47.8 A heat recovery ventilator is used to pre-heat $30°F$, 40% RH outside air with $75°F$, 50% RH exhaust air. The HRV effectiveness is 60%. What quantity of heat is recovered?

A. $4.3\frac{Btu}{lb}$

B. $6.5\frac{Btu}{lb}$

C. $10.8\frac{Btu}{lb}$

D. $27.1\frac{Btu}{lb}$

Let State 1 refer to the entering outside air condition. Let State 2 refer to the leaving outside air after being heated through the ventilator. Let State 3 refer to the entering return air condition. Ignore the leaving exhaust air as it is not relevant.

Recall the distinction between *heat* recovery and *energy* recovery. Energy recovery devices transmit latent energy in addition to sensible heat. Heat-Recovery devices drive exclusively Sensible Energy Recovery and the humidity need not be considered. Therefore, the effectivenss of a heat recovery ventilator is given by a the ratio of ΔT_{actual} to ΔT_{ideal}. (Energy recovery effectiveness would depend on changes in enthalpy rather than temperature.)

$$\varepsilon = \frac{\Delta T_{actual}}{\Delta T_{ideal}} = \frac{T_2 - 30°F}{75°F - 30°F} = 0.6$$

$$T_2 = 57°F$$

The total heat transfer by the heat recovery device is given by the equation below. Sicne there is no mass flow rate or volume rate given and the problem is asking for the quantity of heat rather than the rate of heat transfer, divide both sides by $\dot{m}$ and solve for q, heat per unit mass. The delta T is the actual increase in temperature experienced by the outside air.

$$\dot{Q} = \dot{m}c_p\Delta T$$

$$\frac{\dot{Q}}{\dot{m}} = q = c_p\Delta T = \left(0.24\frac{Btu}{lb \cdot °F}\right)(57°F - 30°F) = 6.48\frac{Btu}{lb}$$

Answer B

47.9 The maximum pressure achieved in the cylinder of a car engine is $800psi$. How much force will be exerted on a $3.7in$ piston?

A. $700lb_f$

B. $2,200lb_f$

C. $4,300lb_f$

D. $8,600lb_f$

A useful representation of pressure is the amount of force applied over an area. This can be expressed through the formula below and rearranged to solve for the force, F.

$$P = \frac{F}{A}$$

$$F = PA$$

Determine the area of the piston.

$$A = \frac{\pi}{4}D^2 = \frac{\pi}{4}\left(3.7in\right)^2 = 10.75in^2$$

Solve for the force.

$$F = PA = \left(800\frac{lb_f}{in^2}\right)\left(10.75in^2\right) = 8600lb_f$$

Answer D

47.10 A spring with 10 coils has squared ends and a shear modulus of $10 \times 10^6 psi$. The diameter of the wire is $0.15in$ and the average coil diameter is $1in$. What is the spring constant?

A. $52\frac{lb_f}{in}$

B. $63\frac{lb_f}{in}$

C. $79\frac{lb_f}{in}$

D. $105\frac{lb_f}{in}$

The Spring Constant for a Helical Compression Spring can be determined using the following formula, where k is the spring constant, d is the diameter of the wire, G is the shear modulus, D is the coil diameter, and $N$is the number of *active* coils.

$$k = \frac{d^4 G}{8D^3 N}$$

Using the table Type of Spring Ends, note that for squared ends the total number of coils N_t is the number of active coils plus two. Solve for the number of active coils.