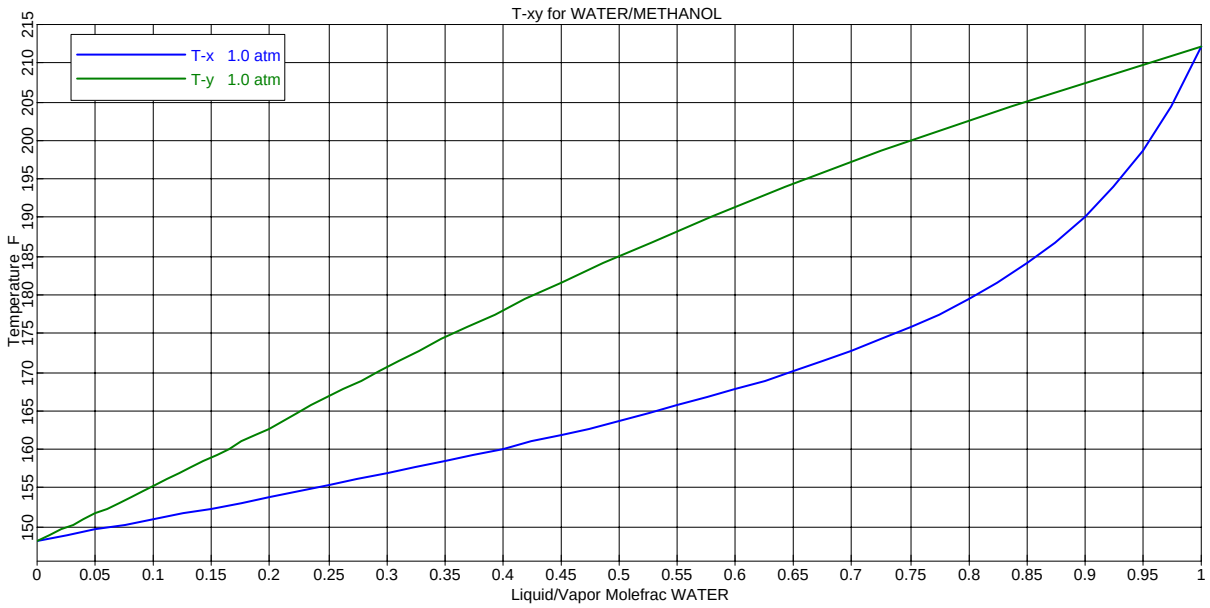
Final Homework and Solution

Question:

A total of 100 lb-mol per hour of a 40 mol% methanol and 60 mol% water mixture is to be separated at 1 atm to give a distillate that contains 92 mol% methanol and a bottom product that contains 4 mol% methanol. A total condenser is to be used and the reflux will be returned to the column as a saturated liquid at its bubble point. An operating reflux ratio of 1.5 times the minimum will be used. The feed is introduced into the column as a saturated liquid at its bubble point. Use Aspen Plus to complete the following: (a) generate a Txy diagram for the water-methanol system at 1 atm, (b) determine the minimum number of theoretical stages, (c) determine the minimum reflux ratio, (d) determine the heat loads of the condenser and reboiler for the condition of minimum reflux, (e) determine the quantities of the distillate and bottom streams using the actual reflux ratio, (f) determine the actual number of theoretical stages, (g) determine the heat load of the condenser for the actual reflux ratio, (h) generate a plot of the temperature profile and composition profile as a function of stage number (for both methanol and water).

Solution:

(a) From Aspen:



(b) The minimum number of theoretical stages is equal to 4.06 stages per a DSTWU simulation.

(c) The minimum molar reflux ratio is 0.504 per a DSTWU simulation.

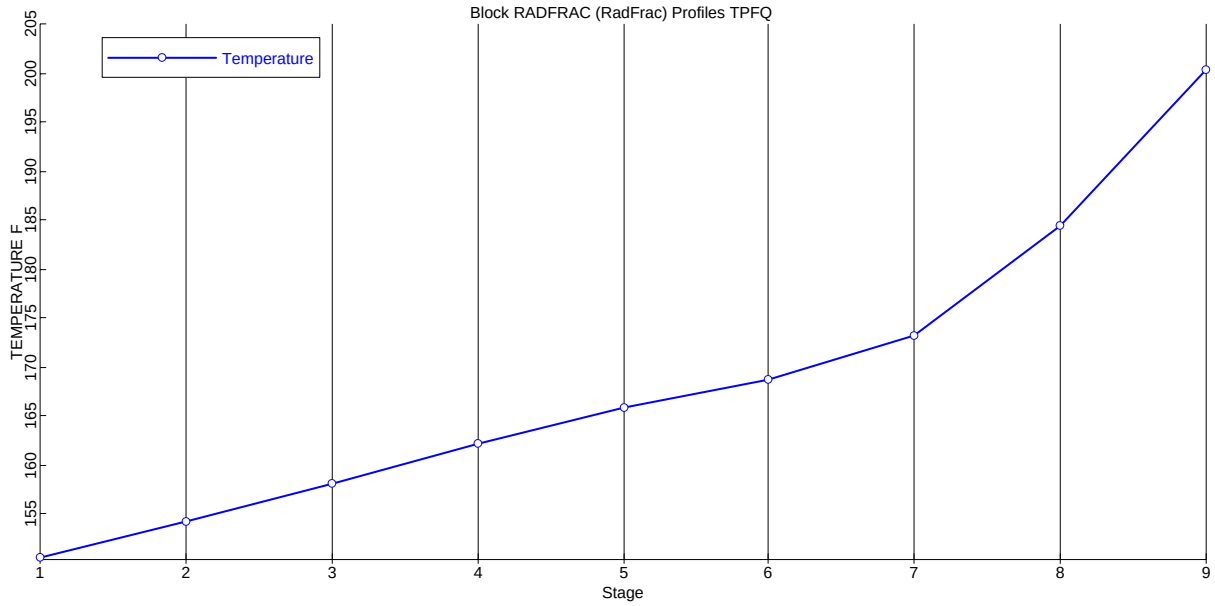
(d) At minimum reflux, the condenser duty is ~951,298 BTU/hr and the reboiler duty is ~989,263 BTU/hr (from a DSTWU simulation).

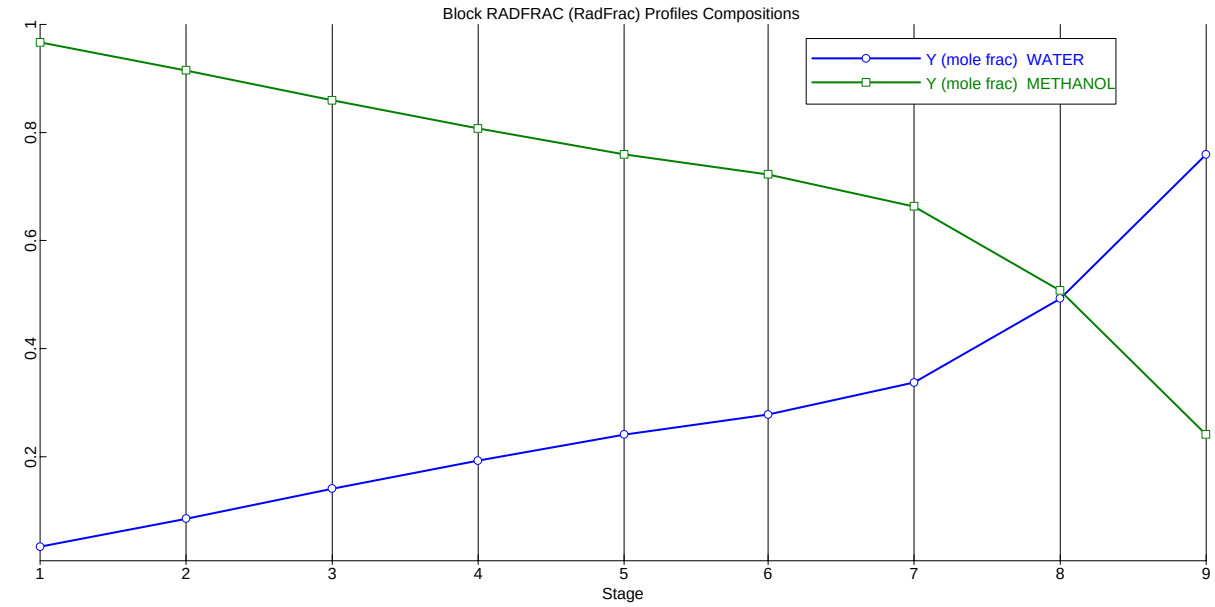
(e) The actual distillate rate is 41.1 lbmol/hr and the actual bottoms rate is 58.9 lbmol/hr from a RadFrac simulation.

(f) The actual number of theoretical stages is 8 stages per a RadFrac simulation.

(g) The heal load for the condenser at the actual operation conditions is 1,114,319 BTU/hr per a RadFrac simulation.

(h) From a RadFrac simulation:





DSTWU Report with Solutions:

*** RESULTS ***

DISTILLATE TEMP. (F)	150.380
BOTTOM TEMP. (F)	201.425
MINIMUM REFLUX RATIO	0.50445
ACTUAL REFLUX RATIO	0.50496
MINIMUM STAGES	4.06022
ACTUAL EQUILIBRIUM STAGES	196.222
NUMBER OF ACTUAL STAGES ABOVE FEED	122.013
DIST. VS FEED	0.41110
CONDENSER COOLING REQUIRED (BTU/HR)	951,298.
NET CONDENSER DUTY (BTU/HR)	-951,298.
REBOILER HEATING REQUIRED (BTU/HR)	989,262.
NET REBOILER DUTY (BTU/HR)	989,262.

RadFrac Report with Solutions:

*** SUMMARY OF KEY RESULTS ***

TOP STAGE TEMPERATURE	F	150.557
BOTTOM STAGE TEMPERATURE	F	200.382
TOP STAGE LIQUID FLOW	LBMOL/HR	31.0995
BOTTOM STAGE LIQUID FLOW	LBMOL/HR	58.9000
TOP STAGE VAPOR FLOW	LBMOL/HR	0.0
BOTTOM STAGE VAPOR FLOW	LBMOL/HR	64.9746
MOLAR REFLUX RATIO		0.75668
MOLAR BOILUP RATIO		1.10313
CONDENSER DUTY (W/O SUBCOOL)	BTU/HR	-1,114,320.
REBOILER DUTY	BTU/HR	1,150,940.