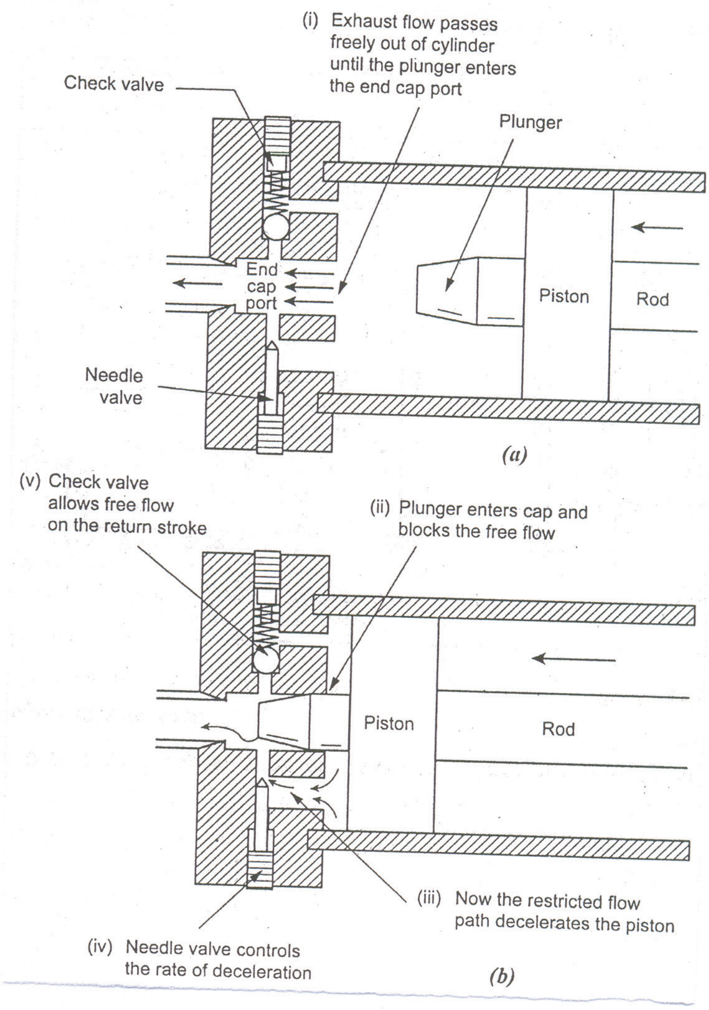
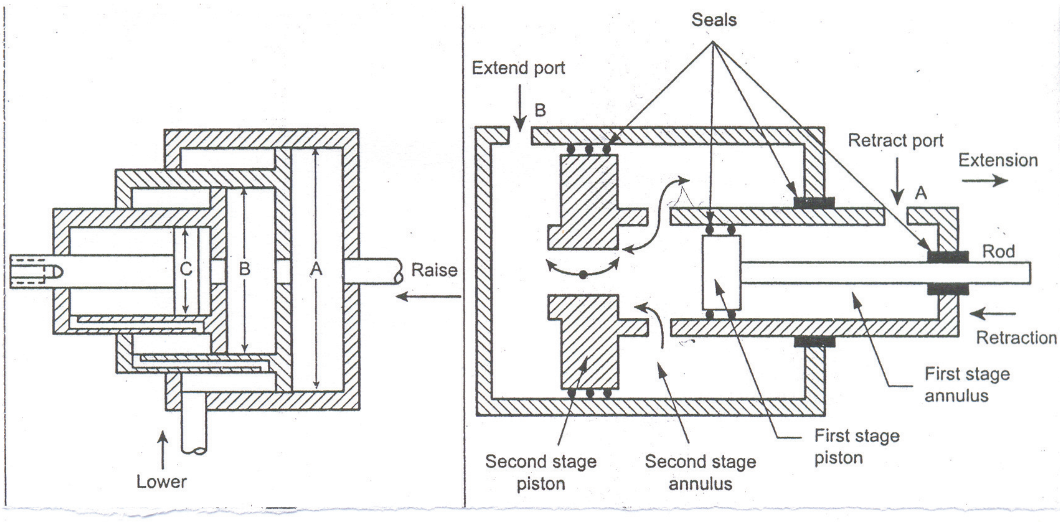


11. Explain with a diagram the working of a Telescopic cylinder. [Dec. 2008, Dec. 2010, Dec. 2011, Dec. 2012, May 2008).

Telescopic cylinders are used where long work-strokes are needed. A telescopic cylinder provides a relatively long working stroke for an overall reduced length by employing multiple pistons which telescope into each other.

One very simple application is the high-lift fork truck.



Since the diameter 'A' of the ram is relatively large, this ram produces a large force for the begining of the lift of load (Higher force is required to begin the lifting of load, once lifting started, the required force to continue raising the load will be lower). When ram A reaches the end of the stroke, ram B begins to move. This ram 'B' provides the required smaller force to continue raising the load. After ram 'B' reaches the end of stroke, ram 'C' still with smaller force is used to continue the lifting of load. These three rams can be retracted either by gravity or by pressurized fluid acting on each ram.

12. Classify the hydraulic actuators and explain any three type of special actuator. [Dec. 2011, May 2013 Dec 2013]

The fluid discharged by the pump is directed to the "hydraulic actuator". The actuator converts the pressure energy of the fluid into mechanical energy. There are three basic types of hydraulic actuator

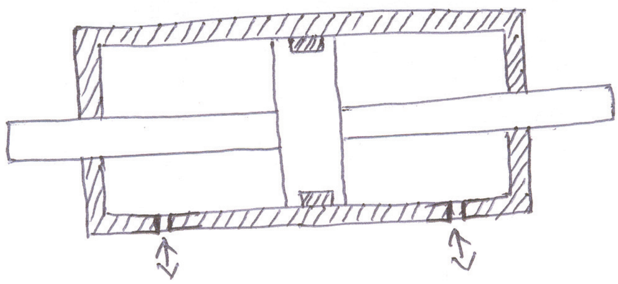
1. Linear motion - hydraulic cylinder
2. Rotary (continuous) motion - Hydraulic motor
3. Rotary (limited angle of movement) motion - Semi-rotary actuator.

Refer Answer of Question No. 9

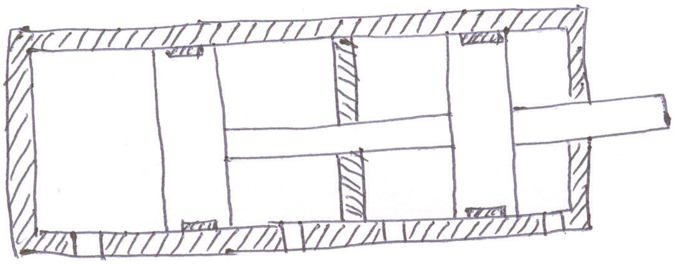
Special cylinders:

(i) Double rod cylinder:

Double rod cylinder is with a single piston and a piston rod extending from each end. This cylinder allows work to be performed at either or both ends. It may be desirable where operating speed and return speed are equal.



(ii) Tandem cylinder:



Tandem cylinder design has two cylinders mounted inline with pistons connected by a common piston rod. These cylinders provide increased output force when the bore size of a cylinder is limited. But the length of cylinder is more than the standard cylinder and also requires a larger flow rate to achieve a speed because flow must go to both pistons.

(iii) Telescopic cylinder:

Refer Question No. 11.

13. Explain briefly about the fluid motors. (May 2009, Dec. 2010) Dec. 2012, Dec. 2013

Fluid motor is one of the hydraulic actuators which converts the pressure energy of the fluid into continuous rotation - Mechanical energy.

It is opposite to pump, instead of pushing on the fluid as pumps do, motors are actuated by the fluid. The fluid forces the motor to create a rotary motion. This rotary motion of the motor is mechanically linked to the work load. In this way, hydraulic motors develop torque and produce continuous rotary motion. ~~Thus, a h~~

Hydraulic motors are classified as follows:

(i) Gear type motors

(ii) Vane type motors

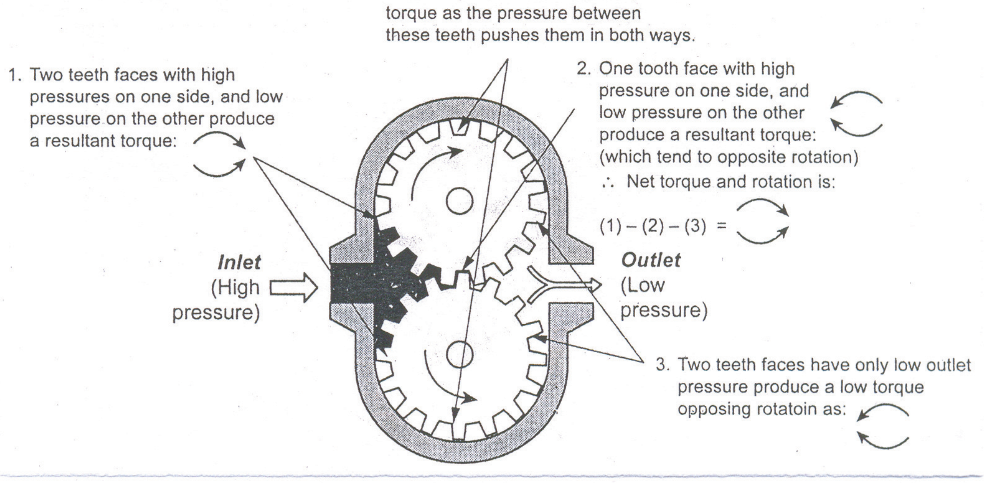
(iii) Piston type motors

(a) Axial type

(b) Radial type

Gear type motor:

A gear motor consists basically of a housing with inlet and outlet ports, and a pair of meshing external gears. One gear is attached to a shaft that is connected to the load. The other gear is a driver gear. The gear motor develops an output torque at its shaft by allowing hydraulic pressure to act on gear teeth.



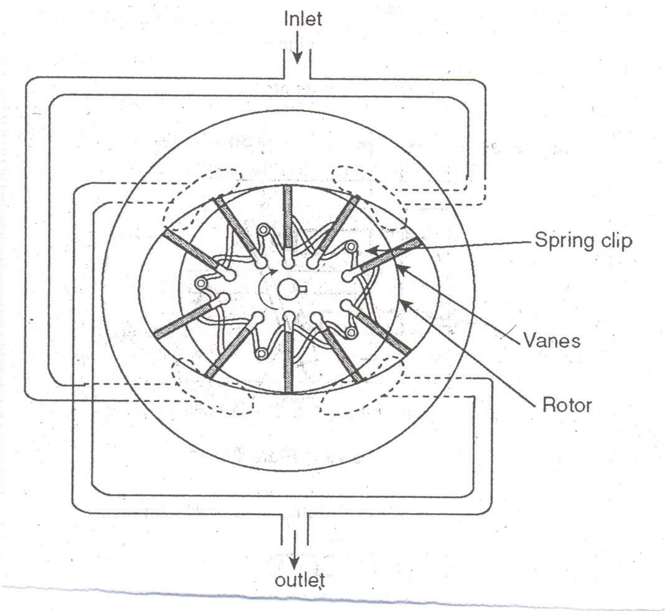
Gear motors are used when relatively high Speed and low torque is needed, Such as fan drives, compressor drives etc.

Gerotor motor is a popular type of internal gear motor. It consists of an inner drive gear and an outer gear. The inner gear is attached to a shaft which is connected to a load. Fluid pressure acting on the unequally exposed teeth results in a torque at the motor Speed.

Gerotor motor is more Suitable for low Speed applications. Due to compactness, these motors are very popular in mobile equipments especially agricultural machines like harvestors, movers etc.

Vane type Motors:

The Vane motors are similar in Construction to the balanced Vane pumps except that the vanes must be held tightly against the contour of the cam ring.

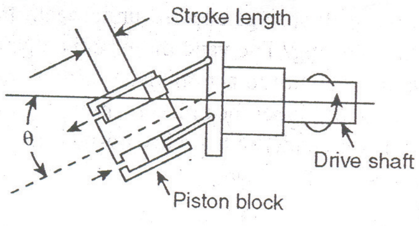


This is generally done with Springs applied underneath the vanes to hold them against the surface of the cam ring. The vane motor develops an output torque at its shaft by allowing hydraulic pressure to act on vanes which are extended. The larger the exposed area of the Vanes ~~the~~ or higher pressure, more torque will be developed at the Shaft. They are generally considered to be low-to-medium torque motors.

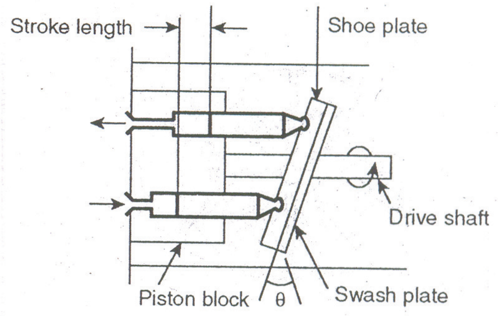
Piston type motors:

Piston motor develops an output torque at its shaft by allowing hydraulic pressure to act on pistons. piston designs may be either axial or radial type.

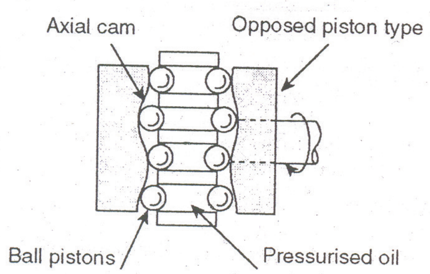
Axial piston motors are of two categories:
(i) Swash plate or Bent-Axis type
(ii) Cam lobe opposed ball type



(a) Bent-axis type



(b) Swash Plate Type



(c) Cam Lobe Ball Type

The swash plate type motor consists of a port plate, cylinder barrel, pistons, shoe plate, swash plate and a shaft. The arrangement is similar to swash plate pump. When the fluid pressure acts on a piston, a force is developed which pushes the piston out and causes the piston shoe to slide across the swash plate surface. As the piston shoe slides, it develops a torque attached to the barrel.

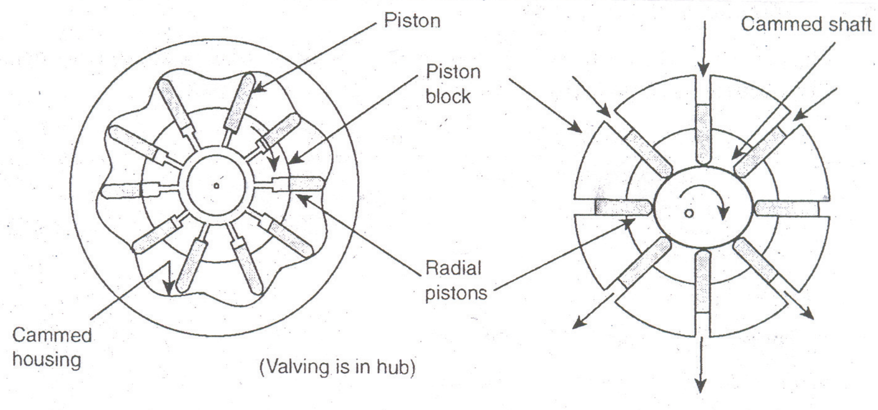
The cam lobe opposed ball type consists of a double cam arrangement and a piston block containing a number of cylinders, each with a pair of opposing ball pistons. The pistons are borne on cam plates. Distributor plates feed pressure fluid to the cylinders forcing out the pistons against the cam tracks. The tangential component of reaction force causes the cylinder block to rotate. The used fluid is returned through another set of distributor plates as the pistons are pushed back by the cam plates.
These motors are used in mobile applications and can be directly mounted on wheel rims or sprockets for crawler chains.

Radial piston Motors ~~pumps~~:

Radial piston motors can be broadly classified as

(i) Eccentric Cam Shaft type

(ii) Multi lobe Cam type



(a) Multi Lobe Cam Type (b) Eccentric Cam Shaft Type

In eccentric Cam Shaft type, a number of large bore pistons are arranged radially round a Shaft which has an equally large eccentric Cam. The pressure on the piston produces thrust on the eccentric causing ~~the~~ the rotation of the Shaft.

The multi lobe Cam motors comprise of a center-rotating piston assembly and a fixed outer Cam ring with eight lobes. A central valve distributes pressurised fluid to the cylinder which are forced outwards on to the cam. As they follow the Cam profile, the piston block rotates driving the output Shaft.

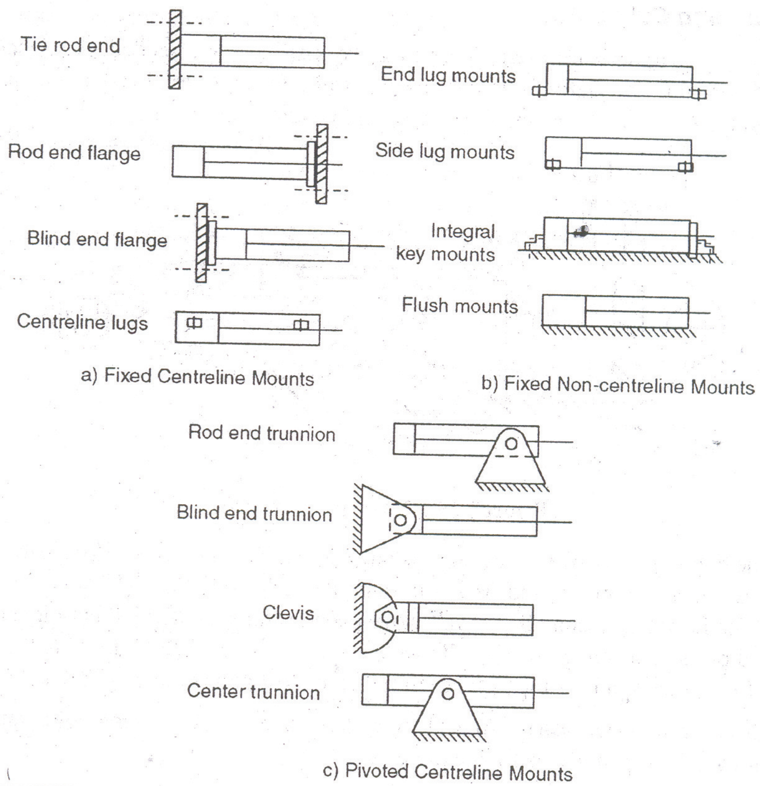
The radial piston motors are generally used as low Speed high torque motors. They are used in heavy-duty applications such as hoisting, rolling mills, road rollers, etc.

14 Discuss any two types of cylinder mountings with neat diagram. Sketch six cylinder mounts. [Dec. 2009, May 2010]

The types of Mountings on cylinders are numerous, and they can accomodate a wide variety of applications. The most common mountings are

- lugs
- flange
- trunnion
- clevis and
- extended tie rods.

One of the most important considerations in selecting a particular mounting style is whether the major force applied to the load will result in tension or compression of the piston rod. The ratio of rod length to diameter should not exceed 6:1 proportion at full extension. This helps to prevent the rod from buckling due to compression or tensile shock forces.



a) Fixed Centreline Mounts

b) Fixed Non-centreline Mounts

c) Pivoted Centreline Mounts

Alignment of the rod with the resistive load is another important consideration while selecting cylinder mounts. Mis-alignment or non-axial loading also tend to place unnecessary loads on the rod and rod guides, bushes or bearings. Due to the immense loads and the extreme forces introduced by the rod there are large stresses on the rod at full extension. centre lugs, centre trunnions and clevis arrangements tend to help keep the rod or shaft in line with the load.

<u>Fixed centre line Mounts:</u> These are used for thrusts that occur linearly or in the centre line with the cylinder. proper alignment is essential to prevent compound stresses that may cause excessive friction and bending as the piston rod extends. Additional holding strength may be essential with long stroke cylinders.

<u>Fixed Non-centre line Mounts:</u> These are convenient where exceptionally heavy linear thrusts are encountered. Generally integral keys or pins are used if excessive hydraulic shock is expected. This helps to releive shear loads. Since the cylinder has to expand and contract with temperature changes, only one end should be keyed or pinned.

<u>Pivoted centre line Mounts:</u> These are used to compensate for thrusts that occur in multiple planes or if the attached load travels in a curved path. Ball joints, trunnions and clevis mounts allow thrusts to be taken up along the cylinder centrelines.

15. A gear pump has 75 mm outside dia, 50mm inside dia, 25mm width. If the volumetric efficiency is 95% at rated pressure, what is the actual flow rate? The pump speed is 1200 rpm. [Dec. 2009]

<u>Given Data:</u>

$D_o = 75 mm = 75 \times 10^{-3} m$

$D_i = 50 mm = 50 \times 10^{-3} m$

$b = 25 mm = 25 \times 10^{-3} m$

$\eta_v = 95\%$

$N = 1200 rpm$

<u>Asked Data:</u>

$Q_A = ?$

Solution:

Volumetric displacement of the gear pump, $V_D = \frac{\pi}{4}[D_o^2 - D_i^2] \times b$

$= \frac{\pi}{4}[(75\times10^{-3})^2 - (50\times10^{-3})^2] \times 25\times10^{-3}$

$= 6.136\times10^{-5}$ m^3/rev

Theoritical flow rate, $Q_T = V_D \times N$

$= 6.136\times10^{-5} \times 1200$

$= 0.0736$ m^3/min

WKT,

$$\eta_v = \frac{Q_A}{Q_T}$$

$\Rightarrow Q_A = \eta_v \times Q_T$

$= 0.95 \times 0.0736$

$= 0.06992$ m^3/min

16. A pump has a displacement volume of 100×10^{-6} m3. It delivers 1.5×10^{-3} m^3/s at 1000 rpm and 70×10^5 N/m^2 pressure. If the prime mover input torque is 120 Nm. (Dec. 2009, May 2012)
   (i) what is overall efficiency of the pump?
   (ii) what is the theoretical torque required to operate the pump?

Given Data:

$V_D = 100\times10^{-6}$ m^3

$Q_A = 1.5\times10^{-2}$ m^3/sec $= 1.5\times10^{-2}\times60$ m^3/min

$N = 1000$ rpm

$P = 70\times10^5$ N/m^2

$T_A = 120$ Nm

Asked Data:

(i) $\eta_o = ?$

(ii) $T_T = ?$

Solution :

WKT,

$$\eta_o = \frac{P \times Q_A}{2\pi N T_A} \times 100$$

$$= \frac{70 \times 10^5 \times 1.5 \times 10^{-3} \times 60}{2 \times \pi \times 1000 \times 120} \times 100$$

$$= 83.56 \%$$

$$T_T = \frac{P \times V_P}{2\pi}$$

$$= \frac{70 \times 10^5 \times 100 \times 10^{-6}}{2\pi}$$

$$= 111.41 \text{ Nm}$$

17. A pump supplies oil at 0.002 m^3/s to a 50 mm dia double acting cylinder and the rod dia is 20 mm. If the load is 6000 N both in extending and retracting, find
   (i) piston velocity during extension and retraction
   (ii) pressure during extension and retraction
   (iii) power during extension and retraction.

Given Data :

$Q = 0.002 \ m^3/sec$

$D = 50 \ mm = 50 \times 10^{-3} \ m$

$d = 20 \ mm = 20 \times 10^{-3} \ m$

$F = 6000 \ N$

Asked Data:

(i) V_E & V_R

(ii) P_{rE} & P_{rR}

(iii) P_E & P_R

Solution:

$$V_E = \frac{Q}{A} = \frac{0.002}{\frac{\pi}{4}(50\times10^{-3})^2}$$

$$= 1 \text{ m/sec}$$

$$V_R = \frac{Q}{A-a} = \frac{0.002}{\frac{\pi}{4}\left[(50\times10^{-3})^2 - (20\times10^{-3})^2\right]}$$

$$= 1.2 \text{ m/sec} \quad [\therefore \text{Return Stroke is faster}]$$

$$Pr.E = \frac{F}{A} = \frac{6000}{\frac{\pi}{4}[50\times10^{-3}]^2}$$

$$= 30.6 \text{ bar}$$

$$Pr.R = \frac{F}{A-a} = \frac{6000}{\frac{\pi}{4}\left[(50\times10^{-3})^2 - (20\times10^{-3})^2\right]}$$

$$= 36.4 \text{ bar}$$

$$P_E = Pr.E \times Q = 30.6\times10^5 \times 0.002$$

$$= 6.12 \text{ KW}$$

$$P_R = Pr.R \times Q = 36.4\times10^5 \times 0.002$$

$$= 7.28 \text{ KW}$$

18. The power and load carrying capacity of a hydraulic cylinder (extension) are 10KW and 20000N respectively. Find the piston velocity during extension. If the area of the piston side and rod side is 2:1, find the retraction speed. The pump delivers oil at 0.2 m³/min. (May 2005)

Given Data:

$P_E = 10\text{KW}$

$F = 20000\text{N}$

$\frac{A}{a} = 2$

$Q = 0.2 \text{ m}^3/\text{min}$

Asked Data:

(i) V_E

(ii) V_R.

Solution:

WKT,

$$P_E = \frac{Pr.E \times Q}{60}$$

$$Pr.E = \frac{P_E \times 60}{Q}$$

$$= \frac{10 \times 10^3 \times 60}{0.2}$$

$$= 30 \text{ bar}$$

$$A = \frac{F}{Pr.E}$$

$$= \frac{20000}{30 \times 10^5}$$

$$= 0.0067 \text{ m}^2$$

$$V_E = \frac{Q}{A}$$

$$= \frac{0.2/60}{0.0067}$$

$$= 0.4975 \text{ m/sec}$$

$$V_R = \frac{Q}{A-a}$$

$$= \frac{Q}{0.5A}$$

$$= \frac{0.2/60}{0.00335}$$

$$= 0.995 \text{ m/sec}$$

19. Howmuch hydraulic power would a pump produce when operating at 125 bars and delivering 1.25 lps of oil? What power rated electric motor would be selected to drive this pump if its overall efficiency is 88%. [May 2008]

Given Data:

$P_r = 125$ bar $= 125 \times 10^5$ N/m^2

$Q = 1.25$ lps $= 1.25 \times 10^{-3}$ m^3/sec

$\eta_o = 88\%$

Asked Data:

(i) Power = ?

Solution:

$P = P_r \times Q$

$= 125 \times 10^5 \times 1.25 \times 10^{-3}$

$= 15.625$ kW

WKT,

$$\eta_o = \frac{\text{Power delivered by Pump}}{\text{Power delivered to Pump}}$$

$$\text{Power delivered to pump} = \frac{\text{Power delivered by pump}}{\eta_o}$$

$$= \frac{15.625}{0.88}$$

$= 17.76$ kW