LAMPIRAN

Lampiran 1. Tabel Konduktifitas Termal Bahan

Thermal conductivities of some materials at room conditions

Material	Thermal conductivity, W/m · K
Diamond	2300
Silver	429
Copper	401
Gold	317
Aluminium	237
Iron	80.2
Mercury (ℓ)	8.54
Glass	1.4
Brick	0.72
Water (ℓ)	0.613
Human skin	0.37
Wood (oak)	0.17
Helium (g)	0.152
Soft rubber	0.13
Glass fiber	0.043
Air (g)	0.026
Urethane, rigid foam	0.026

Sumber : Cengel, Y.A & Moran M.J, Thermodynamics an Engineering Aproach

Lampiran 2. Tabel Panas Spesifik (*Cp*)

TABLE 20.1 Specific Heats of Some Substances at 25°C and Atmospheric Pressure

Substance	Specific Heat *c* J/kg·°C	Specific Heat *c* cal/g·°C
Elemental Solids		
Aluminum	900	0.215
Beryllium	1 830	0.436
Cadmium	230	0.055
Copper	387	0.092 4
Germanium	322	0.077
Gold	129	0.030 8
Iron	448	0.107
Lead	128	0.030 5
Silicon	703	0.168
Silver	234	0.056
Other Solids		
Brass	380	0.092
Glass	837	0.200
Ice (− 5°C)	2 090	0.50
Marble	860	0.21
Wood	1 700	0.41
Liquids		
Alcohol (ethyl)	2 400	0.58
Mercury	140	0.033
Water (15°C)	4 186	1.00
Gas		
Steam (100°C)	2 010	0.48

Lampiran 3. Tabel Emisivitas Bahan-Logam

18.1 References

1	Mikaél A. Bramson: *Infrared Radiation, A Handbook for Applications*, Plenum press, N.Y.
2	William L. Wolfe, George J. Zissis: *The Infrared Handbook*, Office of Naval Research, Department of Navy, Washington, D.C.
3	Madding, R. P.: *Thermographic Instruments and systems*. Madison, Wisconsin: University of Wisconsin – Extension, Department of Engineering and Applied Science.
4	William L. Wolfe: *Handbook of Military Infrared Technology*, Office of Naval Research, Department of Navy, Washington, D.C.
5	Jones, Smith, Probert: *External thermography of buildings...*, Proc. of the Society of Photo-Optical Instrumentation Engineers, vol.110, Industrial and Civil Applications of Infrared Technology, June 1977 London.
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7	Vlcek, J: *Determination of emissivity with imaging radiometers and some emissivities at* $\lambda = 5$ *µm*. Photogrammetric Engineering and Remote Sensing.
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Figure 18.1 T: Total spectrum; **SW:** 2–5 µm; **LW:** 8–14 µm, **LLW:** 6.5–20 µm; **1:** Material; **2:** Specification; **3:** Temperature in °C; **4:** Spectrum; **5:** Emissivity: **6:** Reference

1	2	3	4	5	6
Aluminum	anodized, black, dull	70	LW	0.95	9
Aluminum	anodized, black, dull	70	SW	0.67	9
Aluminum	anodized, light gray, dull	70	LW	0.97	9

Iron, cast	casting	50	T	0.81	1
Iron, cast	ingots	1000	T	0.95	1
Iron, cast	liquid	1300	T	0.28	1
Iron, cast	machined	800–1000	T	0.60–0.70	1
Iron, cast	oxidized	38	T	0.63	4
Iron, cast	oxidized	100	T	0.64	2
Iron, cast	oxidized	260	T	0.66	4
Iron, cast	oxidized	538	T	0.76	4

Lampiran 4. Tabel Emisivitas Bahan-Nonlogam

Nonmetallic Substances[b]

Description/Composition		Temperature (K)	Emissivity ε
Aluminum oxide	(*n*)	600	0.69
		1000	0.55
		1500	0.41
Asphalt pavement	(*h*)	300	0.85–0.93
Building materials			
Asbestos sheet	(*h*)	300	0.93–0.96
Brick, red	(*h*)	300	0.93–0.96
Gypsum or plaster board	(*h*)	300	0.90–0.92
Wood	(*h*)	300	0.82–0.92
Cloth	(*h*)	300	0.75–0.90
Concrete	(*h*)	300	0.88–0.93
Glass, window	(*h*)	300	0.90–0.95
Ice	(*h*)	273	0.95–0.98
Paints			
Black (Parsons)	(*h*)	300	0.98
White, acrylic	(*h*)	300	0.90
White, zinc oxide	(*h*)	300	0.92
Paper, white	(*h*)	300	0.92–0.97
Pyrex	(*n*)	300	0.82
		600	0.80
		1000	0.71
		1200	0.62
Pyroceram	(*n*)	300	0.85
		600	0.78
		1000	0.69
		1500	0.57
Refractories (furnace liners)			
Alumina brick	(*n*)	800	0.40
		1000	0.33
		1400	0.28
		1600	0.33
Magnesia brick	(*n*)	800	0.45
		1000	0.36
		1400	0.31
		1600	0.40
Kaolin insulating brick	(*n*)	800	0.70
		1200	0.57
		1400	0.47
		1600	0.53
Sand	(*h*)	300	0.90
Silicon carbide	(*n*)	600	0.87
		1000	0.87
		1500	0.85
Skin	(*h*)	300	0.95
Snow	(*h*)	273	0.82–0.90

Lampiran 5. Sifat-sifat Gas *Propane, Butane* dan LPG

Property	Propane	Butane	LPG
Molecular weight	44,09	58,12	49,7 (av.)
Carbon content (wt %)	81,72	82,66	82,15
Hydrogen content (wt %)	18,28	17,34	17,85
Carbon : hydrogen ratio by weight	4,47	4,77	4,60
Density of liquid at 15°C (kg/ℓ)	0,510	0,575	0,536
Boiling point of liquid at atm. Pres. (kg/m^3)	-42,1	-0,5	-42,1 -0,5
Density of gas at 15°C & atm. pres.(kg/m^3)	1,86	2,46	2,10
Volume ratio of gas: liquid at STP	274:1	233:1	258:1
Volume of gas from 1kg liquid at STP (ℓ)	537	405	484
Mass ratio of gas: air at 15°C &atm. Pres.	1,52:1	2,01:1	1,716:1
Latent heat of vaporization at 15°C(kJ/kg)	20,43	21,27	20,77
Vapor pressure at 20°C (kPa abs.)	710	110	500
Sp. Heat of vapor at atm. Pres. (Cal/g. °C)	0,388	0,397	0,392
Wobbe number (kcal/Nm^3)	19000	21600	
Limits of flammability in air (vol% gas)	2,2-10	1,8-9	1,8-10
Limits of flammability in oxygen (vol% gas)	2-50	2-50	2-50
Max. Flame temperature in air(°C)	1930	1900	1900
Max. flame temperature in oxygen (°C)	2740	2700	2700
Air reqd. for combustion at STP (m^3/kg LPG)	12,10	11,93	12,03

Lampiran 6. Nilai Kalor dari Berbagai Bahan Bakar Gas

Gas	Gross Heating Value		Net Heating Value	
	(*Btu/ft*^{3})	(*Btu/lb*)	(*Btu/ft*^{3})	(*Btu/lb*)
Acetylene (ethyne) - C_2H_2	1,498	21,569	1,447	20,837
Benzene	3,741	18,150	3,590	17,418
Blast Furnace gas	92	1,178	92	1,178
Blue water gas		6,550		
Butane - C_4H_{10}	3,225	21,640	2,977	19,976
Butylene (Butene)	3,077	20,780	2,876	19,420
Carbon to CO_2		14,150		14,150
Carbon to CO		3,960		3,960
Carbon monoxide - CO	323	4,368	323	4,368
Carburetted Water Gas	550	11,440	508	10,566
Coal gas	149	16,500		
Coke Oven Gas	574	17,048	514	15,266
Digester Gas (Sewage or Biogas)	690	11,316	621	10,184
Ethane - C_2H_6	1,783	22,198	1,630	20,295
Ethyl alcohol saturated with water	1,548	12,804		
Ethylene	1,631	21,884	1,530	20,525
Hydrogen (H_2)	325	61,084	275	51,628
Hydrogen Sulphide	672	7,479		
Methane - CH_4	1,011	23,811	910	21,433
Methyl alcohol saturated with water	818	9,603		
Naphthalene	5,859	17,298		
Natural Gas (typical)	950 - 1,150	19,500 - 22,500	850 - 1,050	17,500 - 22,000
Octane saturated with water	6,239	20,542	3,170	10,444
Pentane	3,981	20,908	3,679	19,322
Propane - C_3H_8	2,572	21,564	2,371	19,834
Propene (Propylene) - C_3H_6	2,332	20,990	2,181	19,630
Propylene	2,336	21,042	2,185	19,683
Sulphur		3,940		
Toulene	4,408	18,129	4,206	17,301
Water Gas (bituminous)	261	4,881	239	4,469
Xylene	5,155	18,410		

Lampiran 7. Tabel Hasil Perhitungan

Tanpa Selubung

NO	Time	m H2O	Cp Air	T		T2 - T1	Estored	m gas	LHV	Egenerated	Efisiensi
	(detik)	(kg)	(KJ/kg K)	T1 (K)	T2 (K)	(K)	(KJ)	(kg)	(KJ/kg)	(KJ)	(%)
1	60	1	4,2	298	304	6	25,2	0,001575	46365,08	73,025001	34,50873
2	120	1	4,2	298	311,8	13,8	57,96	0,00315	46365,08	146,050002	39,68504
3	180	1	4,2	298	319,7	21,7	91,14	0,004725	46365,08	219,075003	41,60219
4	240	1	4,2	298	328,1	30,1	126,42	0,0063	46365,08	292,100004	43,2797
5	300	1	4,2	298	335,7	37,7	158,34	0,007875	46365,08	365,125005	43,36597
6	360	1	4,2	298	343,7	45,7	191,94	0,00945	46365,08	438,150006	43,80691
7	420	1	4,2	298	351,3	53,3	223,86	0,011025	46365,08	511,175007	43,79322
8	480	1	4,2	298	358,3	60,3	253,26	0,0126	46365,08	584,200008	43,35159
Goal	553	1	4,2	298	368	70	294	0,01451625	46366,08	673,0616088	43,68099

Selubung Keramik

NO	Time	m H2O	Cp Air	T		T2 - T1	Estored	m gas	LHV	Egenerated	Efisiensi
	(detik)	(kg)	(KJ/kg K)	T1 (K)	T2 (K)	(K)	(KJ)	(kg)	(KJ/kg)	(KJ)	(%)
1	60	1	4,2	298	306,1	8,1	34,02	0,001575	46365,08	73,025001	46,58678
2	120	1	4,2	298	313,6	15,6	65,52	0,00315	46365,08	146,050002	44,86135
3	180	1	4,2	298	321,3	23,3	97,86	0,004725	46365,08	219,075003	44,66963
4	240	1	4,2	298	329,2	31,2	131,04	0,0063	46365,08	292,100004	44,86135
5	300	1	4,2	298	337,7	39,7	166,74	0,007875	46365,08	365,125005	45,66655
6	360	1	4,2	298	346,4	48,4	203,28	0,00945	46365,08	438,150006	46,39507
7	420	1	4,2	298	354,2	56,2	236,04	0,011025	46365,08	511,175007	46,17597
8	480	1	4,2	298	363,3	65,3	274,26	0,0126	46365,08	584,200008	46,94625
Goal	521	1	4,2	298	368	70	294	0,01367625	46366,08	634,1141016	46,3639

Selubung Aluminium

NO	Time	m H2O	Cp Air	T		T2 - T1	Estored	m gas	LHV	Egenerated	Efisiensi
	(detik)	(kg)	(KJ/kg K)	T1 (K)	T2 (K)	(K)	(KJ)	(kg)	(KJ/kg)	(KJ)	(%)
1	60	1	4,2	298	304,3	6,3	26,46	0,001575	46365,08	73,025001	36,23417
2	120	1	4,2	298	311,9	13,9	58,38	0,00315	46365,08	146,050002	39,97261
3	180	1	4,2	298	320,5	22,5	94,5	0,004725	46365,08	219,075003	43,13591
4	240	1	4,2	298	328,7	30,7	128,94	0,0063	46365,08	292,100004	44,14242
5	300	1	4,2	298	337,1	39,1	164,22	0,007875	46365,08	365,125005	44,97638
6	360	1	4,2	298	345,1	47,1	197,82	0,00945	46365,08	438,150006	45,14892
7	420	1	4,2	298	353,6	55,6	233,52	0,011025	46365,08	511,175007	45,68298
8	480	1	4,2	298	361,7	63,7	267,54	0,0126	46365,08	584,200008	45,79596
Goal	530	1	4,2	298	368	70	294	0,0139125	46366,08	645,068088	45,57658

Selubung Besi

NO	Time	m H2O	Cp Air	T		T2 - T1	Estored	m gas	LHV	Egenerated	Efisiensi
	(detik)	(kg)	(KJ/kg K)	T1 (K)	T2 (K)	(K)	(KJ)	(kg)	(KJ/kg)	(KJ)	(%)
1	60	1	4,2	298	303,6	5,6	23,52	0,001575	46365,08	73,025001	32,20815
2	120	1	4,2	298	312	14	58,8	0,00315	46365,08	146,050002	40,26018
3	180	1	4,2	298	320,8	22,8	95,76	0,004725	46365,08	219,075003	43,71106
4	240	1	4,2	298	329,2	31,2	131,04	0,0063	46365,08	292,100004	44,86135
5	300	1	4,2	298	337,7	39,7	166,74	0,007875	46365,08	365,125005	45,66655
6	360	1	4,2	298	346,4	48,4	203,28	0,00945	46365,08	438,150006	46,39507
7	420	1	4,2	298	354,9	56,9	238,98	0,011025	46365,08	511,175007	46,75111
8	480	1	4,2	298	359,8	61,8	259,56	0,0126	46365,08	584,200008	44,42999
Goal	552	1	4,2	298	368	70	294	0,01449	46366,08	671,8444992	43,76013