Name: Key

6.1-6.3 Power Additional Review

Short Answer

1. List the two formulas that express fluid power.

$Pwr = p\dot{V}$ $Pwr = -\Delta p\,\dot{V}$

Problem

A laser cooling system needs a pump that develops a pressure difference (Δp) of 35 psi (gage) and a flow rate (Q_v) of 1.5 ft^3/min.

2. Find the fluid power developed in ft·lb/sec.

$\dot{V} = \frac{1.5\,ft^3}{min} \cdot \frac{1\,min}{60\,s} = 0.025\,ft^3/s$

$Pwr = -\Delta p\,\dot{V}$

$\Delta p = \frac{35\,lb}{in^2} \cdot \frac{12\,in}{ft} \cdot \frac{12\,in}{ft} = \frac{5040\,lb}{ft^2}$

$= -\frac{5040\,lb}{ft^2} \cdot \frac{0.025\,ft^3}{s}$

$\boxed{= 126\,ft\cdot lb/s}$

3. A hydraulic cylinder produces a power of 7500 watts with an output force of 2000 Newtons and has an area of 40 cm^2. What's the pressure difference across the piston face in N/m^2? (Remember: Pressure = Force/Area.)

$40\,cm^2 \cdot \frac{1\,m}{100\,cm} \cdot \frac{1\,m}{100\,cm} = 0.004\,m^2$

$P = \frac{F}{A} = \frac{2000\,N}{0.004\,m^2}$

$= 500{,}000\,Pa$

$\boxed{500\,kPa}$

4. A pump must deliver a pressure of 50 psi. The flow rate must be 20 gal/min. The pump is powered by an electric motor that operates on 120 V. Assume that both pump and motor are 100% efficient (which is quite unlikely). How much current does the motor draw? (Hint: Use the formula $P_{fluid} = (\Delta p) \times \frac{V}{t}$ and $P_{elec} = (\Delta V) \times I$. Also use the relationships 1 ft^3 = 7.48 gal, 1 ft^2 = 144 in^2 and 1 min = 60 sec.)

$\frac{20\,gal}{min} \cdot \frac{1\,ft^3}{7.48\,gal} \cdot \frac{1\,min}{60\,s} = \frac{0.0446\,ft^3}{s}$ $\frac{50\,lb}{in^2} \cdot \frac{12\,in}{1\,ft} \cdot \frac{12\,in}{1\,ft} = \frac{7200\,lb}{ft^2}$

$Pwr_{(f)} = \frac{7200\,lb}{ft^2} \cdot \frac{0.0446\,ft^3}{s} = 320.86\,\frac{ft\cdot lb}{s} \cdot \frac{1\,hp}{550\,\frac{ft\cdot lb}{s}} = 0.583\,hp \cdot \frac{746\,W}{hp} = 435.2\,W$

$435.2\,W = 120\,V\,(I)$ $\boxed{I = 3.63\,A}$

5. A motor produces energy at the rate of $\frac{1}{2}$ hp. While it is operating it draws a current of 3.5 A on a 120- V outlet. What is the efficiency of this motor?

$0.5\,hp \cdot \frac{746\,W}{1\,hp} = 373\,W$

$Pwr = VI$
$= (120\,V)(3.5)$
$= 420\,W$

$\frac{373\,W}{420\,W} = .888 = \boxed{89\%}$

6. A car engine causes an 1100kg car to accelerate from 0km/hr to 100km/hr in 4 seconds. The car does this in a distance of 55.56m. What is the total power output of the car's engine in horsepower?

$m = 1100\,kg$

$\Delta v = \frac{100\,km}{hr} \cdot \frac{1000\,m}{1\,Km} \cdot \frac{1\,hr}{3600\,s} = 27.78\,m/s$

$F = ma$

$= (1100\,kg)(6.94\,m/s^2)$

$= 7638.89\,N$

$a = \frac{\Delta v}{\Delta t} = \frac{27.78\,m/s}{4\,s} = 6.94\,m/s^2$

$Pwr = \frac{F \cdot d}{\Delta t} = \frac{7638.89\,N \cdot 55.56\,m}{4\,s} = 106104.17\,W \times \frac{1\,hp}{746\,W}$

142.23 hp

7. The average power output of this airplane is 50hp at a constant velocity of 100mi/hr. What is the drag force on the plane?

$Pwr = Fv$

$\frac{100\,mi}{hr} \cdot \frac{5280\,ft}{1\,mi} \cdot \frac{1\,hr}{3600\,s} = 146.67\,ft/s$

$50\,hp \cdot \frac{550\,ft \cdot lb/s}{1\,hp} = 27{,}500\,\frac{ft \cdot lb}{s} = F\,(146.67\,ft/s)$

$187.5\,lb = F$

8. How much current flows through a 120W flood light when it operates at 120V?

$Pwr = VI$

$120\,watts = 120\,V \cdot I$

$1\,amp = I$

9. A 10 Ohm resistor is connected across a potential difference. If 5A of current are in the resistor, what power is dissipated by the resistor?

$R = 10\,\Omega \qquad I = 5\,A$

$V = IR$

$V = (5\,A)(10\,\Omega)$

$V = 50\,V$

$Pwr = VI$

$= (50\,V)(5\,A)$

$= 250\,W$

OR

$Pwr = I^2 R$

$= (5\,A)^2(10\,\Omega)$

$= 250\,W$

10. The transmission of a car spins at 3500rpm when 120hp is delivered to it. What torque is produced by the motor?

$Pwr = \tau \omega$

$\frac{3500\ rev}{min} \cdot \frac{2\pi\ rad}{rev} \cdot \frac{1\ min}{60s} = 366.52\ \frac{rad}{s}$

$120\ hp = \tau (366.52)$

$\frac{120\ hp}{1} \cdot \frac{550\ \frac{ft \cdot lb}{s}}{1\ hp} = 66{,}000$

$66{,}000\ \frac{ft \cdot lb}{s} = \tau (366.52/s)$

$\boxed{180.07\ ft \cdot lb = \tau}$

11. A tank of compressed air is used to inflate small river rafts. A raft, which is initially flat, has a final volume of $15ft^3$. The atmospheric pressure is 14.2psi. What is the power, in horsepower, from the compressed air that is required to fill the raft in 30s?

$Pwr = P\dot{V}$

$\frac{14.2\ lb}{in^2} \cdot \frac{12\ in}{1\ ft} \cdot \frac{12\ in}{1\ ft} = 2044.8\ lb/ft^2$

$= \frac{2044.8\ lb}{ft^2} \cdot \frac{15\ ft^3}{30\ s}$

$= 1022.4\ \frac{lb \cdot ft}{s} \cdot \frac{1\ hp}{550\ ft \cdot lb/s} = \boxed{1.86\ hp}$

12. A piston in a robotic arm moves a 1000N load a distance of 13cm in 2s. The system's pump delivers high-pressure fluid at a rate of $130cm^3/s$. What is the pressure of the fluid?

$Pwr = \frac{W}{\Delta t} = \frac{F \cdot d}{\Delta t} = \frac{1000N \cdot .13m}{2s} = 65\ W$

$\frac{130\ cm^3}{s} \cdot \frac{1m}{100\ cm} \cdot \frac{1m}{100} \cdot \frac{1m}{100}$

$0.00013\ m^3/s$

$Pwr = -\Delta P \dot{V}$

$65\ W = -(\Delta P)(.00013\ m^3/s)$

$500{,}000\ Pa = \Delta P$ $\boxed{500\ kPa}$

13. How much would it cost to operate a fan with a power output of 36W for 30 days if it is left on for 8 hours per day. Energy is \$0.075 per kWh.

$E = Pwr\ \Delta t$

$36\ W \cdot \frac{1\ kW}{1000W} = 0.036\ kW$

$30\ days \times \frac{8\ hr}{day} = 240\ hr$

$= (036kW)(240h)$

$= 8.64\ kWh$

$8.64\ kWh \cdot \frac{0.075}{kWh} = 0.648 = 65¢$

14. A dynamometer measures the power output of a car's engine as 200hp. The engine consumes 15.5kg/h of gasoline. What is the efficiency of the engine?

$Input\ Pwr = \frac{15.5\ kg}{hr} \cdot 46 \cdot 10^6 \frac{J}{kg} \cdot \frac{1hr}{3600s} = 1.98 \times 10^5\ W$

$200\ hp \cdot \frac{746w}{hp} = 149{,}200\ W$

$Eff = \frac{1.492 \times 10^5\ W}{1.98 \times 10^5\ W} = 0.753$

75.3%