EET-120 Fluid Power Handouts

Cylinder Force, Speed & Power

Pneumatic and hydraulic actuators are both powered by moving fluids. In the first case, the fluid is compressed air; in the second case, the fluid is usually pressurized oil. The operation of these actuators is generally similar except in their ability to contain the pressure of the fluid. Pneumatic systems typically operate

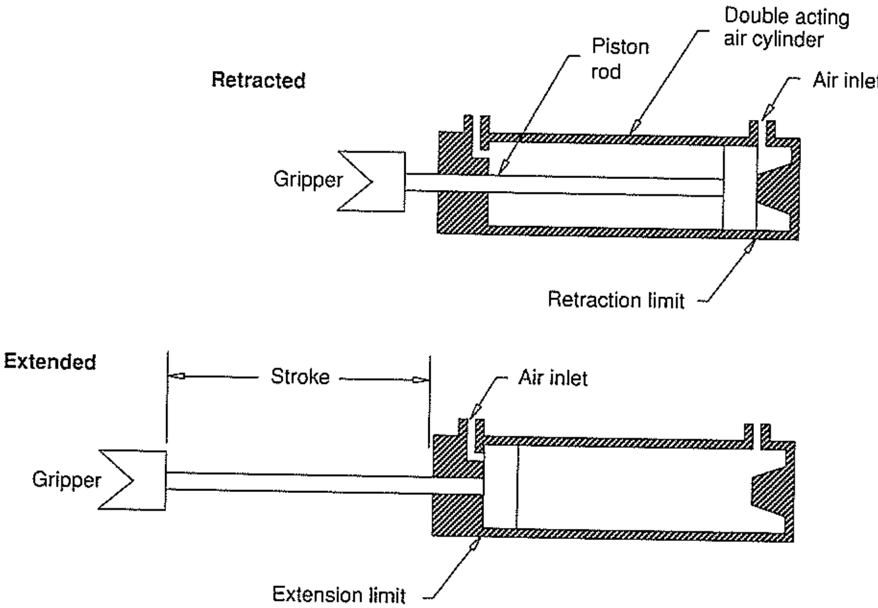

Figure 2.3.15 Linear actuator for motion position.

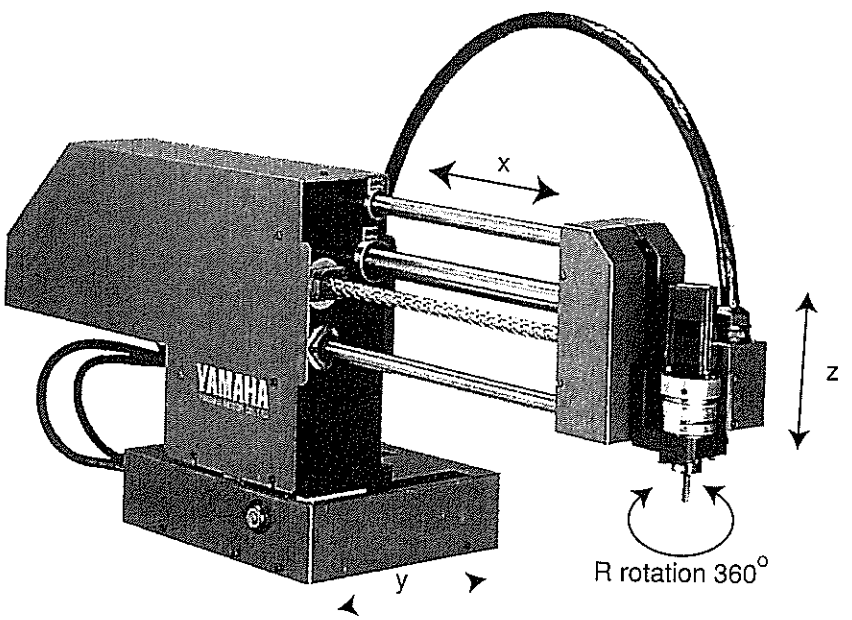

Figure 2.3.16 The Yamaha model YP304A Pick & Place-type robot is a four-axis unit that uses actuator stroke to position the end-of-arm tooling. *(Courtesy of Yamaha Robotics, Inc.)*

with pressure at about one hundred pounds per square inch and hydraulic systems at one thousand to three thousand pounds per square inch.

There are two relationships of particular interest when discussing actuators: the piston velocity of the actuator and the force output of the actuator with respect to the input power. The force output and piston velocity of double-acting cylinders are not the same for extension and retraction strokes. This phenomenon is due to the effect of the rod and is defined by Equations 2.3.1 through 2.3.4.

Extension stroke:

$$force\ (lb) = pressure\ (psi) \times piston\ area\ (in.^2) \qquad \text{(Equation 2.3.1)}$$

$$velocity\ (ft/sec) = \frac{input\ flow\ (ft^3/sec)}{piston\ area\ (ft^2)} \qquad \text{(Equation 2.3.2)}$$

Retraction stroke:

$$force\ (lb) = pressure\ (psi) \times [piston\ area\ (in.^2) - rod\ area\ (in.^2) \qquad \text{(Equation 2.3.3)}$$

$$velocity\ (ft/sec) = \frac{input\ flow\ (ft^3/sec)}{piston\ area\ (ft^2) - (rod\ area\ (ft^2)} \qquad \text{(Equation 2.3.4)}$$

The horsepower developed by a cylinder can be found using Equations 2.3.5 or 2.3.6.

$$horsepower = \frac{piston\ velocity\ (ft/sec) \times force\ (lb)}{550} \qquad \text{(Equation 2.3.5)}$$

$$horsepower = \frac{input\ flow\ (gpm) \times pressure\ (lb/in.^2)}{1714} \qquad \text{(Equation 2.3.6)}$$

Example: A hydraulic cylinder has a piston diameter of 2.0 in., a fluid pressure of 1200 lb/in.^{2}, a flow rate of 142 in.^{3}/min, and a stroke of 10 in. Find the force and the velocity generated by the piston.

Solution

Using Equation 2.3.1:

$$\begin{aligned} force &= pressure \times piston\ area \\ &= 1200 \times (0.785 \times 2^2) \\ &= 3770\ lb \end{aligned}$$

Using Equation 2.3.2:

$$velocity = \frac{input\ flow}{piston\ area} = \frac{142}{3.14} = 45.2\ inch/min = 0.0628\ ft/sec$$

Note: The length of the stroke has no bearing on the operating force and velocity.

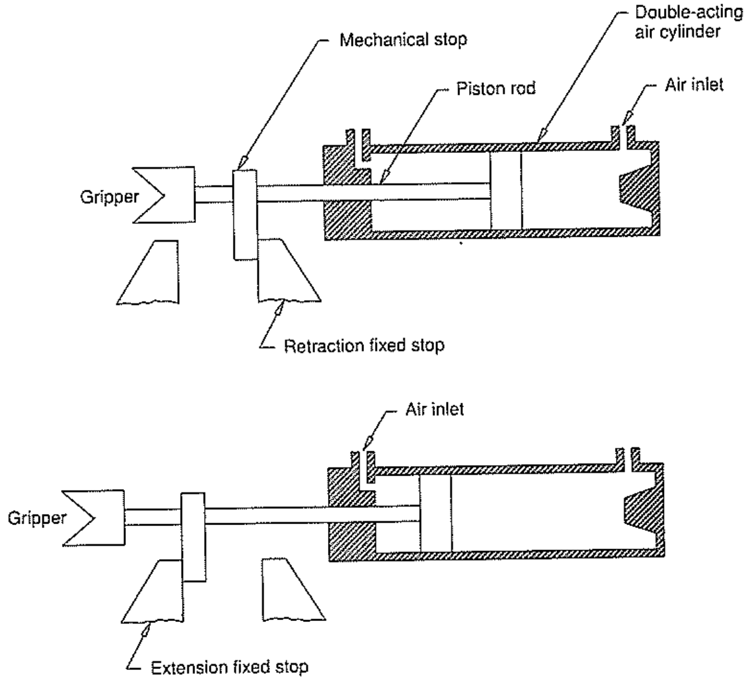

Figure 2.3.17 Fixed stops arrangement for motion position

Fixed stops are often blocks used to stop the extension or retraction of actuator before it reaches its full stroke. Figure 2.3.17 shows such an installati

Variable stops are often screws, collars, or sliding blocks that can be adjus so that they can vary the stroke of the actuator. Figure 2.3.18 shows an exam of this type of robot stop.