Abstract

In recent times there is an increasing interest in the use of natural gas (NG) as fuel in vehicular and stationary applications due to its safe and clean burning nature and relative abundance. However safe and compact storage of natural gas is still a challenge today. Among the different storage methods available for storage, storing NG in adsorbed form (ANG) using highly microporous adsorbents like activated carbon is promising. However, the exothermic and endothermic nature of adsorption/desorption processes and poor transport properties of the adsorbent beds call for improved heat and mass transfer management. The present volume of work mainly concentrates on heat and mass transfer analyses of different adsorbed natural gas reactors subjected to variable charge-discharge conditions. These analyses are useful for small vehicular applications as well as large scale transport or stationary applications. The delivery capacity is an important performance parameter for ANG reactors designed for vehicular applications. Hence the effects of important design and operating parameters such as external fluid temperature and the specific discharge rate on delivery capacity are studied in detail using appropriate mathematical models. A frame work is developed to carry out the 2^{nd} law analysis with a view to optimise relevant design and operating parameters so as to minimise the external heating requirements during the discharge process and keep the system within safe operating pressure limits. The heat and mass transfer analysis of the tubular reactor is then generalised by the process of non-dimensionalisation of the governing non-linear differential equations and development of physically significant non-dimensional numbers. Then using the physically and statistically significant non-dimensional numbers, correlations are developed for important performance parameters such as charge-discharge time, energy consumption, maximum bed temperature etc. These correlations cover a large range of design and operating conditions and can be used for quick performance evaluation of ANG systems. In recent times there is renewed interest in running locomotives using NG. Since fuel systems for locomotives require storage on much larger scale compared to automotives, studies are also carried out on systems suitable for large scale ANG storage. As a part of this study, a novel shell-and-tube type ANG reactor is proposed for NG storage and discharge using external water which acts as thermal storage medium. Literature review shows that though there are many studies on equilibrium storage capacity of different activated carbons, dynamic performance comparison of ANG systems based on different activated carbons are still scarce in open literature. This aspect is also addressed

using the heat and mass transfer models developed. Since large scale utilization of ANG requires inexpensive and readily available adsorbents, there is a need to characterize indigenously developed adsorbents. Hence an experimental test-rig is designed and fabricated to carry out experimental studies and develop relevant structural, thermodynamic and kinetic property data of a locally available adsorbent derived from coconut shell. These studies show that the inexpensive and easily available, coconut shell based adsorbent can be used in applications that do not demand very high delivery capacities. Finally the results obtained from all the theoretical and experimental works are summarized with comments on future works needed in this area.

Key words: Adsorbed natural gas, charge characteristics, heat and mass transfer, entropy, regression equations, delivery capacity, large scale storage