# LECTURE 37 – PNEUMATIC ACTUATORS

## SELF EVALUATION QUESTIONS AND ANSWERS

**1. A pneumatic cylinder has a bore of 200 mm and a piston rod diameter of 140 mm. For an extend speed of 5m/min. Calculate**

a) **The supply flow rate**
b) **The flow rate from the annulus side on extend**
c) **The retract speed using $Q_E$**
d) **The flow rate from the full bore end on retract**

**2. A compressor supplies air at 0.002 $m^3/s$ to a 50mm diameter double acting cylinder and a rod diameter is 20mm. If the load is 1000N both in extending and retracting, find**

a. **Piston velocity during the extension stroke and retraction stroke**
b. **Pressure during the extension stroke and retraction stroke**
c. **Power during the extension stroke and retraction stroke**

**3. A pneumatic cylinder has to move a table of weight 2000N. Speed of the cylinder is to be accelerated up to a velocity of 0.13m/s in 0.5 seconds and brought to stop within a distance of 0.02m. Assume coefficient of sliding friction as 0.15 and cylinder bore diameter as 50mm. Calculate the surge pressure.**

**Q1Solution**

a) Flow rate of oil to extend cylinder at 5m/min

$Q_E$ = area of piston × velocity

$=\frac{\pi}{4}\times (200/1000)^2\times\frac{5}{60} = 0.00262 m^3/min$

=0.00262 ×60 ×1000 = 157 LPM

b). Flow of oil leaving cylinder $q_E$is given by

$q_E =$ annulus area × velocity

$= \frac{\pi}{4}\times((200/1000)^2- (140/1000)^2)\times\frac{5}{60}$ = 80 LPM

c). The same fluid flow rate used to extend the cylinder(157LPM) is used to retract the cylinder. Retract cylinder velocity V is given by

v= $Q_E$/ (A-a)

$Q_E$= 157 LPM = 0.00262$m^3$

(A-a)= annulus area= 0.01602$m^2$

$v= \frac{0.00262}{0.01602}$ =0.614m/s = 9.8 m/min

d) Flow from full bore end of cylinder $Q_R$ is given by

Q= A× v

= 0.03142×0.164 =0.00515$m^3$/s = 309 LPM

**Q2 Solution**

Oil flow rate from pump, Q = 0.002 $m^3$/s

Diameter of the cylinder, $d_P$ = 50mm = 0.05 m

Diameter of the rod, $d_r$= 20mm= 0.02m

Load during the extension and retraction F = 1000N

**Part a**

Piston velocity during extension stroke $V_E = \frac{Q}{A_P}$

$= \frac{0.002}{\frac{\pi}{4} \times 0.05^2} = 1\ m/s$

Piston velocity during retraction stroke $V_R = \frac{Q}{A_P - A_R}$

$= \frac{0.002}{\frac{\pi}{4} \times (0.05^2 - 0.02^2)} = 1.2\ m/s$

**Part b**

Cylinder pressure during extension stroke $P_E = \frac{F}{A_P} = \frac{1000}{\frac{\pi}{4} \times 0.05^2}$ = 5.1 bar

Cylinder pressure during retraction stroke $P_R = \frac{F}{A_P - A_R} = \frac{1000}{\frac{\pi}{4} \times (0.05^2 - 0.02^2)} = 6.06 bar$

**Part c**

Cylinder power during extension stroke = $\frac{\mathrm{P_E} \times \mathrm{Q}}{1000} = \frac{5.1 \times 10^5 \times 0.002}{1000} = 1.02\ kW$

Cylinder power during extension stroke = $\frac{\mathrm{P_R} \times \mathrm{Q}}{1000} = \frac{6.06 \times 10^5 \times 0.002}{1000} = 1.21\ kW$

**Q3 Solution**

Initial velocity u = 0m/s

Final velocity v= 0.13m/s

Acceleration a = $\frac{v-u}{t} = \frac{0.13-0}{0.5} = 0.26\ \mathrm{m/s^2}$

Force required to move the piston = Dynamic force + frictional force

$= \left[\frac{w}{g} \times a\right] + \mu.w = \left[\frac{2000}{9.81} \times 0.26\right] + 0.15 \times 2000$

= 353 N

To overcome this force, the pressure required in the hydraulic cylinder is

$= \frac{353}{\frac{\pi}{4} \times 0.05^2} = 1.79 \times 10^5 Pa = 1.79 bar$

From the equation for velocity, acceleration and distance $v^2 - u^2 = 2as$

$a = \frac{v^2 - u^2}{2s} = \frac{0^2 - 0.13^2}{2 \times 0.02} = -0.4225m$

(The –ve sign indicates that it is deceleration)

The total force required to stop the motion of a cylinder

$$= \frac{2000}{9.81} \times 0.4225 + 2000 \times 0.15 = 386.1N$$

Then pressure created by this opposing force is

$$= \frac{386.1}{\frac{\pi}{4} \times 0.05^2} = 1.96 \times 10^5 Pa = 1.96 bar$$

Thus surge pressure $P_s = P_1 + P_2 = 1.79 + 1.92 = 3.75$ bar