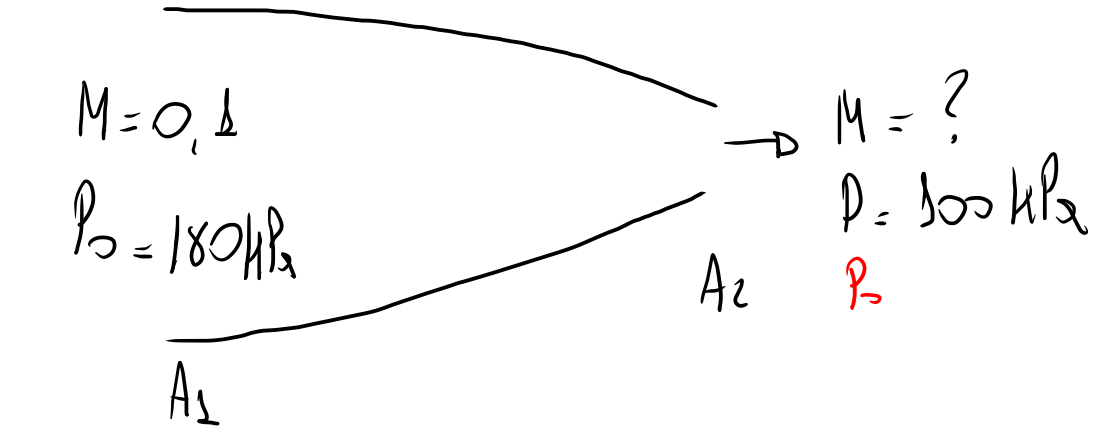
Escoamentos Compressíveis

Expansão em Bocal isoentrópico

Escoamento entra no bocal de exaustão de uma turbina a gás a M_1=0,1 e P_0=180KPa. Qual a razão de área A_2/A_1 irá expandir a saída para pressão ambiente P_{amb}=100KPa?

Escoamento entra no bocal de exaustão de uma turbina a gás a $M_1=0,1$ e $P_0=180KPa$. Qual a razão de área A_2/A_1 irá expandir a saída para pressão ambiente $P_{amb}=100KPa$?

$k = 1,4$
ar



$$h_{01} = h_1 + \frac{V_1^2}{2} = h_2 + \frac{V_2^2}{2} = h_{02}$$

$$T_{01} = T_{02} \rightarrow P_{01} = P_{02}$$

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$$h_0 = h + \frac{V^2}{2}$$

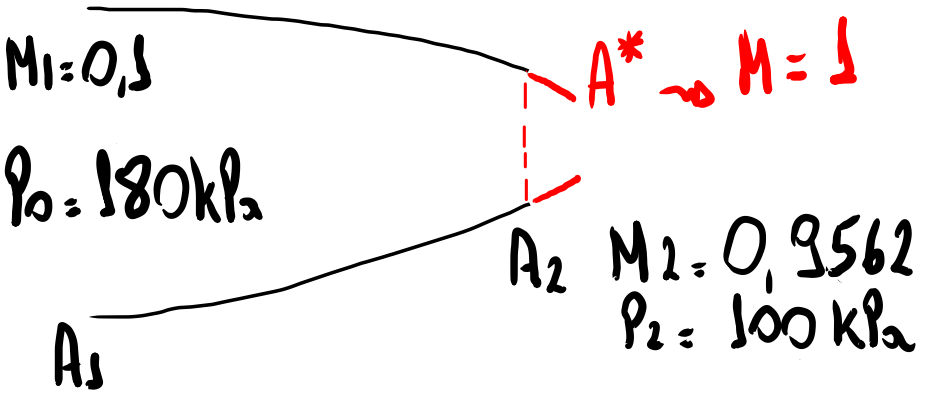
$$\frac{T_0}{T} = \left(\frac{P_0}{P}\right)^{\frac{k-1}{k}} \qquad k = 1,4$$

$$1 + \left(\frac{k-1}{2}\right) M^2 = \left(\frac{P_0}{P}\right)^{\frac{k-1}{k}}$$

$$M^2 = \frac{\left(\frac{P_0}{P}\right)^{\frac{k-1}{k}} - 1}{\frac{k-1}{2}} = \frac{\left(\frac{180}{100}\right)^{\frac{1,4-1}{1,4}} - 1}{\frac{1,4-1}{2}}$$

$$M_2 \cong 0,9562$$

$$\frac{A}{A^*} = \frac{1}{M}\left(\frac{2}{k+1}\right)^{\frac{1}{2}\frac{k+1}{k-1}}\left(1+\frac{k-1}{2}M^2\right)^{\frac{1}{2}\frac{k+1}{k-1}}$$



p/ $M_2 = 0{,}9562 \rightsquigarrow \frac{A_2}{A^*} = 1{,}0016$

p/ $M_1 = 0{,}1 \rightsquigarrow \frac{A_1}{A^*} = 5{,}8218$

$$\frac{A_2}{A_1} = \frac{A_2}{A^*} \cdot \frac{A^*}{A_1}$$

$$\frac{A_2}{A_1} = 1{,}0016 \cdot \frac{1}{5{,}8218} \rightsquigarrow \frac{A_2}{A_1} = 0{,}1720$$

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Isentropic Flow Tables

γ = 1.4

M	P/P$_0$	T/T$_0$	A/A*	M	P/P$_0$	T/T$_0$	A/A*
0.00	1.0000	1.0000	Infinite	0.35	0.9188	0.9761	1.7780
0.01	0.9999	1.0000	57.8738	0.36	0.9143	0.9747	1.7358
0.02	0.9997	0.9999	28.9421	0.37	0.9098	0.9733	1.6961
0.03	0.9994	0.9998	19.3005	0.38	0.9052	0.9719	1.6587
0.04	0.9989	0.9997	14.4815	0.39	0.9004	0.9705	1.6234
0.05	0.9983	0.9995	11.5914	0.40	0.8956	0.9690	1.5901
0.06	0.9975	0.9993	9.6659	0.41	0.8907	0.9675	1.5587
0.07	0.9966	0.9990	8.2915	0.42	0.8857	0.9659	1.5289
0.08	0.9955	0.9987	7.2616	0.43	0.8807	0.9643	1.5007
0.09	0.9944	0.9984	6.4613	0.44	0.8755	0.9627	1.4740
0.10	0.9930	0.9980	5.8218	0.45	0.8703	0.9611	1.4487
0.11	0.9916	0.9976	5.2992	0.46	0.8650	0.9594	1.4246
0.12	0.9900	0.9971	4.8643	0.47	0.8596	0.9577	1.4018
0.13	0.9883	0.9966	4.4969	0.48	0.8541	0.9559	1.3801
0.14	0.9864	0.9961	4.1824	0.49	0.8486	0.9542	1.3595

$M = 0,1 \Rightarrow \frac{A_1}{A^*} = 5,8218$ (5,822)

Isentropic Flow Tables

γ = 1.4

M	P/P$_0$	T/T$_0$	A/A*	M	P/P$_0$	T/T$_0$	A/A*
0.70	0.7209	0.9107	1.0944	1.05	0.4979	0.8193	1.0020
0.71	0.7145	0.9084	1.0873	1.06	0.4919	0.8165	1.0029
0.72	0.7080	0.9061	1.0806	1.07	0.4860	0.8137	1.0039
0.73	0.7016	0.9037	1.0742	1.08	0.4800	0.8108	1.0051
0.74	0.6951	0.9013	1.0681	1.09	0.4742	0.8080	1.0064
0.75	0.6886	0.8989	1.0624	1.10	0.4684	0.8052	1.0079
0.76	0.6821	0.8964	1.0570	1.11	0.4626	0.8023	1.0095
0.77	0.6756	0.8940	1.0519	1.12	0.4568	0.7994	1.0113
0.78	0.6691	0.8915	1.0471	1.13	0.4511	0.7966	1.0132
0.79	0.6625	0.8890	1.0425	1.14	0.4455	0.7937	1.0153
0.80	0.6560	0.8865	1.0382	1.15	0.4398	0.7908	1.0175
0.81	0.6495	0.8840	1.0342	1.16	0.4343	0.7879	1.0198
0.82	0.6430	0.8815	1.0305	1.17	0.4287	0.7851	1.0222
0.83	0.6365	0.8789	1.0270	1.18	0.4232	0.7822	1.0248
0.84	0.6300	0.8763	1.0237	1.19	0.4178	0.7793	1.0276
0.85	0.6235	0.8737	1.0207	1.20	0.4124	0.7764	1.0304
0.86	0.6170	0.8711	1.0179	1.21	0.4070	0.7735	1.0334
0.87	0.6106	0.8685	1.0153	1.22	0.4017	0.7706	1.0366
0.88	0.6041	0.8659	1.0129	1.23	0.3964	0.7677	1.0398
0.89	0.5977	0.8632	1.0108	1.24	0.3912	0.7648	1.0432
0.90	0.5913	0.8606	1.0089	1.25	0.3861	0.7619	1.0468
0.91	0.5849	0.8579	1.0071	1.26	0.3809	0.7590	1.0504
0.92	0.5785	0.8552	1.0056	1.27	0.3759	0.7561	1.0542
0.93	0.5721	0.8525	1.0043	1.28	0.3708	0.7532	1.0581
0.94	0.5658	0.8498	1.0031	1.29	0.3658	0.7503	1.0621
0.95	0.5595	0.8471	1.0021	1.30	0.3609	0.7474	1.0663
0.96	0.5532	0.8444	1.0014	1.31	0.3560	0.7445	1.0706
0.97	0.5469	0.8416	1.0008	1.32	0.3512	0.7416	1.0750
0.98	0.5407	0.8389	1.0003	1.33	0.3464	0.7387	1.0796
0.99	0.5345	0.8361	1.0001	1.34	0.3417	0.7358	1.0842

SAÍDA

$\frac{P}{P_0} = \frac{100}{180} = 0,555$

0,95	0,5595	1,0021
M	0,555	A/A*
0,96	0,5532	1,0014

$M = 0,9562$ (0,3562)

$\frac{A_2}{A^*} = 1,00166$ (1,0016)

$\frac{A_2}{A_1} = \frac{A_2}{A^*} \cdot \frac{A^*}{A_1} = 0,112$

Escoamento entra no bocal de exaustão de uma turbina a gás a M_1=0,1 e P_0=180KPa. Qual a razão de área A_2/A_1 irá expandir a saída para pressão ambiente P_{amb}=100KPa?

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$$M_1 = 0,1 \Rightarrow \frac{A_1}{A^*} \approx \frac{5,981 + 5,75}{2} = 5,865 \quad (5,822)$$

$$M_2 = 0,3562 \Rightarrow \frac{A_2}{A^*} \approx 1,0$$

$$\frac{A_2}{A_1} = \frac{A_2}{A^*} \cdot \frac{A^*}{A_1} = \frac{1,0}{5,865} = 0,1705 \quad (0,172)$$