



ME MSc (Engg.) Thesis Colloquium



Fundamental Studies on Adsorption of Water Vapor by Silica Gel

ABSTRACT

Adsorption is surface phenomenon governed by thermodynamic variables such as pressure and temperature. During the adsorption process, molecules of a substance termed as adsorbate usually in gas or liquid phase accumulates at the surface of another liquid or solid substrate termed as adsorbent. Accumulation of adsorbate at surface of adsorbent leads to reduction in pressure and concentration of adsorbate. In engineering applications, this swing in pressure and temperature is used to develop compressor-less, thermally driven adsorption refrigeration systems. The most commonly used silica gel - water as an adsorbent-adsorbate pair has lowest regeneration temperature and hence, is used for adsorption cooling systems that utilize waste heat or solar heat for desorption process. To design and evaluate performance of a silica gel and water adsorption cooling system knowledge of adsorption equilibrium and kinetics governing the uptake of adsorbate is necessary. Among the various models available in literature, description of adsorption equilibria for silica gel and water pair is given by Tóth's adsorption isotherms. The kinetics of adsorption is best described by (Linear Driving Force) LDF, and Langmuir models. Both these are semi empirical with equilibrium constants being estimated derived from bulk experimental measurements. This thesis explores applicability of above models for a single silica gel particle.

The work presented in this thesis is divided in two sections. First part deals with fundamental experimental bulk uptake measurements using a highly sensitive strain gauge sensor that records the change in weight of adsorbent during adsorption in diffusive and convective environments. Uptake of water by silica gel is measured for a range of Reynolds numbers varying from 0-75. These measurements are further supplemented by use of non-intrusive optical diagnostics technique such as shadowgraph, TDLAS and PIV to gain greater insight into adsorption kinetics and corroborate the efficacy of bulk uptake measurements. TDLAS provides the concentration gradients of water vapor in radial and azimuthal directions whereas shadowgraphs provide the growth of the adsorbate layer around the silica gel particle. Micro-PIV is employed to visualize the flow inside water drop evaporating in presence and absence of silica gel particle and estimate the rate of evaporation from water drop. In the second part of this thesis, a multi-physics model using Langmuir kinetics is developed using COMSOL CFD solver to estimate uptake kinetics diffusion rates. The model predicts experimental data well for low Reynolds number (0-1) but a substantially deviates for higher Reynolds numbers. These results seem to suggest the LDF kinetics model used to describe kinetics for bulk silica gel measurements may not be applicable for sparsely populated silica gel beds.

ABOUT THE SPEAKER

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