LAMPIRAN

Lampiran 1 Tabel appendix penentuan massa jenis dan viskositas

TABLE A–9

Properties of saturated water

Temp. T, °C	Saturation Pressure P_{sat}, kPa	Density ρ, kg/m³ Liquid	Density ρ, kg/m³ Vapor	Enthalpy of Vaporization h_{fg}, kJ/kg	Specific Heat c_p, J/kg · K Liquid	Specific Heat c_p, J/kg · K Vapor	Thermal Conductivity k, W/m · k Liquid	Thermal Conductivity k, W/m · k Vapor	Dynamic Viscosity μ, kg/m · s Liquid	Dynamic Viscosity μ, kg/m · s Vapor	Prandtl Number Pr Liquid	Prandtl Number Pr Vapor	Volume Expansion Coefficient β, 1/K Liquid
0.01	0.6113	999.8	0.0048	2501	4217	1854	0.561	0.0171	1.792×10^{-2}	0.922×10^{-5}	13.5	1.00	-0.068×10^{-2}
5	0.8721	999.9	0.0068	2490	4205	1857	0.571	0.0173	1.519×10^{-2}	0.934×10^{-5}	11.2	1.00	0.015×10^{-2}
10	1.2276	999.7	0.0094	2478	4194	1862	0.580	0.0176	1.307×10^{-2}	0.946×10^{-5}	9.45	1.00	0.733×10^{-2}
15	1.7051	999.1	0.0128	2466	4185	1863	0.589	0.0179	1.138×10^{-2}	0.959×10^{-5}	8.09	1.00	0.138×10^{-2}
20	2.339	998.0	0.0173	2454	4182	1867	0.598	0.0182	1.002×10^{-2}	0.973×10^{-5}	7.01	1.00	0.195×10^{-2}
25	3.169	997.0	0.0231	2442	4180	1870	0.607	0.0186	0.891×10^{-2}	0.987×10^{-5}	6.14	1.00	0.247×10^{-2}
30	4.246	996.0	0.0304	2431	4178	1875	0.615	0.0189	0.798×10^{-2}	1.001×10^{-5}	5.42	1.00	0.294×10^{-2}
35	5.628	994.0	0.0397	2419	4178	1880	0.623	0.0192	0.720×10^{-2}	1.016×10^{-5}	4.83	1.00	0.337×10^{-2}
40	7.384	992.1	0.0512	2407	4179	1885	0.631	0.0196	0.653×10^{-2}	1.031×10^{-5}	4.32	1.00	0.377×10^{-2}
45	9.593	990.1	0.0655	2395	4180	1892	0.637	0.0200	0.596×10^{-2}	1.046×10^{-5}	3.91	1.00	0.415×10^{-2}
50	12.35	988.1	0.0831	2383	4181	1900	0.644	0.0204	0.547×10^{-2}	1.062×10^{-5}	3.55	1.00	0.451×10^{-2}
55	15.76	985.2	0.1045	2371	4183	1908	0.649	0.0208	0.504×10^{-2}	1.077×10^{-5}	3.25	1.00	0.484×10^{-2}
60	19.94	983.3	0.1304	2359	4185	1916	0.654	0.0212	0.467×10^{-2}	1.093×10^{-5}	2.99	1.00	0.517×10^{-2}
65	25.03	980.4	0.1614	2346	4187	1926	0.659	0.0216	0.433×10^{-2}	1.110×10^{-5}	2.75	1.00	0.548×10^{-2}
70	31.19	977.5	0.1983	2334	4190	1936	0.663	0.0221	0.404×10^{-2}	1.126×10^{-5}	2.55	1.00	0.578×10^{-2}
75	38.58	974.7	0.2421	2321	4193	1948	0.667	0.0225	0.378×10^{-2}	1.142×10^{-5}	2.38	1.00	0.607×10^{-2}
80	47.39	971.8	0.2935	2309	4197	1962	0.670	0.0230	0.355×10^{-2}	1.159×10^{-5}	2.22	1.00	0.653×10^{-2}
85	57.83	968.1	0.3536	2296	4201	1977	0.673	0.0235	0.333×10^{-2}	1.176×10^{-5}	2.08	1.00	0.670×10^{-2}
90	70.14	965.3	0.4235	2283	4206	1993	0.675	0.0240	0.315×10^{-2}	1.193×10^{-5}	1.96	1.00	0.702×10^{-2}
95	84.55	961.5	0.5045	2270	4212	2010	0.677	0.0246	0.297×10^{-2}	1.210×10^{-5}	1.85	1.00	0.716×10^{-2}
100	101.33	957.9	0.5978	2257	4217	2029	0.679	0.0251	0.282×10^{-2}	1.227×10^{-5}	1.75	1.00	0.750×10^{-2}
110	143.27	950.6	0.8263	2230	4229	2071	0.682	0.0262	0.255×10^{-2}	1.261×10^{-5}	1.58	1.00	0.798×10^{-2}
120	198.53	943.4	1.121	2203	4244	2120	0.683	0.0275	0.232×10^{-2}	1.296×10^{-5}	1.44	1.00	0.858×10^{-2}
130	270.1	934.6	1.496	2174	4263	2177	0.684	0.0288	0.213×10^{-2}	1.330×10^{-5}	1.33	1.01	0.913×10^{-2}
140	361.3	921.7	1.965	2145	4286	2244	0.683	0.0301	0.197×10^{-2}	1.365×10^{-5}	1.24	1.02	0.970×10^{-2}
150	475.8	916.6	2.546	2114	4311	2314	0.682	0.0316	0.183×10^{-2}	1.399×10^{-5}	1.16	1.02	1.025×10^{-2}
160	617.8	907.4	3.256	2083	4340	2420	0.680	0.0331	0.170×10^{-2}	1.434×10^{-5}	1.09	1.05	1.145×10^{-2}
170	791.7	897.7	4.119	2050	4370	2490	0.677	0.0347	0.160×10^{-2}	1.468×10^{-5}	1.03	1.05	1.178×10^{-2}
180	1,002.1	887.3	5.153	2015	4410	2590	0.673	0.0364	0.150×10^{-2}	1.502×10^{-5}	0.983	1.07	1.210×10^{-2}
190	1,254.4	876.4	6.388	1979	4460	2710	0.669	0.0382	0.142×10^{-2}	1.537×10^{-5}	0.947	1.09	1.280×10^{-2}
200	1,553.8	864.3	7.852	1941	4500	2840	0.663	0.0401	0.134×10^{-2}	1.571×10^{-5}	0.910	1.11	1.350×10^{-2}
220	2,318	840.3	11.60	1859	4610	3110	0.650	0.0442	0.122×10^{-2}	1.641×10^{-5}	0.865	1.15	1.520×10^{-2}
240	3,344	813.7	16.73	1767	4760	3520	0.632	0.0487	0.111×10^{-2}	1.712×10^{-5}	0.836	1.24	1.720×10^{-2}
260	4,688	783.7	23.69	1663	4970	4070	0.609	0.0540	0.102×10^{-2}	1.788×10^{-5}	0.832	1.35	2.000×10^{-2}
280	6,412	750.8	33.15	1544	5280	4835	0.581	0.0605	0.094×10^{-2}	1.870×10^{-5}	0.854	1.49	2.380×10^{-2}
300	8,581	713.8	46.15	1405	5750	5980	0.548	0.0695	0.086×10^{-2}	1.965×10^{-5}	0.902	1.69	2.950×10^{-2}
320	11,274	667.1	64.57	1239	6540	7900	0.509	0.0836	0.078×10^{-2}	2.084×10^{-5}	1.00	1.97	
340	14,586	610.5	92.62	1028	8240	11,870	0.469	0.110	0.070×10^{-2}	2.255×10^{-5}	1.23	2.43	
360	18,651	528.3	144.0	720	14,690	25,800	0.427	0.178	0.060×10^{-2}	2.571×10^{-5}	2.06	3.73	
374.14	22,090	317.0	317.0	0	—	—	—	—	0.043×10^{-2}	4.313×10^{-5}			

Note 1: Kinematic viscosity ν and thermal diffusivity α can be calculated from their definitions, $\nu = \mu/\rho$ and $\alpha = k/\rho c_p = \nu/\mathrm{Pr}$. The temperatures 0.01°C, 100°C, and 374.14°C are the triple-, boiling-, and critical-point temperatures of water, respectively. The properties listed above (except the vapor density) can be used at any pressure with negligible error except at temperatures near the critical-point value.

Note 2: The unit kJ/kg · °C for specific heat is equivalent to kJ/kg · K, and the unit W/m · °C for thermal conductivity is equivalent to W/m · K.

Source: Viscosity and thermal conductivity data are from J. V. Sengers and J. T. R. Watson, *Journal of Physical and Chemical Reference Data* 15 (1986), pp. 1291–1322. Other data are obtained from various sources or calculated.

Lampiran 2 Data primer penelitian

Variasi	Re	Debit		Percobaan Differential Pressure Meter (InHg)					Hasil konversi satuan (Pa)				
		LPM	m^3/s	1	2	3	4	5	1	2	3	4	5
1	2348,43	2	$3,33 . 10^{-5}$	0,009	0,01	0,009	0,008	0,008	30,47	33,86	30,47	27,09	27,09
2	2465,86	2,1	$3,50 . 10^{-5}$	0,009	0,01	0,01	0,009	0,009	30,47	33,86	33,86	30,47	30,47
3	2583,28	2,2	$3,66 . 10^{-5}$	0,01	0,011	0,011	0,01	0,01	33,86	37,25	37,25	33,86	33,86
4	2700,70	2,3	$3,83 . 10^{-5}$	0,01	0,011	0,012	0,011	0,01	33,86	37,25	40,63	37,25	33,86
5	2818,12	2,4	$4,0 . 10^{-5}$	0,011	0,012	0,012	0,013	0,011	37,25	40,64	40,63	44,02	37,25
6	2935,54	2,5	$4,16 . 10^{-5}$	0,011	0,013	0,012	0,013	0,012	37,25	44,02	40,63	44,02	40,63
7	3052,97	2,6	$4,33 . 10^{-5}$	0,012	0,013	0,014	0,014	0,013	40,63	44,02	47,40	47,40	44,02
8	3170,39	2,7	$4,50 . 10^{-5}$	0,013	0,014	0,015	0,015	0,013	44,02	47,40	50,79	50,79	44,02
9	3287,81	2,8	$4,66 . 10^{-5}$	0,014	0,014	0,015	0,016	0,016	47,40	47,40	50,79	54,18	54,18
10	3405,23	2,9	$4,83 . 10^{-5}$	0,014	0,015	0,016	0,016	0,016	47,40	50,79	54,18	54,18	54,18
11	3522,65	3	$5,0 . 10^{-5}$	0,015	0,015	0,016	0,017	0,017	50,79	50,79	54,18	57,56	57,56
12	3640,07	3,1	$5,16 . 10^{-5}$	0,016	0,016	0,017	0,017	0,017	54,18	54,18	57,56	57,56	57,56

Lampiran 3 Hasil keseluruhan penelitian

No	Re	Debit	Hasil perhitungan koefisien gesek transisi tiap percobaan (Pa)					Hasil perhitungan koefisien gesek transisi teori (Pa)			Koefisien gesek untuk pengecekan kondisi	
		LPM	1	2	3	4	5	Nirkuladse	Celebrook	Moody	Laminar	Turbulent
1	2348,43	2	$6,81.10^{-2}$	$7,50.10^{-2}$	$6,81.10^{-2}$	$6,13.10^{-2}$	$6,13.10^{-2}$	$4,7.10^{-2}$	$4,71.10^{-2}$	$4,70.10^{-2}$	$1,32.10^{-2}$	$1,15.10^{-2}$
2	2465,86	2,1	$6,18.10^{-2}$	$6,80.10^{-2}$	$6,80.10^{-2}$	$6,18.10^{-2}$	$6,18.10^{-2}$	$4,63.10^{-2}$	$4,64.10^{-2}$	$4,60.10^{-2}$	$1,39.10^{-2}$	$1,15.10^{-2}$
3	2583,28	2,2	$6,20.10^{-2}$	$6,76.10^{-2}$	$6,76.10^{-2}$	$6,20.10^{-2}$	$6,20.10^{-2}$	$4,57.10^{-2}$	$4,57.10^{-2}$	$4,57.10^{-2}$	$1,45.10^{-2}$	$1,15.10^{-2}$
4	2700,70	2,3	$5,67.10^{-2}$	$6,19.10^{-2}$	$6,70.10^{-2}$	$6,19.10^{-2}$	$5,67.10^{-2}$	$4,50.10^{-2}$	$4,50.10^{-2}$	$4,50.10^{-2}$	$1,52.10^{-2}$	$1,15.10^{-2}$
5	2818,12	2,4	$5,68.10^{-2}$	$6,16.10^{-2}$	$6,16.10^{-2}$	$6,63.10^{-2}$	$5,68.10^{-2}$	$4,44.10^{-2}$	$4,45.10^{-2}$	$4,45.10^{-2}$	$1,58.10^{-2}$	$1,15.10^{-2}$
6	2935,54	2,5	$5,240.10^{-2}$	$6,11.10^{-2}$	$5,67.10^{-2}$	$6,11.10^{-2}$	$5,67.10^{-2}$	$4,39.10^{-2}$	$4,39.10^{-2}$	$4,35.10^{-2}$	$1,65.10^{-2}$	$1,15.10^{-2}$
7	3052,97	2,6	$5,25.10^{-2}$	$5,65.10^{-2}$	$6,06.10^{-2}$	$6,06.10^{-2}$	$5,65.10^{-2}$	$4,34.10^{-2}$	$4,34.10^{-2}$	$4,30.10^{-2}$	$1,72.10^{-2}$	$1,15.10^{-2}$
8	3170,39	2,7	$5,244.10^{-2}$	$5,62.10^{-2}$	$5,99.10^{-2}$	$5,99.10^{-2}$	$5,24.10^{-2}$	$4,29.10^{-2}$	$4,29.10^{-2}$	$4,25.10^{-2}$	$1,78.10^{-2}$	$1,15.10^{-2}$
9	3287,81	2,8	$5,22.10^{-2}$	$5,22.10^{-2}$	$5,57.10^{-2}$	$5,92.10^{-2}$	$5,92.10^{-2}$	$4,24.10^{-2}$	$4,24.10^{-2}$	$4,24.10^{-2}$	$1,85.10^{-2}$	$1,15.10^{-2}$
10	3405,23	2,9	$4,87.10^{-2}$	$5,19.10^{-2}$	$5,52.10^{-2}$	$5,52.10^{-2}$	$5,52.10^{-2}$	$4,20.10^{-2}$	$4,20.10^{-2}$	$4,20.10^{-2}$	$1,91.10^{-2}$	$1,15.10^{-2}$
11	3522,65	3	$4,85.10^{-2}$	$4,85.10^{-2}$	$5,16.10^{-2}$	$5,46.10^{-2}$	$5,46.10^{-2}$	$4,15.10^{-2}$	$4,16.10^{-2}$	$4,15.10^{-2}$	$1,98.10^{-2}$	$1,15.10^{-2}$
12	3640,07	3,1	$4,83.10^{-2}$	$4,83.10^{-2}$	$5,11.10^{-2}$	$5,11.10^{-2}$	$5,11.10^{-2}$	$4,11.10^{-2}$	$4,12.10^{-2}$	$4,10.10^{-2}$	$2,05.10^{-2}$	$1,15.10^{-2}$

Lampiran 4 Foto pengambilan data selisih tekanan