

Ecoulement compressible isentropique de gaz parfait

Notations:

M	: Nombre de Mach
U	: Vitesse
P	: Pression
ρ	: Masse volumique
T	: Température absolue
A	: Aire d'une section droite
P_i	: Pression d'arrêt isentropique
ρ_i	: Masse volumique d'arrêt isentropique
T_i	: Température d'arrêt isentropique
A_c	: Aire de la section droite au col de la tuyère

Relations de St-Venant :

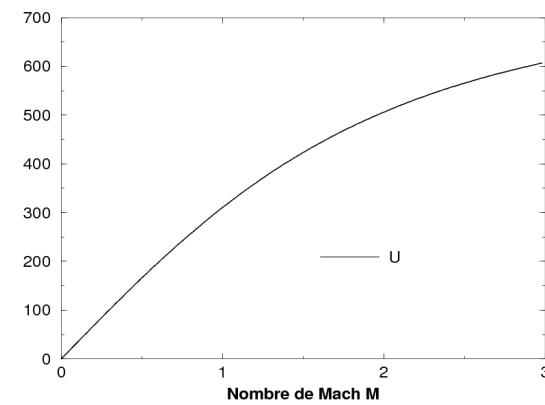
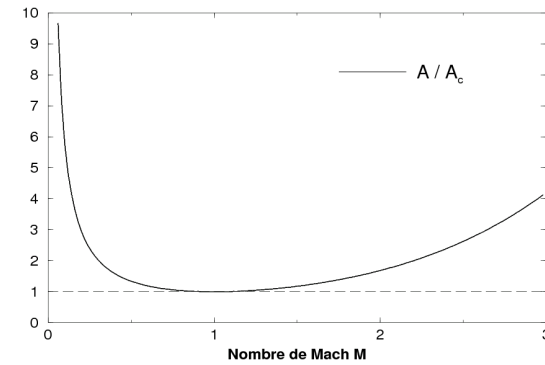
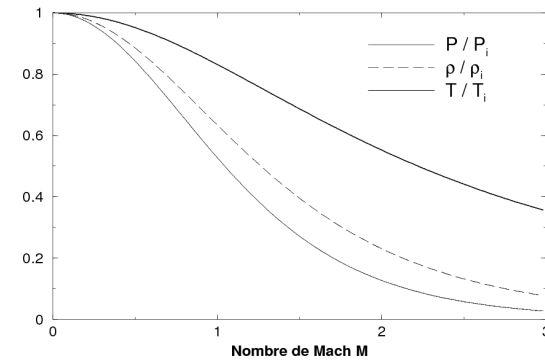
$$\frac{T}{T_i} = \left(1 + \frac{\gamma-1}{2} M^2\right)^{-1} \quad (1)$$

$$\frac{P}{P_i} = \left(1 + \frac{\gamma-1}{2} M^2\right)^{\frac{-\gamma}{\gamma-1}} \quad (2)$$

$$\frac{\rho}{\rho_i} = \left(1 + \frac{\gamma-1}{2} M^2\right)^{\frac{-1}{\gamma-1}} \quad (3)$$

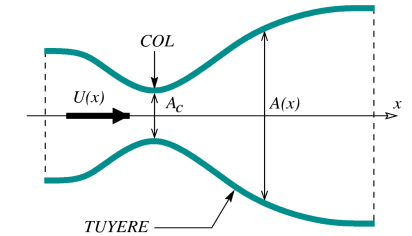
$$\text{Si } M_c = 1 : \frac{A}{A_c} = \frac{1}{M} \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma+1}{2(\gamma-1)}} \left(1 + \frac{\gamma-1}{2} M^2\right)^{\frac{\gamma+1}{2(\gamma-1)}} \quad (4)$$

$$U = \left\{ \frac{2\gamma r}{\gamma-1} T_i \left[1 - \left(\frac{P}{P_i}\right)^{\frac{\gamma-1}{\gamma}} \right] \right\}^{1/2} \quad (5)$$



Ecoulement isentropique
 $p/\rho^\gamma = Cte$
 de gaz parfait $p = \rho r T$

Données numériques:
 $\gamma = 1.405$, $T_i = 288K$



M	P/P_i	ρ/ρ_i	T/T_i	A/A_c	U^*
0.00	1.0000	1.0000	1.0000	inf	0.00
0.02	0.9997	0.9998	0.9999	28.9262	6.81
0.04	0.9989	0.9992	0.9997	14.4735	13.63
0.06	0.9975	0.9982	0.9993	9.6606	20.44
0.08	0.9955	0.9968	0.9987	7.2577	27.25
0.10	0.9930	0.9950	0.9980	5.8187	34.04
0.12	0.9899	0.9928	0.9971	4.8617	40.83
0.14	0.9864	0.9903	0.9960	4.1802	47.61
0.16	0.9822	0.9873	0.9948	3.6708	54.38
0.18	0.9776	0.9840	0.9935	3.2762	61.14
0.20	0.9724	0.9803	0.9920	2.9620	67.88
0.22	0.9667	0.9762	0.9903	2.7063	74.61
0.24	0.9606	0.9718	0.9885	2.4944	81.31
0.26	0.9539	0.9670	0.9865	2.3162	88.00
0.28	0.9468	0.9619	0.9844	2.1646	94.67
0.30	0.9393	0.9564	0.9821	2.0342	101.32
0.32	0.9313	0.9506	0.9797	1.9210	107.94
0.34	0.9229	0.9445	0.9771	1.8221	114.53
0.36	0.9141	0.9380	0.9744	1.7351	121.10
0.38	0.9049	0.9313	0.9716	1.6581	127.64
0.40	0.8953	0.9243	0.9686	1.5895	134.16
0.42	0.8854	0.9170	0.9655	1.5284	140.64
0.44	0.8751	0.9094	0.9623	1.4735	147.09
0.46	0.8645	0.9016	0.9589	1.4242	153.51
0.48	0.8537	0.8935	0.9554	1.3797	159.89
0.50	0.8425	0.8852	0.9518	1.3395	166.23
0.52	0.8312	0.8767	0.9481	1.3030	172.55
0.54	0.8195	0.8679	0.9442	1.2700	178.82
0.56	0.8077	0.8590	0.9403	1.2400	185.05
0.58	0.7956	0.8498	0.9362	1.2127	191.25
0.60	0.7834	0.8405	0.9321	1.1880	197.40
0.62	0.7710	0.8310	0.9278	1.1654	203.51
0.64	0.7585	0.8214	0.9234	1.1449	209.58
0.66	0.7458	0.8116	0.9189	1.1264	215.61
0.68	0.7331	0.8017	0.9144	1.1095	221.59
0.70	0.7202	0.7917	0.9097	1.0942	227.53
0.72	0.7073	0.7815	0.9050	1.0804	233.42
0.74	0.6943	0.7713	0.9002	1.0680	239.26
0.76	0.6813	0.7610	0.8953	1.0569	245.06
0.78	0.6683	0.7506	0.8903	1.0470	250.81
0.80	0.6552	0.7402	0.8853	1.0382	256.51
0.82	0.6422	0.7296	0.8802	1.0304	262.16
0.84	0.6292	0.7191	0.8750	1.0237	267.76
0.86	0.6162	0.7085	0.8697	1.0178	273.32
0.88	0.6033	0.6979	0.8644	1.0129	278.82
0.90	0.5904	0.6873	0.8591	1.0088	284.27
0.92	0.5776	0.6766	0.8537	1.0056	289.68
0.94	0.5649	0.6660	0.8482	1.0031	295.03
0.96	0.5523	0.6554	0.8427	1.0014	300.32
0.98	0.5398	0.6448	0.8372	1.0003	305.57

M	P/P_i	ρ/ρ_i	T/T_i	A/A_c	U^*
1.00	0.5274	0.6342	0.8316	1.0000	310.77
1.02	0.5152	0.6237	0.8260	1.0003	315.91
1.04	0.5031	0.6132	0.8203	1.0013	321.00
1.06	0.4911	0.6028	0.8146	1.0029	326.04
1.08	0.4792	0.5924	0.8089	1.0051	331.02
1.10	0.4675	0.5821	0.8032	1.0079	335.95
1.12	0.4560	0.5718	0.7974	1.0113	340.83
1.14	0.4446	0.5617	0.7917	1.0152	345.66
1.16	0.4335	0.5516	0.7859	1.0197	350.43
1.18	0.4224	0.5416	0.7801	1.0248	355.16
1.20	0.4116	0.5316	0.7742	1.0304	359.83
1.22	0.4010	0.5218	0.7684	1.0365	364.44
1.24	0.3905	0.5121	0.7626	1.0431	369.01
1.26	0.3802	0.5024	0.7567	1.0503	373.52
1.28	0.3701	0.4929	0.7509	1.0579	377.98
1.30	0.3602	0.4835	0.7450	1.0661	382.39
1.32	0.3505	0.4742	0.7392	1.0748	386.75
1.34	0.3410	0.4650	0.7333	1.0840	391.05
1.36	0.3317	0.4559	0.7275	1.0937	395.31
1.38	0.3225	0.4469	0.7217	1.1039	399.51
1.40	0.3136	0.4381	0.7159	1.1146	403.66
1.42	0.3049	0.4294	0.7101	1.1258	407.77
1.44	0.2963	0.4208	0.7043	1.1374	411.82
1.46	0.2880	0.4123	0.6985	1.1496	415.82
1.48	0.2798	0.4040	0.6927	1.1623	419.78
1.50	0.2719	0.3957	0.6870	1.1756	423.68
1.52	0.2641	0.3876	0.6813	1.1893	427.54
1.54	0.2565	0.3797	0.6756	1.2035	431.35
1.56	0.2491	0.3718	0.6699	1.2182	435.11
1.58	0.2419	0.3641	0.6642	1.2335	438.82
1.60	0.2348	0.3566	0.6586	1.2493	442.49
1.62	0.2280	0.3491	0.6530	1.2656	446.11
1.64	0.2213	0.3418	0.6474	1.2824	449.68
1.66	0.2148	0.3346	0.6418	1.2998	453.21
1.68	0.2084	0.3275	0.6363	1.3177	456.69
1.70	0.2022	0.3206	0.6308	1.3362	460.13
1.72	0.1962	0.3138	0.6254	1.3552	463.52
1.74	0.1904	0.3071	0.6199	1.3748	466.87
1.76	0.1847	0.3005	0.6145	1.3949	470.17
1.78	0.1791	0.2941	0.6092	1.4156	473.44
1.80	0.1738	0.2878	0.6038	1.4369	476.66
1.82	0.1685	0.2816	0.5985	1.4588	479.83
1.84	0.1634	0.2755	0.5933	1.4813	482.97
1.86	0.1585	0.2695	0.5880	1.5044	486.06
1.88	0.1537	0.2637	0.5828	1.5281	489.11
1.90	0.1490	0.2580	0.5777	1.5524	492.13
1.92	0.1445	0.2524	0.5726	1.5774	495.10
1.94	0.1401	0.2469	0.5675	1.6030	498.03
1.96	0.1358	0.2415	0.5625	1.6292	500.93
1.98	0.1317	0.2362	0.5575	1.6561	503.78

M	P/P_i	ρ/ρ_i	T/T_i	A/A_c	U^*
2.00	0.1277	0.2311	0.5525	1.6837	506.60
2.02	0.1238	0.2260	0.5476	1.7120	509.38
2.04	0.1200	0.2211	0.5427	1.7409	512.12
2.06	0.1163	0.2162	0.5378	1.7705	514.83
2.08	0.1127	0.2115	0.5330	1.8009	517.50
2.10	0.1093	0.2069	0.5283	1.8319	520.14
2.12	0.1059	0.2023	0.5235	1.8637	522.73
2.14	0.1027	0.1979	0.5188	1.8963	525.30
2.16	0.0995	0.1935	0.5142	1.9296	527.83
2.18	0.0965	0.1893	0.5096	1.9636	530.33
2.20	0.0935	0.1851	0.5050	1.9985	532.79
2.22	0.0906	0.1810	0.5005	2.0341	535.22
2.24	0.0878	0.1771	0.4960	2.0705	537.61
2.26	0.0851	0.1732	0.4916	2.1078	539.98
2.28	0.0825	0.1694	0.4872	2.1459	542.31
2.30	0.0800	0.1657	0.4828	2.1848	544.61
2.32	0.0775	0.1620	0.4785	2.2246	546.89
2.34	0.0751	0.1585	0.4742	2.2652	549.13
2.36	0.0728	0.1550	0.4700	2.3068	551.34
2.38	0.0706	0.1516	0.4658	2.3492	553.52
2.40	0.0684	0.1483	0.4616	2.3925	555.67
2.42	0.0663	0.1450	0.4575	2.4368	557.79
2.44	0.0643	0.1418	0.4534	2.4820	559.89
2.46	0.0623	0.1387	0.4493	2.5282	561.95
2.48	0.0604	0.1357	0.4453	2.5753	563.99
2.50	0.0586	0.1327	0.4414	2.6235	566.01
2.52	0.0568	0.1298	0.4375	2.6726	567.99
2.54	0.0551	0.1270	0.4336	2.7228	569.95
2.56	0.0534	0.1242	0.4297	2.7740	571.88
2.58	0.0518	0.1215	0.4259	2.8262	573.79
2.60	0.0502	0.1189	0.4221	2.8795	575.67
2.62	0.0487	0.1163	0.4184	2.9339	577.53
2.64	0.0472	0.1138	0.4147	2.9894	579.36
2.66	0.0458	0.1113	0.4110	3.0461	581.17
2.68	0.0444	0.1089	0.4074	3.1038	582.95
2.70	0.0430	0.1066	0.4038	3.1628	584.71
2.72	0.0417	0.1043	0.4003	3.2229	586.45
2.74	0.0405	0.1020	0.3968	3.2842	588.17
2.76	0.0393	0.0998	0.3933	3.3467	589.86
2.78	0.0381	0.0977	0.3899	3.4104	591.53
2.80	0.0369	0.0956	0.3865	3.4754	593.18
2.82	0.0358	0.0936	0.3831	3.5417	594.80
2.84	0.0348	0.0916	0.3798	3.6092	596.41
2.86	0.0337	0.0896	0.3765	3.6781	597.99
2.88	0.0327	0.0877	0.3732	3.7483	599.56
2.90	0.0318	0.0858	0.3700	3.8198	601.10
2.92	0.0308	0.0840	0.3668	3.8927	602.63
2.94	0.0299	0.0822	0.3636	3.9670	604.13
2.96	0.0290	0.0805	0.3605	4.0427	605.61
2.98	0.0282	0.0788	0.3574	4.1198	607.08

* dans le cas où $T_i = 288\text{ K}$