Lab Session 9

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AIM

The goal of the laboratory session is to estimate the temperature of the stream 3 and the cooling requirements of cooler C1.

METHOD

Approach 1: Let the rate of heat in stream 1 be H_1, stream 2 be H_2, and so on.

Approach 2: Using the equation given in table, we calculate the specific heat capacity of each component.

Approach 3: Using the below equation, we can use fsolve to estimate temperature of stream 3,

$$\sum_{i=1}^{N} \mathrm{n}_\mathrm{i}^1\, \mathrm{H}_\mathrm{i}^1\, (T^1) + \mathrm{n}_\mathrm{i}^2\, \mathrm{H}_\mathrm{i}^2\, (T^2) + \mathrm{n}_\mathrm{i}^{5\mathrm{R}}\, \mathrm{H}_\mathrm{i}^{5\mathrm{R}}\, (T^{5R}) = \sum_{i=1}^{n} \mathrm{n}_\mathrm{i}^3\, \mathrm{H}_\mathrm{i}^3\, (T^3)$$

Approach 4: To calculate the cooling requirements, we can calculate the heat rejected using below equation,

$$Q_{rejected} = \frac{H5+H6-H4}{3.6}$$

RESULTS AND ANALYSIS

The estimated temperature of the stream 3 is 113.53 ^{o}C.
The cooling requirements of cooler C1 is to release 46.447 KW.

CONCLUSION

The temperature of stream 3 comes out to be lesser than those of stream 1 and 2. Furthermore, the temperature of stream 4 is given 210^{o}C. The cooler C1 releases heat at the rate of 46.447 KW to bring down the temperature of stream 5 and 6. This helps in separation of vapour components from liquid components.

APPENDIX

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% molar flow rate of stream 3
n3 = [4064 10266.1 14.8 3.1];

% molar flow rate of stream 4
n4 = [2844.8 6608.5 1233.9 1222.3];

% molar flow rate of stream n5R
n5R = 0.95*[2172.6 6595.8 15.5 3.3];
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% molar flow rate of stream 6
n6 = [(2844.8-2172.6) (6608.5-6595.8) (1233.9-15.5) (1222.3-3.3)];

% total enthalpy of stream 1
h1 = 2000*CO2(25, 210);

% total enthalpy of stream 2
h2 = 4000*H2(25, 210);

% total enthalpy of stream 4
h4=n4(1)*(CO2(25,210))+n4(2)*(H2(25,210))+n4(3)*(CH3OH_l(25,64.7)+35.27+CH3OH(64.7,210))+n4(4)*(0.
0754*75+40.656+H2O(100,210));

% enthalpy of components of stream 5
H_CH3OH_5 = CH3OH(64.7,40) + CH3OH_l(25,64.7) + 35.27;
H_H2O_5 = H2O(100, 40) + 0.0754*75 + 40.656;
h5R = n5R(1)*CO2(25, 40)+n5R(2)*H2(25,40)+n5R(3)*H_CH3OH_5 + n5R(4)*H_H2O_5;

% total enthalpy of stream 5
h5=h5R/0.95;

% total enthalpy of stream 6
h6=n6(1)*CO2(25,40)+ n6(2)*H2(25,40)+ n6(3)*CH3OH_l(25,40) +n6(4)*(0.0754*15);

t_fun = @(t) (n3(1)*CO2(25,t)+n3(2)*H2(25,t)+n3(3)*(CH3OH_l(25,64.7) + 35.27 +
CH3OH(64.7,t))+n3(4)*(0.0754*75 + 40.656 + H2O(100,t))-h1-h2-h5R)
temp = fsolve(t_fun, 175);

% calculation of cooling requirements of cooler C1
Q_rejected = (h5+h6-h4)/3.6;


function H_CO2 = CO2(Tmin, Tmax)
fun =@(T) (36.11*10^-3 + 4.233*10^-5*T -2.877*10^-8*T.^2 + 7.464*10^-12*T.^3);
H_CO2 = integral(fun, Tmin, Tmax);
end

function H_H2 = H2(Tmin, Tmax)
fun =@(T) (28.84*10^-3 + 0.00765*10^-5*T + 0.3288*10^-8*T.^2 -0.8698*10^-12*T.^3);
H_H2 = integral(fun, Tmin, Tmax);
end

function H_CH3OH = CH3OH(Tmin, Tmax)
fun =@(T) (42.93*10^-3 + 8.301*10^-5*T -1.87*10^-8*T.^2 -8.03*10^-12*T.^3);
H_CH3OH = integral(fun, Tmin, Tmax);
end

function H_CH3OH_l = CH3OH_l(Tmin, Tmax)
fun =@(T) (75.86*10^-3 + 16.83*10^-5*T);
H_CH3OH_l = integral(fun, Tmin, Tmax);
end

function H_H2O = H2O(Tmin, Tmax)
fun =@(T) (33.46*10^-3 + 0.688*10^-5*T +0.7604*10^-8*T.^2 -3.593*10^-12*T.^3);
H_H2O = integral(fun, Tmin, Tmax);
end
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