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Dynamics of Adsorptive Systems for Heat Transformation

Optimization of Adsorber, Adsorbent and Cycle

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Contents

Chapter 1
Adsorptive Heat Transformation and Storage: Thermodynamic and Kinetic Aspects

Nomenclature

A	Adsorber
Ad-HEx	Adsorbent–heat exchanger
AHP	Adsorption heat pump
AHT	Adsorptive heat transformer
C	Condenser, thermal capacity J K^{-1}
COP	Coefficient of performance
d	Thickness, m
ΔF	Adsorption potential, J mol^{-1}
E	Evaporator
LTJ	Large Temperature Jump method
LPJ	Large Pressure Jump method
h	Convective heat transfer coefficient, W m^{-2} K^{-1}
HEx	Heat exchanger
HMT	Heat and mass transfer
m	Dry adsorbent mass, kg
P	Pressure, Pa
PD	Pressure driven
Q	Thermal energy, J
R	Universal gas constant, J mol^{-1} K^{-1}
S	Solid, entropy J kg^{-1}, heat transfer surface area, m^2
SP	Specific power, W kg^{-1}
T	Temperature, K
TD	Temperature driven
U	Overall heat transfer coefficient, W m^{-2} K^{-1}
V	Vapour
w	Water uptake, g g-1
W	Work, J

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Greek Symbols

Δ	Differential operator
λ	Thermal conductivity, W m^{-1} K^{-1}

Subscripts

0	Initial stage, saturation vapour
ads	Adsorbent/adsorption
c	Cooling
con	Condensation
des	Desorption
ef	Effective
ev	Evaporation
f	Fluid
h	Heating
H	High
L	Low
M	Medium
met	Metal
us	Useful
w	Wall/solid side

At present, the majority of thermodynamic cycles of heat engines are high-temperature cycles that are realized by internal combustion engines, steam and gas turbines, etc. [1]. Traditional heat engine cycles are mainly based on burning of organic fuel that may result in dramatic increase of CO_2 emissions and global warming. The world community has realized the gravity of these problems and taken initiatives to alleviate or reverse this situation. Fulfilment of these initiatives requires, first of all, the replacement of fossil fuels with renewable energy sources (e.g. the sun, wind, ambient heat, natural water basins, soil, air). These new heat sources have significantly lower temperature potential than that achieved by burning of fossil fuels which opens a niche for applying adsorption technologies for heat transformation and storage [2].

A classical heat engine consumes heat Q_1 from a heat source with high temperature T_M, discharges heat Q_2 to a heat sink with lower temperature T_L and produces the maximal work $W = Q_1 - Q_2 = Q_1 (1 - T_L/T_M)$ [3] (the left part of Fig. 1.1). The produced work can be used to drive a heat pumping cycle (the right part of Fig. 1.1). An adsorptive heat transformer (AHT) operates between three thermostats (T_L, T_M, T_H) (Fig. 1.2) and consumes/produces only thermal energy. In this chapter, we shortly survey the fundamentals of the heat transformation via adsorption processes: