

Appendix III

Sample Experimental Data

This appendix gives experimental data for few selected test runs conducted to study thermal performance and emission constituents for selected compression ratios, injection pressures and loads. B100 indicates pure Karanja biodiesel.

Table III.1 Thermal performance data of the VCR diesel engine running on Diesel oil (Diesel, diesel) and different blends of diesel and biodiesel

1. Compression ratio : 18

2. Injection pressure : 200 bar

Load (kg)	Fuel	BMEP (bar)	BSFC (kg/kWh)	BTHE (%)	Vol. Eff (%)	HBP (%)	HGas (%)	EGT (°C)
0	Diesel	0.01	27.80	0.45	89.39	0.33	22.2	175.67
3	Diesel	0.95	0.6	15.72	89.59	15.04	23.51	196.27
6	Diesel	1.73	0.42	23.15	89.29	21.46	22.78	237.55
9	Diesel	2.55	0.35	26.17	89.14	26.17	23.13	288
12	Diesel	3.36	0.3	31.25	87.6	29.29	24.08	350.75
0	B20	0.02	21.25	0.43	93.76	0.43	45.86	185.56
3	B20	1.08	0.61	15.26	93.93	15.72	32.93	210.96
6	B20	2.1	0.45	22.35	93.57	22.59	31.57	254.67
9	B20	3.11	0.3	25.86	93.36	29.68	30.9	289.53
12	B20	4.11	0.31	30.5	92.59	30.5	29.03	348.56
0	B40	0.02	20.13	0.4	94.44	0.45	36.82	180.65
3	B40	1.15	0.63	15.04	94.44	15.26	28.71	201.85
6	B40	2.05	0.4	22.7	94.07	22.7	29.2	239.68
9	B40	3.12	0.3	25.42	93.59	29.64	30.56	286.53
12	B40	4.16	0.32	30.05	93.19	32.63	31.18	347.96
0	B60	0.01	34.36	0.38	90.61	0.26	29.69	182.89

3	B60	1.16	0.65	14.82	90.62	12.97	21.67	208.23
6	B60	2.12	0.44	20.38	90.42	20.38	22.72	247.9
9	B60	3.08	0.35	25.08	90.25	25.85	24.49	299.65
12	B60	4.15	0.32	29.32	89.95	29.32	24.92	356.04
0	B80	0.02	25.4	0.36	92.98	0.36	39.99	187.53
3	B80	1.12	0.67	13.63	92.32	14.82	29.28	209
6	B80	2.1	0.39	20.35	92.09	23.21	29	242.69
9	B80	3.11	0.36	25.46	92.08	34.18	35.14	290.62
12	B80	4.12	0.33	28.75	91.17	32.25	30.35	346.99
0	B100	0.01	22.05	0.32	89.65	0.41	27.3	179.35
3	B100	1.04	0.7	12.58	89.72	13.63	21.97	198.69
6	B100	2.08	0.45	20.03	89.47	20.03	21.7	240.38
9	B100	3.07	0.37	24.39	89.45	24.39	21.46	281.85
12	B100	4.14	0.34	28.65	89.19	26.64	21.71	343.77

Table III.2 Thermal performance data of the VCR diesel engine running on Diesel oil and different blends of diesel and biodiesel

1. Load : 12kg
2. Injection pressure : 200 bar

Compression ratio	Fuel	BMEP (bar)	BSFC (kg/kWh)	BTHE (%)	Vol. Eff (%)	HBP (%)	HGas (%)	EGT (°C)
14	Diesel	4.08	0.31	27.78	88.63	27.76	41.57	423.71
15	Diesel	4.06	0.29	30.69	89.27	30.69	27.8	407.05
16	Diesel	4.09	0.31	29.01	88.89	29.01	24.92	398.1
17	Diesel	4.13	0.3	30.56	89.01	30.56	25.92	383.77
17.5	Diesel	4.11	0.29	30.66	88.52	30.66	24.79	366.92
18	Diesel	4.06	0.31	29.2	87.6	29.29	24.08	350.75
14	B20	4.12	0.32	25.89	92.2	26.49	32.2	420.87

15	B20	4.08	0.31	28.96	92.3	29.62	31.57	406.25
16	B20	4.09	0.32	27.57	91.65	28.89	29.81	396.76
17	B20	4.1	0.31	29.65	92.98	28.87	34.96	377.98
17.5	B20	4.12	0.29	29.16	93.39	29.16	30.02	360.67
18	B20	4.11	0.32	28.54	92.59	28.84	29.03	348.56
14	B40	4.1	0.34	24.87	93.69	25.48	31.71	419.6
15	B40	4.14	0.32	26.34	93.75	28.54	31.53	400.45
16	B40	4.16	0.33	26.98	93.61	28.67	32.38	390.67
17	B40	4.1	0.32	27.45	93.4	28.51	30.44	372.79
17.5	B40	4.14	0.31	28.12	93.34	28.34	31.58	358.35
18	B40	4.16	0.32	27.95	93.19	28.01	31.18	347.96
14	B60	4.11	0.35	23.79	89.88	24.05	24.22	418.46
15	B60	4.12	0.34	24.89	89.87	27.59	24.45	398.67
16	B60	4.14	0.33	25.87	87.15	28.04	24.61	386.98
17	B60	4.13	0.31	26.43	87.05	28.97	23.51	367.89
17.5	B60	4.14	0.32	26.46	88.56	27.67	22.72	356.78
18	B60	4.15	0.33	27.03	89.95	27.45	24.92	347.3
14	B80	4.12	0.37	22.65	92.34	23.59	31.48	417.39
15	B80	4.08	0.35	23.78	92.22	26.41	32.02	395.8
16	B80	4.14	0.34	24.65	93.76	27.54	29.55	383.98
17	B80	4.1	0.33	25.76	90.9	27.79	29.71	364.01
17.5	B80	4.11	0.31	26.01	90.95	27.56	29.26	354.25
18	B80	4.12	0.34	26.98	91.17	26.98	30.35	346.99
14	B100	4.11	0.39	21.33	89.23	23.04	23.39	415.87
15	B100	4.13	0.36	22.67	89.41	25.13	24.31	390.61
16	B100	4.25	0.35	23.98	89.2	25.57	24.32	380.15
17	B100	4.09	0.33	24.61	92.34	26.48	31.48	360.75
17.5	B100	4.07	0.32	25.61	89.76	26.46	23.87	350.78

18	B100	4.14	0.34	26.64	89.19	26.64	21.71	343.77
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Table III.3 Thermal performance data of the VCR diesel engine running on Diesel oil and different blends of diesel and biodiesel

1. Load : 12kg
2. Compression ratio : 18

Injection Pressure (bar)	Fuel	BMEP (bar)	BSFC (kg/kWh)	BTHE (%)	Vol. Eff (%)	HBP (%)	HGas (%)	EGT (°C)
150	Diesel	4.09	0.32	31.34	88.68	23.56	25.87	326.24
200	Diesel	4.06	0.3	31.9	88.51	29.29	24.08	350.75
250	Diesel	4.11	0.28	32.7	89.29	39.41	23.98	370.26
150	B20	4.09	0.33	29.85	90.67	23.45	28.9	324.7
200	B20	4.11	0.31	30.5	92.59	28.84	29.03	348.92
250	B20	4.12	0.29	31.25	91.76	37.41	27.46	368.9
150	B40	4.15	0.33	29.64	94.44	22.15	32.9	323.56
200	B40	4.16	0.31	30.25	93.19	28.01	31.18	346.89
250	B40	4.18	0.29	31.09	94.07	37.1	33.87	366.9
150	B60	4.13	0.34	28.64	89.85	21.09	23.89	321.9
200	B60	4.15	0.32	29.89	89.95	27.45	24.92	345.78
250	B60	4.17	0.3	29.87	89.97	36.23	25.67	366.09
150	B80	4.1	0.35	28.03	92.98	21.15	29.89	320.76
200	B80	4.12	0.33	29.65	91.17	26.98	30.35	344.87
250	B80	4.15	0.32	29.02	92.09	34.96	31.2	365.23
150	B100	4.15	0.35	27.46	89.65	20.98	21.23	319.56
200	B100	4.14	0.34	28.09	89.19	26.64	21.71	343.77
250	B100	4.18	0.32	28.83	89.47	32.78	23.98	364.59

Table III.4 Thermal performance data of the VCR diesel engine running on Diesel oil and different blends of diesel and biodiesel

1. Load : 12 kg
2. Compression ratio : 18
3. Injection pressure 200 bar

Fuel	BMEP (bar)	BSFC (kg/kWh)	BTHE (%)	Vol. Eff (%)	HBP (%)	HGas (%)	EGT (°C)
Diesel	3.36	0.3	31.25	88.51	29.29	24.08	350.75
B20	4.11	0.31	30.5	92.59	30.5	29.03	348.56
B40	4.16	0.32	30.05	93.19	32.63	31.18	347.96
B60	4.15	0.32	29.32	89.95	29.32	24.92	356.04
B80	4.12	0.33	28.75	91.17	32.25	30.35	346.99
B100	4.14	0.34	28.65	89.19	26.64	21.17	343.77

Table III.5 Exhaust emission data of the VCR diesel engine running on Diesel oil and different blends of diesel and biodiesel

1. Compression ratio : 14
2. Injection pressure : 200 bar

Load (kg)	Fuel	CO ₂ (%)	CO (%)	NO _x (ppm)	HC (ppm)	O ₂ (%)	SO _x (ppm)	HSU (%)
0	Diesel	0.83	0.012	9	6	19.81	23	23
3	Diesel	1.34	0.0136	37	5	18.99	11	11
6	Diesel	1.65	0.0148	75	5	18.67	5	5
9	Diesel	2.01	0.0203	118	6	18.18	5	5
12	Diesel	2.57	0.022	160	8	17.51	5	5
0	B20	0.88	0.011	15	5	19.58	19	19
3	B20	1.4	0.012	42	4	18.97	8	8
6	B20	1.7	0.017	81	5	18.42	4	4
9	B20	2.11	0.018	118	6	18.22	4	4

12	B20	2.6	0.02	161	7	17.56	3	3
0	B40	0.87	0.01	15	4	19.87	15	15
3	B40	1.47	0.011	38	4	19.04	6	6
6	B40	1.75	0.013	82	3	18.69	4	4
9	B40	2.17	0.015	124	4	18.25	3	3
12	B40	2.65	0.016	163	6	17.43	2	2
0	B60	0.89	0.008	15	3	19.91	13	13
3	B60	1.52	0.009	44	3	19.15	5	5
6	B60	1.79	0.012	81	2	18.67	5	5
9	B60	2.19	0.015	129	4	18.21	3	3
12	B60	2.63	0.015	167	5	17.69	1	1
0	B80	0.92	0.005	17	2	19.94	6	6
3	B80	1.58	0.007	46	3	19.08	3	3
6	B80	1.82	0.013	84	2	18.56	2	2
9	B80	2.18	0.011	132	3	17.96	1	1
12	B80	2.68	0.013	175	4	17.59	0	0
0	B100	0.96	0.004	19	2	20.03	4	4
3	B100	1.6	0.006	58	3	19.33	3	3
6	B100	1.84	0.012	87	2	18.95	1	1
9	B100	2.24	0.009	135	2	18.44	1	1
12	B100	2.7	0.011	179	4	17.62	0	0

Table III.6 Exhaust emission data of the VCR diesel engine running on Diesel oil and different blends of diesel and biodiesel**1. Load : 12 kg****2. Injection pressure : 200 bar**

Compression ratio	Fuel	CO ₂ (%)	CO (%)	NO _x (ppm)	HC (ppm)	O ₂ (%)	SO _x (ppm)	HSU (%)
14	Diesel	2.72	0.043	225	18	15.79	76	17.1
15	Diesel	2.48	0.0293	217	16	16.67	23	13.3
16	Diesel	2.4	0.0205	186	12	17.42	13	11.1
17	Diesel	2.45	0.0166	188	7	17.63	7	9.8
17.5	Diesel	2.57	0.015	156	6	17.62	5	9.1
18	Diesel	2.62	0.0152	125	5	17.62	9	9.4
14	B20	2.75	0.049	177	17	17	60	19.8
15	B20	2.65	0.037	170	14	17.23	35	14.5
16	B20	2.54	0.018	151	8	17.41	19	13.2
17	B20	2.55	0.009	149	7	17.5	13	11.2
17.5	B20	2.52	0.004	146	6	17.59	5	11.2
18	B20	2.78	0.012	130	6	17.47	9	11
14	B40	2.82	0.053	162	16	17.26	64	16.1
15	B40	2.7	0.022	150	13	17.49	29	12.5
16	B40	2.68	0.018	168	8	17.31	17	11.4
17	B40	2.64	0.009	158	6	17.54	7	10.6
17.5	B40	2.75	0.007	138	4	17.69	5	10.5
18	B40	2.7	0.007	140	5	17.67	5	10.9
14	B60	2.88	0.068	149	13	17.34	64	17.9
15	B60	2.71	0.027	143	11	17.47	39	15.5
16	B60	2.75	0.008	165	6	17.4	11	13.7
17	B60	2.65	0.009	166	5	17.32	9	12.8
17.5	B60	2.84	0.008	167	4	17.43	9	12.1

18	B60	2.8	0.007	146	5	17.5	9	12.4
14	B80	2.96	0.079	140	14	17.37	60	16.4
15	B80	2.75	0.019	139	10	17.41	29	14
16	B80	2.75	0.017	145	5	17.64	23	12.3
17	B80	2.71	0.011	146	4	17.21	15	12.1
17.5	B80	3.05	0.01	136	3	17.56	15	12
18	B80	3.1	0.006	160	3	17.56	13	12
14	B100	3.26	0.084	132	12	16.81	127	19.9
15	B100	2.71	0.049	135	8	17.09	60	17.3
16	B100	2.86	0.018	173	5	17.29	27	13.8
17	B100	2.85	0.011	179	3	17.45	9	12
17.5	B100	3.15	0.007	179	3	17.51	3	11.7
18	B100	3.26	0.005	166	2	17.91	3	11.8

Table III.7 Exhaust emission data of the VCR diesel engine running on Diesel oil and different blends of diesel and biodiesel

1. Load : 12 kg
2. Compression ratio : 18

Injection Pressure (bar)	Fuel	CO ₂ (%)	CO (ppm)	NO _x (ppm)	HC (ppm)	O ₂ (%)	SO _x (ppm)	HSU (%)
150	Diesel	2.01	181	125	24	16.7	9	16.4
200	Diesel	2.35	152	149	12	17.62	5	9.4
250	Diesel	2.6	110	184	6	18.69	2	6.9
150	B20	2.05	163	127	20	16.8	10	17
200	B20	2.37	120	153	10	17.47	3	10.56
250	B20	2.62	82	185	5	18.75	2	7.5
150	B40	2.1	137	132	17	17.08	8	17.4

200	B40	2.39	100	155	9	17.67	2	11.09
250	B40	2.7	70	187	4	18.76	1	7.9
150	B60	2.14	121	135	14	17.26	5	17.9
200	B60	2.48	85	159	6	17.5	1	11.25
250	B60	2.75	59	190	3	18.98	2	8.1
150	B80	2.2	101	140	12	17.14	3	18.12
200	B80	2.55	76	163	6	17.56	0	11.56
250	B80	2.8	50	195	3	18.87	1	8.3
150	B100	2.24	86	137	10	17.3	2	18.43
200	B100	2.59	60	166	5	17.91	0	11.8
250	B100	2.82	45	198	3	19.1	1	8.5

Table III.8 Exhaust emission data of the VCR diesel engine running on Diesel oil and different blends of diesel and biodiesel

1. Load : 12 kg
2. Compression ratio : 18
3. Injection pressure : 200 bar

Fuel	CO ₂ (%)	CO (ppm)	NO _x (ppm)	HC (ppm)	O ₂ (%)	SO _x (ppm)	HSU (%)
Diesel	2.62	0.0152	125	5	17.62	9	9.4
B20	2.78	0.012	130	6	17.47	9	11
B40	2.7	0.007	140	5	17.67	5	10.9
B60	2.8	0.007	146	5	17.5	9	12.4
B80	3.1	0.006	160	3	17.56	13	12
B100	3.26	0.005	166	2	17.91	3	11.8

Table III.9.1: Airfuel ratio data of the VCR Diesel Engine running on Diesel Oil and different Blends of Diesel and Biodiesel

1. Load : 12kg
2. IP : 200bar

CR	HSD	B20	B40	B60	B80	B100
14	36.94	28.87	29.22	21.86	28.99	20.78
15	27.51	30.41	30.88	23.85	30.36	22.72
16	26.04	28.72	32.55	25.13	28.73	23.69
17	27.46	35.96	32.57	25.12	29.95	28.99
17.5	27.32	32.22	34.24	25.17	30.06	25.06
18	25.94	32.13	34.18	26.43	33.35	23.81

Table III.9.2: Airfuel ratio data of the VCR Diesel Engine running on Diesel Oil and different Blends of Diesel and Biodiesel

1. CR : 18
2. IP : 200 bar

Load	Diesel	B20	B40	B60	B80	Karanja biodiesel
0	68.64	108.16	108.52	70.14	91.57	79.11
3	49.3	63.83	58.46	42.31	57.26	45.34
6	38.18	41.62	48.72	36.24	47.69	35.83
9	31.09	32.13	41.64	31.53	47.27	29.5
12	25.94	27.86	34.18	26.43	33.35	23.81

Table III.9.3 : Airfuel ratio data of the VCR Diesel Engine running on Diesel Oil and different Blends of Diesel and Biodiesel

1. Load : 12kg
2. CR : 18

IP	Diesel	B20	B40	B60	B80	Karanja biodiesel
150	25.2	27.1	33.5	25.9	32.6	23.2
200	25.94	27.86	34.18	26.43	33.35	23.81
250	26.8	28.5	34.9	27.1	33.56	24.4

VARIATION OF AIRFUEL RATIO WITH COMPRESSION RATIO, LOAD AND INJECTION PRESSURE.

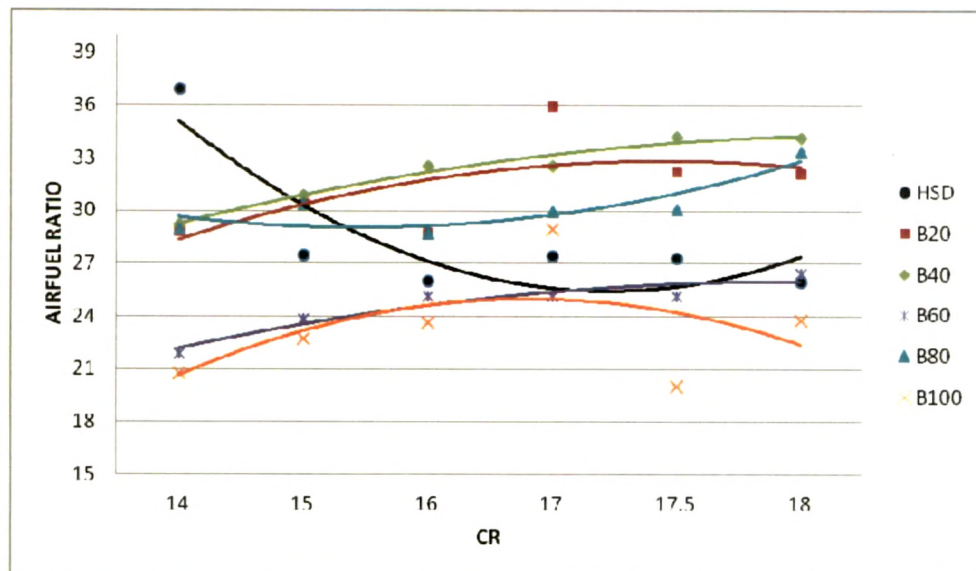


Figure 1: Variation of Airfuel ratio with CR at a load of 12kg and IP of 200bar

It is seen that(Figure 1) as CR increases (Figure 1) from 14 to 18 A/F ratio decreases for diesel from 35 to 27 initially upto 15CR and is maintained the almost same at about 26 at all higher CRs. Similar trend of constant Airfuel ratio of about 24 is maintained at higher CRs for B100. A lower Airfuel for biodiesel infers slightly higher rate of fuel consumption for biodiesel as compared to diesel. B20 behaves closer to diesel at higher CRs. Relatively higher A/Fs for fuel blends may be due to dissimilar combustion characteristics of diesel and biodiesel. A/Fs show an increase in trend with CR for biodiesel and other blends due to improved combustion characteristics because of higher temperature of compressed air. Lower the blend proportion higher the A/F ratio since the behaviour is closer to diesel.

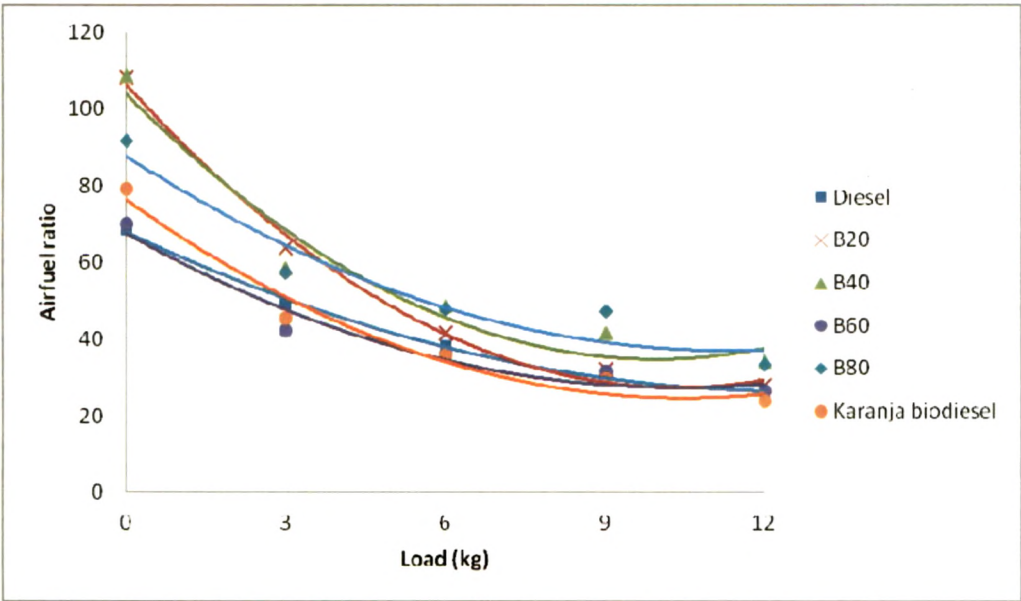


Figure 2: Variation of Airfuel ratio with load at CR of 18 and IP of 200bar

The plot below (Figure 2) shows the variations of the Air-fuel ratio with Load,. With increase in load it is observed that the Air-fuel ratio show a decreasing a trend for all tested fuels, indicating that a richer mixture is required at higher loads. At low loads the Air-fuel ratio is about 10% higher for biodiesel as compared. But as load increases the A/F requirement is the same for both the fuels, indicating comparable performance at higher loads. B20 behaves closer to diesel at higher loads as expected.

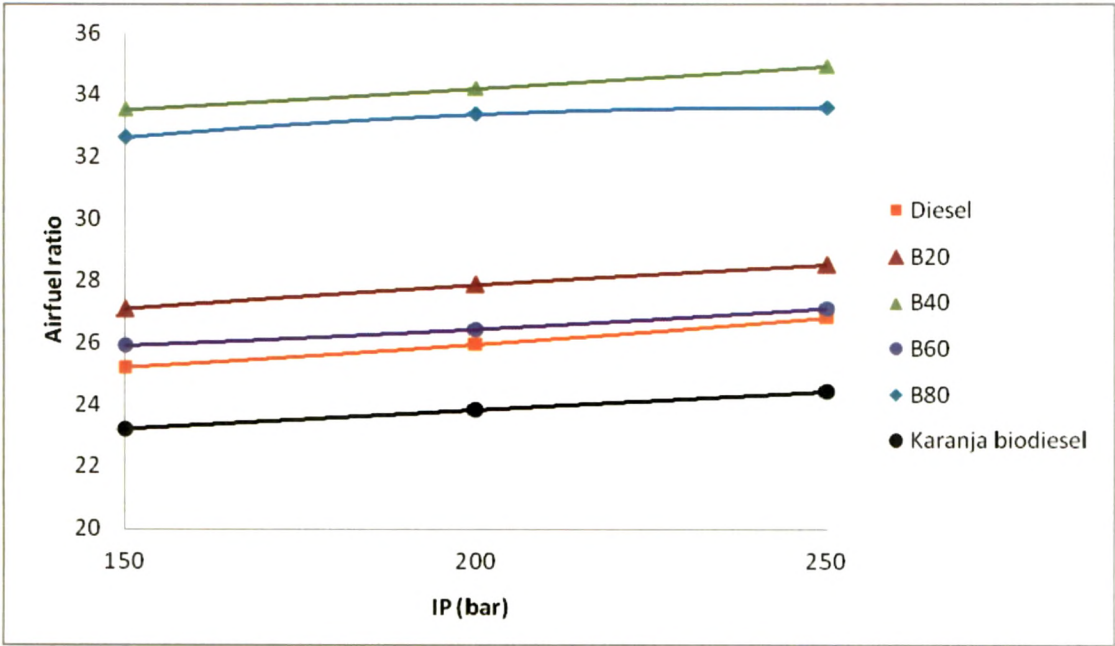


Figure 3: Variation of Air-fuel ratio with IP for full load of 12kg and CR of 18

It is observed that A/F increases (Figure 3) marginally with increase in injection pressure for all the fuels tested at a load of 12kg and CR of 18. This indicates that higher injection pressure results in better atomization of fuel and relatively higher the A/F ratio required which indicates that the engine runs on relatively lean mixture to take up the same load at higher CRs.