

Minimizing Process Water and Energy Consumption in Styrene Production by Ethylbenzene Dehydrogenation

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Mass Balance Results and Energy Balance

The result of the mass balance and energy balance in the process of forming dimethyl ether through the methanol dehydration process after the creation process is as follows.

Table 8. Mass balance and energy balance in the process of forming dimethyl ether

Total Phase Properties								
	Unit	Feed (Ethyl benzene)	1	2	3	4	5	6
Vapour Fraction		0	0	0	0	1	1	1
Temperature	C	25	25.01927	136	131.3065	250	99.95941	506.1845
Pressure	kPa	150	200	200	200	200	101.325	101.325
Molar Flow	kgmole/h	43.19308	43.19308	43.19308	53.25	53.25	70.3942	1538.333
Mass Flow	kg/h	4585.636	4585.636	4585.636	5618.041	5618.041	1268.159	27713.23
Actual Volume Flow	m ³ /h	5.310312	5.310172	6.030763	7.34238	1117.2	2136.604	98285.18
Heat Flow	kJ/h	-481643	-481289	464065.9	609411.9	3716367	-1.7E+07	-3.5E+08
		7	8	9	10	11	12	13
Vapour Fraction		1	1	0.00E+00	1.00E+00	8.31E-01	5.00E-01	0.00E+00
Temperature	C	605.1128	650	2.29E+01	2.60E+02	8.20E+01	8.90E+01	2.29E+01
Pressure	kPa	200	200	2.10E+00	1.80E+00	1.50E+00	1.30E+00	2.10E+00
Molar Flow	kgmole/h	745.5	745.5	3.94E+01	3.12E+02	3.12E+02	1.92E+02	3.94E+01
Mass Flow	kg/h	18088.99	18088.99	1.20E+04	8.80E+04	8.80E+04	3.96E+04	1.20E+04
Liquid Volume Flow	m ³ /h	27190.89	28586.94	4.77E+02	3.35E+03	3.55E+03	1.37E+03	4.77E+02
		14	15	16	17	18	19	20
Vapour Fraction		1	1	1	1	1	0.478596	0.051855
Temperature	C	650	640.5904	650	648.8192	350	100	30
Pressure	kPa	178.2	156.4	156.4	134.6	134.6	134.6	134.6
Molar Flow	kgmole/h	778.1753	782.8693	782.8693	784.0212	784.0212	784.0212	784.0212
Mass Flow	kg/h	18089.06	18089.06	18089.06	18089.05	18089.05	18089.05	18089.05
Actual Volume Flow	m ³ /h	33495.91	38005.77	38398.32	44629.21	30108.13	8566.224	779.1289
Heat Flow	kJ/h	-1.4E+08	-1.4E+08	-1.4E+08	-1.4E+08	-1.5E+08	-1.8E+08	-1.9E+08
		21	22	23	24	25	26	27
Vapour Fraction		1	0	0	1	0	0	0
Temperature	C	30	30	30	102.1747	160.3882	109.6607889	109.7313
Pressure	kPa	134.6	134.6	134.6	118.9	165.2	60	200
Molar Flow	kgmole/h	40.65563	52.41397	690.9516	9.480184	42.93379	10.05733419	10.05733
Mass Flow	kg/h	395.7974	5245.708	12447.55	788.4466	4457.261	1032.450946	1032.451
Actual Volume Flow	m ³ /h	760.7984	5.927402	12.40317	240.4693	5.829962	1.312227336	1.312031
Heat Flow	kJ/h	-225510	3754474	-2E+08	705872.3	4520387	144880.2974	145125.2

		28	29	30	31	32	33	34
Vapour Fraction		0	1	1	1	1	0.763738	1
Temperature	C	109.7327	777.2827	664.9454	652.8902	652.1996	108.1003	342.415
Pressure	kPa	200	300	300	300	120	134.6	134.6
Molar Flow	kgmole/h	10.05692	846.0833	846.0833	846.0833	846.0833	690.9516	690.9516
Mass Flow	kg/h	1032.405	15242.28	15242.28	15242.28	15242.28	12447.55	12447.55
Actual Volume Flow	m³/h	1.311962	24613.89	21969.4	21685.41	54216.48	12295.96	26201.19
Heat Flow	kJ/h	145346.1	-1.8E+08	-1.8E+08	-1.9E+08	-1.9E+08	-1.7E+08	-1.6E+08
		35	36	37	Water	Produk (Styrene)		
Vapour Fraction		1	1	1	0	0		
Temperature	C	342.415	342.415	342.415	27	104.3358431		
Pressure	kPa	134.6	134.6	134.6	101.325	30		
Molar Flow	kgmole/h	621.8565	69.09516	621.8565	70.3942	32.87645113		
Mass Flow	kg/h	11202.79	1244.755	11202.79	1268.159	3424.810287		
Actual Volume Flow	m³/h	23581.07	2620.119	23581.07	1.260806	4.131014326		
Heat Flow	kJ/h	-1.4E+08	-1.6E+07	-1.4E+08	-2E+07	3887554.019		

Composition								
	Ethyl benzene	1	2	3	4	5	6	7
Comp Mole Frac (E-Benzene)	1	1	1	0.947491	0.947491	0	0	0
Comp Mole Frac (Styrene)	0	0	0	0.006634	0.006634	0	0	0
Comp Mole Frac (Hydrogen)	0	0	0	8.12E-26	8.12E-26	0	0	0
Comp Mole Frac (Benzene)	0	0	0	0.000436	0.000436	0	0	0
Comp Mole Frac (Ethylene)	0	0	0	7.90E-18	7.90E-18	0	0	0
Comp Mole Frac (Toluene)	0	0	0	0.045439	0.045439	0	0	0
Comp Mole Frac (Methane)	0	0	0	1.64E-21	1.64E-21	0	0	0
Comp Mole Frac (H ₂ O)	0	0	0	1.11E-18	1.11E-18	1	1	1
	8	9	10	11	12	13	14	15
Comp Mole Frac (E-Benzene)	0	0	0	0.067678	0.067678	0.020909	0.020909	0.012665
Comp Mole Frac (Styrene)	0	0	0	0.000474	0.000474	0.040602	0.040602	0.043276
Comp Mole Frac (Hydrogen)	0	0	0	5.80E-27	5.80E-27	0.03821	0.03821	0.038777
Comp Mole Frac (Benzene)	0	0	0	3.11E-05	3.11E-05	0.001871	0.001871	0.004938
Comp Mole Frac (Ethylene)	0	0	0	5.64E-19	5.64E-19	0.001842	0.001842	0.004909
Comp Mole Frac (Toluene)	0	0	0	0.003246	0.003246	0.005047	0.005047	0.007139
Comp Mole Frac (Methane)	0	0	0	1.17E-22	1.17E-22	0.001938	0.001938	0.004048
Comp Mole Frac (H ₂ O)	1	1	1	0.928571	0.928571	0.889581	0.889581	0.884247
	16	17	18	19	20	21	22	23
Comp Mole Frac (E-Benzene)	0.012665	0.009951	0.009951	0.009951	0.002085	0.147239	7.03E-22	0.012665
Comp Mole Frac (Styrene)	0.043276	0.042277	0.042277	0.042277	0.005848	0.627856	1.56E-20	0.043276
Comp Mole Frac (Hydrogen)	0.038777	0.036558	0.036558	0.036558	0.704565	0.000324	1.20E-06	0.038777
Comp Mole Frac (Benzene)	0.004938	0.007336	0.007336	0.007336	0.012768	0.099829	2.42E-15	0.004938
Comp Mole Frac (Ethylene)	0.004909	0.007306	0.007306	0.007306	0.137612	0.00255	1.56E-10	0.004909

Comp Mole Frac (Toluene)	0.007139	0.008355	0.008355	0.008355	0.004799	0.121248	8.10E-19	0.007139
Comp Mole Frac (Methane)	0.004048	0.005268	0.005268	0.005268	0.101058	0.000419	9.85E-10	0.004048
Comp Mole Frac (H ₂ O)	0.884247	0.882948	0.882948	0.882948	0.031266	0.000535	0.999999	0.884247
	24	25	26	27	28	29	30	31
Comp Mole Frac (E-Benzene)	0.01324	0.176827	0.722167	0.722167	0.721973	0	0	0
Comp Mole Frac (Styrene)	0.000991	0.766273	0.034933	0.034933	0.035126	0	0	0
Comp Mole Frac (Hydrogen)	0.001794	1.01E-25	4.30E-25	4.30E-25	4.30E-25	0	0	0
Comp Mole Frac (Benzene)	0.549484	0.000541	0.00231	0.00231	0.002308	0	0	0
Comp Mole Frac (Ethylene)	0.014096	9.80E-18	4.18E-17	4.18E-17	4.18E-17	0	0	0
Comp Mole Frac (Toluene)	0.415116	0.056359	0.24059	0.24059	0.240592	0	0	0
Comp Mole Frac (Methane)	0.002318	2.03E-21	8.67E-21	8.67E-21	8.66E-21	0	0	0
Comp Mole Frac (H ₂ O)	0.00296	1.37E-18	5.86E-18	5.86E-18	5.85E-18	1	1	1
	32	33	34	35	36	37	Water	Produk (Styrene)
Comp Mole Frac (E-Benzene)	0	7.03E-22	7.03E-22	7.03E-22	7.03E-22	7.03E-22	0	0.01
Comp Mole Frac (Styrene)	0	1.56E-20	1.56E-20	1.56E-20	1.56E-20	1.56E-20	0	0.99
Comp Mole Frac (Hydrogen)	0	1.20E-06	1.20E-06	1.20E-06	1.20E-06	1.20E-06	0	9.76E-31
Comp Mole Frac (Benzene)	0	2.42E-15	2.42E-15	2.42E-15	2.42E-15	2.42E-15	0	6.45E-27
Comp Mole Frac (Ethylene)	0	1.56E-10	1.56E-10	1.56E-10	1.56E-10	1.56E-10	0	1.00E-30
Comp Mole Frac (Toluene)	0	8.10E-19	8.10E-19	8.10E-19	8.10E-19	8.10E-19	0	1.99E-13
Comp Mole Frac (Methane)	0	9.85E-10	9.85E-10	9.85E-10	9.85E-10	9.85E-10	0	1.00E-30
Comp Mole Frac (H ₂ O)	1	0.999999	0.999999	0.999999	0.999999	0.999999	1	9.96E-31