

### Perhitungan Laju Bahan Bakar

$$FCR = \frac{\text{Banyaknya bahan bakar yang digunakan (kg)}}{\text{waktu beroperasi (jam)}}$$

$$FCR = \frac{0.255 \text{ kg}}{2 \text{ jam}}$$

$$FCR = 0.1275 \text{ kg/jam}$$

### Perhitungan Efisiensi Thermal

$$Et = \frac{E_1 + E_2}{E_{Minyak}} \times 100\%$$

$$Et = \frac{(m C_{p_{air}} \Delta t) + (hfg * m_{uap})}{m_{minyak \text{ terpakai}} * LHV_{Minyak}} \times 100\%$$

$$Et = \frac{((3 \text{ kg} * 4.18 \text{ kJ/kg} \cdot \text{C} * 100 \text{ }^\circ\text{C} - 28 \text{ }^\circ\text{C}) + (2260 \text{ kJ/kg} * 1.18 \text{ kg}))}{0.258 \text{ kg} * 41509.72 \text{ kJ/kg}} \times 100\%$$

$$Et = \frac{902.88 \text{ kJ} + 2666.8 \text{ kJ}}{10709.508 \text{ kJ}} \times 100\%$$

$$Et = 33,33 \%$$

*Perhitungan Persentasi Sumbu*

Diameter kolom sumbu = 5 mm, r = 2,5 mm

$$L = \pi r^2$$

$$L = \pi 2,5^2$$

$$L = 19,625 \text{ mm}^2$$

*Persentase 20 % serat tembaga*

$$0,2 = \frac{\pi r^2}{19,625}$$

$$\pi r^2 = 0,2 * 19,625 \text{ mm}^2$$

$$\pi r^2 = 3,925 \text{ mm}^2$$

$$r^2 = \frac{3,925 \text{ mm}^2}{3,14}$$

$$r^2 = 1,25 \text{ mm}$$

$$r = \sqrt{1,25} \text{ mm}$$

$$r = 1,1180 \text{ mm}$$

$$D = 2,236 \text{ mm}$$

*Persentase 40 % serat tembaga*

$$0,4 = \frac{\pi r^2}{19,625}$$

$$\pi r^2 = 0,4 * 19,625 \text{ mm}^2$$

$$\pi r^2 = 7,85 \text{ mm}^2$$

$$r^2 = \frac{7,85 \text{ mm}^2}{3,14}$$

$$r^2 = 2,5 \text{ mm}$$

$$r = 1,58 \text{ mm}$$

$$D = 3,16 \text{ mm}$$

*Persentase 50 % serat tembaga*

$$0,5 = \frac{\pi r^2}{19,625}$$

$$\pi r^2 = 0,5 * 19,625 \text{ mm}^2$$

$$\pi r^2 = 9,8125 \text{ mm}^2$$

$$r^2 = \frac{9,8125 \text{ mm}^2}{3,14}$$

$$r^2 = 3,125 \text{ mm}$$

$$r = \sqrt{3,125} \text{ mm}$$

$$r = 1,7677 \text{ mm}$$

$$D = 3,53 \text{ mm}$$

*Persentase 60 % serat tembaga*

$$0,6 = \frac{\pi r^2}{19,625}$$

$$\pi r^2 = 0,6 * 19,625 \text{ mm}^2$$

$$\pi r^2 = 11,775 \text{ mm}^2$$

$$r^2 = \frac{11,775 \text{ mm}^2}{3,14}$$

$$r^2 = 3,75 \text{ mm}$$

$$r = \sqrt{3,75} \text{ mm}$$

$$r = 1,9304 \text{ mm}$$

$$D = 3,87 \text{ mm}$$

Tabel 6. Hubungan % tembaga dengan ketinggian pengurangan minyak.

t (menit)	Ketinggian pengurangan minyak (cm)				
	0 %	20 %	40 %	50 %	60 %
0	0,0	0,0	0,0	0,0	0,0
5	0,3	0,3	0,2	0,2	0,2
10	0,5	0,5	0,6	0,5	0,4
15	0,8	0,7	1,0	0,8	0,6
20	1,0	1,0	1,3	1,1	1,0
25	1,3	1,3	1,8	1,4	1,2
30	1,5	1,5	2,3	2,0	1,5
35	2,0	2,5	3,4	2,4	2,0
40	2,5	2,8	3,8	3,0	2,4
45	2,7	3,2	4,2	3,8	3,2
50	2,9	3,6	4,8	4,3	3,7
55	3,0	4,2	5,3	4,6	4,2
60	3,3	4,5	5,5	5,0	4,4
65	3,5	4,8	5,7	5,3	4,7
70	3,7	5,1	5,9	5,5	4,9
75	-	5,5	6,5	5,7	5,3
80	-	5,8	6,7	5,9	5,7
85	-	6,1	7,0	6,0	5,9
90	-	6,2	-	-	6,1
95	-	6,5	-	-	6,3
100	-	6,8	-	-	6,5
105	-	7,1	-	-	-
110	-	7,5	-	-	-

Tabel 7. Karakteristik minyak solar, minyak jelantah sawit, dan biofuel minyak jelantah sawit (Rahmat, 2007).

Parameter	Minyak Solar	Minyak Jelantah Sawit	Biofuel Minyak Jelantah Sawit
Kerapatan Sfesifik 60/60 °F	0,820 – 0,870	0,9104	0,8733
Viskositas Kinematis 40°C, cst	2,0 – 5,0	39,07	4,553
Titik Tuang, °F	Maksimal 65	50	55,4
Titik Nyala, °F	Minimal 150	478	363,2
Kadar Air, % Volume	Maksimal 0,05	Trace	Trace
Sisa Karbon, %	Maksimal 0,1	0,318	0,0087
Nilai Pembakaran Kotor, BTU/lb	19,031 – 19,220	18,952	19,089
Nilai Pembakaran Bersih, BTU/lb	17,856 – 17,977	17,832	17,918

Tabel 8. Perbandingan minyak jelantah, biodiesel minyak jelantah dan minyak diesel (Rahmat, 2007).

Fuel Property	Waste vegetable oil	Biodiesel from waste vegetable oil	Commercial diesel fuel
Kinematic viscosity ( $\text{mm}^2/\text{s}$ , at 313 K)	36,4	5,3	1,9 – 4,1
Density (kg/L, at 288 K)	0,924	0,897	0,075 – 0,840
Flash point (K)	485	469	340 – 358
Pour point (K)	284	262	254 – 260
Cetane number	49	54	40 – 46
Ash content (%)	0,006	0,004	0,008 – 0,010
Sulfur content (%)	0,09	0,06	0,35 – 0,55
Carbon residue (%)	0,46	0,33	0,35 – 0,40
Water content (%)	0,42	0,04	0,02 – 0,05
Higer heatine value (MJ/kg)	41,40	42,65	45,62 – 46,48
Free fatty acid (mg KOH/g oil)	1,32	0,10	-
Iodine value	141,5	-	-

Tabel 9. Nilai Spesifik Enthalpi Uap Air ( Hydrogen Analysis Resource center, 2010).

## Steam Tables

Pressure		Temperature °C	Specific enthalpy			Specific volume steam m <sup>3</sup> /kg
bar	kPa		Water (hf) kJ/kg	Evaporation (hfg) kJ/kg	Steam (hg) kJ/kg	
0.30	30	69.113	289.331	2335.28	2624.61	5.229.76
0.50	50	81.338	340.578	2304.77	2645.35	3.240.85
0.78	78	91.782	384.469	2276.10	2662.57	2.217.61
0.98	98	98.204	411.524	2261.38	2672.91	1.777.59
1.00	100	99.632	417.547	2257.63	2675.18	1.694.32
1.01325	101.325	100.001	419.101	2256.66	2675.76	1.673.60
0	0	100.001	419.101	2256.66	2675.76	1.673.59
0.1	10	102.660	430.327	2249.62	2679.95	1.532.56
0.2	20	105.128	440.758	2243.05	2683.81	1.414.08
0.3	30	107.434	450.510	2236.86	2687.37	1.313.11
0.4	40	109.600	459.676	2231.02	2690.69	1.225.99
0.5	50	111.642	468.351	2225.47	2693.86	1.150.03
0.6	60	113.577	476.534	2220.19	2696.72	1.083.20
0.7	70	115.416	484.336	2215.13	2699.47	1.023.92
0.8	80	117.169	491.779	2210.29	2702.07	0.970.98
0.9	90	118.844	498.898	2205.64	2704.54	0.923.40
1.0	100	120.449	505.725	2201.16	2706.88	0.880.39
1.1	110	121.991	512.284	2196.83	2709.12	0.841.33
1.2	120	123.474	518.599	2192.65	2711.25	0.805.68
1.3	130	124.903	524.690	2188.60	2713.29	0.773.01
1.4	140	126.283	530.574	2184.67	2715.25	0.742.97
1.5	150	127.617	536.266	2180.86	2717.13	0.715.23
1.6	160	128.909	541.781	2177.15	2718.93	0.689.56
1.7	170	130.161	547.130	2173.54	2720.67	0.665.71
1.8	180	131.376	552.334	2170.02	2722.34	0.643.60
1.9	190	132.557	557.374	2166.58	2723.95	0.622.76
2.0	200	133.705	562.289	2163.23	2725.52	0.603.36
2.2	220	135.819	571.749	2156.74	2728.48	0.568.06
2.4	240	138.011	580.741	2150.53	2731.27	0.536.76
2.6	260	140.013	589.333	2144.55	2733.89	0.508.82
2.8	280	141.927	597.559	2138.80	2736.36	0.483.71
3.0	300	143.762	605.453	2133.24	2738.70	0.461.02
3.2	320	145.525	613.044	2127.87	2740.92	0.440.41
3.4	340	147.221	620.367	2122.67	2743.09	0.421.61
3.6	360	148.858	627.417	2117.61	2745.03	0.404.98
3.8	380	150.438	634.242	2112.70	2746.94	0.388.54
4.0	400	151.966	640.849	2107.92	2748.77	0.373.93
4.5	450	155.584	656.515	2096.49	2753.00	0.341.86
5.0	500	158.949	671.117	2085.70	2756.82	0.314.96
5.5	550	162.096	684.611	2075.47	2760.28	0.293.02
6.0	600	165.059	697.720	2065.72	2763.44	0.272.32
6.5	650	167.858	709.944	2056.39	2766.33	0.255.12
7.0	700	170.518	721.661	2047.43	2768.99	0.239.99
7.5	750	173.039	732.641	2038.81	2771.45	0.226.58
8.0	800	175.451	743.238	2030.49	2773.72	0.214.61
8.5	850	177.765	753.468	2022.43	2775.83	0.203.86
9.0	900	179.974	763.168	2014.63	2777.80	0.194.13
9.5	950	182.103	772.576	2007.05	2779.62	0.185.31
10.0	1000	184.154	781.699	1999.67	2781.33	0.177.29
10.5	1050	186.133	790.433	1992.49	2782.92	0.169.88
11.0	1100	188.045	798.931	1985.48	2784.41	0.163.10
11.5	1150	189.897	807.171	1978.63	2785.80	0.156.84
12.0	1200	191.691	815.171	1971.94	2787.11	0.151.05
12.5	1250	193.432	822.948	1965.38	2788.33	0.145.67
13.0	1300	195.128	830.515	1958.96	2789.46	0.140.66
13.5	1350	196.767	837.888	1952.67	2790.56	0.135.98
14.0	1400	198.368	845.077	1946.49	2791.57	0.131.60
14.5	1450	199.928	852.093	1940.42	2792.51	0.127.90
15.0	1500	201.456	858.947	1934.46	2793.40	0.123.64
15.5	1550	202.934	865.648	1928.59	2794.24	0.120.01
16.0	1600	204.364	872.203	1922.82	2795.02	0.116.99
17.0	1700	207.188	884.907	1911.53	2796.44	0.110.29
18.0	1800	209.873	897.116	1900.57	2797.68	0.104.63
19.0	1900	212.436	908.873	1889.89	2798.77	0.099.32
20.0	2000	214.990	920.290	1879.49	2799.71	0.094.88
21.0	2100	217.319	931.192	1869.32	2800.51	0.090.64
22.0	2200	219.626	941.818	1859.38	2801.20	0.086.76
23.0	2300	221.867	952.195	1849.65	2801.77	0.083.19