Mechanical Engineering Doctoral Defense

Application of Ultrasound in Regeneration of Adsorbents

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Abstract

Desorption processes are an important part of all processes which involve utilization of solid adsorbents such as adsorption cooling, sorption thermal energy storage, and drying and dehumidification processes and are inherently energy-intensive. Here we investigate how those energy requirements can be reduced through the application of ultrasound for three widely used adsorbents namely zeolite 13X, activated alumina and silica gel. To determine and justify the effectiveness of incorporating ultrasound from an energy-savings point of view, an approach of constant overall input power of 20 and 25 W was adopted. To measure the extent of the effectiveness of using ultrasound, the ultrasonic-power-to-total power ratios of 0.2, 0.25, 0.4 and 0.5 were investigated and the results compared with those of no-ultrasound (heat only) at the same total power. Duplicate experiments were performed at three nominal frequencies of 28, 40 and 80 kHz to observe the influence of frequency on regeneration dynamics. Regarding moisture removal, application of ultrasound results in higher desorption rate compared to a non-ultrasound process. A nonlinear inverse proportionality was observed between the effectiveness of ultrasound and the frequency at which it is applied. Based on the variation of desorption dynamics with ultrasonic power and frequency, three mechanisms of reduced adsorbate adsorption potential, increased adsorbate surface energy and enhanced mass diffusion are proposed. Two analytical models that describe the desorption process were developed based on the experimental data from which novel efficiency metrics were proposed, which can be employed to justify incorporating ultrasound in regeneration and drying processes.

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