Example 5: Mass-Balance Only with Three Constraints/Targets (or Design-specs)

Let's add a 3rd design-spec to Example 4.

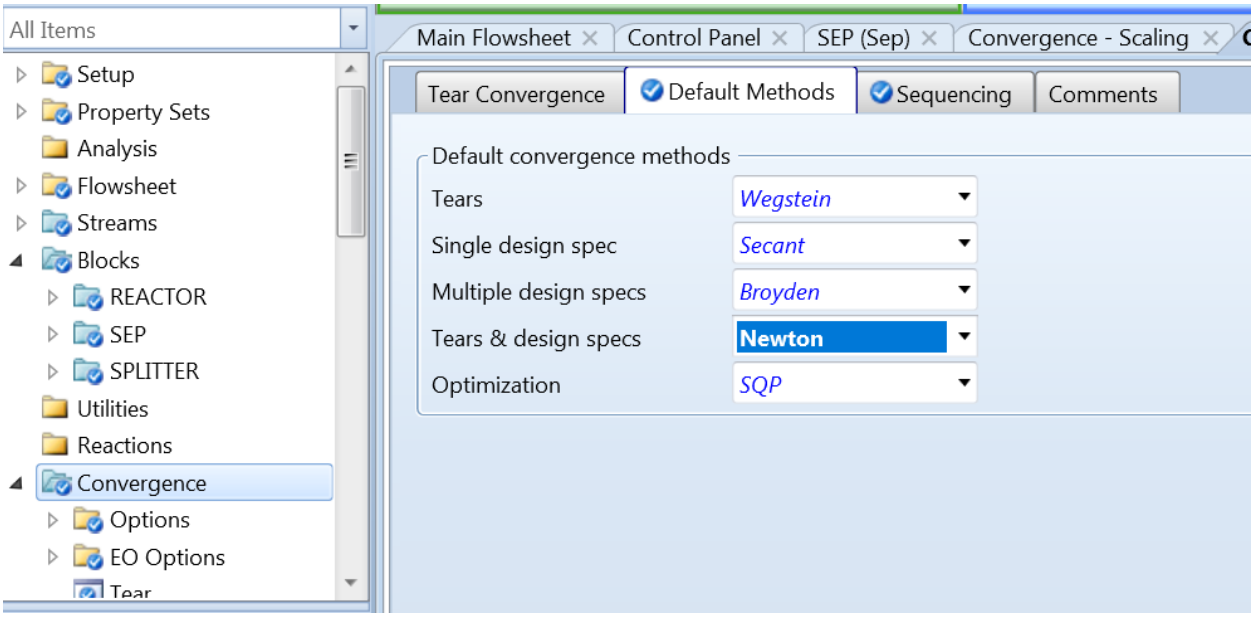
This time, we want the ratio of the flow rate of the recycle stream to that of S1 to be a certain value, say 3.0. In Example 4, the recycle flow rate is 180 lbmol/hr, while that of S1 is 58.3853. So currently the ratio is a bit too high at 3.0830. What can affect this ratio? It's clear that the splitter fraction controls the flow rate of the recycle stream. So we can vary the split fraction of the splitter going to the recycle stream, which currently has a value of 0.90.

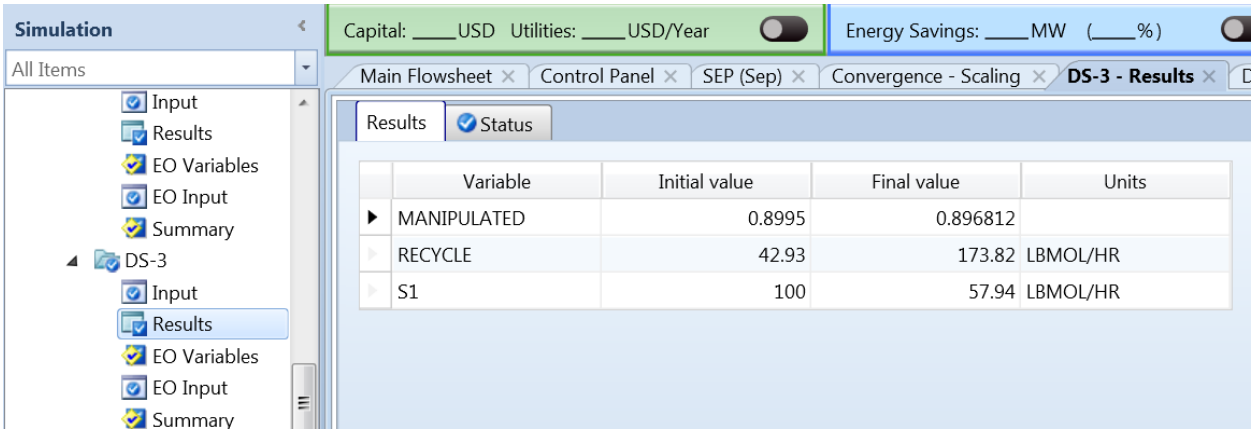
Set up a third design-spec to:

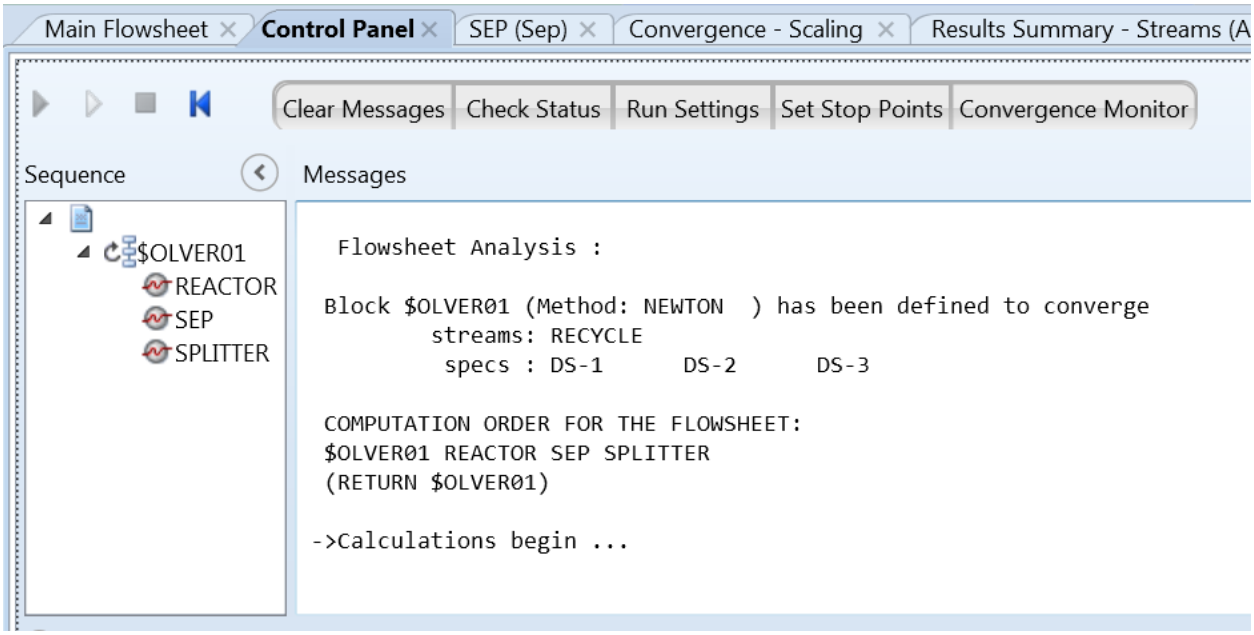
1. Vary the split fraction the recycle stream in the flow splitter by specifying a range for A+ to adjust (0.85 – 0.90).
2. Specify the ratio of RECYCLE/S1 flow rates at 3.0.
3. Specify the tolerance of the target (plus/minus).

Points to observe:

1. Notice that there are now 4 convergence loops, namely one for the tear stream and three for the three design-specs. However, converging the 4 loops simultaneously using Broyden no longer works because we hit the maximum number of iterations of 30 using Broyden. While it's possible to increase this maximum number of iterations, it's better to switch another convergence algorithm, which is Newton. Newton's method will converge the 4 loops.
2. The total number of iterations for the collapsed single loop using Newton is 38 (passes).
3. The process feed flow (S1) was found to be 57.94 lbmol/hr (DS-1), the split fraction of methane going to Stream S3 was found to be 0.936652 (DS-2), and the split fraction going to RECYCLE is 0.896812 (DS-3).
4. Note that RECYCLE flow rate = 173.82 lbmol/hr, while S1 flow rate = 57.94 lbmol/hr. Taking the ratio of the two numbers 173.82/57.94 = 3.0 exactly.


All Items
Setup
Property Sets
Analysis
Flowsheet
Streams
Blocks
REACTOR
SEP
SPLITTER
Utilities
Reactions
Convergence
Options
EO Options
Main Flowsheet
Control Panel
SEP (Sep)
Convergence - Scaling
Tear Convergence
Default Methods
Sequencing
Comments
Default convergence methods
Tears
Wegstein
Single design spec
Secant
Multiple design specs
Broyden
Tears & design specs
Newton
Optimization
SQP


Simulation
All Items
Input
Results
EO Variables
EO Input
Summary
DS-3
Input
Results
EO Variables
EO Input
Summary
Capital: ____USD Utilities: ____USD/Year
Energy Savings: ____MW (____%)
Main Flowsheet
Control Panel
SEP (Sep)
Convergence - Scaling
DS-3 - Results
Results
Status
Variable
Initial value
Final value
Units
MANIPULATED
0.8995
0.896812
RECYCLE
42.93
173.82
LBMOL/HR
S1
100
57.94
LBMOL/HR



		S1	S2	S3	S4	S6	RECYCLE
From			REACTOR	SEP	SEP	SPLITTER	SPLITTER
To		REACTOR	SEP	SPLITTER			REACTOR
Stream Class		CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN
Average MW		22.618092	22.962351	23.077104	22.376125	23.077104	23.077104
Mole Flows	lbmol/hr	57.939971	231.76013	193.82016	37.93997	19.999998	173.82016
CH4	lbmol/hr	23.175988	72.425049	67.837055	4.5879936	6.9999991	60.837054
O2	lbmol/hr	28.969985	5.7939971	0	5.7939971	0	0
CO2	lbmol/hr	0	78.28191	74.367815	3.9140955	7.6738979	66.693916
H2O	lbmol/hr	0	23.59927	0.4719854	23.127285	0.0487034	0.423282
H2	lbmol/hr	5.7939971	51.659904	51.143305	0.516599	5.2773973	45.865907
Mole Fractions							
CH4		0.4	0.3125	0.35	0.1209277	0.35	0.35
O2		0.5	0.025	0	0.1527149	0	0
CO2		0	0.3377713	0.3836949	0.1031655	0.3836949	0.3836949
H2O		0	0.1018263	0.0024352	0.6095757	0.0024352	0.0024352
H2		0.1	0.2229025	0.2638699	0.0136162	0.2638699	0.2638699
Mass Flows	lb/hr	1310.4916	5321.7575	4472.808	848.94951	461.54202	4011.2659