

**SUPPORTING INFORMATION (SI)**

**Improving Heat Efficiency of Aniline Production Process by  
Modifying Heat Transfer Fluid Looping System in Heating and  
Cooling Process**

**Muhammad Ahdan <sup>a</sup>, Alfian Rizky Saputra <sup>b</sup>, Rifqy Ivan <sup>c</sup>, Yohanes Mangarohontua  
Panjaitand <sup>d</sup>**

*Department of Chemical Engineering, Faculty of Engineering, Universitas Diponegoro, Indonesia.*

*<sup>a</sup> ahdan02@gmail.com; <sup>b</sup> aaxyrs1723@gmail.com; <sup>c</sup> rifqyivan23@gmail.com; <sup>d</sup> yohanes1506@gmail.com*

Table S1. Heat and material balance of modified process using Aspen HYSYS

Stream No.		Nitrobenzene	Fresh Hydrogen	Hydrogen	1	2	3	4	5	6	7
<b>Total Phase Properties</b>											
Vapor Fraction		0.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000	0.9702
Temperature	°C	27.0	27.0	219.4	27.1	229.5	77.3	220.0	310.0	310.0	38.7
Pressure	atm	1.00	1.00	1.50	1.60	1.50	1.50	1.50	1.50	1.50	1.40
Molecular Weight		123.109	2.016	2.896	123.109	123.109	2.016	4.086	57.117	4.127	4.127
Molar Flow	kgmole/h	100.000	303.509	10000.000	100.000	100.000	303.509	10100.000		10000.737	10000.737
Mass Flow	kg/h	12310.940	611.875	28960.367	12310.940	12310.940	611.875	41271.307		41271.456	41271.456
Heat Flow	kJ/h	2229325.364	17254.705	-55071474.139	2230162.343	9839349.829	451974.048	-45232124.311		-63549721.705	-160264081.537
Std Gas Flow	m3/h	2364.444	7176.310	236444.364	2364.444	2364.444	7176.310	238808.808		236461.784	236461.784
<b>Vapor Phase Properties</b>											
Mass Flow	kg/h		611.875	28960.367		12310.940	611.875	41271.307		41271.456	28366.025
Molecular Weight			2.016	2.896		123.109	2.016	4.086		4.127	2.924
Mass Density	kg/m3		0.082	0.107		4.477	0.105	0.151		0.129	0.160
Actual Gas Volume Flow	m3/h		7475.164	269452.742		2749.656	5818.293	272470.375		319029.728	177604.332
Compressibility Factor			1.000	1.000		1.000	1.000	1.000		1.000	1.000
Cp/Cv			1.413	1.394		1.048	1.411	1.368		1.359	1.405
Viscosity	cP		0.009	0.013		0.009	0.010	0.013		0.015	0.008
Heat Capacity	kJ/kg.°C		14.101	10.151		1.479	14.159	7.558		7.625	9.861
Thermal Conductivity	W/m.K		0.176	0.234		0.018	0.198	0.226		0.248	0.165
<b>Liquid Phase Properties</b>											
Mass Flow	kg/h	12310.940			12310.940						12905.431
Molecular Weight		123.109			123.109				57.117		43.272
Mass Density	kg/m3	1196.405			1196.385				3173.167		1005.448
Actual Liquid Volume Flow	m3/h	10.290			10.290						12.836
Viscosity	cP	2.537			2.534				0.186		5.538
Heat Capacity	kJ/kg.°C	1.162			1.162				3.043		2.484
Thermal Conductivity	W/m.K	0.135			0.135				0.115		0.296
Surface Tension	dyne/cm	70.493			70.483				7.606		
<b>Composition</b>											
Nitrobenzene	weight %	1.0000	0.0000	0.0011	1.0000	1.0000	0.0000	0.2991	0.0055	0.0030	0.0030
Hydrogen	weight %	0.0000	1.0000	0.6625	0.0000	0.0000	1.0000	0.4649	0.0099	0.4503	0.4503
Aniline	weight %	0.0000	0.0000	0.0449	0.0000	0.0000	0.0000	0.0315	0.9406	0.2555	0.2555
Water	weight %	0.0000	0.0000	0.2914	0.0000	0.0000	0.0000	0.2045	0.0439	0.2911	0.2911
Ethylene Glycol	weight %	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<b>Composition</b>											
Nitrobenzene	mole %	1.0000	0.0000	0.0000	1.0000	1.0000	0.0000	0.0099	0.0026	0.0001	0.0001
Hydrogen	mole %	0.0000	1.0000	0.9517	0.0000	0.0000	1.0000	0.9423	0.2812	0.9219	0.9219
Aniline	mole %	0.0000	0.0000	0.0014	0.0000	0.0000	0.0000	0.0014	0.5769	0.0113	0.0113
Water	mole %	0.0000	0.0000	0.0468	0.0000	0.0000	0.0000	0.0464	0.1393	0.0667	0.0667
Ethylene Glycol	mole %	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	mole %	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table S1. Continued

8	9	10	11	12	13	15	14	16	17	18	19
0.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	0.0000	0.6565	0.0000	0.0000	1.0000
38.7	38.7	38.7	73.0	223.8	30.0	300.0	30.0	122.1	27.0	27.0	120.2
1.40	1.40	1.40	1.84	1.50	1.00	1.44	1.54	1.34	1.00	2.08	1.97
43.272	2.924	2.924	2.924	2.924	27.925	27.925	27.925	27.925	18.015	18.015	18.015
298.242	9702.495	9696.491	9696.491	9696.491	1519.813	1519.813	1519.813	1519.813	1157.785	1157.785	1157.785
12905.431	28366.025	28348.492	28348.492	28348.492	42440.965	42440.965	42440.965	42440.965	20857.610	20857.610	20857.610
-52429582.926	-107834498.611	-107767749.040	-98161462.296	-55523448.187	-490514388.221	-393797096.303	-490511456.135	-436435110.412	-329678997.312	-329675983.107	-275596725.036
7051.766	229410.017	229268.055	229268.055	229268.055	35935.119	35935.119	35935.119	35935.119	27375.170	27375.170	27375.170
	28366.025	28348.492	28348.492	28348.492		42440.965		19400.377			20857.610
2.924	2.924	2.924	2.924	2.924		27.925		19.444			18.015
0.160	0.160	0.160	0.189	0.108		0.856		0.804			1.102
	177604.332	177494.427	149670.202	263578.471		49557.945		24144.647			18934.227
1.000	1.000	1.000	1.000	1.000		1.000		1.000			1.000
1.405	1.405	1.405	1.403	1.394		1.140		1.259			1.253
0.008	0.008	0.008	0.009	0.013		0.015		0.010			0.013
9.861	9.861	9.861	9.894	10.066		2.420		2.076			2.288
0.165	0.165	0.165	0.179	0.235		0.044		0.026			0.026
12905.431					42440.965		42440.965	23040.589	20857.610	20857.610	
43.272					27.925		27.925	44.133	18.015	18.015	
1005.448					1064.526		1064.542	1019.678	1005.831	1005.857	
12.836					39.868		39.868	22.596	20.737	20.736	
5.538					2.265		2.264	0.844	0.851	0.851	
2.484					3.430		3.430	3.315	4.220	4.220	
0.296					0.408		0.408	0.306	0.614	0.614	
					58.489		58.487	41.584	71.754	71.752	
0.0070	0.0012	0.0012	0.0012	0.0012	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.6552	0.6552	0.6552	0.6552	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.7162	0.0459	0.0459	0.0459	0.0459	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.2767	0.2977	0.2977	0.2977	0.2977	0.5000	0.5000	0.5000	0.5000	1.0000	1.0000	1.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.5000	0.5000	0.5000	0.5000	0.0000	0.0000	0.0000
0.0025	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.9502	0.9502	0.9502	0.9502	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.3328	0.0014	0.0014	0.0014	0.0014	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.6647	0.0483	0.0483	0.0483	0.0483	0.7750	0.7750	0.7750	0.7750	1.0000	1.0000	1.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.2250	0.2250	0.2250	0.2250	0.0000	0.0000	0.0000
1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000