Effects of nucleation and crystal growth rates on crystal size distribution for seeded batch potash alum crystallization process

*Siti Zubaidah Adnan, Noor Asma Fazli Abdul Samad**
Faculty of Chemical & Process Engineering Technology, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Kuantan, Pahang, Malaysia
(*) Corresponding Author

ABSTRACT

The driving force of the cooling crystallization process is supersaturation, where the supersaturation level during the crystallization process is crucial to grow the crystal sufficiently. Nucleation and crystal growth rates are two concurrent phenomena occurring during crystallization. Both are supersaturation functions that determine the growth of seed crystals and the formation of fine crystals. Trade-offs between nucleation and crystal growth are essential for achieving the large size of seed crystals with the minimum number of fine crystals. Thus, the objective of this study is to analyze the effects of nucleation and crystal growth rates on final product quality, which is crystal size distribution (CSD). Modeling of the crystallization process using a potash alum case study is highlighted and simulated using Matlab software. Then, the effects of nucleation rate, crystal growth rate, and both nucleation and crystal growth rates on CSD are evaluated using local sensitivity analysis based on the one-factor-at-a-time (OFAT) method. Based on simulation results for all strategies, a low combined rate delivers the best performance of the final CSD compared to others. Its primary peak has a mean crystal size of 455 µm with 0.0078 m^3/m volume distribution. This means that the grown seed crystals are large with high volume distribution compared to the nominal strategy, which is at the mean crystal size of 415 µm and 0.00434 m^3/m. Meanwhile, the secondary peak has the mean crystal size of 65 µm, 0.00028 m^3/m in volume distribution. This corroborates the least number of fine crystals at the considerably small size compared to nominal's (0.00151 m^3/m, 35 µm). Overall, the low nucleation and crystal growth rates strategy provides useful insights into designing temperature profiles during the linear cooling crystallization process, whereby achievable supersaturation levels in obtaining large crystals with fewer crystal fines are provided via simulation.

KEYWORDS

Crystallization; Crystal Growth Rate; Crystal Size Distribution; Local Sensitivity Analysis; Nucleation Rate; OFAT

ACKNOWLEDGEMENT
The financial support provided by Universiti Malaysia Pahang (UMP) under Doctorate Research Scheme (DRS) is duly appreciated.