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Cockshutt, E. P.

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SUBJECT **Rayleigh Line Tabulation**

PREPARED BY **E.P. Cockshutt**

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RAYLEIGH LINE TABULATION

E.P. Cockshutt

SUMMARY:

Numerical Rayleigh Line data with $\gamma = 1.3$ are tabulated for the subsonic regime (M=0.00 to 1.00) for increments of Mach number of 0.01. A numerical example is included to illustrate the use of this table.

NOMENCLATURE:

M	-	Mach Number
P_S	-	Static Pressure
P_T	-	Total Pressure
T_S	-	Static Temperature
T_T	-	Total Temperature
V	-	Velocity
γ	-	Ratio of Specific Heats

N.B.: The asterisk (*) is used to denote the value of a variable at the thermally choked condition.

1.0 INTRODUCTION:

The Rayleigh Line is used in the analysis of reheat and ramjet combustion processes; it is defined as a one-dimensional, constant-area, frictionless flow subject to a total temperature change. Because of the complexity of the governing equations, it is necessary to use either trial and error calculations or tabulated data in most applications.

2.0 DESCRIPTION OF TABLE:

Tabulated Rayleigh Line data are already available for $\gamma = 1.3$ (an appropriate value for reheat calculations) in Keenan and Kaye's "Gas Tables"; their table is set up in terms of the local Mach number, M, for increments of 0.05. In this note the same tabular form is used but entries are included for increments of Mach number of 0.01 instead of 0.05 for the subsonic regime.

The dependent variables which are given as functions of the Mach number are:

(1) the total temperature - T_T

(2) the static temperature - T_S

(3) the static pressure - P_S

(4) the total pressure - P_T

(5) the velocity - V

These are all expressed as ratios of the desired quantity to the same quantity at the thermally choked condition (marked *); this is clarified in the following example.

3.0 NUMERICAL EXAMPLE:

A reheat system has an inlet Mach number, M_1, equal to 0.25 and is to operate with a temperature ratio of 2.0 (i.e., $T_{T2} \div T_{T1} = 2.0$). It is desired to find the outlet temperatures, pressures and velocity in terms of the inlet values.

From the tabulated data one finds, corresponding to $M = 0.25$,

$$\frac{T_{T1}}{T_{T^*}} = 0.2482$$

$$\frac{T_{S1}}{T_{S^*}} = 0.2828$$

$$\frac{P_{S1}}{P_{S^*}} = 2.127$$

$$\frac{P_{T1}}{P_{T^*}} = 1.209$$

$$\frac{V_1}{V^*} = 0.1329$$

Since $\frac{T_{T2}}{T_{T1}} = 2.0$

Then $\frac{T_{T2}}{T_{T^*}} = 0.2482 \times 2.0 = 0.4964$

Interpolating in the table, one uses this value to establish the remaining values; hence

$$M_2 = 0.388$$

$$\frac{T_{S2}}{T_{S^*}} = 0.557$$

$$\frac{P_{S2}}{P_{S^*}} = 1.923$$

$$\frac{P_{T2}}{P_{T^*}} = 1.157$$

$$\frac{V_2}{V^*} = 0.2896$$

Finally, the desired ratios are computed thus

$$\frac{T_{S2}}{T_{S1}} = \frac{0.557}{0.2828} = 1.97$$

$$\frac{P_{S2}}{P_{S1}} = \frac{1.923}{2.127} = 0.904$$

$$\frac{P_{T2}}{P_{T1}} = \frac{1.157}{1.209} = 0.957$$

$$\frac{V_2}{V_1} = \frac{0.2896}{0.1329} = 2.18$$

M	$\frac{T_T}{T_T^*}$	$\frac{T_S}{T_S^*}$	$\frac{P_S}{P_S^*}$	$\frac{P_T}{P_T^*}$	$\frac{V}{V^*}$
.00	0	0	2.300	1.255	0
.01	.00046	.00053	2.300	1.255	.00023
.02	.00184	.00211	2.299	1.255	.00092
.03	.00413	.00475	2.297	1.254	.00207
.04	.00733	.00843	2.295	1.254	.00367
.05	.01143	.01314	2.293	1.253	.00573
.06	.01641	.01887	2.289	1.252	.00824
.07	.02227	.02559	2.285	1.251	.01120
.08	.02898	.03330	2.281	1.250	.01460
.09	.03653	.04196	2.276	1.249	.01844
.10	.04489	.05155	2.270	1.247	.02270
.11	.05405	.06204	2.264	1.245	.02740
.12	.06396	.07340	2.258	1.244	.03251
.13	.07462	.08560	2.251	1.242	.03803
.14	.08599	.09860	2.243	1.240	.04396
.15	.09803	.11236	2.234	1.237	.05028
.16	.11072	.1269	2.226	1.235	.05698
.17	.12402	.1420	2.217	1.233	.06406
.18	.13791	.1578	2.207	1.230	.07151
.19	.15234	.1742	2.197	1.227	.07931
.20	.16726	.1912	2.186	1.224	.08745
.21	.1827	.2087	2.175	1.221	.09593
.22	.1985	.2266	2.164	1.218	.1047
.23	.2147	.2450	2.152	1.215	.1138
.24	.2313	.2637	2.140	1.212	.1233
.25	.2482	.2828	2.127	1.209	.1329
.26	.2654	.3022	2.114	1.205	.1429
.27	.2829	.3218	2.101	1.202	.1532
.28	.3005	.3416	2.087	1.198	.1636
.29	.3183	.3615	2.073	1.195	.1744
.30	.3363	.3816	2.059	1.191	.1853
.31	.3544	.4017	2.045	1.187	.1965
.32	.3725	.4219	2.030	1.183	.2078
.33	.3907	.4420	2.015	1.180	.2194
.34	.4089	.4622	2.000	1.176	.2311
.35	.4270	.4822	1.984	1.172	.2430
.36	.4451	.5021	1.968	1.168	.2551
.37	.4631	.5219	1.952	1.164	.2673
.38	.4811	.5415	1.936	1.160	.2796
.39	.4989	.5609	1.920	1.156	.2921

M	$\frac{T_T}{T_T^*}$	$\frac{T_S}{T_S^*}$	$\frac{P_S}{P_S^*}$	$\frac{P_T}{P_T^*}$	$\frac{V}{V^*}$
.40	.5165	.5800	1.904	1.152	.3046
.41	.5339	.5989	1.888	1.147	.3173
.42	.5511	.6175	1.871	1.143	.3300
.43	.5682	.6358	1.854	1.139	.3429
.44	.5850	.6537	1.838	1.135	.3558
.45	.6015	.6713	1.821	1.131	.3687
.46	.6177	.6885	1.804	1.127	.3817
.47	.6336	.7053	1.787	1.123	.3947
.48	.6493	.7217	1.770	1.119	.4078
.49	.6646	.7378	1.753	1.115	.4209
.50	.6796	.7533	1.736	1.111	.4340
.51	.6943	.7684	1.719	1.107.	.4471
.52	.7086	.7831	1.702	1.103	.4602
.53	.7226	.7974	1.685	1.100	.4733
.54	.7362	.8111	1.668	1.096	.4863
.55	.7494	.8244	1.651	1.092	.4994
.56	.7623	.8372	1.634	1.088	.5124
.57	.7748	.8496	1.617	1.085	.5254
.58	.7868	.8614	1.600	1.081	.5383
.59	.7985	.8728	1.583	1.077	.5512
.60	.8099	.8837	1.567	1.074	.5640
.61	.8209	.8942	1.550	1.070	.5768
.62	.8315	.9041	1.534	1.067	.5895
.63	.8417	.9136	1.517	1.063	.6022
.64	.8516	.9227	1.501	1.060	.6148
.65	.8611	.9312	1.485	1.057	.6272
.66	.8702	.9393	1.468	1.054	.6397
.67	.8789	.9470	1.452	1.051	.6520
.68	.8873	.9542	1.437	1.048	.6642
.69	.8953	.9610	1.421	1.045	.6764
.70	.9029	.9673	1.405	1.043	.6885
.71	.9102	.9732	1.389	1.040	.7004
.72	.9172	.9787	1.374	1.037	.7123
.73	.9239	.9838	1.359	1.035	.7241
.74	.9302	.9885	1.344	1.032	.7357
.75	.9361	.9928	1.329	1.030	.7473
.76	.9418	.9967	1.314	1.028	.7588
.77	.9472	1.0003	1.299	1.026	.7701
.78	.9522	1.0034	1.284	1.023	.7813
.79	.9569	1.0063	1.270	1.021	.7925

M	$\frac{T_T}{T_T^*}$	$\frac{T_S}{T_S^*}$	$\frac{P_S}{P_S^*}$	$\frac{P_T}{P_T^*}$	$\frac{V}{V^*}$
.80	.9614	1.0088	1.255	1.019	.8035
.81	.9656	1.0109	1.241	1.017	.8144
.82	.9695	1.0127	1.227	1.016	.8252
.83	.9731	1.0142	1.213	1.014	.8359
.84	.9765	1.0155	1.200	1.012	.8465
.85	.9796	1.0163	1.186	1.011	.8569
.86	.9824	1.0169	1.173	1.010	.8672
.87	.9850	1.0173	1.159	1.008	.8775
.88	.9874	1.0173	1.146	1.007	.8876
.89	.9895	1.0171	1.133	1.006	.8976
.90	.9914	1.0166	1.120	1.005	.9075
.91	.9931	1.0159	1.108	1.004	.9172
.92	.9946	1.0150	1.095	1.003	.9269
.93	.9960	1.0138	1.083	1.002	.9364
.94	.9971	1.0125	1.070	1.001	.9458
.95	.9980	1.0108	1.058	1.001	.9552
.96	.9987	1.0090	1.046	1.001	.9643
.97	.9993	1.0071	1.035	1.000	.9734
.98	.9997	1.0049	1.023	1.000	.9824
.99	.9999	1.0026	1.011	1.000	.9913
1.00	1.0000	1.0000	1.000	1.000	1.0000