

ABSTRACT

In search of new technology for human space exploration, oscillatory flow has shown the potential to help solve some of the problems associated with replenishing breathable air inside spacecraft and planetary surface habitats. It is a purely mechanical separation process to be used in the removal of carbon dioxide and other chemical species that are noxious to humans in a spaceship environment. The technique is based on the rate of movement of each species in a mixture relative to the fluid motion is different due to the differing diffusion coefficients.

This work presents some insight on the physics behind the phenomenon of oscillatory flows in wavy-walled geometries. Flow profiles in channels and tubes with sinusoidal wavy-walls have been studied analytically. The overall mass transfer and separation of dilute species in these geometrical configurations were then investigated. The energy dissipation in channels and tubes with straight and wavy-walls are also presented and compared.

Experiments have been conducted to validate the accuracy of the models developed in this dissertation. The models qualitatively predicted the overall trend and the physics of the phenomenon that occurred in the experiments, especially the separation ratio of gaseous species obtained experimentally. In fact, both theory and experiment show that depending on the magnitude of the Strouhal number, the faster diffusing species can either have a higher, a lower, or the same mass transfer than the slower diffusing species as Reynolds number increases. This finding was found to be attributed to the strength of the vortices formed during oscillatory flow in wavy-walled geometries. It was found that the separation of dilute species in wavy-walled geometries increases by about 68% over that in straight-walled geometries.