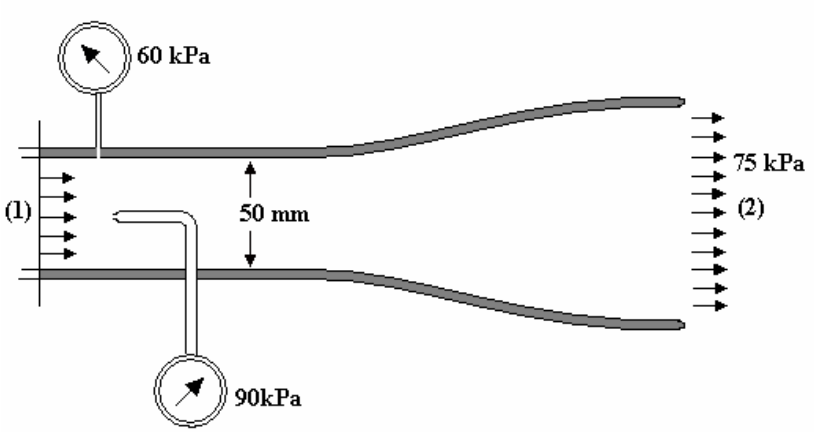
D203 Q6 2003

PART A

When the flow is supersonic shock waves occur and some of the total pressure is lost in friction so the pressure gauge does not record the true total pressure.

PART B

p_1 = 60 kPa p_2 = 75 kPa p_o = 90 kPa T_1 = 275 K D_1 = 0.05 m c_p=1005 J/kk K



$A_1=\pi D_1^2/4 = 1.963 \times 10^{-3}$ m^2 $\rho_1 = p_1/RT_1 = 0.76$ kg/m^3 $a_1 = (\gamma RT_1)^{1/2} = 332.4$ m/s

STAGNATION TEMP $T_o = T_1\left(\frac{p_o}{p_1}\right)^{\frac{?-1}{?}} = 275\left(\frac{90}{60}\right)^{0.286} = 308.8\text{K}$

VELOCITY $u_1=\{2c_p(T_o-T_1)\}^{1/2} = \{2 \times 1005(308.8 - 275)]^{1/2} = 260.6$ m/s

MACH NUMBER $M_1=u_1/a_1 = 260.6/332.4 = 0.784$

MASS FLOW $m = \rho_1 A_1 u_1 = 0.389$ kg/s

CHECK $T_o = T_1\left\{1+\frac{?-1}{2}M_1^2\right\} = 275\left\{1+\frac{1.4-1}{2}x0.784^2\right\} = 308.8\text{K}$

PART C

$$T_2 = \frac{T_o}{\left(\frac{p_o}{p_2}\right)^{\frac{?-1}{?}}} = \frac{308.8}{\left(\frac{90}{75}\right)^{\frac{1.4-1}{1.4}}} = 293.1\,\text{K}$$

$\rho_2 = p_2/RT_2 = 0.892$ kg/m^3 $a_2 =(\gamma RT_2)^{1/2} = 343.2$ m/s

VELOCITY $u_2=\{2c_p(T_o-T_2)\}^{1/2} = \{2 \times 1005(308.8 - 293.1)]^{1/2} = 177.5$ m/s

MACH NUMBER $M_2=u_2/a_2 = 177.5/343.2 = 0.517$

MASS FLOW $m = 0.389$ kg/s $= \rho_2 A_2 u_2$ $A_2 = m/\rho_2 u_2 = 2.458 \times 10^{-3}$ m^2

$D_2=(4A_2/\pi)^{½} = 0.056$ or 56 mm