Process Units
Need a modelling framework

Statfjord C Process

- Inlet Separator: 71 bar, 91°C
- Dehydration: 69 bar, 91°C
- Crude Flash 1: 23 bar, 87°C
- Crude Flash 2: 7 bar, 84°C
- Crude Flash 3: 1.7 bar, 77°C
- Coalescer: 1.7 bar, 77°C
- Gas Turbine
- To Reinjection
- To Pipeline
- Export
- Metering
- Prod. Water Treatment
- Disposal
- Sygna
- Statfjord Nord
- Statfjord Øst
- Templates

Statfjord C Wells

- Gas Turbine
- To Reinjection
- Export
- Metering
- Metering
- Metering

Imagination at work
The energy of a system is something that changes by the amount of work and heat added or removed from a system. The difference stored in the system can be stored as different types of energy: potential, kinetic, internal, displacement, surface, electric, magnetic and others.
Energy Balance: 1st law

\[ \dot{m}U_1 + \dot{m}P_1 v_1 + Q = \dot{m}U_2 + \dot{m}P_2 v_2 - W \]
With Displacement Work

\[
\dot{m}U_1 + \dot{m}P_1 v_1 + Q = \dot{m}U_2 + \dot{m}P_2 v_2 - W
\]
Second Law

Energy spontaneously disperses from being localized to becoming spread out if it is not hindered from doing so.

\[ \Delta S = \frac{q_{\text{rev}}}{T} \]

Efficiency = \( \frac{W}{q_{\text{rev}}} \)

\[
P_1 \quad V_1 \quad P=0 \\
\begin{array}{c}
P_2 \\
V_2
\end{array}
\]

\[ S_2 - S_1 = k \ln \left( \frac{V_2}{V_1} \right)^{N_A} = kN_A \ln \left( \frac{V_2}{V_1} \right) = R \ln \left( \frac{V_2}{V_1} \right) \]
Or in Other Words

\[ Q \]

\[ U_1, S_1, P_1, T_1, V_1 \]
\[ T_2, P_2 \]

\[ U_2, S_2, P_2, T_2, V_2 \]
\[ T_2, P_2 \]

\[ W \]
Or for a Flow System

- $U_1$, kJ/kg
- $H_1$, kJ/kg
- $S_1$, kJ/kgK
- $P_1$, kPa
- $V_1$, m$^3$/kg
- Mass, kg/s

- $U_2$, kJ/kg
- $H_2$, kJ/kg
- $S_2$, kJ/kgK
- $P_2$, kPa
- $V_2$, m$^3$/kg
- Mass, kg/s

Heat, $Q$ (kJ/s)

Shaft Work, $W_{\text{max}}$ (kJ/s)
Process Units

Inlet Separator

• Separates Free Oil, Gas, Water
• Provides slug capacity
• Separator is designed to:
  - Slow down the liquid-phase
  - Enhance stratified flow
  - Give time for droplets to coalesce
  - Give time for gas bubbles to rise to surface
• Second stage often two-phase (gas-liquid)
Process Units: Recompression

Scrubbers/Coolers protect Compressor
Scrubber liquid sometimes recycled
Final cooler conditions affect Vapor Pressure
Separator

F, mol/s

y

x

V, mol/s

L, mol/s
Process Units in Hysys

Hydrocarbon phase behaviour control

These two are well described by thermodynamic theory

- **Dewpoint at chosen pressure**
  - Solve by varying temperature and liquid composition until

\[
1 = \sum_{i=1}^{N_c} \frac{K_i}{z_i}
\]

- **TVP (Bubble Point)**
  - Solve by varying pressure and vapor composition until

\[
1 = \sum_{i=1}^{N_c} K_i z_i
\]

These two are well described by thermodynamic theory

- **RVP**
  - Simulate experiment
  - Cold liquid, warm/wet gas in correct volumetric ratio
  - Solve flash equation by solving for total volume (varying pressure)
Separator Modelling in Hysys

Known

• Fluid Conditions from Feed
• Phase rates known from Feed Rate

Performs only a split
Compressor/Expander Pump Modelling in Hysys

Known:
- Feed condition and rates known from stream
- Outlet pressure is specified either directly or from another stream
- Adiabatic or polytropic efficiencies are specified

Unknown: Outlet T

Solution:
- Entropy balance to Outlet P
- Adiabatic balance from Outlet P, Intermediate Enthalpy and Efficiency
Heat Transfer Modelling in Hysys

Known: Inlet Conditions and Outlet T
Unknown: Duty (heat to be added or removed)
Solve by enthalpy balance

° Known: Feed Rates and inlet conditions on each stream, 1 Approach
° Unknown: Outlet condition on other stream
° Solve by Enthalpy balance
Valve Modelling in Hysys

Known
- Feed condition from Stream
- Outlet pressure

Unknown
- Outlet Condition

Solution
- Enthalpy Balance
Effect of Valves

<table>
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<th>Pressure bara</th>
<th>Oil volume factor Bo&lt;sup&gt;(1)&lt;/sup&gt;</th>
<th>Gas Oil ratio Rs&lt;sup&gt;(2)&lt;/sup&gt;</th>
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</table>

Liquid density at STP: 0.8632 g/cm³

* Formation pressure
** Saturation pressure
Effect of Coolers on Gas

Compressor

Cooler

Separator

Inlet Separator

69 bar, 91°C

Scrubber

Cooler

Separator

Inlet Separator

69 bar, 91°C

Scrubber

Compressor

Separator

Inlet Separator

69 bar, 91°C

Scrubber

Cooler

Separator

Inlet Separator

69 bar, 91°C

Scrubber

Compressor

Separator

Inlet Separator

69 bar, 91°C

Scrubber

Cooler
Effect of Relief Valves

Pressure

Temperature

Separator

$T_{sep}$, $P_{sep}$