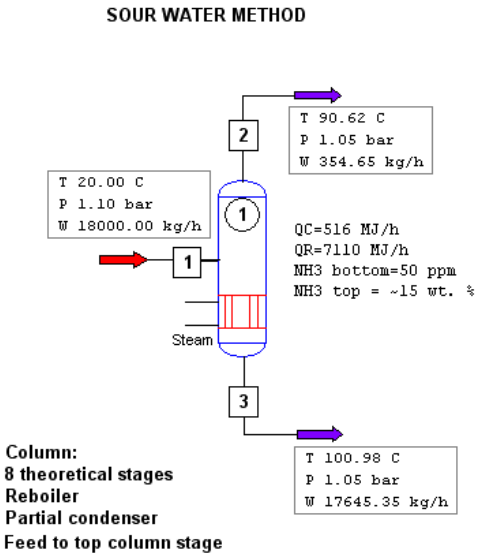
Dynamics: Stripping Biogas Permeate. Process Desing and Start-up Study

DESCRIPTION:

Permeate from biogas production, 18000 kg/h, containing 0.6 wt. % of ammonia, 0.3 wt. % of carbon dioxide, and water is to be separated into 15 wt. % ammonia as byproduct. The wastewater must be purified to 50 ppm of ammonia.

The design task is to find distillation column operating parameters and size. This is traditional design according to steady state solution. Ultimate task is to simulate real system in dynamics to determine whether assumed equipment parameters would allow startup and normal operation of the distillation column.

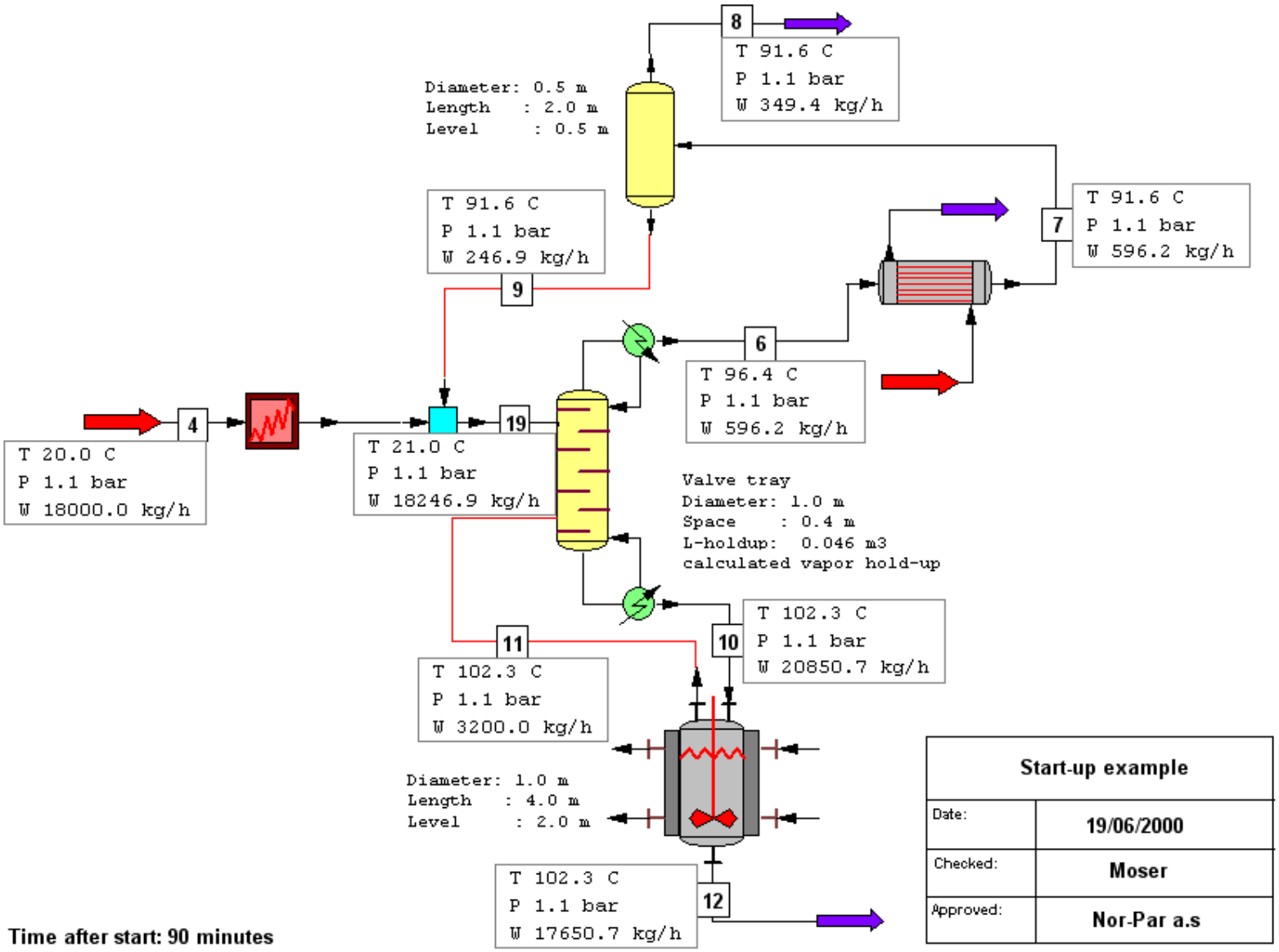
The steady state design gave these results:



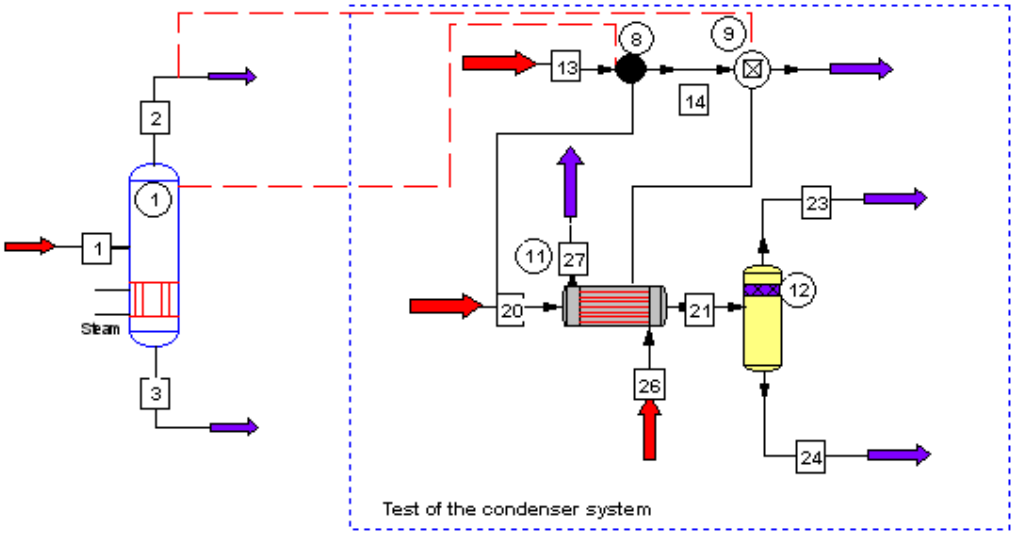
Stream No.	1	2	3
Name			
- - Overall - -			
Mass flow kg/h	18000.0	354.6	17645.4
Temp C	20.0	90.6	101.0
Pres bar	1.1	1.0	1.0
Vapor mole fraction	0.0000	1.000	0.0000
Component mass fractions			
Ammonia	0.003000	0.149776	0.000050
Carbon Dioxide	0.006000	0.304486	0.000001
Water	0.991000	0.545738	0.999949

Continuing the steady state calculation in CHEMCAD, it would be possible to get concentration, pressure and temperature profiles of the column, as well as tray or packing hydraulic calculations. With CC-Therm module, heat exchangers for condenser and reboiler could be designed. Size of vessels could be determined. **CHEMCAD can do all calculations and produce all documentation required for traditional steady state process design.**

It is more interesting, however, to design and simulate a real system to avoid future operation problems. Steady state calculations have been performed at preparatory stage, to determine required equipment sizes and initial state of the dynamic simulation. For instance, it is necessary to know heat transfer area of heat exchangers and heat transfer coefficient. Sizes of reboiler and overhead tank, as well as initial loads must be determined.

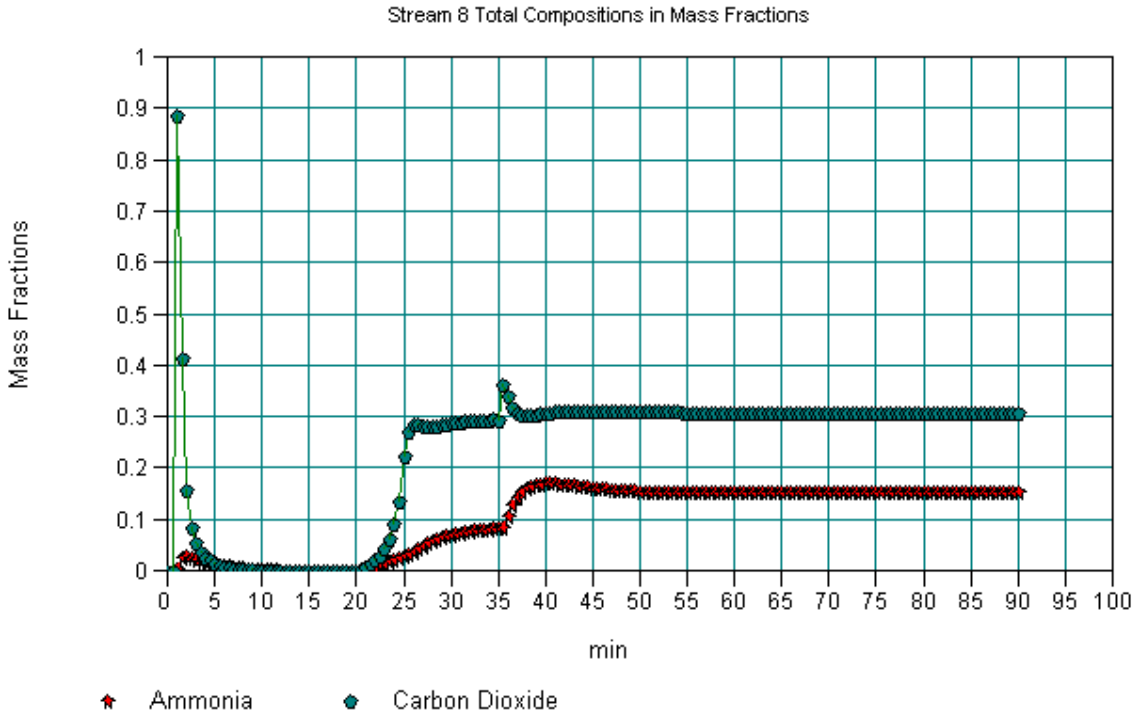

8
T 91.6 C
P 1.1 bar
W 349.4 kg/h
Diameter: 0.5 m
Length : 2.0 m
Level : 0.5 m
T 91.6 C
P 1.1 bar
W 246.9 kg/h
9
7
T 91.6 C
P 1.1 bar
W 596.2 kg/h
6
T 96.4 C
P 1.1 bar
W 596.2 kg/h
4
T 20.0 C
P 1.1 bar
W 18000.0 kg/h
19
T 21.0 C
P 1.1 bar
W 18246.9 kg/h
Valve tray
Diameter: 1.0 m
Space : 0.4 m
L-holdup: 0.046 m3
calculated vapor hold-up
T 102.3 C
P 1.1 bar
W 20850.7 kg/h
10
11
T 102.3 C
P 1.1 bar
W 3200.0 kg/h
Diameter: 1.0 m
Length : 4.0 m
Level : 2.0 m
T 102.3 C
P 1.1 bar
W 17650.7 kg/h
12
Time after start: 90 minutes
Start-up example
Date: 19/06/2000
Checked: Moser
Approved: Nor-Par a.s

The picture below shows handy calculation to determine condenser system parameters.

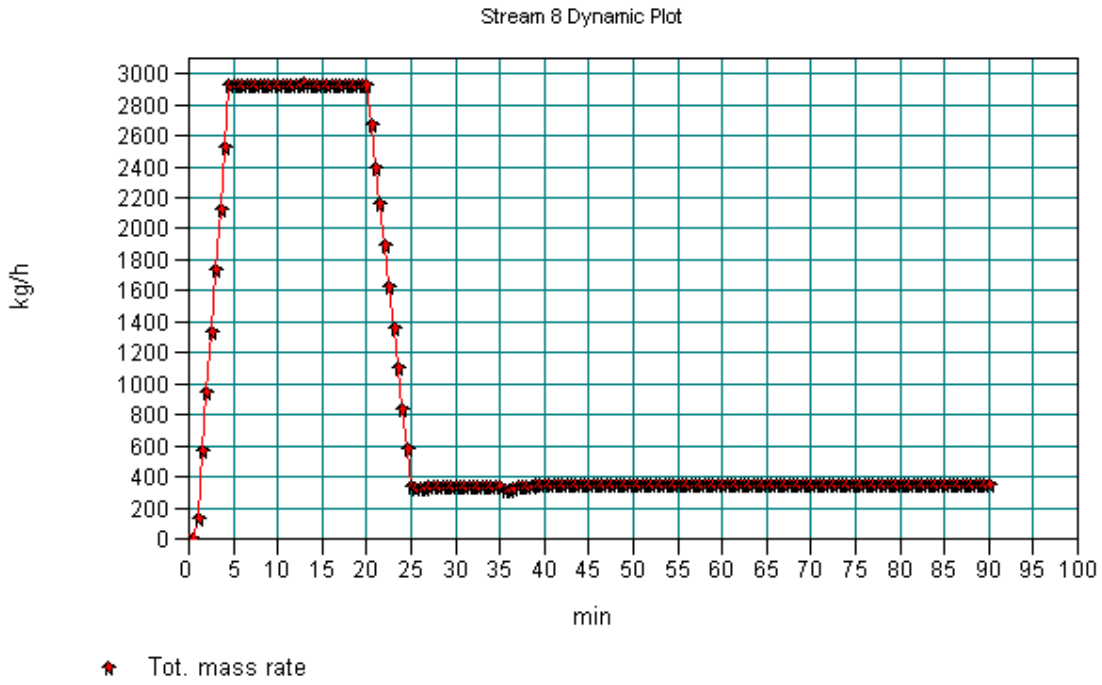


Auxilliary calculations to determine condenser heat transfer area and overhead tank size

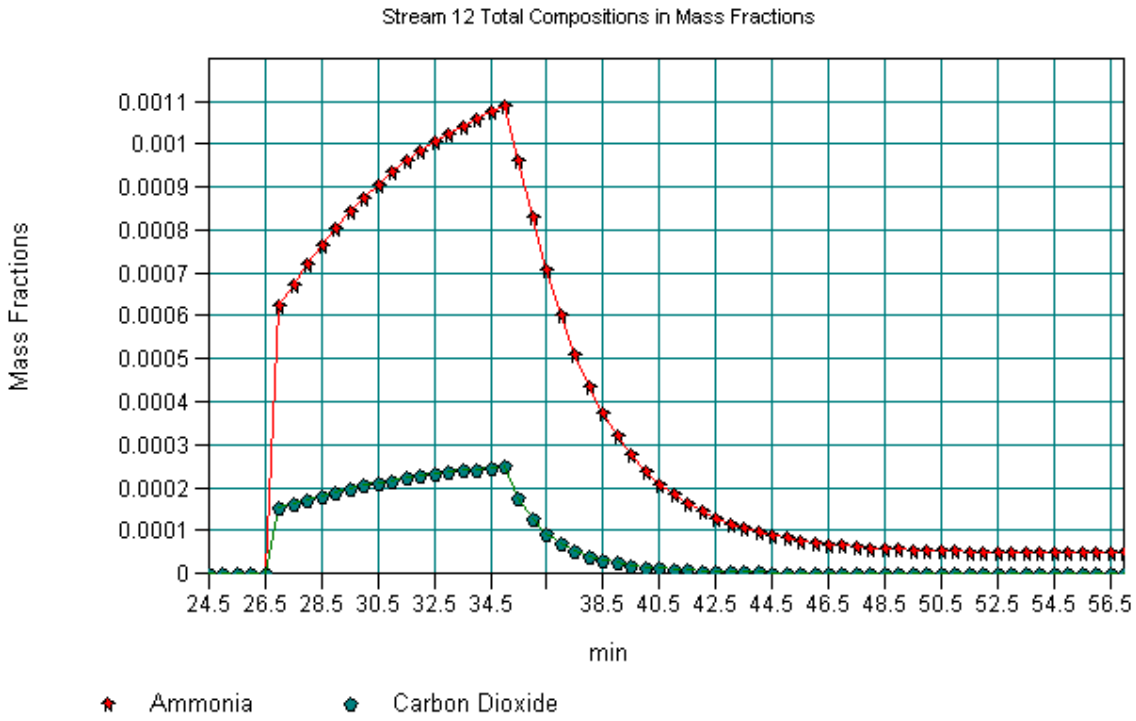
After the preparatory phase, it was possible to set up dynamic flowsheet (see picture at previous page) that simulates start-up of the distillation column (total startup time is 35 minutes). For simplicity, built-in controllers have been used.



Vapor distillate compositions over time. The system can reach constant desired ammonia concentration after 50 minutes

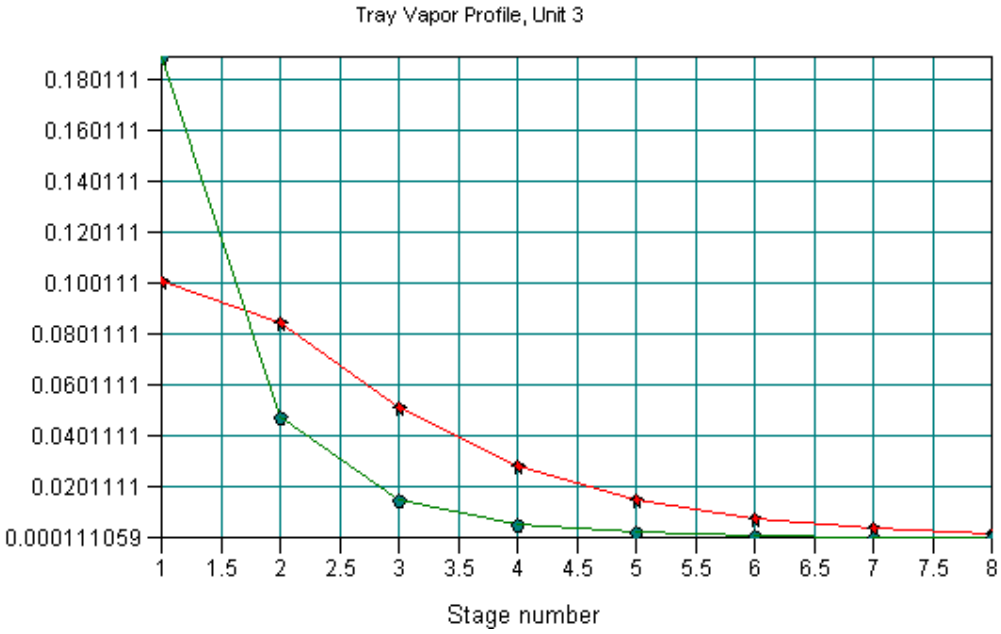


Vapor distillate mass flow rate over time

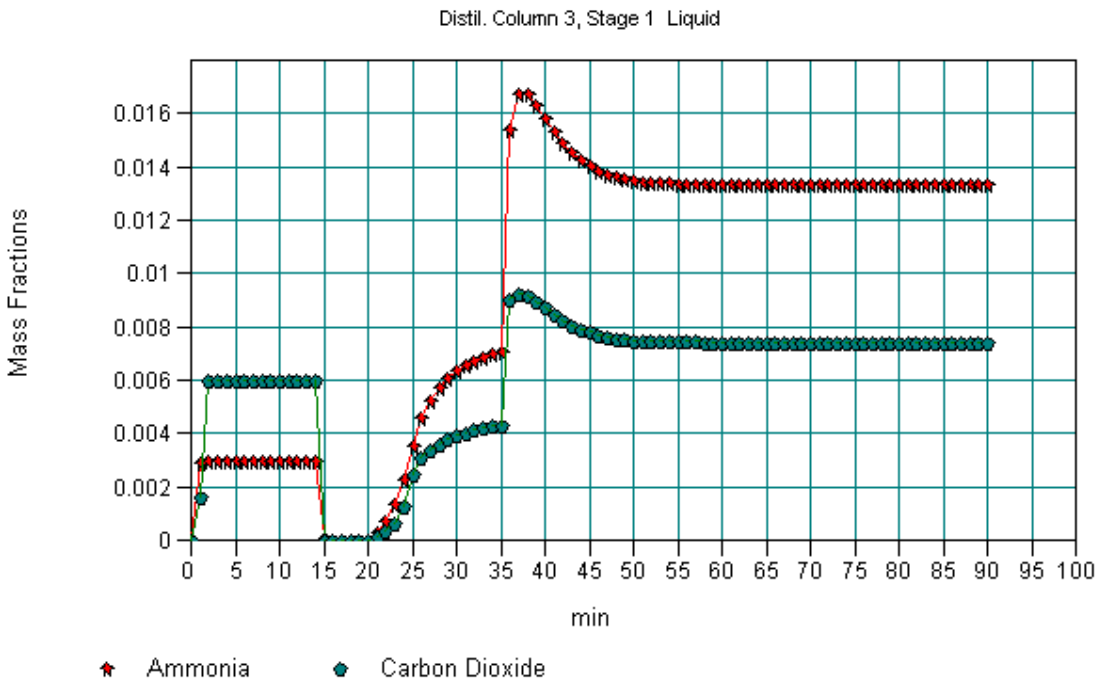


Composition of bottoms. Bottoms can reach desired purity after 52 minutes from the start of the process

Reflux rate over time



Composition profile (weight fractions) in the column at last moment of simulation



Composition at the top of the column (liquid phase) over time

The presented model can be easily expanded into full system including heat exchangers, control valves, PID controllers, etc.