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APPENDICES

APPENDIX A

Table A.1.1 Process data of HDA plant alternative 1

Name	FFtol		FFH_2		Rtol		$v_1$out		bp_1	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.00000	0.00000	1.00000	1.00000	0.00000	0.00000	1.00000	1.00000	0.90932	0.90878
Temperature [°C]	30.00000	30.00000	30.00000	30.00000	140.27199	142.46194	29.99705	29.99705	63.51789	61.10720
Pressure [Psia]	635.00000	635.00000	635.00000	635.00000	605.00000	605.00000	605.00000	605.00000	605.00000	605.00000
Molar Flow [kgmole/h]	130.00000	144.64374	222.71614	245.70197	38.61616	23.97238	222.71614	245.70197	104.35062	124.64123
Comp Mole Frac [Hydrogen]	0.00000	0.00000	0.97000	0.97000	0.00000	0.00000	0.97000	0.97000	0.42902	0.43533
Comp Mole Frac [Methane]	0.00000	0.00000	0.03000	0.03000	0.00000	0.00000	0.03000	0.03000	0.47709	0.47086
Comp Mole Frac [Benzene]	0.00000	0.00000	0.00000	0.00000	0.00064	0.00086	0.00000	0.00000	0.00815	0.00880
Comp Mole Frac [Toluene]	1.00000	1.00000	0.00000	0.00000	0.99934	0.99912	0.00000	0.00000	0.08574	0.08500
Comp Mole Frac [BiPhenyl]	0.00000	0.00000	0.00000	0.00000	0.00002	0.00002	0.00000	0.00000	0.00000	0.00000

Name	cHEin		cHEout		vbp_1out		$m_4$out		Rin	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.90932	0.90878	1.00000	1.00000	0.91025	0.90966	1.00000	1.00000	1.00000	1.00000
Temperature [°C]	63.51789	61.10720	609.99576	610.32853	62.88729	60.51198	584.02005	579.24967	621.11111	621.11111
Pressure [Psia]	605.00000	605.00000	543.00000	544.18300	543.00000	544.18300	543.00000	544.18300	503.00000	502.64000
Molar Flow [kgmole/h]	1883.28032	1872.81170	1883.28032	1872.81170	104.35062	124.64123	1987.63094	1997.45293	1987.63094	1997.45293
Comp Mole Frac [Hydrogen]	0.42902	0.43533	0.42902	0.43533	0.42902	0.43533	0.42902	0.43533	0.42902	0.43533
Comp Mole Frac [Methane]	0.47709	0.47086	0.47709	0.47086	0.47709	0.47086	0.47709	0.47086	0.47709	0.47086
Comp Mole Frac [Benzene]	0.00815	0.00880	0.00815	0.00880	0.00815	0.00880	0.00815	0.00880	0.00815	0.00880
Comp Mole Frac [Toluene]	0.08574	0.08500	0.08574	0.08500	0.08574	0.08500	0.08574	0.08500	0.08574	0.08500
Comp Mole Frac [BiPhenyl]	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table A.1.1 Process data of HDA plant alternative 1 (cont)

Name	Rout		quench		m_4out		Rin		Rout	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	1.00000	1.00000	0.00000	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
Temperature (°C)	665.67038	669.18903	45.46224	45.45683	584.02005	579.24967	621.11111	621.11111	665.67038	669.18903
Pressure (Psia)	486.00000	485.48200	486.00000	485.48200	543.00000	544.18300	503.00000	502.64000	486.00000	485.48200
Molar Flow (kgmole/h)	1987.63098	1997.45296	49.00000	52.93976	1987.63094	1997.45293	1987.63094	1997.45293	1987.63098	1997.45296
Comp Mole Frac (Hydrogen)	0.36518	0.36525	0.00465	0.00453	0.42902	0.43533	0.42902	0.43533	0.36518	0.36525
Comp Mole Frac (Methane)	0.54233	0.54317	0.04505	0.04461	0.47709	0.47086	0.47709	0.47086	0.54233	0.54317
Comp Mole Frac (Benzene)	0.07058	0.07667	0.70969	0.78335	0.00815	0.00880	0.00815	0.00880	0.07058	0.07667
Comp Mole Frac (Toluene)	0.02050	0.01270	0.22442	0.14139	0.08574	0.08500	0.08574	0.08500	0.02050	0.01270
Comp Mole Frac (BiPhenyl)	0.00140	0.00222	0.01619	0.02612	0.00000	0.00000	0.00000	0.00000	0.00140	0.00222

Name	quench		m_2out		toX_1		hHEin		hHEout	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.00000	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	0.97042	0.97836
Temperature (°C)	45.46224	45.45683	621.06708	621.11113	621.06708	621.11113	621.06708	621.11096	119.43767	123.55475
Pressure (Psia)	486.00000	485.48200	486.00000	485.48200	486.00000	485.48200	486.00000	485.33000	480.00000	479.16300
Molar Flow (kgmole/h)	49.00000	52.93976	2036.63098	2050.39272	2036.63098	2050.39272	2036.63098	2050.39271	2036.63098	2050.39268
Comp Mole Frac (Hydrogen)	0.00465	0.00453	0.35651	0.35593	0.35651	0.35593	0.35651	0.35593	0.35651	0.35593
Comp Mole Frac (Methane)	0.04505	0.04461	0.53036	0.53030	0.53036	0.53030	0.53036	0.53030	0.53036	0.53030
Comp Mole Frac (Benzene)	0.70969	0.78335	0.08596	0.09492	0.08596	0.09492	0.08596	0.09492	0.08596	0.09492
Comp Mole Frac (Toluene)	0.22442	0.14139	0.02541	0.01602	0.02541	0.01602	0.02541	0.01602	0.02541	0.01602
Comp Mole Frac (BiPhenyl)	0.01619	0.02612	0.00176	0.00284	0.00176	0.00284	0.00176	0.00284	0.00176	0.00284

Table A.1.1 Process data of HDA plant alternative 1 (cont)

Name	coolout		gas		liq		purge		grecycle	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.89149	0.89145	1.00000	1.00000	0.00000	0.00000	1.00000	1.00000	1.00000	1.00000
Temperature (°C)	45.00000	45.00000	45.00000	45.00002	45.00000	45.00002	45.00000	45.00002	45.00000	45.00002
Pressure (Psia)	476.80000	475.85900	476.80000	475.85900	476.80000	475.85900	476.80000	475.85900	476.80000	475.85900
Molar Flow (kgmole/h)	2036.63098	2050.39266	1815.63910	1827.83135	220.99188	222.56130	219.34045	244.69651	1596.29865	1583.13483
Comp Mole Frac (Hydrogen)	0.35651	0.35593	0.39934	0.39872	0.00465	0.00453	0.39934	0.39872	0.39934	0.39872
Comp Mole Frac (Methane)	0.53036	0.53030	0.58944	0.58944	0.04505	0.04461	0.58944	0.58944	0.58944	0.58944
Comp Mole Frac (Benzene)	0.08596	0.09492	0.01004	0.01109	0.70969	0.78335	0.01004	0.01109	0.01004	0.01109
Comp Mole Frac (Toluene)	0.02541	0.01602	0.00119	0.00075	0.22442	0.14139	0.00119	0.00075	0.00119	0.00075
Comp Mole Frac (BiPhenyl)	0.00176	0.00284	0.00000	0.00000	0.01619	0.02612	0.00000	0.00000	0.00000	0.00000

Name	v4out		dischg		p1out		toquench		toC1	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	1.00000	1.00000	1.00000	1.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Temperature (°C)	44.97574	44.60401	70.31439	70.50648	45.25334	45.25212	45.25334	45.25212	45.25334	45.25212
Pressure (Psia)	475.00000	446.80000	605.00000	605.00000	551.60000	550.75400	551.60000	550.75400	551.60000	550.75400
Molar Flow (kgmole/h)	219.34045	244.69651	1596.29865	1583.13483	220.99188	222.56130	49.00000	52.93976	171.99188	169.62154
Comp Mole Frac (Hydrogen)	0.39934	0.39872	0.39934	0.39872	0.00465	0.00453	0.00465	0.00453	0.00465	0.00453
Comp Mole Frac (Methane)	0.58944	0.58944	0.58944	0.58944	0.04505	0.04461	0.04505	0.04461	0.04505	0.04461
Comp Mole Frac (Benzene)	0.01004	0.01109	0.01004	0.01109	0.70969	0.78335	0.70969	0.78335	0.70969	0.78335
Comp Mole Frac (Toluene)	0.00119	0.00075	0.00119	0.00075	0.22442	0.14139	0.22442	0.14139	0.22442	0.14139
Comp Mole Frac (BiPhenyl)	0.00000	0.00000	0.00000	0.00000	0.01619	0.02612	0.01619	0.02612	0.01619	0.02612

Table A.1.1 Process data of HDA plant alternative 1 (cont)

Name	v11out		v5out		d1		b1		v6out	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.00000	0.00000	0.02954	0.02943	1.00000	1.00000	0.00000	0.00000	1.00000	1.00000
Temperature (°C)	45.46224	45.45683	45.97125	45.93972	51.04971	50.32124	190.51377	187.46922	50.14766	49.41655
Pressure (Psia)	486.00000	485.48200	152.00000	150.22700	150.00000	150.00000	153.00000	150.56700	120.00000	120.00000
Molar Flow (kgmole/h)	49.00000	52.93976	171.99188	169.62154	8.92567	8.69490	163.06621	160.92649	8.92567	8.69490
Comp Mole Frac (Hydrogen)	0.00465	0.00453	0.00465	0.00453	0.08965	0.08834	0.00000	0.00000	0.08965	0.08834
Comp Mole Frac (Methane)	0.04505	0.04461	0.04505	0.04461	0.86801	0.87017	0.00000	0.00000	0.86801	0.87017
Comp Mole Frac (Benzene)	0.70969	0.78335	0.70969	0.78335	0.04200	0.04130	0.74623	0.82344	0.04200	0.04130
Comp Mole Frac (Toluene)	0.22442	0.14139	0.22442	0.14139	0.00034	0.00019	0.23669	0.14902	0.00034	0.00019
Comp Mole Frac (BiPhenyl)	0.01619	0.02612	0.01619	0.02612	0.00000	0.00000	0.01708	0.02754	0.00000	0.00000

Name	v7out		d2		b2		v8out		p2out	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.45070	0.43494	0.00000	0.00000	0.00000	0.00000	0.11624	0.11625	0.00000	0.00000
Temperature (°C)	116.79289	116.68007	105.54995	105.54983	144.66713	153.90518	80.85270	80.85093	144.74760	154.00755
Pressure (Psia)	32.00000	33.58400	30.00000	30.00000	33.00000	36.89400	15.00000	15.00000	53.00000	64.86300
Molar Flow (kgmole/h)	163.06621	160.92649	121.69729	132.52128	41.36892	28.40474	121.69729	132.52128	41.36892	28.40474
Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Methane)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Benzene)	0.74623	0.82344	0.99970	0.99978	0.00060	0.00073	0.99970	0.99978	0.00060	0.00073
Comp Mole Frac (Toluene)	0.23669	0.14902	0.00030	0.00021	0.93208	0.84327	0.00030	0.00021	0.93208	0.84327
Comp Mole Frac (BiPhenyl)	0.01708	0.02754	0.00000	0.00000	0.06732	0.15600	0.00000	0.00000	0.06732	0.15600

Table A.1.1 Process data of HDA plant alternative 1 (cont)

Name	$v_9$out		d_3		b_3		v_{10}out		$p_3$out	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.00932	0.06255	0.00000	0.00000	0.00000	0.00000	0.35924	0.35353	0.00000	0.00000
Temperature (°C)	143.37335	145.57140	137.63744	137.62778	292.68143	292.15065	259.38998	259.37957	140.21783	141.72702
Pressure (Psia)	32.00000	30.23400	30.00000	30.00000	31.00000	30.72800	16.00000	16.00000	635.00000	1003.80800
Molar Flow (kgmole/h)	41.36892	28.40474	38.58418	23.97238	2.78474	4.43221	2.78474	4.43221	38.58418	23.97238
Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Methane)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Benzene)	0.00060	0.00073	0.00064	0.00086	0.00000	0.00000	0.00000	0.00000	0.00064	0.00086
Comp Mole Frac (Toluene)	0.93208	0.84327	0.99934	0.99912	0.00026	0.00035	0.00026	0.00035	0.99934	0.99912
Comp Mole Frac (BiPhenyl)	0.06732	0.15600	0.00002	0.00002	0.99974	0.99965	0.99974	0.99965	0.00002	0.00002

Name	$v_3$out	
	steady state	dynamic
Vapour Fraction	0.00000	0.00000
Temperature (°C)	140.27200	142.46194
Pressure (Psia)	605.00000	605.00000
Molar Flow (kgmole/h)	38.58418	23.97238
Comp Mole Frac (Hydrogen)	0.00000	0.00000
Comp Mole Frac (Methane)	0.00000	0.00000
Comp Mole Frac (Benzene)	0.00064	0.00086
Comp Mole Frac (Toluene)	0.99934	0.99912
Comp Mole Frac (BiPhenyl)	0.00002	0.00002

Table A.1.2 Energy stream data of HDA plant alternative 1

Name	qfur		qcooler		qc_1		qc_2		qc_3	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Heat Fow (kw)	1388.74257	1566.50954	3189.62955	3434.00391	189.60023	179.57246	4007.46522	4074.92418	427.00988	297.126798

Name	qr_1		qr_2		qr_3		wkcomp		wkp_1	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Heat Fow (kw)	1272.24116	1222.66819	3413.66888	3511.35683	467.81367	359.89953	377.81969	377.819699	3.97953	3.979538

Name	wkp_2		wkp_3		qx_1	
	steady state	dynamic	steady state	dynamic	steady state	dynamic
Heat Fow (kw)	0.2669872	0.26661706	7.30638249	7.30638218	-	0

Table A.2.1 Process data of HDA plant alternative 2

Name	FFH$_2$		v$_1$out		FFtol		v$_2$out		Rtol	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	1.00000	1.00000	1.00000	1.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Temperature (C)	30.00000	30.00000	29.99705	29.99686	30.00000	30.00000	30.11499	30.12150	182.60467	181.97799
Pressure (psia)	635.00000	635.00000	605.00000	603.30262	635.00000	635.00000	605.00000	603.30262	605.00000	603.30262
Molar Flow (kgmole/h)	222.71614	221.29956	222.71614	221.29956	131.08954	129.41345	131.08954	129.41345	33.49568	40.03108
Comp Mole Frac (Hydrogen)	0.97000	0.97000	0.97000	0.97000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Methane)	0.03000	0.03000	0.03000	0.03000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Benzene)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00087	0.00123
Comp Mole Frac (Toluene)	0.00000	0.00000	0.00000	0.00000	1.00000	1.00000	1.00000	1.00000	0.99870	0.99833
Comp Mole Frac (BiPhenyl)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00043	0.00044

Name	tox$_1$		cHEout		hHEout		Rin		Rout	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	-	1.00000	1.00000	1.00000	0.98744	0.98603	1.00000	1.00000	1.00000	1.00000
Temperature (C)	-	621.11112	596.66667	604.56530	129.46983	128.75233	621.11111	621.11112	665.47890	665.07352
Pressure (psia)	-	487.05487	543.00000	545.90695	480.00000	480.57736	503.00000	504.23495	486.00000	487.05487
Molar Flow (kgmole/h)	-	2064.19859	1879.46101	1886.07211	2032.81533	2064.19870	1983.60001	2015.37945	1983.60005	2015.37940
Comp Mole Frac (Hydrogen)	-	0.35869	0.43904	0.43001	0.36721	0.35869	0.43904	0.43001	0.37620	0.36727
Comp Mole Frac (Methane)	-	0.52924	0.46895	0.47692	0.52130	0.52924	0.46895	0.47692	0.53314	0.54097
Comp Mole Frac (Benzene)	-	0.08446	0.00813	0.00804	0.08528	0.08446	0.00813	0.00804	0.06962	0.06946
Comp Mole Frac (Toluene)	-	0.02594	0.08387	0.08503	0.02449	0.02594	0.08387	0.08503	0.01968	0.02097
Comp Mole Frac (BiPhenyl)	-	0.00166	0.00001	0.00001	0.00172	0.00166	0.00001	0.00001	0.00136	0.00133

Table A.2.1 Process data of HDA plant alternative 2 (cont)

Name	gas		liq		grecycle		purge		dicharge	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	1.00000	1.00000	0.00000	0.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
Temperature (C)	45.00000	45.00000	45.00000	45.00000	45.00000	45.00000	45.00000	45.00000	70.38487	69.91251
Pressure (psia)	476.80000	477.26383	476.80000	477.26383	476.80000	477.26383	476.80000	477.26383	605.00000	603.30262
Molar Flow (kgmole/h)	1815.93439	1842.43247	216.88093	221.76620	1596.29865	1624.63533	219.63574	217.79714	1596.29865	1624.63533
Comp Mole Frac (Hydrogen)	0.41050	0.40130	0.00477	0.00469	0.41050	0.40130	0.41050	0.40130	0.41050	0.40130
Comp Mole Frac (Methane)	0.57828	0.58753	0.04418	0.04497	0.57828	0.58753	0.57828	0.58753	0.57828	0.58753
Comp Mole Frac (Benzene)	0.01007	0.00994	0.71506	0.70355	0.01007	0.00994	0.01007	0.00994	0.01007	0.00994
Comp Mole Frac (Toluene)	0.00116	0.00122	0.21985	0.23134	0.00116	0.00122	0.00116	0.00122	0.00116	0.00122
Comp Mole Frac (BiPhenyl)	0.00000	0.00000	0.01613	0.01545	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Name	toC_1		v_5out		d_1		b_1		v_4out	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.00000	0.00000	0.02915	0.02977	1.00000	1.00000	0.00000	0.00000	1.00000	1.00000
Temperature (C)	45.25341	45.24750	45.99086	45.96362	51.04137	74.47282	189.39256	189.69911	44.60447	44.58933
Pressure (psia)	551.60000	550.31886	150.30000	150.08353	150.00000	149.99993	150.54317	150.33968	446.80000	446.80000
Molar Flow (kgmole/h)	167.66566	172.94701	167.66566	172.94701	8.57024	9.45864	159.09542	163.48830	219.63574	217.79714
Comp Mole Frac (Hydrogen)	0.00477	0.00469	0.00477	0.00469	0.09333	0.08571	0.00000	0.00000	0.41050	0.40130
Comp Mole Frac (Methane)	0.04418	0.04497	0.04418	0.04497	0.86434	0.82221	0.00000	0.00000	0.57828	0.58753
Comp Mole Frac (Benzene)	0.71506	0.70355	0.71506	0.70355	0.04200	0.09115	0.75132	0.73898	0.01007	0.00994
Comp Mole Frac (Toluene)	0.21985	0.23134	0.21985	0.23134	0.00033	0.00093	0.23168	0.24467	0.00116	0.00122
Comp Mole Frac (BiPhenyl)	0.01613	0.01545	0.01613	0.01545	0.00000	0.00000	0.01700	0.01634	0.00000	0.00000

Table A.2.1 Process data of HDA plant alternative 2 (cont)

Name	d2		b2		tov9		v9out		p2out	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Temperature (C)	105.55001	105.54866	143.65031	143.32186	143.90473	143.57822	143.93694	143.60707	143.90473	143.57822
Pressure (psia)	30.00000	29.99995	32.20905	32.16384	95.96762	95.58683	75.75319	76.87491	95.96762	95.58683
Molar Flow (kgmole/h)	119.58017	120.79627	423.65750	426.80919	39.51434	42.68918	39.51434	42.68918	423.65659	426.83202
Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Methane)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Benzene)	0.99970	0.99970	0.00095	0.00116	0.00095	0.00116	0.00095	0.00116	0.00095	0.00116
Comp Mole Frac (Toluene)	0.00030	0.00030	0.93077	0.93620	0.93077	0.93619	0.93077	0.93619	0.93077	0.93619
Comp Mole Frac (BiPhenyl)	0.00000	0.00000	0.06828	0.06265	0.06828	0.06266	0.06828	0.06266	0.06828	0.06266

Name	v12out		toTop3		d3		b3		hCRout	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	1.00000	1.00000	0.01889	0.00805	1.00000	1.00000	0.00000	0.00000	0.00000	0.00000
Temperature (C)	143.02286	143.02286	180.17695	181.05154	180.64937	181.56308	346.88665	347.54321	178.16575	178.13319
Pressure (psia)	27.20905	27.20905	75.42000	76.73903	75.41960	76.73643	76.43487	77.19769	72.51885	72.51954
Molar Flow (kgmole/h)	0.00091	0.00000	9.98685	9.98685	46.81733	50.01704	2.68386	2.65814	43.50738	50.00990
Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Methane)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Benzene)	0.00205	0.00205	0.00087	0.00123	0.00099	0.00123	0.00000	0.00000	0.00099	0.00123
Comp Mole Frac (Toluene)	0.99616	0.99616	0.99870	0.99833	0.99861	0.99833	0.00026	0.00027	0.99861	0.99833
Comp Mole Frac (BiPhenyl)	0.00179	0.00179	0.00042	0.00044	0.00041	0.00044	0.99974	0.99973	0.00041	0.00044

Table A.2.1 Process data of HDA plant alternative 2 (cont)

Name	v_{15}in		v_{15}out		$p_3$out		tov$_{11}$		Tout$_2$	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.00000	0.00000	0.01889	0.00805	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Temperature (C)	182.40862	181.86269	180.17488	181.05154	182.40862	181.86269	182.40862	181.86269	178.16984	178.15609
Pressure (psia)	875.00000	769.95696	75.42000	76.73903	875.00000	769.95696	875.00000	769.95696	72.51885	72.51954
Molar Flow (kgmole/h)	9.98685	9.98685	9.98685	9.98685	43.46780	50.01793	33.48095	40.03108	43.46780	50.01793
Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Methane)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Benzene)	0.00093	0.00123	0.00093	0.00123	0.00093	0.00123	0.00093	0.00123	0.00093	0.00123
Comp Mole Frac (Toluene)	0.99863	0.99833	0.99863	0.99833	0.99863	0.99833	0.99863	0.99833	0.99863	0.99833
Comp Mole Frac (BiPhenyl)	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044

Name	$v_8$out		v_{10}out		bp$_2$		hCRin		v_{16}out	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.11624	0.11623	0.18475	0.19346	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
Temperature (C)	80.85283	80.85269	332.80374	332.80333	180.64937	181.56299	180.64937	181.56299	180.32205	181.08893
Pressure (psia)	15.00006	15.00006	61.43492	61.43492	75.41960	76.73643	75.41960	76.73643	72.51885	72.51954
Molar Flow (kgmole/h)	119.58017	120.79627	2.68386	2.65814	3.30995	0.00799	43.50738	50.00904	3.30995	0.00799
Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Methane)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Benzene)	0.99970	0.99970	0.00000	0.00000	0.00099	0.00123	0.00099	0.00123	0.00099	0.00123
Comp Mole Frac (Toluene)	0.00030	0.00030	0.00026	0.00027	0.99861	0.99833	0.99861	0.99833	0.99861	0.99833
Comp Mole Frac (BiPhenyl)	0.00000	0.00000	0.99974	0.99973	0.00041	0.00044	0.00041	0.00044	0.00041	0.00044

Table A.2.1 Process data of HDA plant alternative 2 (cont)

Name	vbp1out		mbpout		hHEin		Toltol		Rgas	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.91292	0.91208	1.00000	1.00000	1.00000	1.00000	0.00000	0.00000	1.00000	1.00000
Temperature (C)	64.80321	65.89894	571.29498	573.20771	620.18979	621.11098	65.85703	71.13267	70.38274	69.91251
Pressure (psia)	543.00000	545.90695	543.00000	545.90695	486.00000	486.90219	605.00000	603.30262	605.00000	603.30262
Molar Flow (kgmole/h)	104.13900	129.30731	1983.60001	2015.37942	2032.81533	2064.19857	164.58522	169.44453	1596.29865	1624.63533
Comp Mole Frac (Hydrogen)	0.43904	0.43001	0.43904	0.43001	0.36721	0.35869	0.00000	0.00000	0.41022	0.40130
Comp Mole Frac (Methane)	0.46895	0.47692	0.46895	0.47692	0.52130	0.52924	0.00000	0.00000	0.57854	0.58753
Comp Mole Frac (Benzene)	0.00813	0.00804	0.00813	0.00804	0.08528	0.08446	0.00018	0.00029	0.01009	0.00994
Comp Mole Frac (Toluene)	0.08387	0.08503	0.08387	0.08503	0.02449	0.02594	0.99974	0.99961	0.00115	0.00122
Comp Mole Frac (BiPhenyl)	0.00001	0.00001	0.00001	0.00001	0.00172	0.00166	0.00009	0.00010	0.00000	0.00000

Name	cHEin		quench		M2out		coolout		toquench	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.91199	0.91119	0.00000	0.00000	1.00000	1.00000	0.89331	0.89257	0.00000	0.00000
Temperature (C)	65.44733	66.50737	45.46230	45.44923	620.18304	621.11111	45.00000	44.99998	45.25341	45.24750
Pressure (psia)	605.00000	603.30262	486.00000	487.05487	486.00000	487.05487	476.80000	477.26383	551.60000	550.31886
Molar Flow (kgmole/h)	1879.46101	1886.07211	49.21528	48.81918	2032.81533	2064.19859	2032.81533	2064.19869	49.21528	48.81918
Comp Mole Frac (Hydrogen)	0.43904	0.43001	0.00477	0.00469	0.36721	0.35869	0.36721	0.35869	0.00477	0.00469
Comp Mole Frac (Methane)	0.46895	0.47692	0.04418	0.04497	0.52130	0.52924	0.52130	0.52924	0.04418	0.04497
Comp Mole Frac (Benzene)	0.00813	0.00804	0.71506	0.70355	0.08524	0.08446	0.08528	0.08446	0.71506	0.70355
Comp Mole Frac (Toluene)	0.08387	0.08503	0.21985	0.23134	0.02453	0.02594	0.02449	0.02594	0.21985	0.23134
Comp Mole Frac (BiPhenyl)	0.00001	0.00001	0.01613	0.01545	0.00172	0.00166	0.00172	0.00166	0.01613	0.01545

Table A.2.1 Process data of HDA plant alternative 2 (cont)

Name	$v_3$out		$p_1$out		$v_6$out		$v_7$out		boil$_2$	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.00000	0.00000	0.00000	0.00000	1.00000	1.00000	0.44966	0.45005	0.88837	0.89418
Temperature (C)	45.46230	45.44923	45.25341	45.24750	50.14428	73.52086	115.39876	115.72673	165.55556	164.02629
Pressure (psia)	486.00000	487.05487	551.60000	550.31886	120.00000	120.00000	31.04000	31.00942	32.26000	32.17249
Molar Flow (kgmole/h)	49.21528	48.81918	216.88093	221.76620	8.57024	9.45864	159.09542	163.48830	384.14225	384.29872
Comp Mole Frac (Hydrogen)	0.00477	0.00469	0.00477	0.00469	0.09333	0.08571	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Methane)	0.04418	0.04497	0.04418	0.04497	0.86434	0.82221	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Benzene)	0.71506	0.70355	0.71506	0.70355	0.04200	0.09115	0.75132	0.73898	0.00108	0.00116
Comp Mole Frac (Toluene)	0.21985	0.23134	0.21985	0.23134	0.00033	0.00093	0.23168	0.24467	0.93066	0.93661
Comp Mole Frac (BiPhenyl)	0.01613	0.01545	0.01613	0.01545	0.00000	0.00000	0.01700	0.01634	0.06826	0.06223
Name	cCRin		tankout		vtb$_2$		coldout$_2$		v_{13}out	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.00000	0.00000	0.00000	0.00000	1.00000	1.00000	0.00000	0.00000	0.08217	0.09586
Temperature (C)	143.90473	143.57822	143.65031	143.32328	143.65031	143.32328	159.62708	161.80618	147.65246	147.77379
Pressure (psia)	95.96762	95.58683	32.20905	32.16384	32.20905	32.16384	93.06687	92.65595	35.09687	35.39529
Molar Flow (kgmole/h)	384.14225	384.14285	423.65659	426.83202	0.00091	0.00000	384.14225	384.14288	384.14225	384.14288
Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Methane)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Benzene)	0.00095	0.00116	0.00095	0.00116	0.00205	0.00249	0.00095	0.00116	0.00095	0.00116
Comp Mole Frac (Toluene)	0.93077	0.93619	0.93077	0.93619	0.99616	0.99587	0.93077	0.93618	0.93077	0.93618
Comp Mole Frac (BiPhenyl)	0.06828	0.06266	0.06828	0.06266	0.00179	0.00164	0.06828	0.06266	0.06828	0.06266

Table A.2.1 Process data of HDA plant alternative 2 (cont)

Name	$boil_2out$		vtb_3		$v_{14}out$		retol		m_4out	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.88831	0.89373	1.00000	1.00000	1.00000	1.00000	0.00000	0.00000	0.07154	0.00000
Temperature (C)	165.55556	164.23459	178.16984	178.15609	177.60242	177.60242	182.60269	181.97799	178.16984	178.15579
Pressure (psia)	32.26000	32.17249	72.51885	72.51954	67.51885	67.51885	605.00000	603.30262	72.51885	72.51954
Molar Flow (kgmole/h)	384.14225	384.29872	3.34953	0.00000	3.34953	0.00000	33.48095	40.03108	46.81733	50.01789
Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Methane)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Benzene)	0.00095	0.00116	0.00169	0.00224	0.00169	0.00169	0.00093	0.00123	0.00099	0.00123
Comp Mole Frac (Toluene)	0.93077	0.93574	0.99829	0.99774	0.99829	0.99829	0.99863	0.99833	0.99861	0.99833
Comp Mole Frac (BiPhenyl)	0.06828	0.06311	0.00002	0.00002	0.00002	0.00002	0.00044	0.00044	0.00041	0.00044

Name	m_1out		bp_1	
	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.91199	0.91119	0.91199	0.91119
Temperature (C)	65.44733	66.50737	65.44733	66.50737
Pressure (psia)	605.00000	603.30262	605.00000	603.30262
Molar Flow (kgmole/h)	1983.60001	2015.37942	104.13900	129.30731
Comp Mole Frac (Hydrogen)	0.43904	0.43001	0.43904	0.43001
Comp Mole Frac (Methane)	0.46895	0.47692	0.46895	0.47692
Comp Mole Frac (Benzene)	0.00813	0.00804	0.00813	0.00804
Comp Mole Frac (Toluene)	0.08387	0.08503	0.08387	0.08503
Comp Mole Frac (BiPhenyl)	0.00001	0.00001	0.00001	0.00001

Table A.2.2 Energy stream data of HDA plant alternative 2

Name	qfur		qcooler		wkcomp		wkp_1		qc_1	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Heat Flow (kW)	1835.54932	1808.63718	3665.89480	3701.56981	378.19653	378.19653	3.90333	3.90333	172.12705	158.42355

Name	qr_1		qc_2		wkp_2		qr_3		qar_2	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Heat Flow (kW)	1217.41769	1244.89686	3993.76802	4009.80564	8.70598	8.70598	525.02436	559.62515	3058.00936	2998.18203

Name	wkp_3	
	steady state	dynamic
Heat Flow (kW)	11.65052	11.65052

Table A.3.1 Process data of HDA plant alternative 5

Name	Rout		FFH_2		v_1out		Rgas		m_1out	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	0.91082	0.90763
Temperature (C)	665.57522	667.44739	30.00000	30.00000	29.99705	29.99705	73.52314	74.71973	68.26475	67.99159
Pressure (psia)	486.00000	480.91142	635.00000	635.00000	605.00000	605.00001	605.00000	605.00001	605.00000	605.00001
Molar Flow (kgmole/h)	1987.49567	1924.81381	222.71614	225.67307	222.71614	225.67307	1596.29865	1530.54258	1987.49563	1924.81247
Comp Mole Frac (Hydrogen)	0.36424	0.36255	0.97000	0.97000	0.97000	0.97000	0.39752	0.39748	0.42797	0.42979
Comp Mole Frac (Methane)	0.54319	0.54222	0.03000	0.03000	0.03000	0.03000	0.59103	0.59087	0.47806	0.47336
Comp Mole Frac (Benzene)	0.07058	0.07399	0.00000	0.00000	0.00000	0.00000	0.01024	0.01051	0.00823	0.00836
Comp Mole Frac (Toluene)	0.02059	0.01962	0.00000	0.00000	0.00000	0.00000	0.00121	0.00113	0.08572	0.08848
Comp Mole Frac (BiPhenyl)	0.00140	0.00163	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00001

Name	Rin		coolout		gas		liq		p_1out	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	1.00000	1.00000	0.89172	0.88824	1.00000	1.00000	0.00000	0.00000	0.00000	0.00000
Temperature (C)	621.11111	621.11126	45.00000	44.99998	45.00000	45.00002	45.00000	45.00002	45.25311	45.25325
Pressure (psia)	503.00000	497.56569	462.80000	457.73562	462.80000	457.73562	462.80000	457.73562	537.60000	532.68292
Molar Flow (kgmole/h)	1987.49563	1924.81195	2036.49567	1974.40131	1815.98237	1753.75048	220.51330	220.65093	220.51330	220.65093
Comp Mole Frac (Hydrogen)	0.42797	0.42979	0.35558	0.35355	0.39821	0.39748	0.00450	0.00442	0.00450	0.00442
Comp Mole Frac (Methane)	0.47806	0.47336	0.53118	0.52969	0.59035	0.59087	0.04388	0.04340	0.04388	0.04340
Comp Mole Frac (Benzene)	0.00823	0.00836	0.08596	0.09033	0.01023	0.01051	0.70966	0.72473	0.70966	0.72473
Comp Mole Frac (Toluene)	0.08572	0.08848	0.02552	0.02438	0.00121	0.00113	0.22567	0.20914	0.22567	0.20914
Comp Mole Frac (BiPhenyl)	0.00001	0.00001	0.00176	0.00205	0.00000	0.00000	0.01629	0.01832	0.01629	0.01832

Table A. 3.1 Process data of HDA plant alternative 5 (cont)

Name	$m_2$out		dischg		v_{13}out		purge		grecycle	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	1.00000	1.00000	1.00000	1.00000	0.00000	0.00000	1.00000	1.00000	1.00000	1.00000
Temperature (C)	620.94633	621.11002	73.52842	74.71973	45.41757	45.41776	45.00000	45.00002	45.00000	45.00002
Pressure (psia)	486.00000	480.91142	605.00000	605.00001	486.00000	480.91142	462.80000	457.73562	462.80000	457.73562
Molar Flow (kgmole/h)	2036.49567	1974.40160	1596.29865	1530.54258	49.00000	49.58779	219.68372	223.20791	1596.29865	1530.54258
Comp Mole Frac (Hydrogen)	0.35558	0.35355	0.39821	0.39748	0.00450	0.00442	0.39821	0.39748	0.39821	0.39748
Comp Mole Frac (Methane)	0.53118	0.52969	0.59035	0.59087	0.04388	0.04340	0.59035	0.59087	0.59035	0.59087
Comp Mole Frac (Benzene)	0.08596	0.09033	0.01023	0.01051	0.70966	0.72473	0.01023	0.01051	0.01023	0.01051
Comp Mole Frac (Toluene)	0.02552	0.02438	0.00121	0.00113	0.22567	0.20914	0.00121	0.00113	0.00121	0.00113
Comp Mole Frac (BiPhenyl)	0.00176	0.00205	0.00000	0.00000	0.01629	0.01832	0.00000	0.00000	0.00000	0.00000
Name	**Toltot**		**$v_5$out**		**FFtol**		**hHE_2in**		**hHE_2out**	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.00000	0.00000	0.02817	0.02788	0.00000	0.00000	1.00000	1.00000	1.00000	1.00000
Temperature (C)	70.39310	67.07645	45.95561	45.94231	30.00000	30.00000	621.13731	621.10988	353.37185	345.43915
Pressure (psia)	605.00000	605.00001	152.00000	150.26386	635.00000	635.00000	481.84974	480.76697	475.90417	474.92061
Molar Flow (kgmole/h)	168.48085	168.59683	171.51330	171.06314	144.75999	132.83060	1996.12267	1974.40172	1997.61759	1974.40093
Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00450	0.00442	0.00000	0.00000	0.35339	0.35355	0.35339	0.35355
Comp Mole Frac (Methane)	0.00000	0.00000	0.04388	0.04340	0.00000	0.00000	0.53004	0.52969	0.53004	0.52969
Comp Mole Frac (Benzene)	0.00006	0.00005	0.70966	0.72473	0.00000	0.00000	0.09720	0.09033	0.09722	0.09033
Comp Mole Frac (Toluene)	0.99981	0.99983	0.22567	0.20914	1.00000	1.00000	0.01637	0.02438	0.01637	0.02438
Comp Mole Frac (BiPhenyl)	0.00013	0.00012	0.01629	0.01832	0.00000	0.00000	0.00299	0.00205	0.00299	0.00205

Table A3.1 Process data of HDA plant alternative 5 (cont)

Name	d_1		vtb_1		t_1out		p_2out		b_1	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	1.00000	1.00000	1.00000	1.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Temperature (C)	129.21268	41.67218	192.22442	189.22194	192.22442	189.22194	192.42376	189.41656	192.42376	189.41656
Pressure (psia)	162.12013	149.97952	162.69095	150.70763	162.69095	150.70763	191.73337	179.38275	191.73337	179.38275
Molar Flow (kgmole/h)	12.52873	8.43067	0.00000	0.00000	332.42494	336.91143	332.42494	336.91143	156.58049	162.63259
Comp Mole Frac (Hydrogen)	0.05844	0.08969	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Methane)	0.58170	0.88037	0.00037	0.00027	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Comp Mole Frac (Benzene)	0.35645	0.02971	0.89866	0.85340	0.81858	0.76076	0.81858	0.76076	0.81858	0.76076
Comp Mole Frac (Toluene)	0.00341	0.00022	0.09980	0.14558	0.15231	0.21997	0.15231	0.21997	0.15231	0.21997
Comp Mole Frac (BiPhenyl)	0.00000	0.00000	0.00117	0.00075	0.02910	0.01926	0.02910	0.01926	0.02910	0.01926

Name	bp_1		CHE_1in		vbp_1out		m_4out		bp_2	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.90737	0.90763	0.90737	0.90763	1.00000	0.90834	0.98159	0.97587	0.98159	0.97587
Temperature (C)	64.96963	67.99159	64.96963	67.99159	140.38323	67.52788	140.33698	137.92675	140.37058	137.92674
Pressure (psia)	604.99421	605.00001	604.99421	605.00001	560.24228	560.68587	560.24228	560.68587	560.24228	560.68587
Molar Flow (kgmole/h)	0.00000	4.87338	1945.25072	1919.93909	0.00000	4.87338	1944.60646	1924.81095	67.89323	0.00000
Comp Mole Frac (Hydrogen)	0.43493	0.42979	0.43493	0.42979	0.43755	0.42979	0.43480	0.42979	0.43485	0.42979
Comp Mole Frac (Methane)	0.46880	0.47336	0.46880	0.47336	0.46553	0.47336	0.46892	0.47336	0.46900	0.47336
Comp Mole Frac (Benzene)	0.00895	0.00836	0.00895	0.00836	0.00898	0.00836	0.00896	0.00836	0.00895	0.00836
Comp Mole Frac (Toluene)	0.08732	0.08848	0.08731	0.08848	0.08793	0.08848	0.08732	0.08848	0.08719	0.08848
Comp Mole Frac (BiPhenyl)	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001

Table A.3.1 Process data of HDA plant alternative 5 (cont)

Name	$boil_2$		d_2		b_2		v_8out		vtb_2	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	1.00000	0.99673	0.02659	0.00000	0.00000	0.00000	0.14159	0.11589	1.00000	1.00000
Temperature (C)	343.28715	194.68039	105.54358	105.47441	147.86487	144.05796	80.85000	80.85049	147.87146	144.05775
Pressure (psia)	32.05146	32.06644	29.99921	29.99999	32.05021	32.06226	15.00006	15.00006	32.05021	32.06226
Molar Flow (kgmole/h)	200.21915	379.75463	128.39381	123.75232	233.76372	418.62813	128.39381	123.75232	0.00000	0.00000
Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Methane)	0.00000	0.00000	0.00001	0.00001	0.00000	0.00000	0.00001	0.00001	0.00000	0.00000
Comp Mole Frac (Benzene)	0.00017	0.00022	0.99969	0.99968	0.00017	0.00022	0.99969	0.99968	0.00039	0.00048
Comp Mole Frac (Toluene)	0.83924	0.91918	0.00030	0.00031	0.83938	0.91919	0.00030	0.00031	0.99493	0.99738
Comp Mole Frac (BiPhenyl)	0.16059	0.08060	0.00000	0.00000	0.16045	0.08059	0.00000	0.00000	0.00468	0.00214

Name	toR_1		cR_1in		cR_1out		hHR_1out		p_3out	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.00000	0.00000	0.00000	0.00000	0.98452	0.97524	1.00000	1.00000	0.00000	0.00000
Temperature (C)	192.42376	189.41656	192.39841	189.39444	222.68692	210.21648	307.59114	301.70731	148.04859	144.57506
Pressure (psia)	191.73337	179.38275	171.17245	159.15080	163.93262	152.02573	472.92362	472.03627	83.17429	164.28483
Molar Flow (kgmole/h)	175.84444	174.27884	175.84444	174.27884	175.84135	174.27786	1890.94619	1867.45307	232.54216	418.65375
Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.35339	0.35355	0.00000	0.00000
Comp Mole Frac (Methane)	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.53004	0.52969	0.00000	0.00000
Comp Mole Frac (Benzene)	0.81858	0.76076	0.81858	0.76076	0.81857	0.76076	0.09721	0.09033	0.00017	0.00022
Comp Mole Frac (Toluene)	0.15231	0.21997	0.15231	0.21997	0.15231	0.21997	0.01637	0.02438	0.83934	0.91919
Comp Mole Frac (BiPhenyl)	0.02910	0.01926	0.02910	0.01926	0.02912	0.01926	0.00299	0.00205	0.16050	0.08059

Table A. 3.1 Process data of HDA plant alternative 5 (cont)

Name	d_3		b_3		bp_5		cCRin		vbp_5out	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	1.00000	1.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Temperature (C)	180.90991	180.97032	346.50898	346.55378	148.04794	144.57507	148.04794	144.57507	148.06075	144.61682
Pressure (psia)	75.67981	75.62040	76.05035	76.05475	83.17429	164.28483	83.17429	164.28483	75.18204	138.67196
Molar Flow (kgmole/h)	32.65899	44.56702	4.54811	3.11357	22.11209	41.19859	180.86589	338.57434	22.11209	41.19859
Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Methane)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Benzene)	0.00020	0.00024	0.00000	0.00000	0.00017	0.00022	0.00017	0.00022	0.00017	0.00022
Comp Mole Frac (Toluene)	0.99934	0.99921	0.00034	0.00026	0.83934	0.91919	0.83934	0.91919	0.83934	0.91919
Comp Mole Frac (BiPhenyl)	0.00046	0.00055	0.99966	0.99974	0.16050	0.08059	0.16050	0.08059	0.16050	0.08059

Name	vbp_3out		m_6out		bp_4		hR_2in		$v_{10}out$	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	0.01635	0.00000
Temperature (C)	353.32703	345.42442	310.08474	304.12153	310.08478	304.12153	310.08478	304.12153	165.96393	160.71493
Pressure (psia)	472.92362	472.03627	472.92362	472.03627	472.92362	472.03627	472.92362	472.03627	48.66181	57.73650
Molar Flow (kgmole/h)	106.94844	106.94839	1997.89463	1974.40146	101.10555	99.91966	1896.78908	1874.48180	199.42656	379.75018
Comp Mole Frac (Hydrogen)	0.35339	0.35355	0.35339	0.35355	0.35339	0.35355	0.35339	0.35355	0.00000	0.00000
Comp Mole Frac (Methane)	0.53004	0.52969	0.53004	0.52969	0.53004	0.52969	0.53004	0.52969	0.00000	0.00000
Comp Mole Frac (Benzene)	0.09722	0.09033	0.09721	0.09033	0.09721	0.09033	0.09721	0.09033	0.00017	0.00022
Comp Mole Frac (Toluene)	0.01637	0.02438	0.01637	0.02438	0.01637	0.02438	0.01637	0.02438	0.83934	0.91918
Comp Mole Frac (BiPhenyl)	0.00299	0.00205	0.00299	0.00205	0.00299	0.00205	0.00299	0.00205	0.16049	0.08060

Table A. 3.1 Process data of HDA plant alternative 5 (cont)

Name	m7out		v12out		vtb3		t3out		p4out	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	1.00000	1.00000	0.13722	0.13760	1.00000	1.00000	0.00000	0.00000	0.00000	0.00000
Temperature (C)	196.39988	169.04728	336.13160	336.15266	179.56720	178.88528	179.56720	178.88528	182.44281	181.75328
Pressure (psia)	467.94591	467.20392	64.77073	64.77073	74.48167	73.48891	74.48167	73.48891	605.09397	605.22463
Molar Flow (kgmole/h)	2000.68870	1974.40168	4.54811	3.11357	0.00000	0.00000	32.62421	44.56769	32.62421	44.56769
Comp Mole Frac (Hydrogen)	0.35339	0.35355	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Methane)	0.53004	0.52969	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Benzene)	0.09721	0.09033	0.00000	0.00000	0.00036	0.00044	0.00020	0.00024	0.00020	0.00024
Comp Mole Frac (Toluene)	0.01637	0.02438	0.00034	0.00026	0.99962	0.99954	0.99934	0.99921	0.99934	0.99921
Comp Mole Frac (BiPhenyl)	0.00299	0.00205	0.99966	0.99974	0.00002	0.00003	0.00046	0.00054	0.00046	0.00054

Name	reflux		v3out		v11out		totop3		x2out	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.00000	0.00000	0.00000	0.00000	0.01622	0.01154	0.01623	0.01154	1.00000	0.99673
Temperature (C)	182.44282	181.75328	182.44288	181.75342	180.38900	180.35082	180.38588	180.35082	343.27324	194.68014
Pressure (psia)	605.09397	605.22463	604.99421	605.00001	75.68237	75.62296	75.68237	75.62296	32.05146	32.06644
Molar Flow (kgmole/h)	8.80133	8.80146	23.82288	35.76623	8.80133	8.80146	8.80133	8.80146	200.21915	379.75463
Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Methane)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Benzene)	0.00020	0.00024	0.00020	0.00024	0.00020	0.00024	0.00020	0.00024	0.00017	0.00022
Comp Mole Frac (Toluene)	0.99934	0.99921	0.99934	0.99921	0.99934	0.99921	0.99934	0.99921	0.83924	0.91918
Comp Mole Frac (BiPhenyl)	0.00046	0.00054	0.00046	0.00054	0.00046	0.00054	0.00046	0.00054	0.16059	0.08060

Table A. 3.1 Process data of HDA plant alternative 5 (cont)

Name	hHE$_1$in		cHE$_1$out		hHE$_1$out		toquench		toC$_1$	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	1.00000	1.00000	1.00000	0.97613	0.93105	0.93554	0.00000	0.00000	0.00000	0.00000
Temperature (C)	183.14143	169.04728	156.71350	138.06023	94.27361	99.47467	45.25311	45.25325	45.25311	45.25325
Pressure (psia)	472.00000	467.20392	563.00000	560.68587	466.00000	461.46542	537.60000	532.68292	537.60000	532.68292
Molar Flow (kgmole/h)	2036.49567	1974.40168	1883.15211	1919.93757	2036.49567	1974.40129	49.00000	49.58779	171.51330	171.06314
Comp Mole Frac (Hydrogen)	0.35558	0.35355	0.42797	0.42979	0.35558	0.35355	0.00450	0.00442	0.00450	0.00442
Comp Mole Frac (Methane)	0.53118	0.52969	0.47806	0.47336	0.53118	0.52969	0.04388	0.04340	0.04388	0.04340
Comp Mole Frac (Benzene)	0.08596	0.09033	0.00823	0.00836	0.08596	0.09033	0.70966	0.72473	0.70966	0.72473
Comp Mole Frac (Toluene)	0.02552	0.02438	0.08572	0.08848	0.02552	0.02438	0.22567	0.20914	0.22567	0.20914
Comp Mole Frac (BiPhenyl)	0.00176	0.00205	0.00001	0.00001	0.00176	0.00205	0.01629	0.01832	0.01629	0.01832

Name	quench		V$_4$out		V$_2$out		Rtol		cHE$_2$out	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.00000	0.00000	1.00000	1.00000	0.00000	0.00000	0.00000	0.00000	1.00000	1.00000
Temperature (C)	45.41754	45.41776	44.59008	44.65805	30.11499	30.11499	183.86324	181.75342	474.57592	465.73594
Pressure (psia)	486.00000	480.91142	432.80000	432.80000	605.00000	605.00001	605.00000	605.00001	520.27635	518.80906
Molar Flow (kgmole/h)	49.00000	49.58779	219.68372	223.20791	130.00000	132.83060	38.48085	35.76623	1877.10959	1924.81161
Comp Mole Frac (Hydrogen)	0.00450	0.00442	0.39821	0.39748	0.00000	0.00000	0.00000	0.00000	0.43482	0.42979
Comp Mole Frac (Methane)	0.04389	0.04340	0.59035	0.59087	0.00000	0.00000	0.00000	0.00000	0.46894	0.47336
Comp Mole Frac (Benzene)	0.70992	0.72473	0.01023	0.01051	0.00000	0.00000	0.00028	0.00024	0.00896	0.00836
Comp Mole Frac (Toluene)	0.22535	0.20914	0.00121	0.00113	1.00000	1.00000	0.99917	0.99921	0.08728	0.08848
Comp Mole Frac (BiPhenyl)	0.01635	0.01832	0.00000	0.00000	0.00000	0.00000	0.00056	0.00054	0.00001	0.00001

Table A. 3.1 Process data of HDA plant alternative 5 (cont)

Name	bot_1		$boil_1$		V_7out		V_6out		$V_{14}out$	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.00000	0.00000	0.98508	1.00000	0.48182	0.45199	1.00000	1.00000	1.00000	1.00000
Temperature (C)	192.22471	189.22251	222.48444	225.08656	113.97786	115.12013	127.15063	40.76390	186.41981	186.41981
Pressure (psia)	162.69095	150.70763	162.75145	150.81541	30.94965	30.95551	119.96895	119.96895	121.53246	121.53246
Molar Flow (kgmole/h)	332.42536	336.91062	175.83899	174.27877	156.58049	162.63259	12.52873	8.43067	0.00000	0.00000
Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.05844	0.08969	0.00000	0.00000
Comp Mole Frac (Methane)	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.58170	0.88037	0.00028	0.00028
Comp Mole Frac (Benzene)	0.81858	0.76076	0.81858	0.76076	0.81858	0.76076	0.35645	0.02971	0.84614	0.84614
Comp Mole Frac (Toluene)	0.15231	0.21997	0.15231	0.21997	0.15231	0.21997	0.00341	0.00022	0.15287	0.15287
Comp Mole Frac (BiPhenyl)	0.02910	0.01926	0.02911	0.01926	0.02910	0.01926	0.00000	0.00000	0.00071	0.00071
Name	CHE_2in		M_5out		Vbp_2out		$tank_2out$		bp_3	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.98159	0.97587	1.00000	1.00000	0.98358	0.98862	0.00000	0.00000	1.00000	1.00000
Temperature (C)	140.37058	137.92674	463.98225	465.73596	138.86925	465.73583	147.87146	144.05775	353.34155	345.43915
Pressure (psia)	560.24228	560.68587	520.27635	518.80906	520.27635	518.80906	32.05021	32.06226	475.90417	474.92061
Molar Flow (kgmole/h)	1876.71323	1924.81095	1945.00281	1924.81161	67.89323	0.00000	232.54216	418.65375	106.94844	106.94839
Comp Mole Frac (Hydrogen)	0.43484	0.42979	0.43482	0.42979	0.43475	0.43002	0.00000	0.00000	0.35339	0.35355
Comp Mole Frac (Methane)	0.46899	0.47336	0.46894	0.47336	0.46891	0.47311	0.00000	0.00000	0.53004	0.52969
Comp Mole Frac (Benzene)	0.00895	0.00836	0.00896	0.00836	0.00896	0.00837	0.00017	0.00022	0.09722	0.09033
Comp Mole Frac (Toluene)	0.08721	0.08848	0.08728	0.08848	0.08737	0.08849	0.83934	0.91919	0.01637	0.02438
Comp Mole Frac (BiPhenyl)	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.16050	0.08059	0.00299	0.00205

Table A. 3.1 Process data of HDA plant alternative 5 (cont)

Name	hHR_1in		toCR		tov_9		v_9out		cCRout	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	1.00000	1.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Temperature (C)	353.34155	345.43915	148.04845	144.57507	148.04845	144.57507	148.05892	144.71807	170.36586	162.52743
Pressure (psia)	475.90417	474.92061	83.17429	164.28483	83.17429	164.28483	75.76066	75.75239	75.18204	138.67196
Molar Flow (kgmole/h)	1890.66915	1867.45254	202.97798	379.77293	29.56419	38.88082	29.56419	38.88082	177.31447	338.55159
Comp Mole Frac (Hydrogen)	0.35339	0.35355	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Methane)	0.53004	0.52969	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Comp Mole Frac (Benzene)	0.09722	0.09033	0.00017	0.00022	0.00017	0.00022	0.00017	0.00022	0.00017	0.00022
Comp Mole Frac (Toluene)	0.01637	0.02438	0.83934	0.91919	0.83934	0.91919	0.83934	0.91919	0.83934	0.91918
Comp Mole Frac (BiPhenyl)	0.00299	0.00205	0.16050	0.08059	0.16050	0.08059	0.16050	0.08059	0.16049	0.08060

Name	condout		m_8out		cR_2out		hR_2out		vbp_4out	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	0.00217	0.00000	0.00000	0.00000	1.00000	0.99031	1.00000	0.99999	1.00000	1.00000
Temperature (C)	179.51870	178.88078	167.97712	160.61684	297.31604	193.25634	190.02217	161.28145	310.00858	304.09083
Pressure (psia)	74.48167	73.48891	75.18204	138.67196	32.05155	32.06660	467.94591	467.20392	467.94591	467.20392
Molar Flow (kgmole/h)	32.65270	44.56719	199.42656	379.75018	200.14875	379.75080	1899.58315	1874.48202	101.10555	99.91966
Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.35339	0.35355	0.35339	0.35355
Comp Mole Frac (Methane)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.53004	0.52969	0.53004	0.52969
Comp Mole Frac (Benzene)	0.00020	0.00024	0.00017	0.00022	0.00017	0.00022	0.09721	0.09033	0.09721	0.09033
Comp Mole Frac (Toluene)	0.99934	0.99921	0.83934	0.91918	0.83926	0.91918	0.01637	0.02438	0.01637	0.02438
Comp Mole Frac (BiPhenyl)	0.00046	0.00055	0.16049	0.08060	0.16057	0.08060	0.00299	0.00205	0.00299	0.00205

Table A. 3.1 Process data of HDA plant alternative 5 (cont)

Name	v16out		v15out		retol		ar1out		tox1	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Vapour Fraction	1.00000	1.00000	1.00000	1.00000	0.00000	0.00000	0.98508	1.00000	1.00000	1.00000
Temperature (C)	173.90983	173.90983	140.45561	140.45561	182.44282	181.75328	222.48346	225.08656	621.19427	621.11002
Pressure (psia)	44.41206	44.41206	3.24191	3.24191	605.09397	605.22463	162.75145	150.81541	481.99658	480.91142
Molar Flow (kgmole/h)	0.00000	0.00000	0.00000	0.00000	23.82288	35.76623	175.83899	174.27877	1996.06482	1974.40160
Comp Mole Frac (Hydrogen)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.35341	0.35355
Comp Mole Frac (Methane)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00001	0.53006	0.52969
Comp Mole Frac (Benzene)	0.00047	0.00047	0.00051	0.00051	0.00020	0.00024	0.81858	0.76076	0.09718	0.09033
Comp Mole Frac (Toluene)	0.99951	0.99951	0.99753	0.99753	0.99934	0.99921	0.15231	0.21997	0.01636	0.02438
Comp Mole Frac (BiPhenyl)	0.00002	0.00002	0.00196	0.00196	0.00046	0.00054	0.02911	0.01926	0.00299	0.00205

Table A.3.2 Energy stream data of HDA plant alternative 5

Name	qfur		qcooler		wkp1		wkcomp		qc2	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Heat Flow (kW)	5431.3108	5486.2212	1916.3492	2122.575	3.9744629	3.9790994	426.83405	426.80558	4983.9974	5001.0712
Name	wkp3		qr3		wkp4		qc1		wkp2	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Heat Flow (kW)	13.574913	17.919814	546.82636	516.31091	9.0913277	7.9260334	389.52369	409.19211	3.996971	2.9890275
Name	qar2		qar1		qx1					
	steady state	dynamic	steady state	dynamic	steady state	dynamic				
Heat Flow (kW)	64.1231	57.425465	152.3356	147.78966	-	0				

APPENDIX B

HDA Process Equipment Data

Table B.1 Column specifications of HDA plant alternative 1

Detail	Stabilizer Column		Product Column		Recycle Column	
	steady state	dynamic	steady state	dynamic	steady state	dynamic
Inlet stream	$v_5$out	$v_5$out	$v_7$out	$v_7$out	$v_9$out	$v_9$out
Top Pressure (psia)	150.00000	150.00000	30.00000	30.00000	30.00000	30.00000
Bottom Pressure (psia)	153.00000	150.55504	33.00000	32.25611	33.00000	32.25611
Top Temperature (C)	48.88889	48.88889	106.66667	106.66667	139.44444	139.44444
Bottom Temperature (C)	193.33333	193.33333	147.77778	147.77778	292.70000	293.33333
Condenser Duty (kW)	179.97338	176.92956	4004.06811	4066.96295	425.10275	329.77434
Reboiler Duty (kW)	1259.36518	1228.63573	3413.32958	3479.53942	469.40104	390.75457
Specification	Benzene mole fraction in overhead = 0.042		Toluene mole fraction in overhead = 0.0003		Diphenyl mole fraction in overhead = 0.00002	
	Methane mole fraction in bottoms = 0.000001		Benzene mole fraction in bottoms = 0.0006		Toluene mole fraction in bottoms = 0.00026	
Column model	Distillation Column	Distillation Column	Distillation Column	Distillation Column	Distillation Column	Distillation Column
Number of tray	6.00000	6.00000	27.00000	27.00000	7.00000	7.00000
Feed tray	3.00000	3.00000	15.00000	15.00000	5.00000	5.00000
Diameter (m)	1.06680	1.06680	1.82900	1.82900	0.76200	0.76200
Weir length (m)	0.88420	0.88420	1.26500	1.26500	0.51810	0.51810
Weir height (m)	0.05080	0.05080	0.05080	0.05080	0.05080	0.05080
Tray spacing (m)	0.60960	0.60960	0.60960	0.60960	0.60960	0.60960
Tray type	Sieve	Sieve	Sieve	Sieve	Sieve	Sieve
Reboiler vol. (m^3)	7.07900	9.36194	9.06139	11.98420	1.41584	1.87178
Condenser vol. (m^3)	0.28317	0.37454	8.49505	11.23534	2.83168	3.74749

Table B.2 Plug Flow Reactor specification of HDA plant alternative 1

Detail	PFR	
	steady state	dynamic
Pressure Drop (Psia)	17.00000	17.00014
Total Volume (m^3)	115.13183	115.13183
Length (m)	17.37360	17.37360
Diameter (m)	2.90474	2.90474

Table B.3 Heat Exchanger specification of HDA plant alternative 1

Detail	$FEHE_1$	
	steady state	dynamic
Shell Inlet Temperature (C)	621.06708	621.11096
Shell Outlet Temperature (C)	119.43767	123.55475
Shell Side Pressure Drop (Psia)	6.00000	6.00000
Tube Inlet Temperature (C)	63.51789	61.10720
Tube Outlet Temperature (C)	609.99576	610.32853
Tube Side Pressure Drop (Psi)	62.00000	62.00001
LMTD (C)	33.88057	33.88057
UA (kJ/C-h)	1859165	10900000
Duty (kW)	17493.84800	17419.17216
Shell Side Volume (m^3)	14.15842	16.28219
Tube Side Volume (m^3)	14.15842	16.28219

Table B.4 Separator specification of HDA plant alternative 1

Detail	Sep	
	steady state	dynamic
Vessel Temperature [C]	45.00000	45.00003
Vessel Pressure [Psia]	476.80011	475.85867
Liquid Molar Flow [kgmole/h]	220.99188	222.56534
Liquid Volume [m^3]	-	1.13270
vessel Volume [m^3]	2.26535	2.60475

Table B.5 Furnace and Heater specification of HDA plant alternative 1

Detail	Furnace		X_1	
	steady state	dynamic	steady state	dynamic
Feed Temperature [C]	584.02005	579.24956	-	621.11111
Product Temperature [C]	621.11111	621.11113	-	621.11111
Duty [kW]	1388.74257	1566.52153	-	0.00000
Volumn [m^3]	8.49505	11.23471	-	14.15842

Table B.6 Cooler specification of HDA plant alternative 1

Detail	Cooler	
	steady state	dynamic
Feed Temperature [C]	119.43767	123.55570
Product Temperature [C]	45.00000	45.00002
Duty [kW]	3189.62956	3434.08680
Volumn [m^3]	8.50000	8.50000

Table B.7 Valve specification of HDA plant alternative 1

Detail	V_1		V_2		V_3		V_4	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Inlet stream	FFH_2	FFH_2	FFtol	FFtol	p_3out	p_3out	purge	purge
Feed Pressure (Psia)	635.0001517	635.0001517	635.0001517	635.0001517	635.0001517	643.5936765	476.8001139	475.8580113
Product Pressure (Psia)	605.0001445	605.0001512	605.0001445	605.0001512	605.0001445	605.0001331	475.0001135	446.8001067
Molar Flow (kgmole/h)	222.716139	246.4703835	130	145.131058	38.58418269	38.04362145	219.3404537	244.7198707
Pressure Drop (Psia)	30	30.00000717	30	30.00000717	30.00000717	38.59354345	1.80000043	29.05790458
Resistance (Cv or K)	14.05696253	14.05696253	20.89776146	23.83	6.515329618	7.549030358	18.01986041	133.6034201

Detail	V_5		V_6		V_7		V_8	
	steady state	dynamic	steady state	dynamic	steady state	dynamic	steady state	dynamic
Inlet stream	toC_1	toC_1	d_1	d_1	b_1	b_1	d_2	d_2
Feed Pressure (Psia)	551.6001317	550.7523289	150.0000358	150.0000531	153.0000365	150.5673067	30.00000717	29.99997286
Product Pressure (Psia)	152.0000363	150.2276981	120.0000287	120.0000287	32.00000764	30.96490291	15.00000358	15.00000358
Molar Flow (kgmole/h)	171.9918761	169.6207524	8.925665709	8.695042634	163.0662104	160.9257882	121.6972856	132.5397609
Pressure Drop (Psia)	399.6000954	400.5246308	30.00000717	30.00002442	121.0000289	119.6024038	15.00000358	14.99996928
Resistance (Cv or K)	7.749413813	8.8712311	3.641566838	3.641566838	28.00485616	32.036998	41.7589835	47.575895

Detail	V_9		V_{10}		V_{11}	
	steady state	dynamic	steady state	dynamic	steady state	dynamic
Inlet stream	p_2out	p_2out	b_3	b_3	toquench	toquench
Feed Pressure (Psia)	53.00001266	52.43963663	31.0000074	30.73920715	551.6001317	550.7523289
Product Pressure (Psia)	32.00000764	30.44633723	16.00000382	16.00000382	486.0001161	485.4809975
Molar Flow (kgmole/h)	41.36892478	40.88166306	2.784742092	4.432297325	49.00	52.94459115
Pressure Drop (Psia)	21.00000502	21.9932994	15.00000358	14.73920333	65.60001567	65.27133149
Resistance (Cv or K)	9.016642917	10.41492674	1.85899774	2.0899827	4.628576255	4.609297056

Table B.8 Parameter tuning of HDA plant alternative 1

Name	FCtol	PCG	CCG
controlled variable	total toluene flow rate : 168.62 kgmole/hr	gas recycle pressure : 605 Psia	methane in gas recycle : 0.5894 mole-frac
output target object	valve : V_2	valve : V_1	valve : V_4
OP (%)	50.2202	49.99795081	49.9890205
Gain	0.2000	1.9	0.2
Ti	18	6	1020
Control Action	Reverse	Reverse	Direct
Name	**TCR**	**TCS**	**TCE_{1c}**
controlled variable	reactor inlet temperature : 621.1 °C	separator temperature : 45 °C	furnace inlet temperature : 584 °C
output target object	furnace duty (qfur)	cooler duty (qcooler)	valve : VBP_1
OP (%)	17.74562391	28.67168308	51.20399692
Gain	0.14869318	0.124104479	0.399
Ti	12.79256197	12.86656302	5.88
Control Action	Reverse	Direct	Direct
Name	**LCS**	**PC_1**	**TC_1**
controlled variable	separator liquid level : 50 % level	column C_1 pressure : 150 Psia	column C_1 tray-$_6$ temp : 153.9 °C
output target object	valve : V_5	valve : V_6	reboiler duty (qr_1)
OP (%)	50.00022643	50.00592924	48.60364592
Gain	2	1	2
Ti	-	600	720
Control Action	Direct	Direct	Reverse

Table B.8 Parameter tuning of HDA plant alternative 1 (cont)

Name	LC_{12}	PC_2	TC_2
controlled variable	column C_1 reflux drum level 50 % level	column C_2 pressure : 30 Psia	column C_2 tray-12 temp : 120.5 °C
output target object	column C_1 condenser duty (q_{c1})	column C_2 condensre duty (q_{c2})	column C_2 reboiler duty (q_{r2})
OP (%)	30.71522343	52.32830556	50.76094552
Gain	2	1	2
Ti	-	600	480
Control Action	Reverse	Direct	Reverse
Name	LC_{22}	PC_3	TC_3
Controlled variable	column C_2 reflux drum level 50 % level	column C_3pressure : 30 Psia	avg. C_3-tray 1,2,3,4 temp : 228.7 °C
Output target object	valve : V_8	column C_3 condenser duty (q_{c3})	valve : V_{10}
OP (%)	49.99754213	8.472953025	49.98528444
Gain	2	1	0.618474697
Ti	-	900	1200
Tuning method	Direct	Direct	Direct
Name	LC_{32}	TCQ	TC_3
controlled variable	column C_3eflux drum level 50 % level	quenched temperature : 621.1 °C	cooler inlet temperature : 119.6 °C
output target object	valve : V_3	valve : V_{11}	valve : V_{10}
OP (%)	50.08618066	49.99869442	53.0997
Gain	2	0.213366624	0.8700
Ti	-	12.60467805	63.0000
Tuning method	Direct	Direct	Direct

Table B.8 Parameter tuning of HDA plant alternative 1 (cont)

Name	LC_{11}	LC_{21}	LC_{31}
controlled variable	column C_1 base level : 50 % level	column C_2base level : 50 % level	column C_3base level : 50 % level
output target object	valve : V_7	valve : V_9	column C_3 reboiler duty (q_{r3})
OP [%]	50.00044091	50.00792184	29.74775984
Gain	2	2	3
Ti	-	-	-
Tuning method	Direct	Direct	Direct

APPENDIX C

Tuning of Control Structures

C.1 Tuning Controllers

In this chapter tuning methodology are recommended by Luyben et al. (2002). Notice throughout this work use PI controllers. In theory, control performance can be improved by the use of derivative action. But in practice the use of derivative has some significant drawbacks:

1. Three tuning constants must be specified.
2. Signal noise is amplified.
3. Several types of PID control algorithms are used, so important to careful that the right algorithm is used with its matching tuning method.
4. The simulation is an approximation of the real plant. If high-performance controllers are required to get good dynamics from the simulation, the real plant may not work well.

C.2 Tuning Flow, Level and Pressure Loops

The dynamics of flow measurement are fast. The time constants for moving control valves are small. Therefore, the controller can be tuned with a small integral or reset time constant . A value of = 0.3 minutes work in most flow controllers. The value of controller gain should be kept modest because flow measurement signals are sometime noisy due to the turbulent flow through the orifice plate. A value of controller gain of Kc = 0.5 is often used. Derivative action should not be used

Most level controller should use proportional-only action with a gain of 1 to 2. This provides the maximum amount of flow smoothing. Proportional control means there will be steady- state offset (the level will not be returned to its setpoint value). However, maintaining a liquid level at a certain value is often not necessary when the liquid capacity is simply being used as surge volume. So the recommended tuning of a level controller is Kc = 2.

Most pressure controllers can be fairly easily tuned. The process time constant is estimated by dividing the gas volume of the system by the volumetric flowrate of gas flowing through the system. Setting the integral time equal to about 2 to 4 times the process time constant and using a reasonable controller gain usually gives satisfactory pressure control. Typical pressure controller tuning constants for columns and tanks are Kc = 2 and Ti = 10 minutes.

C.3 Relay-Feedback Testing

The relay-feedback test is a tool that serves a quick and simple method for identifying the dynamic parameters that are important for designing a feedback controller. The results of the test are ultimate gain and the ultimate frequency. This information is usually sufficient to permit us to calculate some reasonable controller tuning constants.

The method consists of merely inserting an on-off relay in the feedback loop. The only parameter that must be specified is the height of the relay h. This height is typically 5 to 10 % of the controller-output scale. The loop starts to oscillate around the setpoint, with the controller output switching every time the process-variable (PV) signal crosses the setpoint. Figure shows the PV and OP signals from a typical relay-feedback test.

$$\mathrm{K}_U = 4h/a\pi$$

The period of the output PV curve is the ultimate period Pu. From these two parameters controller tuning constants can be calculated for PI or PID controllers, using a variety of tuning methods proposed in the literature that require only the ultimate gain and ultimate frequency, e.g., Ziegler-Nichols, Tyreus- Luyben, etc.

The test has many positive features that have led to its widespread use in real plants as well in simulation studies:

1. Only one parameter has to be specified (relay height).
2. The time it takes to run the test is short, particularly compared to the extended periods required for methods like PRBS.
3. The test is closed loop, so the process is not driven away from the setpoint.
4. The information obtained is very accurate in the frequency range that is important for the design of a feedback controller (the ultimate frequency).
5. The impact of load changes that occur during the test can be detected by a change to asymmetric in the manipulated variable.

All these features make relay-feedback testing a useful identification tool.

Knowing the ultimate gain Ku and ultimate period Pu permits us to calculate controller setting. There are several methods that require only these two parameters. The Ziegler-Nichols tuning equations for a PI controller are

$$\mathrm{K}_{ZN} = K_U/2.2 \qquad \tau_{ZN} = P_U/1.2$$

These tuning constants are frequently too aggressive for many chemical engineering applications. The Tyreus-Luyben tuning method provides more conservative setting with increased robustness. The TL equations for a PI controller are

$$\mathrm{K}_{TL} = K_U/3.2 \qquad \tau_{TL} = 2.2P_U$$

APPENDIX D

CAPITAL COST AND MANUFACTURING COST DATA

D.1 Estimation of Capital Costs

In this chapter Estimation of Capital Costs are recommended by Richard et al. (2003). Capital cost pertains to the costs associated with construction of a new plant or modification to an existing chemical manufacturing plant. There are five generally accepted classifications of capital cost estimates that are most likely to be encountered in the process industries.

1. Detailed estimate

This type of estimate requires complete engineering of the process and all related off-sites and utilities. Vendor quotes for all expensive item will have been obtained. At the end of a detailed estimate, the plant is ready to go to the construction stage.

2. Definitive estimate

This type of estimate requires preliminary specifications for all the equipment, utilities, instrumentation, electrical, and off sites.

3. Preliminary estimate

This type of estimate requires more accurate sizing of equipment than used in the study estimate. In addition, approximate layout of equipment is made along with estimates of piping, instrumentation, and electrical requirements. Utilities are estimated.

4. Study estimate

This type of estimate utilizes a list of the major equipment found in the process. This includes all pumps, compressors and turbines, columns and vessels, fired heaters, and exchangers. Each piece of equipment is roughly sized and the approximate cost determined. The total cost of equipment is then factored to give the estimated capital cost.

5. Order-of-magnitude estimate

This type of estimate typically relies on cost information for a complete process taken from previously built plants. This cost information is then adjusted using appropriate scaling factors, for capacity, and for capacity, and for inflation, to provide the estimated capital cost.

D.2 Estimating the Total Capital Cost of a Plant

The capital cost for a chemical plant must take into consideration many costs other than the purchased cost of the equipment. As an analogy, consider the costs associated with building a new home.

A summary of the costs that must be considered in the evaluation of the total capital cost of a chemical plant is presented. The estimating procedures to obtain the full capital cost of the plant are described in this section. If an estimate of the capital cost for a process plant is needed and access to a previous estimate for a similar plant with a different capacity is available, then the principles already introduced for the scaling of purchased costs of equipment can be used, namely:

1. The six-tenths-rule may be used to scale up/down to a new capacity.

2. The Chemical Engineering Plant Cost Index should be used to update the capital

costs.

The Chemical Engineering Plant Cost Index (CEPCI) can be used to account for change that result from inflation. The CEPCI values are composite value that reflect the inflation of a mix of goods and services associated with the chemical process industries (CPI)

D.2.1 Module Costing Technique

The equipment module costing technique is a common technique to estimate the cost of a new chemical plant. It is generally accepted as the best for making preliminary cost estimates and is used extensively. This approach, introduce by Guthrie, forms the basis of many of the equipment module techniques in use today. This costing technique relates all costs back to the purchased cost of equipment evaluated for some base conditions. Deviations form these base conditions are handled by using multiplying factors that depend on the following:

1. The specific equipment type
2. The specific system pressure
3. The specific materials of construction

Equation D.1 is used to calculate the bare module cost for each piece of equipment.

$$C_{BM} = C_P^o F_{BM} \qquad (D.1)$$

Where C_{BM} is bare module equipment cost: direct and indirect costs for each unit.

F_{BM} is bare module cost factor: multiplication factor to account for the items specific materials of construction and operating pressure.

D.2.2 Bare Module Cost for Equipment at Base Conditions

The bare module equipment cost represents the sum of direct and indirect costs the conditions specified for the base case are

1. Unit fabricated from most common material, usually carbon steel (CS)

2. Unit operated at near-ambient pressure

Equation D.1 is used to obtain the bare module cost for the base conditions. For these base conditions, a superscript "0" is added to the bare module cost factor and the bare module equipment cost.

D.2.3 Bare Module Cost for Nonbase Case Conditions

For equipment made from other materials of construction and/or operating at non-ambient pressure, the values for F_{BM} and F_P are greater than 1.0. In the equipment module technique, these additional costs are incorporated into the bare module cost factor,F_{BM}. The bare module factor used for the base case,F_{BM}, is replace with an actual bare module cost factor, F_{BM} in Equation D.1 . The information needed to determine this actual bare module factor . The effect of pressure on the cost of equipment is considered first.

Pressure Factors. As the pressure at which a piece of equipment operates increase. As an example, consider the design of a process vessel. Such vessels, when subjected to internal pressure (or external pressure when operating at vacuum) are subject to rigorous mechanic design procedures. For the simple case of a cylindrical vessel operating at above ambient pressure, the relationship between design pressure and wall thickness required to withstand the radial stress in the cylindrical portion of the vessel, as recommended by the ASME

For operating pressures less than -0.5 barg, the vessel must be designed to withstand full vacuum, that is, 1 bar of external pressure. For such operations, strengthening rings must be installed into the vessels to stop the vessel wall from buckling. A pressure factor of 1.25 should be used for such conditions and this is shown in Figure D.2. These pressure factors are presented in the general form given by Equation D.2.

$$\log_{10}F_P = C_1 + C_2 log_{10}P + C_3(log_{10})^2 \qquad (D.2)$$

The value predicted by this equation (using the appropriate constants) gives values of Fp much smaller than those for vessels at the same pressure. This difference arises from the fact that for other equipment, the internals of the equipment make up the major portion of the cost. Therefore, the cost of a thicker outer shell is a much smaller fraction of the equipment cost than for a process vessel, which is nearly totally dependent on the weight of the metal.

Materials of Construction (MOC). The choice of what MOC to use depends on the chemicals that will contact the walls of the equipment. However, the interaction between process streams and MOCs can be very complex and the compatibility of the MOC with the process stream must be investigated fully before the final design is completed.

Many polymeric compounds are nonreactive in both acidic and alkaline environments. However, polymers generally lack the structural strength and resilience of metals. Nevertheless, for operations below about 120 oC in corrosive environments the use of polymers as liners for steel equipment or incorporate into fiberglass structures (at moderate operating pressures) often give the most economical solution. The most common MOCs are still ferrous alloys, in particular carbon steel. Carbon steels are distinguished from other ferrous alloys such as wrought and cast iron by the amount of carbon in them. Carbon steel has less than 1.5 wt % carbon, and it can be given varying amounts of hardness or ductility, it is easy to weld, and it is cheap. It is still the material of choice in the CPI when corrosion is not a concern.

- Low-alloy steels are produced in the same way as carbon steel except amounts of chromium and molybdenum are added (chromium between 4, and 9 wt%). The molybdenum increases the strength of the steel at high temperatures while the addition of chromium makes the steel resistant to mildly acidic and oxidizing atmospheres and to sulfur containing streams

- Stainless steels are so called high-alloy steels containing greater than 12 wt% chromium and possessing a corrosion resistant surface coating, also known as a passive coating. At chromium levels above about 12%, the corrosion of steel to rusting is reduced by over a factor of 10. Chemical resistance is also increased dramatically.

- Nonferrous Alloys are characterized by higher cost and difficulty in machining. Nevertheless, they possess improved corrosion resistance.

- Nickel and its alloys are alloys in which nickel is the major component.

- Titanium and its alloys have good strength-to-weight ratios and very good corrosion resistance to oxidizing agents. However, it is attacked by reducing agents, it is relatively expensive, and it is difficult to weld.

Table D.1 Results of cost estimation for HDA process 1

Name	Capital Cost (US dollar)	Actual Utility Usage	Annual Utility Cost (US dollar)
Compressors	1530000		
FEHE1	248000		
furnace	464000	6270 MJ/h	310000
cooler	912000	13900 MJ/h	500000
XCC1	218000	200 MJ/h	10000
XRC1	375000	4890 MJ/h	244000
XCC2	1080000	16800 MJ/h	840000
XRC2	946000	14400 MJ/h	720000
XCC3	218000	1190 MJ/h	59000
XRC3	218000	1440 MJ/h	72000
P1	37100	4.68 kilowatts	2360
P2	22900	0.318 kilowatts	160
P3	51200	8.6 kilowatts	4330
P CC1 A/B	56200	4.71 kilowatts	2370
P RC1 A/B	56200	4.71 kilowatts	2370
P CC2 A/B	68500	9.41 kilowatts	4740
P RC2 A/B	68500	9.41 kilowatts	4740
P CC3A/B	56200	4.71 kilowatts	2370
P RC3 A/B	56200	4.71 kilowatts	2370
Reactor	888100		
Stabilizer Column	156000		
Product Column	789000		
Recycle Column	90400		
V-L Seperator	240000		
C1 Condensor	33600		
C1 Reboiler	223000		
C2 Condensor	174000		
C2 Reboiler	133000		
C3 Condensor	87700		
C3 Reboiler	51300		
	9550000		2780000

Table D.2 Results of cost estimation for HDA process 2

Name	Capital Cost (US dollar)	Actual Utility Usage	Annual Utility Cost (US dollar)
Compressors	1530000		
FEHE1	248000		
CR	248000		
furnace	527000	7260 MJ/h	360000
cooler	982000	14000 MJ/h	500000
X1	218000	0 MJ/h	0
AR1	863000	12400 MJ/h	620000
XCC1	218000	628 MJ/h	31000
XRC1	372000	4850 MJ/h	242000
XCC2	1060000	15600 MJ/h	780000
XRC3	218000	1780 MJ/h	89000
P1	55700	16.5 kilowatts	8320
P2	35200	10.2 kilowatts	5160
P3	61100	13.7 kilowatts	6900
P CC1 A/B	56200	4.71 kilowatts	2370
P RC1 A/B	56200	4.71 kilowatts	2370
P CC2 A/B	68500	9.41 kilowatts	4740
P RC3 A/B	56200	4.71 kilowatts	2370
reactor	888100		
Stabilizer Column	278000		
Product Column	907000		
Recycle Column	90400		
tank1	97900		
tank2	97900		
V-L Seperator	223000		
C1 Condensor	95300		
C1 Reboiler	81500		
C2 Condensor	67100		
C3 Reboiler	59900		
	9760000		2650000

Table D.3 Results of cost estimation for HDA process 5

Name	Capital Cost (US dollar)	Actual Utility Usage	Annual Utility Cost (US dollar)
Compressors	1530000		
FEHE1	248000		
FEHE2	246000		
CR	224000		
R1	242000		
R2	242000		
furnace	1320000	15600 MJ/h	780000
Cooler	737000	9610 MJ/h	350000
X1	218000	0 MJ/h	0
AR1	218000	91.4 MJ/h	4600
AR2	285000	3550 MJ/h	177000
XCC1	218000	1580 MJ/h	79000
XCC2	1260000	15400 MJ/h	770000
XRC3	218000	1710 MJ/h	85000
P1	36800	4.68 kilowatts	2360
P2	27000	3.53 kilowatts	1780
P3	27800	4.47 kilowatts	2250
P4	41700	6.71 kilowatts	3380
P CC1 A/B	56200	4.71 kilowatts	2370
P CC2 A/B	68500	9.41 kilowatts	4740
P RC3 A/B	56200	4.71 kilowatts	2370
Reactor	888100		
Stabilizer Column	156000		
Product Column	1750000		
Recycle Column	231000		
tank1	97900		
tank2	97900		
tank3	97900		
V-L Seperator	250000		
C1 Condensor	45400		
C2 Condensor	59700		
C3 Reboiler	79600		
	11300000		2264900

VITA

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