

21. An isothermal flow ($T = 70^\circ\text{F}$) passes through a pipe whose diameter is 3.50 ft. The flowing fluid is air. Friction acts in the pipe. At station 1, $V_1 = 75 \text{ ft/s}$ and $p_1 = 73 \text{ psia}$. Between stations 1 and 2, the rate of heat transfer is 42.24 Btu/s. The relative roughness factor $k/D = 0.00005$

Find: (a) M_2 , (b) p_2 , (c) L between 1 and 2

T	70 F				-1 R instead F for mu
	529.67 R				-1 wrong k/D 4f
D	3.5000 ft				-1 2 sig figs
V_1	75.000 ft/s				-1 no mu calc
p_1	73.000 psia				-2 No reynolds
Q^*	42.24 Btu/s				-2 Pressure instead of velocity
k/D	0.00005				-4 supersonic M_2
k	1.4000				
R_{gas}	53.35 ft-lbf/lbm-R				
M_1	0.066479	$=V_1/(49.02*T_1^{0.5})$		$4fL_{\text{max}}/D$	155.54
ρ_{01}	0.37200 lbm/ft ³				
m^*	268.43 lbm/sec				
q	0.15736 Btu/lbm	25.42416			
M_2	0.10300	0.0442		$4fL_{\text{max}}/D$	62.120
P_2	47.117 psia	$=p_1*(M_1/M_2)$			
Tbar	70.000 F				
μ	1.223E-05 lbm/ft-sec	1.229E-05			
Re	7.982E+06				
4f	0.010750	0.011	*from the table on 119		
$4fL/D$	94.485	94.384		$=(-1-(M_1/M_2)^2)/(1.4*M_1^2)+LN(M_1/M_2)^2$	
L	30763 ft	30031 ft			
	5.8262 mi	5.6877 mi			

Problem

Airflow, $D = 5$ feet, $\kappa/D = 0.0001$

$V_1 = 50$ ft/sec, $p_1 = 50$ psia, $T = 80^\circ\text{F} = \text{constant}$

$p_2 = 41.6$ psia

Find: f between 1 and 2

M_2

Q_m between 1 and 2

D	5 ft
V1	50 ft/s
p1	50 psia
T	80 F
	539.67 R
p2	41.6 psia
κ/D	0.0001
k	1.4
R_gas	53.35 ft-lbf/lbm-R

M1	0.043907
$4fL/Dh = [1 - (P2/P1)^2] / \kappa M1^2 + \ln(p2/p1)^2$	
$4fL/Dh$	114.0697

rho1	0.25007 lbm/ft ³
m*	245.51 lbm/sec
Tbar	80.000 F
mu	1.241E-05 lbm/ft-sec
Re	5.038E+06
4f	0.012500 *from the table on 119

L	45628 ft
	8.6416 mi

$P2/P1 = M1/M2$

M2	0.052773
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Q	0.022204 Btu/lbm
Qm*	5.4511 Btu/sec