Department of Energy and Process Engineering, NTNU
TEP4150 Energy management and technology (Energiforvaltning- og teknologi), Thermodynamics-part
EP8110 Eksergianalyse

ise,sep06

Exercise 7

(note: the decimal sign here is comma)

Problem 1

Aluminium (Al) melts at 660 ºC and has a melting heat of 400 kJ/kg.

a) Determine the exergy of melted aluminium at 1000 ºC
b) how much heat and exergy have to be transferred to heat aluminium up from 300 ºC to 1000 ºC (melting included)?

In this problem you can assume the specific heat constant and equal to 0,9 kJ/(kgK) for both solid and liquid aluminium. The ambient temperature is 15 ºC.

Problem 2

Nitrogen (N_2) is extracted from the atmosphere and delivered in liquid state. In this problem we assume that the delivered product is pure N_2 (i.e. no traces of other substances).

Determine how much heat that has to be removed in the cooling, and the exergy (chemical and thermomechanical) of the nitrogen when the delivery is

a) a flow of liquid (saturated) N_2 at 1 atm (1,01325 bar)
b) a flow of liquid (saturated) N_2 at 2,3 bar
c) liquid (saturated) N_2 stored on tank at 1 atm
d) liquid (saturated) N_2 stored on tank at 2,3 bar

Here, the ambient temperature is 4 ºC and the ambient pressure is 1 atm.

e) as item a, but for ambient temperature 1) 20 ºC and 2) 37 ºC
f) as item c, but for ambient temperature 1) 20 ºC and 2) 37 ºC

Data:
At 1 atm N_2 is saturated at 77,3 K. Then, the specific volume for liquid is v_f=0,00124 m^3/kg and the enthalpy of evaporation is h_{fg}=198,84 kJ/kg.
At 2,3 bar N_2 is saturated at 85 K, v_f=0,00130 m^3/kg and h_{fg}=188,15 kJ/kg
N2 in gas phase can be assumed an ideal gas with constant specific heat c_p=1,05 kJ/(kgK)

Problem 3

Both the heating value and the chemical exergy show some variation with the temperature of their definitions.

Determine the lower heating value (LHV), the higher heating value (HHV), and the chemical exergy (on a molar basis) for hydrogen (H_2) when the ambient (atmospheric) temperature is

a) 0 ºC ("normal"-state)
b) 15 ºC ("standard" in ISO-standard)
c) 25 ºC ("standard" in chemical data)
d) 35 ºC

The pressure is 1 atm and the relative humidity is 70% in all cases.
Hint: The specific heat for the relevant gases within this temperature interval show a variation that is so small that they can be assumed constant (but not equal).