulerian-Eulerian method was used to simulate the swelling particle behaviors in loop reactors.

3. Results and discussion

Experimental results shows that, with the increase in temperature, particle swelling develops over two phases, i.e., non-cohesive swelling and cohesive swelling, which is different from the fluidization of cohesive particles in gas−solid systems. Simulation resluts resolves the particle aggregation and plug accumulation in the upstream of the pump and the upper horizontal pipe, revealing the fundamental of reactor blockage. The mesoscale structure, when developing to a certain extent, can cause a sharp increase of pump power consumption. This structure can be characterized by the growth and threshold of the plug volume.

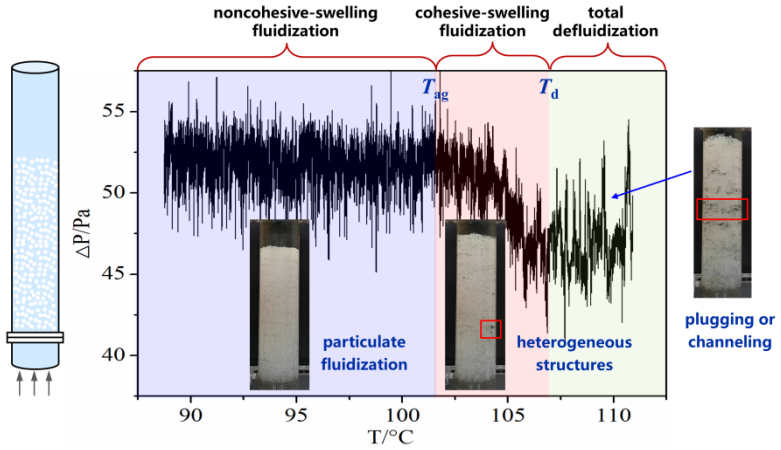

Figure 1. Flow regimes of swelling particle in a liquid-solid fluidized bed.

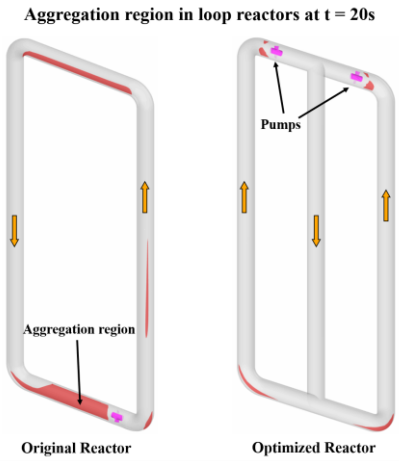

Figure 1. The aggregation region in different loop reactors

4. Conclusions

Based on the experiment of swelling particle fluidization, four regimes can be identified through static bed height and pressure drop measurements, i.e., stable fluidization, noncohesive-swelling fluidization, cohesiveswelling fluidization, and full defluidization. Based on the simulation of swelling particle behaviors in loop reactors, a reactor optimization scheme was heuristically proposed to minimize or eliminate the plug regions by employing two pumps and two cycles.

References

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Keywords
Swelling particle, Fluidization, Loop reactors.