ME-464-A, Design of Fluid-Thermal Systems, Spring 2018 Name: Anthony Bernal

100

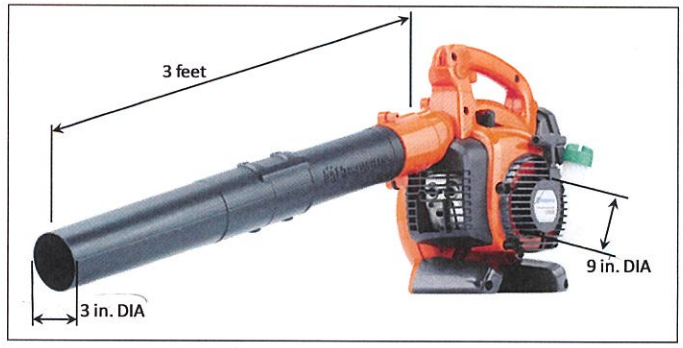
$Q = VA$
$\dot{V} = VA$

QUIZ 3, 4/3/2018

Time allowed: 20 minutes. Closed books, closed notes. Calculator and equation sheets allowed.
Show clearly all steps, including units and assumptions.

PROBLEM 1

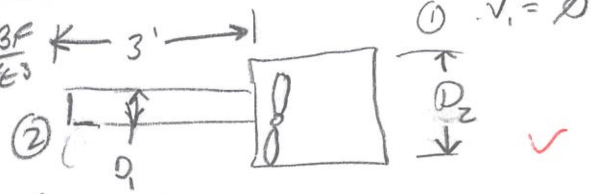
The leaf blower shown operates steadily and discharges air at the exit velocity of 180 ft/s. Assuming that the discharge pipe is of constant diameter with $f = 0.02$, that the minor losses at the blower inlet are $K_{inlet} = 1.3$ and that the air density is $\rho = 0.0735$ lbm/ft^3, **(A):** Estimate the total pressure increase across the blower; **(B):** Estimate the motor power (in HP) if the blower efficiency is 75%. **Note:** 1HP = 550 ft-lbf/s. When writing the energy equation, clearly define the end points.



$\gamma = \frac{\rho g}{g_c}$

$D_1 = 3\,in = 0.25\,ft$ $\rho = 0.0735\ \frac{lbm}{ft^3}$ $\gamma = 0.0735\ \frac{lbf}{ft^3}$

$D_2 = 9\,in = .75\,ft$ $g = 32.2\ \frac{ft}{s^2}$



$V_2 = 180\,ft/s$ (AT EXIT)

$P_{t_1}^{\,0} + \Delta P_{FAN} = P_{t_2} + \Delta P_{Loss}$

$V_{FAN} A_{FAN} = V_{EXIT} A_{EXIT}$

$\Delta P_{loss} = \gamma l_F + \gamma l_m$

$\Delta P_{FAN} = \frac{\rho V^2}{2 g_c} + \gamma\left[\frac{V^2}{2g}\left(f\frac{L}{D} + K\right)\right]$

$V_{FAN} = \frac{V_{EXIT} A_{EXIT}}{A_{FAN}}$

$= \gamma\left(f\frac{L}{D}\frac{V_2^2}{2g} + K\frac{V_{FAN}^2}{2g}\right)$

$V_{FAN} = 20\ \frac{ft}{s}$

$\Delta P_{FAN} = 8.87 + 0.593 + 36.97$

$\Delta P_{FAN} = 46.44$ PSF

$\gamma l_F = 0.0735\ \frac{lbf}{ft^3}\left(0.02\ \frac{3\,ft}{.25\,ft} \times \frac{(180\ ft/s)^2}{2(32.2\ \frac{ft}{s^2})}\right)$

$= 8.87\ \frac{lbf}{ft^2}$

$\gamma l_m = 0.0735\ \frac{lbf}{ft^3}\left(1.3\left(\frac{20\ ft/s^2}{2(32.2)}\right)\right)$

$= 0.593\ \frac{lbf}{ft^2}$

$\dot{W}_{FAN} = \Delta P_{FAN}\ \dot{V}_{FAN}$ ($V_{FAN} A_{FAN}$)

$= (46.44\ \frac{lbf}{ft^2})(180\ \frac{ft}{s})(\frac{\pi (.25)^2}{4})\,ft^2$

$= 410\ \frac{ft\text{-}lbf}{s}$

$P_{t_2} = \frac{(0.0735\ \frac{lbm}{ft^3})(180\ \frac{ft}{s})^2}{2(32.2\ \frac{slug}{lbm})} = 36.97\ \frac{lbf}{ft^2}$

$\dot{W}_{SHAFT} = \frac{\dot{W}_{FAN}}{\eta} = 547.18\ \frac{ft\text{-}lbf}{s}$

$= 0.994 \approx 1$ HP