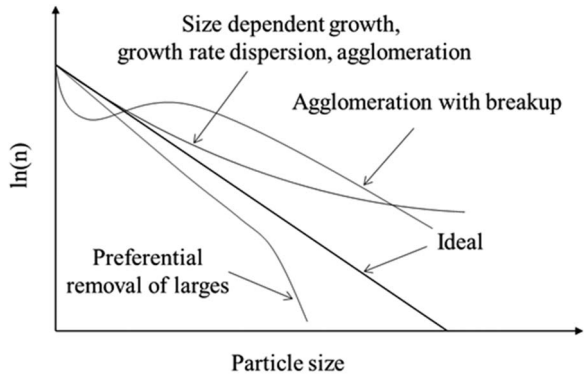

Figure 2.8 Typical deviations from the ideal MSMPR behavior.

2.3.1 MSMPR Crystallizer Configurations

MSMPR crystallizers have gained significant ground in the chemical, food and pharmaceutical industries in the last century due to their simple design and robust operability. However, in the pharmaceutical applications, MSMPR crystallizers often fail to deliver the rigorous CSD requirements, as they inherently produce crystals over a broad size range. In order to overcome this limitation, crystallization systems based on MSMPR cascades were introduced and optimized.[19] The MSMPR cascade design consists of various stages where the operating conditions are chosen to promote different mechanisms (*i.e.* nucleation, dissolution, or growth). In the first MSMPR nucleation occurs, whereas the subsequent crystallizers are designed to promote the crystal growth, and potentially also the dissolution of the fines. Figure 2.9 presents three MSMPR cascades with identical combined volumes.

Each individual MSMPR of the cascade is modeled with the equations presented in the previous section, taking into account that the feeding stream of a crystallizer has identical physical–chemical properties with the corresponding upstream crystallizer.

In order to illustrate the impact of multiple MSMPR stages on the product CSD, a numerical simulation has been carried out for the configurations presented in Figure 2.9. The simulated crystallization system consists of the following solubility and kinetic equations:

$$c_s(T) = \sum_{i=0}^{2} a_i T^i \tag{2.35}$$

$$B = k_b (c - c_s)^b$$

$$G = k_g (c - c_s)^g$$

In the simulations the kinetic and solubility data was taken from the literature,[20] which is listed, together with the process parameters, in Table 2.7.