Available online at website: https://journal.bcrec.id/index.php/jcerp

Journal of Chemical Engineering Research Progress, 2 (1) 2025, 122-131

Research Article

Reducing Energy Consumption of Methanol Production from Syngas by Modifying Heat Transfer Process

Aulya Fauzia Putri*, Dina Fitri Arianti, Parastika Triana Rahayu, Rafi Hafizh Azizi

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

Received: 19th December 2024; Revised: 28th December 2024; Accepted: 1st January 2025
Available online: 22th January 2025; Published regularly: June 2025

SUPPORTING INFORMATION (SI), DOI: https://doi.org/10.9767/jcerp.20307

Table S1. Mass balance and energy balances result after creation process based on HYSYS simulation

HEAT AND MATERIAL BALANCE																						
Stream No.																						
	Unit	Methane	Methane Feed	Air	Air Feed	Syn Gas	Liquid	Syn Gas 2	Methane Residual	Residual Gas	Methanol	Methanol 2	Residual Gas 2	Methanol 4	Methanol Product	Methane Recycle	Methane Feed 2	D	V	Methanol 3	D2	Syn Gas 3
Total Phase Properties																						
Vapour Fraction		1,00	1,00	1,00	1,00	1,00	0,00	1,00	1,00	1,00	0,00	0,08	1,00	0,00	0,00	1,00	1,00	0,00	0,00	0,00	1,00	1,00
Temperature	C	25,00	338,54	25,00	526,77	1000,00	1000,00	100,00	100,00	100,00	100,00	81,02	76,27	76,27	25,00	100,00	328,83	-269,81	76,95	76,27	941,77	84,40
Pressure	atm	1,00	19,74	1,00	19,74	19,74	19,74	19,74	19,74	19,40	19,40	2,00	1,50	1,50	1,00	19,74	19,74	1,00	1,50	1,50	1,00	19,40
Molecular Weight				28,85027039		19,08	19,08										16,04					
Molar Flow	kgmole/h	1000	1000	3000	3000	5418,61399	0	5418,61399	48,61397843	3883,380158	10,54983235	10,54983235	2,33203683	629,2798879	629,2798879	48,61397697	1048,613977	3262,318066	621,0620923	631,6119247	3262,318066	5370,000012
Mass Flow	kg/h	16042,90009	16042,90009	86550,81116	86550,8112	103373,3611	0	103373,3611	779,9091986	102258,722	333,9456204	333,9456204	74,61624459	20086,90117	20086,90117	779,9091753	16822,80926	82431,15019	19827,5718	20161,51742	82431,15019	102593,4519
Heat Flow	kJ/h	-74918257,39	-61211353,73	-24549,16547	46207713,2	-12597108,21	0	-169143658,4	-3516189,774	-240504174	-2461198,795	-2461198,795	-456441,532	-148757784	-152486121,1	-3516189,669	-64727543,4	-178410809,5	-146753028,8	-149214225,6	-21864259,33	-168142037,2
Std Gas Flow	m3/h	100,0527991																				
Vapor Phase Properties																						
Phase - Mass Flow (Vapour Phase)	kgmole/h	16042,90009	16042,90009	86550,81	86550,81	103373,36	0,00	103373,36	779,91	102258,72	0,00	26,07	74,62	0,00		779,91	16822,81	4638,44	0,00	74,62	82431,15	174,80
Phase Molecular Weight (Vapour Phase)		16,04	16,04290009	28,85	28,85	19,08	19,08	19,08	16,04	26,33	26,33	32,01	32,00	32,00		16,04	16,04	7,36	31,93	32,00	25,27	19,10
Phase Mass Density (Vapour Phase)	kg/m3	0,66	6,296830153	1,18	8,62	3,59	3,59	12,28	10,53	17,13	17,13	2,27	1,72	1,72		10,53	6,40	307,74	729,76	1,72	0,25	12,63
Phase Actual Gas Flow (Vapour Phase)	m3/h	24410,39635	2547,045896	73354,23808	10036,6597	28789,49516	<empty>	8414,805786	74,03285305	5968,499338	<empty>	11,50778068	43,43311664	<empty>		74,03285084	2627,78763	<empty>	<empty>	43,43311664	325301,5383	8121,227841
Phase Z Factor (Vapour Phase)		0,997768708	1,001635767	0,999445241	1,006061	1,003851613	1,003852	1,001095933	0,981709823	0,973785692	0,973785692	0,972525802	0,974363777	0,974363777		0,981709823	1,001371495	8,71E-02	2,28E-03	0,974363777	1,000231099	1,000009852
Phase Cp/Cv (Vapour Phase)		1,303626257	1,192413668	1,401173274	1,35156125	1,32118259	1,321183	1,410098928	1,300230544	1,378526006	1,378526006	1,246850977	1,235888956	1,235888956		1,300230544	1,195219907	1	1,397614513	1,235888956	1,289756958	1,415144859
Phase Viscosity (Vapour Phase)	cP	1,13E-02	1,98E-02	1,88E-02	3,97E-02	4,76E-02	4,76E-02	1,75E-02	1,39E-02	1,83E-02	1,83E-02	8,13E-03	7,19E-03	7,19E-03		1,39E-02	1,96E-02	2,77E+39	0,286308519	7,19E-03	5,09E-02	1,70E-02
Phase Mass Heat Capacity (Vapour Phase)	kJ/kh-C	2,248087772	3,327162579	1,012093741	1,11561261	1,793732373	1,793732	1,577847424	2,521757156	1,358625412	1,358625412	1,465713973	1,506567441	1,506567441		2,521757156	3,291766679	10,07870 14	3,761744916	1,506567441	1,464771 85	1,589698626
Phase Thermal Conductivity (Vapour	W/m-K	3,38E-02	6,81E-02	2,59E-02	5,67E-02	0,156364169	0,156364	6,22E-02	4,65E-02	3,92E-02	3,92E-02	1,94E-02	1,75E-02	1,75E-02		4,65E-02	8,63E-02	5,47E-02	0,159920283	1,75E-02	0,106472046	6,04E-02
Liqiud Phase Properties																						
Phase Mass Flow (Liquid Phase)	kgmole/h					0,00	0,00			0,00	333,95	307,88	0,00	20086,90	20086,90			77792,71	19827,57	20086,90		102418,65
Phase Molecular Weight (Liquid Phase)						19,07745437	19,07745			31,65411633	26,3324006	32,01035548	31,99616903	31,92045632	31,92045632			7,356249194	31,92526487	31,99616903		19,10492583
Phase Mass Density (Liquid Phase)	kg/m3					3,590662517	3,590663			703,1157749	17,13307084	2,265156266	1,71795741	730,5858392	786,9074228			307,7373493	729,7605899	1,71795741		12,63275135
Phase Actual Gas Flow (Liquid Phase)	m3/h					28789,49516	<empty>			<empty>	<empty>	11,50778068	43,43311664	<empty>	<empty>			<empty>	<empty>	43,43311664		8121,227841
Phase Viscosity (Liquid Phase)						1,003851613	1,003852			2,85E-02	0,973785692	0,972525802	0,974363777	2,29E-03	1,66E-03			8,71E-02	2,28E-03	0,974363777		1,000009852
Phase Mass Heat Capacity (Liquid Phase)						1,32118259	1,321183			1,39627841	1,378526006	1,246850977	1,235888956	1,397142616	1,382885728			1	1,397614513	1,235888956		1,415144859
Phase Thermal Conductivity (Liquid Phase)	cP					4,76E-02	4,76E-02			0,218230985	1,83E-02	8,13E-03	7,19E-03	0,288504975	0,546531638			2,77E+39	0,286308519	7,19E-03		1,70E-02
Phase Surface Tension (Liquid Phase)	kJ/kh-C					1,793732373	1,793732			3,911379499	1,358625412	1,465713973	1,506567441	3,757357684	3,508858851			10,07870 14	3,761744916	1,506567441		1,589698626
Liquid Volume Flow	W/m-K					0,156364169	0,156364			0,153558106	3,92E-02	1,94E-02	1,75E-02	0,1603199	0,182087118			5,47E-02	0,159920283	1,75E-02		6,04E-02
Composition																						
Methane	weight%	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methanol	weight%	0	0,994886213	0,994886213	0,99488621	0,994886213	0,994886	0,994886213	0,994886213	0,994886213	0,994886213	0,994886213	0,228087793	0,228087793	0,994886213	0,228087793	0,994886213	0,228087793	0,228087793	0,228087793	0,228087793	0,228087793
CO	weight%	0	2,12E-08	2,12E-08	2,12E-08	2,12E-08	2,12E-08	2,12E-08	2,12E-08	2,12E-08	2,12E-08	2,12E-08	2,06E-03	2,06E-03	2,12E-08	2,06E-03	2,12E-08	2,06E-03	2,06E-03	2,06E-03	2,06E-03	2,06E-03
CO2	weight%	0	1,56E-04	1,56E-04	1,56E-04	1,56E-04	1,56E-04	1,56E-04	1,56E-04	1,56E-04	1,56E-04	1,56E-04	0,109491296	0,109491296	1,56E-04	0,109491296	1,56E-04	0,109491296	0,109491296	0,109491296	0,109491296	0,109491296
Oxygen	weight%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitrogen	weight%	0	2,26E-05	2,26E-05	2,26E-05	2,26E-05	2,26E-05	2,26E-05	2,26E-05	2,26E-05	2,26E-05	2,26E-05	0,649222169	0,649222169	2,26E-05	0,649222169	2,26E-05	0,649222169	0,649222169	0,649222169	0,649222169	0,649222169
H2O	weight%	0	4,94E-03	4,94E-03	4,94E-03	4,94E-03	4,94E-03	4,94E-03	4,94E-03	4,94E-03	4,94E-03	4,94E-03	9,23E-04	9,23E-04	4,94E-03	9,23E-04	4,94E-03	9,23E-04	9,23E-04	9,23E-04	9,23E-04	9,23E-04
Hydrogen	weight%	0	5,63E-08	5,63E-08	5,63E-08	5,63E-08	5,63E-08	5,63E-08	5,63E-08	5,63E-08	5,63E-08	5,63E-08	1,02E-02	1,02E-02	5,63E-08	1,02E-02	5,63E-08	1,02E-02	1,02E-02	1,02E-02	1,02E-02	1,02E-02
Composition																						
Comp Mole Frac (Methane)	mole %	1	1	0	0	0,008972	0,008972	0,008972	1	0	0	0	0	0	0	1	1	0	0	0	0	0
Comp Mole Frac (Methanol)	mole %	0	0	0	0	0	0	0	0	0,187445	0,958717	0,958717	0,95124	0,991115	0,991115	0	0	0,034371	0,991516	0,990968	0,034371	0
Comp Mole Frac (CO)	mole %	0	0	0	0	0,168555	0,168555	0,168555	0	0,001932	0,000013	0,000013	0,0000543	2,42E-08	2,42E-08	0	0	0,0023	7,73E-09	0,000000224	0,0023	0,170081
Comp Mole Frac (CO2)	mole %	0	0	0	0	0,015994	0,015994	0,015994	0	0,065512	0,004934	0,004934	0,015082	0,000113	0,000113	0	0	0,077967	0,0000872	0,000168	0,077967	0,016139
Comp Mole Frac (Oxygen)	mole %	0	0	0,21	0,21	1,62E-18	1,62E-18	1,62E-18	0	0	0	0	0	0	0	0	0	0	0	0	0	1,64E-18
Comp Mole Frac (Nitrogen)	mole %	0	0	0,79	0,79	0,437381	0,437381	0,437381	0	0,610273	0,007383	0,007383	0,029115	0,0000257	0,0000257	0	0	0,726452	0,00001	0,000133	0,726452	0,441341
Comp Mole Frac (H2O)	mole %	0	0	0	0	0,031989	0,031988	0,031989	0	0,00135	0,028273	0,028273	0,001669	0,008745	0,008745	0	0	0,00001	0,008387	0,008719	0,00001	0,032278
Comp Mole Frac (Hydrogen)	mole %	0	0	0	0	0,33711	0,33711	0,33711	0	0,133488	0,000681	0,000681	0,002841	0,000000891	0,000000891	0	0	0,1589	0	0,0000114	0,1589	0,340161