LECTURENOTES

ON

HYDRAULICMACHINES&INDUSTRIALFLUID POWER

GaneshInstituteofEngineeringand Technology

SCTE&VT,BHUBANESWAR ODISHA

5th Semester Diploma in Mechanical Engineering

(AsperSyllabus prescribedbySCTE&VT,Odisha)

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CHAPTER01

HYDRAULICTURBINE

INTRODUCTION:-

Hydraulicmachinesaredefinedasthosemachineswhichconvert eitherhydraulicenergy into mechanical energyor mechanical energy into hydraulic energy. The hydraulic machine which convert hydraulic energy into mechanical energy is called turbine and the hydraulic machine which convert mechanical energy into hydraulic energy is called pump.

HYDRAULICTURBINES:-

- The hydraulic machine which convert hydraulic energyinto mechanicalenergyis called turbine.Thismechanicalenergyisused inrunning anelectricgeneratorwhichisdirectly coupled to the turbine shaft.
- Thus, mechanicalenergyisconvertedintoelectricalenergytheelectricpowerwhichis obtained from the hydraulic energy is known as hydro-electric power.

CLASSIFICATIONOFTURBINE

Turbinescanbeclassified onthebasisof:

1. Accordingtotheenergyavailableat theinlet-

(a) Impulseturbine

(b) Reactionturbine

2. Accordingtothedirectionofflowthroughtherunner

a) Tangentialflowturbines

b) Radialflow turbines

c) Axialflowturbine

d) Mixedflowturbine

c)Axialflowturbines

3. Accordingtotheheadavailableatthe

a) Highhead turbine

b) Mediumheadturbine

c) Lowheadturbine

4. Accordingtothespecificspeedofthe turbine

a) Lowspecificspeed turbine

b) Mediumspecificspeedturbine

c) Highspecificspeed turbine

- Ifatthe inletoftheturbinetheenergyavailable is onlykineticenergythenit iscalledan impulse turbine. If at the inlet of the turbine both kinetic as well as pressure energyare available then it is called reaction turbine.
- Ifwater flowsalongthetangent oftherunner, thenit iscalled tangentialflowturbine. If waterflowsalongradialdirection, thenit iscalledradialflowturbine. Ifthewaterflows fromoutwardto inward radiallytheturbine iscalled inward radialflowturbine. ifwater flows from inward to outward the turbine is called outward radial flow turbine.
- Ifthe water flowsthroughthe runner along parallelto the axisofrotationofthe runner, then the turbine is called axial flow turbine.
- Ifthewater flowsthroughtherunner inradialdirectionbut leaves inaxialdirectionthen the turbine is called mixed flow turbine.

IMPULSETURBINE

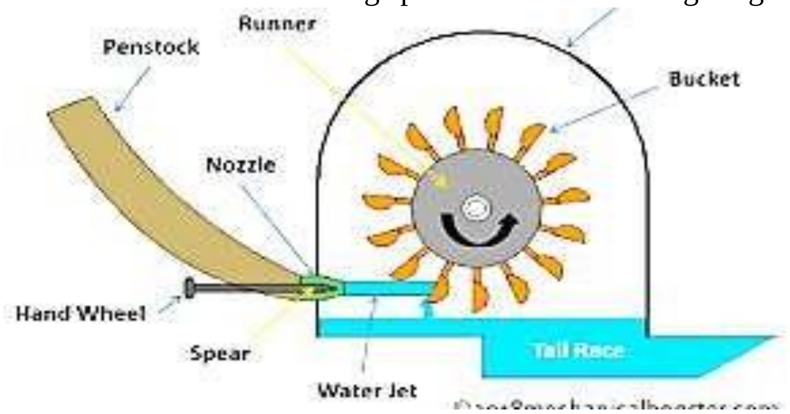
- Peltonwheelisatangentialflow ImpulseTurbine Theenergyavailableat the inletof the Pelton turbine is onlykinetic energy. The pressure at the inlet and outlet of the turbine is atmospheric Pressure. This type of turbine is used for high head.

MainPartsofPeltonwheel

Thevariouspartsofthe Peltonturbine are

1. NozzleandFlowRegulatingArrangement(Spear)

- Nozzle isusedtoincreasethekineticenergyofthewaterthatisgoingtostrikethe buckets or vanes attached to the runner.
- The quantityof water that strikes the buckets is controlled by spear. The spear is installed insidethenozzleandregulatestheflowofwaterthatisgoingto strikeonthe vanes of the runner. A nozzle containing spear is shown in the figure given below.



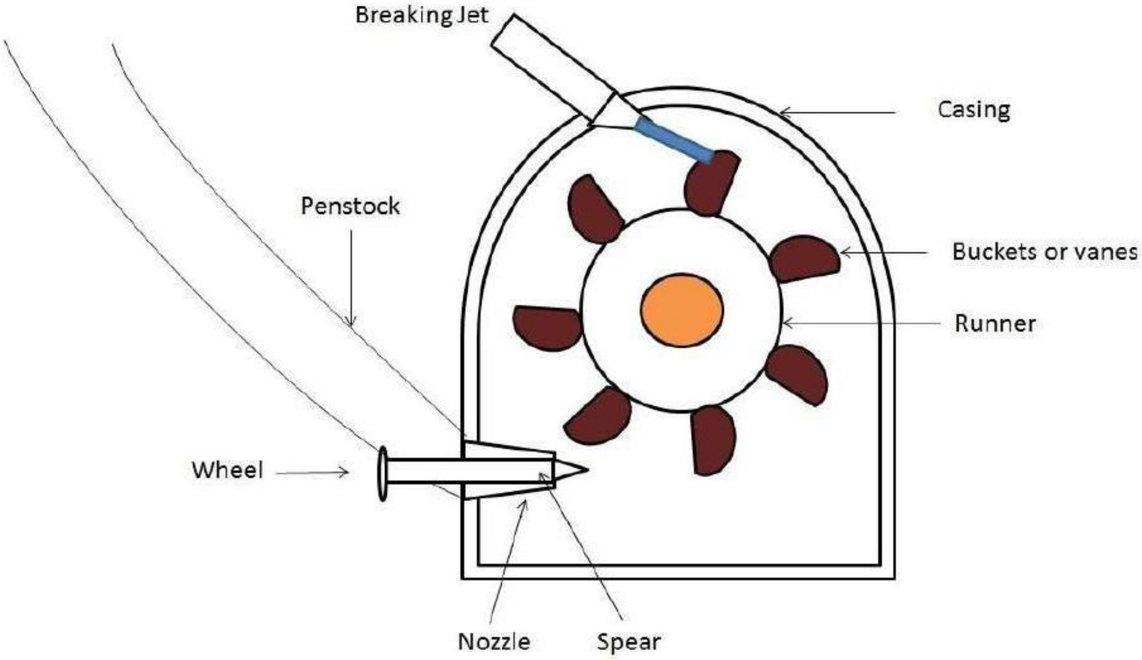
- Thespear isaconicalneedlepresent inthenozzle. It isoperatedbyahandwheelor automatically in an axial direction.
- Whenthespear is moving backwardtherateofflowofwaterincreasesandwhenit is pushed forward the rate of flow of water.

2. RunnerandBuckets

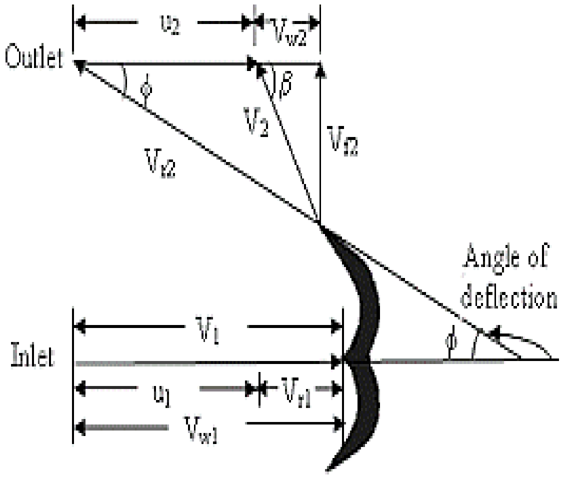
- Runner isarotatingpartoftheturbine. It isacircular discontheperipheryofwhicha number of buckets evenly spaced are fixed.
- Thebucketsaremade bytwo hemisphericalbowljoinedtogether.Each bucket hasa wall in between two hemispherical bowl called splitter.

3. Casing:
   - Theoutercoveringofthisturbine iscalledcasing. ThePeltonturbinewiththecasing is shown in the figure given below.
   - Itpreventsthesplashingofthewater andhelpstodischargethewatertothetrailrace. It also acts as a safeguard in the case of any accident occurs.
   - Castironorfabricated steelplatesareused to makethecasingofthePeltonTurbine.
4. Breakingjet:

   - Breaking jet When the jet of water is completelyclosed bypushing the spear in forwarddirectionthantheamountofwater strikingtherunner becomeszero.Butstill the runner keeps moving due to the inertia of the runner.
   - In order to stopthe runner in the shortest possible time a small nozzle is provided whichdirectsthe jetofwater atthebackofthevanes. This jetofwater usedto stop the runner of the turbine is called breaking jet.



VELOCITYDIAGRAM,WORKDONEANDEFFICIENCIESOFIMPULSE TURBINE



LetV=Velocityofthejet
U=Velocityofthevane(blade)atthe impact point U = $\pi DN/60$

whereD=Diameterofthewheelcorrespondingtothe impact point d= Pitch circle diameter.
Atinlettheshapeofthevaneissuchthatthedirectionofmotionofthejetand the vane is the same hence $\alpha = 0$ and $\theta = 0$
Relative velocity at inlet $V_{r1}=V_1-U_1$
Whirl velocity $V_{w1}=V_1$
Fromthevelocitytriangleatoutlet $V_{r1}=V_{r1}$, $V_{w2}=V_{r2}\cos\phi-U_2$
The force exerted bythe jet ofwater in the direction of motion $F_x=\rho aV_1(V_{w1}+V_{w2})$
Work donebythejet=$\rho aV_1(V_{w1}+V_{w2})U$ Nm/s
Powergiventotherunnerbythe jet= $\rho aV_1(V_{w1}+V_{w2})\,U/1000$ KW
Work done per second per unit weightofwaterstriking/sec=
$\rho aV_1(V_{w1}+V_{w2})\,U$/weightofwaterstrikingpersecond
$=\rho aV_1(V_{w1}+V_{w2})U/\rho aV_1 g$

Hydraulicefficiency
η_h=workdonepersecond/K.Eofjetpersecond
$=\rho aV_1(V_{w1}+V_{w2})U / (1/2\rho aV_1\times V_1)$
$=2(V_{w1}+V_{w2})U/V_1^2$

Maximumefficiency=$(1+\cos\phi)/2$

PointsToBeRememberedForPeltonWheel

(1) Thevelocityofjetatinletisgivenby, $V_1=C_v\sqrt{(2gH)}$
(2) Velocityofwheel(U)is givenby$U=\theta\sqrt{(2gH)}$
(3) Theangleofdeflectionofthejetis165whenitis notgiven

(4) Themeandiameterorpitchdiameterofthe PeltonwheelDisU = πDN/60

(5) Jet ratio: ItisdefinedastheratioofpitchdiameterandPeltonwheeldiameter. it is denoted by m.

M=D/d

(6) Number ofbucket onarunnerZ=1.5+D/2d

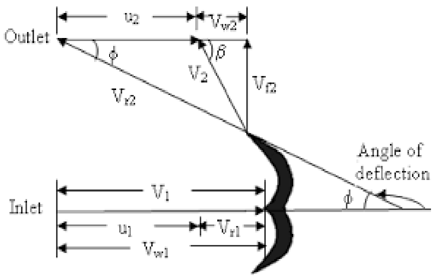
(7) Numberofjet -it isobtainedbydividingthetotalrateofflowthroughtheturbine by the rate of flow of water through a single jet.

PROBLEM-01

APeltonwheelhasa meanbucket speedof10 meterspersecondwitha jetofwaterflowing at the rate of 700 litres/s under a head of 30 meters. The buckets deflect the jet through an angle of 160˚. Calculate the power given by the runner and the hydraulic efficiencyof the turbine. Assume co-efficient of velocity as 0.98.

Solution givendate

SpeedofbucketU = U_1=U_2 = 10m/s



Discharge(Q)= 700litres/s=0.007m^3/s

Angle ofdeflection=160˚

Angle(ϕ)=180-160= 20

Co-efficient of velocity C_v= 0.98

Thevelocityofjet V_1=$C_v\sqrt{(2gH)}$

=0.98x$\sqrt{(2x9.81x30)}$=23.77m/s V_{r1}=

V_1- U_1 =23.77-10 = 13.77 m/s V_{w1} =

V_1= 23.77 m/s

FromtheoutlettriangleV$_{r2}$=V_{r1}= 13.77 m/s

V_{w1}=$V_{r2}\cos\phi$–U_2=2.94m/s Work

done by the jet= ρa V_1(V_{w1}+V_{w2}) U

=1000x23.77(23.77+ 2.94)x10

=186970Nm/s(ans)

power = 186970/1000 = 186.97 kw(ans)

Hydraulicefficiency

ηh=workdoneper second/K.Eofjetpersecond

=2(V_{w1}+V_{w2})U/ $V^2{}_1$

=2x(23.77+2.94) x10)/ 23.77^2

=0.9454=94.54٪(ans)

REACTIONTURBINE:-

- Iftheenergyavailableatthe inletoftheturbine is bothkineticaswellaspressureenergy then the turbine is called reaction turbine.
- Itisuptwo types-

(1) FrancisTurbine

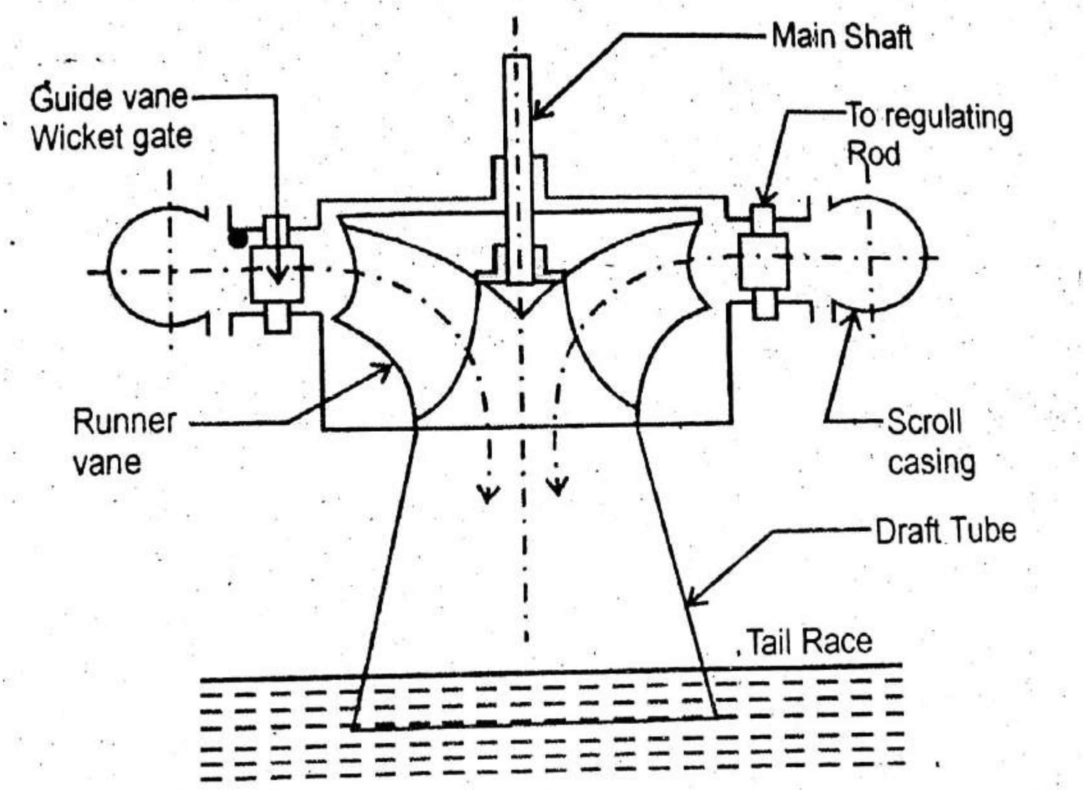
(2) Kaplanturbine

FRANCIS TURBINE

- The Francis turbine is a mixed flow reaction turbine. This turbine is used for medium headswithmediumdischarge. Waterenterstherunnerand flowstowardsthe centreof the wheel in the radial direction and leaves parallel to the axis of the turbine.

PartsofFrancisTurbine

Francisturbineconsistsmainlyofthefollowing parts
a) Spiralorscrollcasing–
b) Guidemechanism–
c) Runnerandturbine mainShaft:
d) Drafttube:
e) Penstock



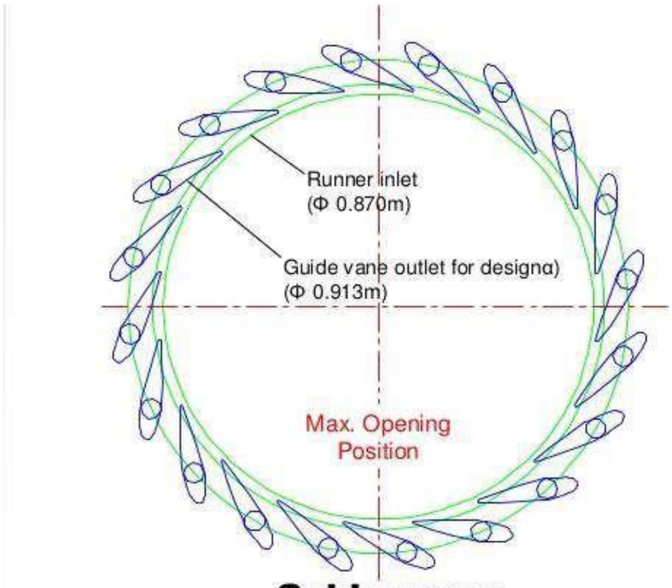
Spiralcasing orscrollCasing:

- ThecasingoftheFrancisturbine isdesigned inaspiral formwithagradually increasing area.
- Mostofthese machineshave verticalshaftsalthoughsomesmaller machinesofthis type have a horizontalshaft. The fluid entersfromthe penstock(pipeline leading to the turbine from the reservoir at high altitude) to a spiral casing that surrounds the runner.

- Thiscasing isknownasscrollcasingor volute. Thecross-sectionalareaofthiscasing decreases uniformly along the circumference to keep the fluid velocity constant in magnitude along its pathtowards the stay vane. This is so because the rateof flow along the fluid path in the volute decreases due to continuous entryofthe fluid to the runner through the openings of the stay vanes.

GuideMechanism:

- It consists of a stationary circular wheel all around the runner of the turbine. The stationaryguidevanesare fixedontheguide mechanism.Theguidevanesallowthe water to strike the vanes fixed on the runner without shock at the inlet.
- Theguidevanes(alsocalledaswicketgates)arefixedbetweentworings.



Guide vanes

- Theguide mechanismprovidestherequiredquantityofwatertotherunnerdepending uponthe load conditions.The guide vanes are in general made of cast iron,

TurbineMainShaft:

- Runner is a circular wheel on which a series of radial curved vanes are fixed. The surfaceofthe vanes is madeverysmooth. Theradialcurvedvansareso shapedthat the water enters and leaves the runner without shocks.

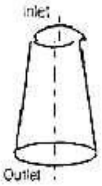
DraftTube:

- The pressure at the exit of the runner of a reaction turbine is generally less than atmospheric pressure. The water at the exit cannot be directly discharged to the tailrace.Atubeorpipeofthegraduallyincreasing area isused fordischargingwater fromthe exit of the turbine to the tailrace. This tube of increasing area is called the draft tube.
- Thewater after doing workontherunner passesonto thetallracethroughatube called a draft tube

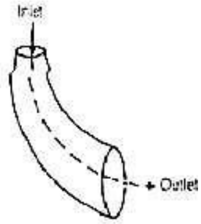
Typesofdraft tube:

I.Conicaldrafttube
ii. Simpleelbowdrafttube

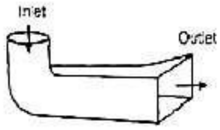
iii. Moodyspreadingdrafttube
iv. Elbowdrafttubewithcircularcross-sectionatinletandrectangularat outlet.



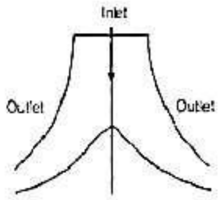
Conical or Divergent Draft Tube



Simple Elbow Draft Tube



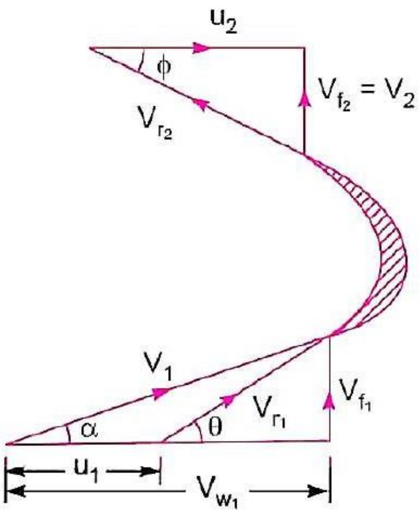
Elbow Tube Having
Circular Cross-section
at inlet and rectangular at Outlet



Hydracone or Moody
Spreading Draft Tube

<u>Velocitytriangle,workdoneandefficienciesofFrancisturbine</u>Let,
V_{w1}= Velocity of whirl at inlet
V_{w2}=Velocityofwhirlatoutlet
U_1= Tangential velocity of whirl at inlet
U_2=Tangentialvelocityofwhirlatoutlet V_{f1}= Velocity of flow at inlet
V_{f2}=VelocityofflowatOutlet
V_1= Absolute velocity of water at the inlet of the runner
V_2=Absolutevelocityofwater attheOutletoftherunner V_{r1}= Relative Velocity at Inlet of the runner
V_{r2}=RelativeVelocityattheoutletoftherunner
ϕ=Vaneangleattheexit.
θ=Vaneangleatinlet ß = Guide vane angle

- Thevelocitytriangleat inlet andoutletoftheFrancisturbine isdrawninthesamewayas in case of inward flow creation turbine. as in case ofFrancis turbine, the discharge is radial at the outlet, the velocityof whirl at the outlet (i.e. Vw2) will be zero. Hence velocity diagram for Francis turbine is shown below
- We Know,absolutevelocityattheoutletis90°i.e.ß=90°



LetV=Velocityofthejet

Theworkdone persecondontherunnerbywaterisgivenby

=ρaV_1[$V_{w1}U_1$]

=ρQ[$V_{w1}U_1$]

Tangentialvelocityofwheelat inlet, U_1=πD_1N/60

Tangentialvelocityofwheelatinlet,U_2= πD_2N/60

Theworkdoneper secondper unitweightofwaterstrikingper secondtotherunner.

=workdoneper second/weight ofwater strikingpesecond

=1/g [$V_{w1}U_1$]

HydraulicefficiencyȠ$_h$=R.P/W.P

=$V_{w1}U_1$/g H

Ratio ofwidthofwheelto itsdiameter n=B_1/D_1Flow ratio (ϕ) = V_{f1}/√(2 g H)

Speed ratio=US_1/√(2 g H)

Problem-02

A reaction turbine works at 450 R.P.M. under a head of120 meters. Its diameter at inlet is 120cmand flowarea is0.4 m^2.Theangle madebytheabsoluteandrelativevelocitiesat inlet are 20 and 60 respectively with the tangential velocity.

Determine-

1. Thevolumeflowrate
2. The powerdeveloped
3. Hydraulic efficiency

Assumewhirlatoutlettobezero.

Solution- given

Speedoftheturbine,(N)=450R.P.M. Head,

H = 120 m

Diameteratinlet D_1=120cm=1.2m
Flow area, $\pi D_1B_1 = 0.4 m^2$
α= 20
θ=60
V_{w2}=0
Tangentialvelocityofwheelatinlet,$U_1= \pi D_1N/60$
$=\pi x1.2x450/60$
= 28.27 m/s
Fromvelocitytriangleat inlet,$\tan\alpha=V_{f1}/V_{w1}$=0.364 V_{f1}
=0.364 x V_{w1}
$\tan\theta=V_{f1}/(V_{w1}-U_1)$
V_{w1}= 35.79 m/s
V_{f1}=13.027 m/s
Volume flowrate, $Q=\pi D_1B_1V_{f1}$=0.4x13.027=5.211m^3/s Work-
done per second, = $\rho Q[V_{w1}U_1]$
=1000x5.211[35.79x28.27]
=5272402Nm/s
Powerdeveloped,p=workdone/ 1000
=5272402/1000=5272.402kw
Hydraulicefficiency, $\eta_h=V_{w1}U_1/gH$

= 35.79x28.27/9.81x120=85.95%

KAPLANTURBINE:-

- KaplanTurbineworksontheprincipleofaxialflowreaction. Inaxialflowturbines,the water flows throughthe runner along the direction parallelto the axis ofrotation ofthe runner. The water at the inlet of the turbine possesses both kinetic energyas well as pressure energy.

- For axial flow reaction turbine, the shaft ofthe turbine is vertical. The lower end ofthe shaft ismade largerwhichisknownashuborboss.Thevanesare fixedtothehubactsas a runner for axial flow reaction turbine.

- Followingaretheimportanttypeofaxialflowturbine-

  1. Propellerturbine

  2. Kaplanturbine

- When the vanes are fixed to the hub and they are not adjustable the turbine is called propeller turbine. And when the vanes are adjustable the turbine is known as Kaplan turbine.

MAINCOMPONENTSOFKAPLANTURBINE

ThemainpartsofKaplanTurbineare,

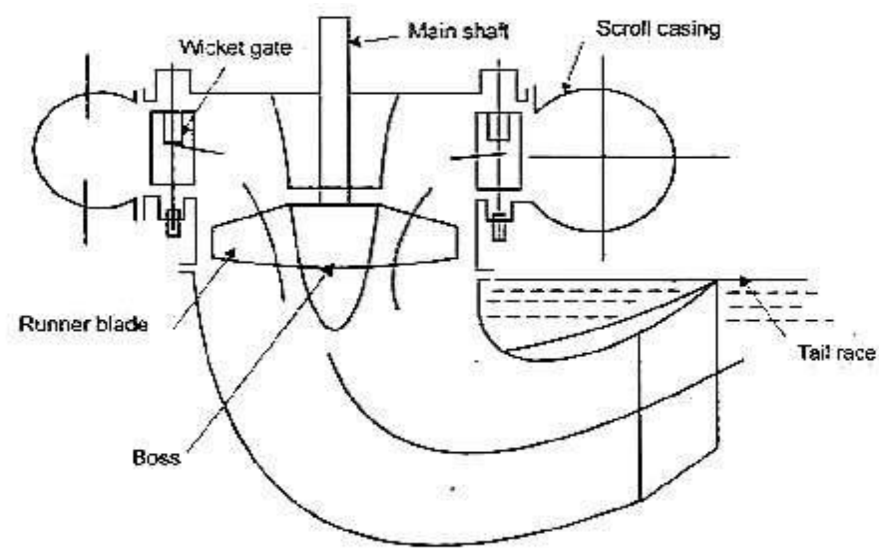


Figure: Kaplan turbine

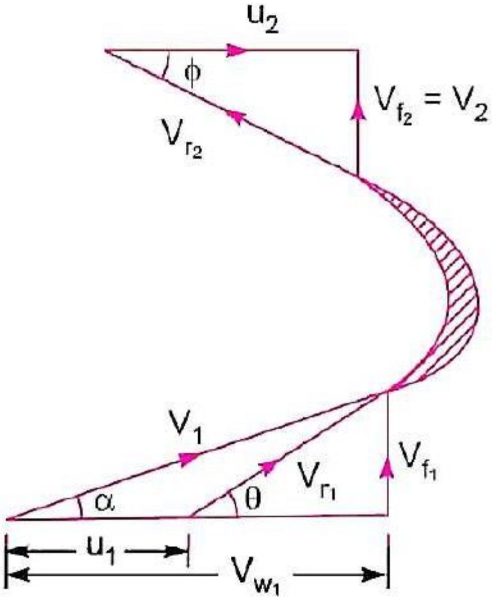
1. ScrollCasing

2. GuideVaneMechanism

3. RUNNER BLADES

4. DRAFTTUBE

VELOCITYDIAGRAM, WORKDONEANDEFFICIENCIESOFKAPLANTURBINE



The workdonepersecondontherunnerby the waterisgiven by=$\rho a V_1[V_{w1}U_1+V_{w2}U_2]$

= $=\rho Q[V_{w1}U_1+V_{w2}U_2]$

Tangentialvelocityofwheelatinlet, $U_1= \pi D_1N/60$

Tangentialvelocityofwheelatinlet,$U_2=\pi D_2N/60$

Theworkdoneper secondper unitweightofwaterstrikingper secondtotherunner.

=workdoneper second/weight ofwater strikingpesecond

$=1/g\ [V_{w1}U_1]$

Hydraulicefficiencyη_h=R.P/W.P.

$=V_{w1}U_1/g\ H$

Ratio ofwidthofwheelto itsdiameter $n=B_1/D_1$Flow ratio $(\phi) = V_{f1}/\sqrt{(2\ g\ H)}$

Speedratio=$U_1/\sqrt{(2\ g\ H)}$

Discharge oftheturbine

$Q=\pi D_1B_1V_{f1}=\pi D_2B_2V_{f2}$

Problem

an inward flow reaction turbine has external and internal diameters as 1m and 0.5 m respectively.thevelocityofflowthroughtherunnerisconstant and isequalto 1.5m/s. determine-

1. Discharge throughtherunner
2. widthofthe turbineatoutletifthe widthofthe turbine atinletis= 200mm

solution
D_1= 1m
D_2=0.5m
$V_{f1}=V_{f2}$=1.5m
B_1=200mm= 0.2m
Discharge(Q) $=\pi D_1 B_1 V_{f1}=\pi x1x0.2x1.5=0.9425 m^3/s$ Also, $\pi D_1 B_1 V_{f1}= \pi D_2 B_2 V_{f2}$

$B_2= D_1 B_1/ D_2$=0.4 m=400 mm(ans)

Differencesbetween ImpulseandReactionTurbines:

ImpulseTurbine	ReactionTurbine
In impulse turbine at the inlet of the turbineonlykineticenergyisavailable.	Inreactionturbinekineticaswellaspressure energy is available.
Airtightcasingisnotnecessary.Casing has no hydraulic function.	Therunnerisenclosedwithanairtightcasing.
Herebreaking jet isrequired.	Itdoesnotrequireanybreakingjet.
Itusesnozzletoconvertpressureenergy into kinetic energy.	Itusesdrafttubetoconvertkineticenergyinto pressure energy.
Theturbinedoesnotrunfullandair hasa free access to the bucket.	Water completely fills at the passage between thebladeswhileflowingbetweentheinletand outlet
Theturbineisalwaysinstalledabovethe tail race	Itmaybeinstalledaboveorbelowthetail race.

SHORTQUESTIONS WITHANSWERS

1) Defineturbine?2018(S)

   Ans–Turbine isahydraulic machinewhichconverthydraulicenergyinto mechanical energy.

2) WhycasingisprovidedinthePeltonwheel? 2019(S)

   Ans-casing isusedtoprevent splashingofwatertotheatmosphereanddischargethe water to the tail race.

3) Giveoneexamplefromeachofthe following water turbine-

   (i) Impulseturbine

   (ii) Reactionturbine

   Ans-Exampleofimpulseturbine-Peltonwheel.

   Example of reaction turbine – Kaplan turbine.

4) Whatissurgetank?2018(s)

   Ans–asurgetankisastandpipeorstoragereservoirwhichissituatedinbetweendam andturbineandconnectedtothepenstockisusedtoabsorbsuddenrisesofpressureas well as to quickly provide extra water during a brief drop in pressure.

LONG QUESTIONS

1) Classifyhydraulicturbine?2018(s)
2) APeltonwheelworkingunder aheadof500mproduces13000kwat 430R.P.M.if the efficiency of wheel is 50% determine-

   (i) Discharge oftheturbine

   (ii) Diameterofthewheel

   (iii) Diameter of the nozzle

   Take C_v= 0.98 2018(S)

3) A Pelton wheel has a mean bucket speed of 10m/s with a jet of water flowing at rate of800 litres/s under a head of40 metres. The bucket deflect the jet through an angle of160˚. Calculatethepowergivenbythewatertotherunner andhydraulicefficiency of the turbine. Assume co-efficient of velocity as 0.98? 2019(S)
4) Drawthelayoutofahydro-electricpowerplantandmentionits features?2019(S)
5) Whatishydraulicturbineandclassifyit?2019(S)

CHAPTER - 02CENTRIFUGALPUMPS

INTRODUCTION:-

The hydraulic machine which convert mechanical energy into hydraulic energy is calledpump. Thehydraulicenergyinthe formofpressureenergy. Ifthe mechanicalenergy is converted into pressure energy by means of centrifugal force acting on the fluid, the hydraulic machine is called centrifugal pump.

Thecentrifugalpumpactsasareversedofaninwardradialflowreactionturbine. This means that the flow in centrifugal pump is in the radial outward direction.

CONSTRUCTIONANDWORKINGPRINCIPLEOFACENTRIFUGALPUMP:

MAINPARTSOFACENTRIFUGAL PUMP:-

Partsofcentrifugalpump aredifferenttypes. Butfollowingarethemainpartsofthepumpas discussed below:

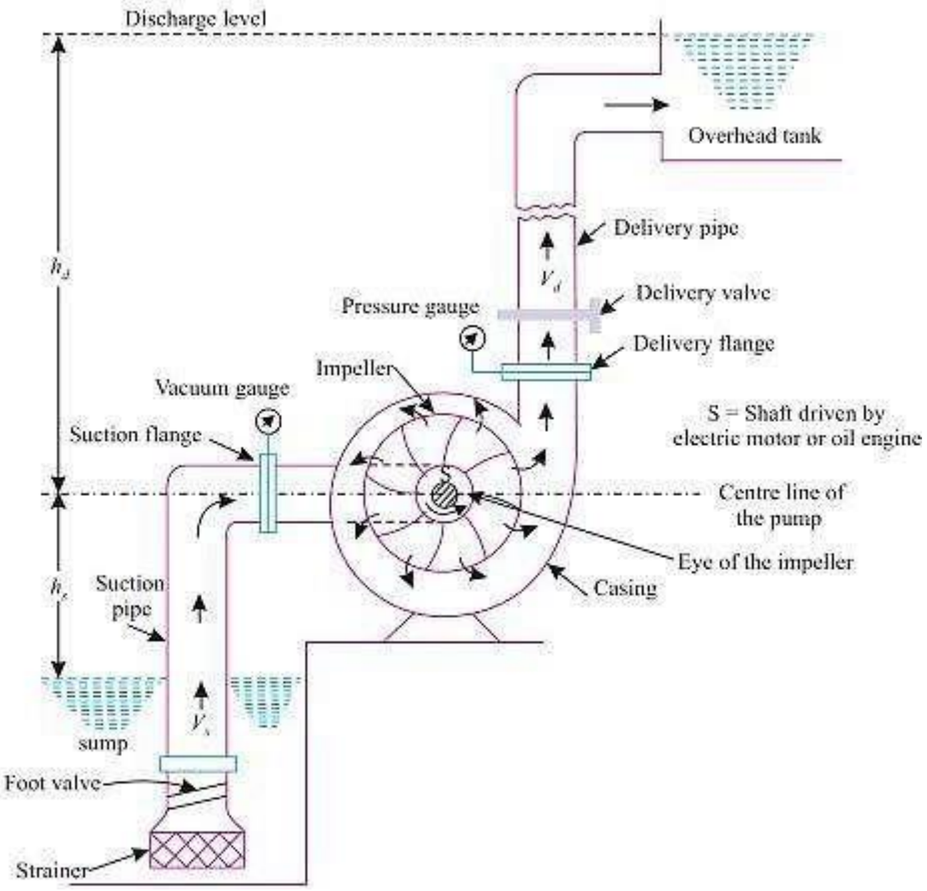
1)Impeller 2)Casing

3)Suctionpipeswithafootvalveandastrainer

4)Deliverypipes

1) Impeller:-
   Therotatingpartofacentrifugalpump is impeller. It consistsofaseriesofbackward curved vanes. The impeller is mounted ona shaft which is connected to a shaft ofan electric motor
2) Casing
   Thecasing ofacentrifugalpump issimilar tothecasing ofareactionturbine. It isanair tight passage surrounding the impeller and is designed in such a waythat the kinetic energyofwaterdischargedattheoutlet oftheimpeller isconvertedintopressureenergy before water leaves the casing and enters the delivery pipe.
   Thefollowing threetypesofthecasingarecommonlyadopted:

(a) Volute casing
(b) Vortexcasing
(c) Casingwithguideblades



(a)The Volute Chamber:

Thevolutechamber isaspiralcasingsurrounding thewheelwhichisalso calledthe impeller. The water which leaves the vanes is directed to move in the volute chambercircumferentially. The area ofthe volute chamber increases graduallyand hence, the velocity gets decreased accompanied by corresponding increase of pressure.

Asthewaterreachesthedeliverypipe, aconsiderablepart ofkineticenergyisconverted into pressure energy.

b)VortexorWhirlpoolChamber:

This is an improvement over the ordinary volute chamber. In this case, the impeller is surroundedbyachamber bycombiningacircular chamber andaspiralchamber. Inthis arrangement the efficiency is increased considerable

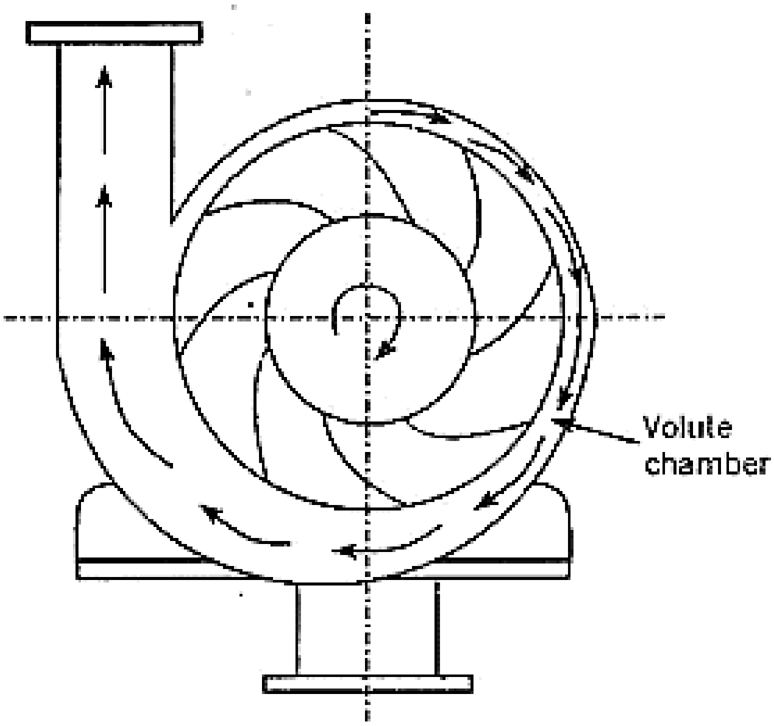


Fig. 24.1. Centrifugal pump with volute chamber.

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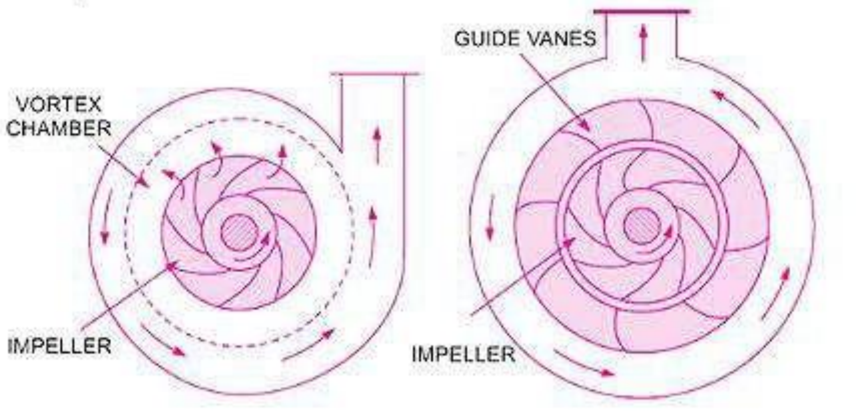


(a) VORTEX CASING (b) CASING WITH GUIDE BLADES

(c) Casingwithguide blades:

Inthistypeofcasingthe impeller issurroundedbyaseriesofguideblades mountedonaring which is known as diffuser. The guide vanes are designed in such a waythat the water from the impeller enters the guide vanes without shock.

3) Suctionpipeswithafootvalveandastrainer

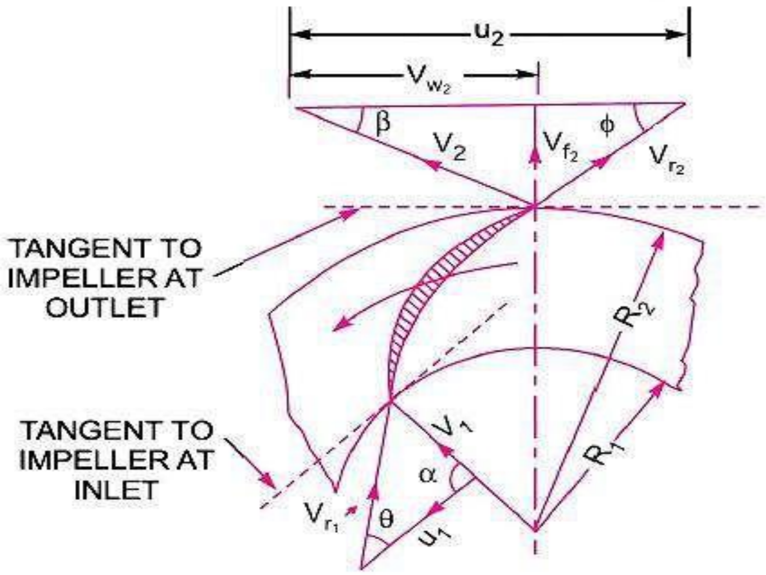
Apipewhoseoneend isconnectedtothe inletofthepumpandotherenddips into waterina sump is known as suction pipe. A foot valve which is a nonreturned valve is fitted at the lower end ofthe suction pipe. The foot valve opens only in upward direction. A strainer is also fitted at the lower end of the suction pipe.

4) Deliverypipe

Apipewhoseoneend isconnectedtotheoutletofthepumpandother enddeliversthewater at a required height is known as delivery pipe

VELOCITYTRIANGLESANDWORKDONEBYCENTRIFUGAL PUMP

Incaseofcentrifugalpumptheworkisdone bythe impeller onthewatertheexpressionfor the work done bythe impeller on water is obtained bydrawing the velocitytriangles.



Let N=Speedofthe impeller inR.P.M D_1= Diameter of the impeller at inlet

u_1=TangentialVelocityofimpelleratinlet

V_1= Absolute velocity of water at inletV_{r1}= Relative velocity of water at inlet

α=Angle made byabsolutevelocityofwater at inlet withthedirectionofmotionofvane θ = Angle made byrelative velocityofwater at inlet with the direction of motion ofvane D_2= Diameter of the impeller at outlet

u_2=TangentialVelocityofimpelleratoutlet

V_2= Absolute velocity of water at outletV_{r2}= Relative velocity of water at outlet

β=Angle madebyabsolutevelocityofwater atoutlet withthedirectionofmotionofvane φ = Angle made byrelative velocityofwater atoutlet withthe directionof motionof vane Tangential velocity of water at inlet, $u_1= \pi D_1 N/60$

Tangentialvelocityofwateratoutlet,$u_2=\pi D_2 N/60$

- As we know that in case of radially inward flow reaction turbine, the work done by the water on the runner per second per unit weight of the water striking per second will be given by following equation as mentioned here.

- Workdonebythewaterontherunnerpersecondperunit weightofthewaterstrikingper second = $(1/g) \times [V_{w1}u_1 - V_{w2}u_2]$

- As we know that a centrifugal pump is the reverse of a radially inward flow reaction turbine,thereforeworkdonebythe impeller onthewaterincaseofacentrifugalpump will be given by following equation as mentioned here.

- Workdonebythe impelleronthewaterpersecondperunit weight ofthewaterstriking per second = - (work done in case of turbine)

- Workdonebythe impelleronthewaterpersecondperunit weight ofthewaterstriking per second = (1/g) x [$V_{w2}u_2$- $V_{w1}u_1$]

- Workdonebythe impelleronthewaterpersecondperunit weight ofthewaterstriking per second = (1/g) x $V_{w2}u_2$

- Because,absolutevelocityofwaterat inletwillmakeanangleof90degreewiththe directionofmotionoftheimpeller atinlet,thereforeangleα=0 andV_{w1}=0.

Aboveequationalso providesthehead impartedtothewater bythe impellerorenergygiven by impeller to the water per unit weight per second.

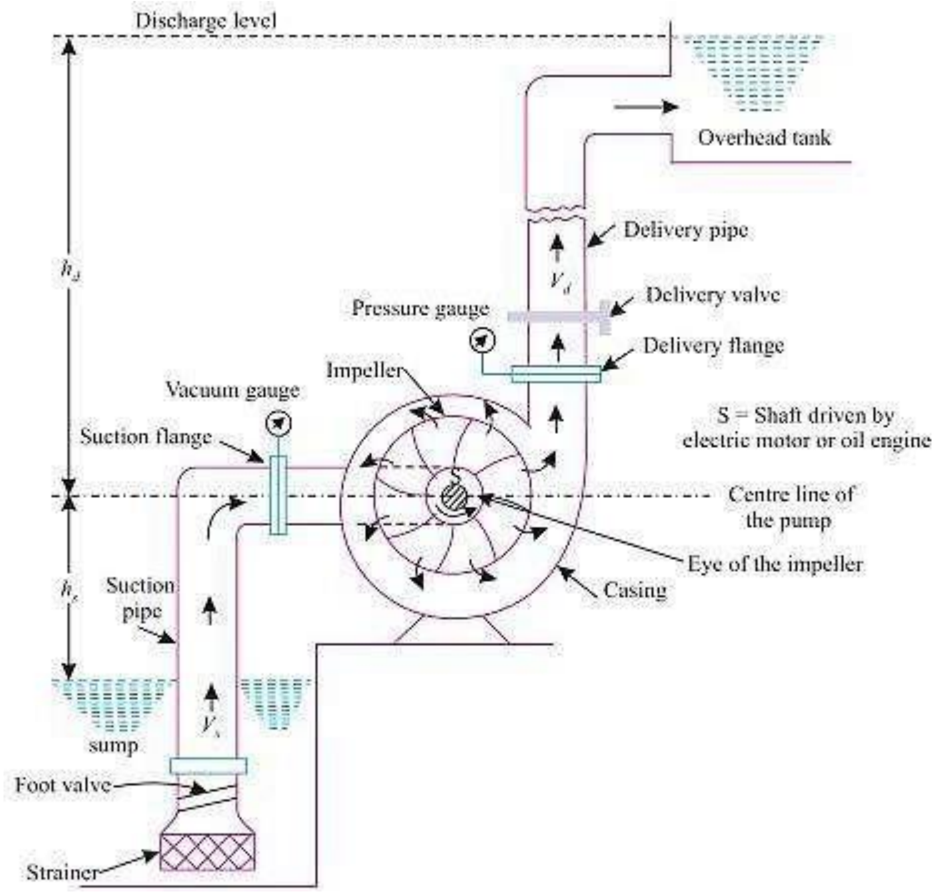
Workdonebythe impelleronwaterpersecond=(W/g) x$V_{w2}u_2$Where, W
= Weight of water
W=ρxgxQ

Where,Q=Flowrateofwater Q =
Area x Velocity of flow
Q =$\pi x D_1 x B_1 x V_{f1} = \pi x D_2 x B_2 x V_{f2}$

Where,
B_1andB_2arethewidthofimpellerandV_{f1}andV_{f2}arethevelocitiesofflowatthe inlet and outlet.

Head impartedtothewaterbythe impellerorenergygivenbyimpellertothewaterperunit weight per second = (1/g) x $V_{w2}u_2$

Differenttypesofheadsofacentrifugalpump



1) Suctionhead

It is the vertical height of the centre line of the centrifugal pump above the water surface inthetankorpump fromwhichwateristobe lifted. Thisheight isalso called suction lift and is denoted by hs.

2) Deliveryheight

Theverticaldistance betweenthecentrelineofthe pumpandthewater surface inthe tank to which water is to be delivered is known as delivery head. It is denoted by h_d.

3) Static head

thesumofsuctionheadanddeliveryhead isknownasstatic head. This isdenotedby Hs and is written as

$$Hs=h_s+h_d$$

4) Manometrichead

The manometrichead isdefinedastheheadagainstwhichacentrifugalhastowork. It is denoted by Hm.

Itisgivenbythefollowingexpressions-

(a) Hm=headimpartedbytheimpeller tothewater–lossofheadinthepump

$=V_{w2}u_{2}$/g-lossofheadin impeller

$==V_{w2}u_{2}$/g(iflossofpumpiszero)

(b) Hm=hs+hd+hfs+hfd+Vd2/2g

where,

hs= suction head

hd=deliveryhead

hfs=head lostduetofrictionin

suctionpipe

hfd=headlostduetofrictionindeliverypipe

2.2EFFICIENCIESOFCENTRIFUGALPUMP

(a)MANOMETRICEFFICIENCY:

Theratioofthe manometricheadtothehead impartedbythe impellertothewateris known as manometric efficiency.

ηman=Manometrichead/headimpartedbytheimpellertowater

$=g \times Hm/ \mathbf{V_{w2}} \times \mathbf{u_2}$

b)Mechanicalefficiency

Theratioofthepoweravailableattheimpellertothe powerattheshaft ofthe centrifugal pump is known as mechanical efficiency.

ηm=workdonebytheimpeller persecond/1000

$\eta m=(W/g)xV_{w2}u_{2}$/1000/(shaftpower)

C)OVERALLEFFICIENCY

Itisdefined astheratioofpoweroutputofthe pump tothepowerinput tothe pump.

ηo=weightofwaterlifted× Hm/1000=WHm/1000

$\eta o=\eta man \times \eta m$

2.3Problemno-01

The internaland externaldiametersofthe impeller ofa centrifugalpump are 200 mm and 400 mmrespectively. The pump is running at 1200 rpm. The vanes angles ofthe impellerat inlet andoutlet are20˚and30˚respectively.Thewaterenterstheimpeller radiallyand velocityofthe flow isconstant. Determinetheworkdonebythe impeller per unit weight of water?

Solution-datagiven

Internaldiameter of impeller, D1=200 mm=0.20m

Externaldiameterofimpeller, D2=400mm=0.40m

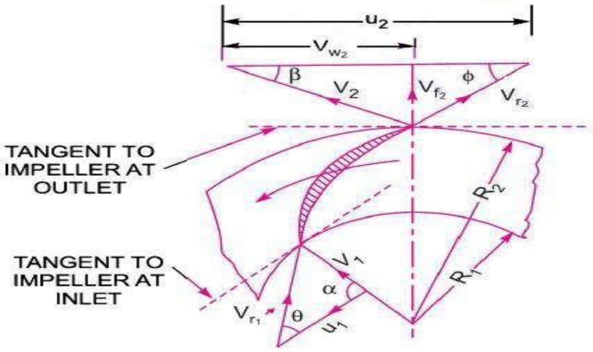
Speed N=1200 rpm

Vaneangleatinlet,θ=20˚

Vaneangleat outlet,Φ=30˚

Waterentersradiallymeans,$\alpha=90^\circ$andVw1=0

VelocityofflowV$_{f1}$=V$_{f2}$



Tangentialvelocityofimpelleratinletandoutletare $u_1= \pi$

$D_1N/60= \pi\times.20\times1200/60=12.56$m/s

$u_2=\pi D_2N/60= \pi\times.40\times1200/60=25.13$m/s

fromtheinletvelocitytriangles,

$\tan\theta=Vf1/u1=Vf1/12.56$m/s

$Vf1 =12.56\tan\theta=12.56\times\tan20=4.57$m/s

Vf2=Vf1=4.57m/s

fromtheinletvelocitytriangles,

$\tan\Phi=V_{f2}/(U_2-V_{w2})=4.57/(25.13-Vw2)$

$25.13-Vw2=4.57/\tan\Phi=7.915$

Vw2=25.13-7,915=17.215m/s

Theworkdonebyimpellerper kg ofwaterpersecond =

$1/g(V_{w2}u_2)=17.215\times25.13/9.81=44.1$Nm/N(ans)

Problemno-02

Acentrifugalpump isto discharge0.118m3/sat aspeed of1450 rpmagainst a head of25m. theimpellerdiameteris250 mmitswidthatoutlet is50mmand manometricefficiencyis75 percent. Determine the vane angle at outer periphery of the impeller?

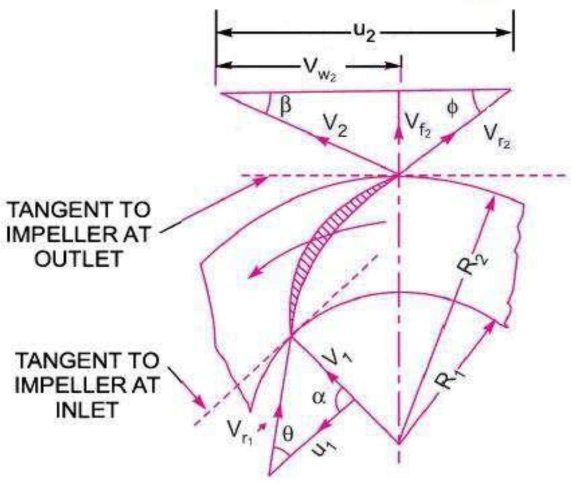
solution

discharge(Q)=0.118m3/s

speed,N= 1450 rpmHead

Hm=25m

DiameteratoutletD2=250mm=0.250m



Width at outlet ,B2= 50 mm =0.50m

Manometricefficiency,η_m=75%=0.75

Tangentialvelocityofimpelleratoutlet,$u_1=\pi D_1 N/60$

$=\pi\times0.25\times1450/60=18.98$m/s

Discharge $Q=\pi x D_2 x B_2 x V_{f2}$

$V_{f2=Q/}\pi x D_2 x B_{2=\ 0.118/}\pi x 0.25 x\ 0.05$

Manometricefficiency$^{\eta}$man=$g\times H_m/V_{w2}\times u_2$

$V_{w2}=9.81x25/^{\eta}$manx18.98=17.23 m/s

Fromthe outlet triangle,tanΦ=$V_{F2}/(U_2-V_{\ W2}$

=3/(18.98-17.23)=1.713

Φ=59.74˚(ans)

SHORTQUESTIONS

01. Whatcavitation?2019(S)
    Ans-cavitationthephenomenonofformationofvapourbubblesandcavities around the impeller when the pressure around the impeller falls below the vapour pressure.

LONG QUESTIONS

1. Explain theconstructionandworkingprinciple ofacentrifugal pump with neat sketch. 2019(S)

2. Find the maximum speed at which a centrifugal pump will start functioningagainstaheadof7.5mifthediametersofimpellerat impeller at outlet and inlet are respectively 100 cm and 50 cm. 2018(S)
3. The impeller of a centrifugalpump is30 cmoutside diameter. The impellervaneanglesare30and25attheinnerand outerperiphery respectively and the speed is 1450 rpm. The velocity of flow through the impeller is constant. Find the work-done by the impeller per kg of water. 2018(S)
4. Whatiscavitation.WhataretheeffectofCavitation.How cavitation can be prevented. 2019(S)
5. The external and internal diameters of the impeller of a centrifugal pumpare100cmand500cmrespectively. Thevaneanglesofinlet and outlet are 30º and 45º respectively and speed of the impeller is 1000rpm.Assumingconstant velocityofflow,calculatework-done by the impeller per KN weight of work-done. 2019(S)

CHAPTER NO - 03RECIPROCATINGPUMPS

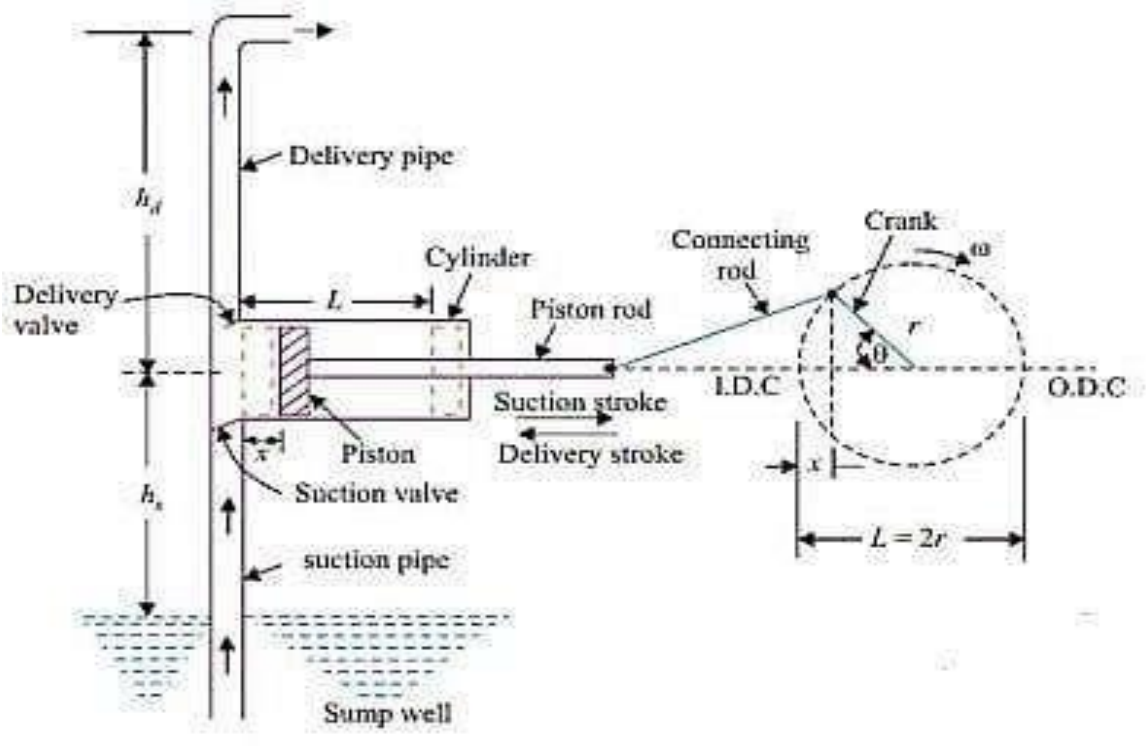
INTRODUCTION:

Thehydraulicmachinewhichconvertmechanicalenergyinto hydraulicenergy is called pump. The hydraulic energy in the form of pressure energy. Ifthe mechanical energy is converted into pressure energyby means ofreciprocating motion of the piston cylinder arrangement then this type of pumpis known as reciprocating pump.

CONSTRUCTIONANDWORKINGPRINCIPLEOFSINGLEACTING RECIPROCATING PUMP

Themaincomponentsofreciprocatingpumpareasfollows:

1. Suctionvalve
2. SuctionPipe
3. SuctionValve
4. Delivery Pipe
5. DeliveryValve
6. Cylinder
7. PistonandPistonRod
8. CrankandConnectingRod
9. Strainer
10. AirVessel



1. **SuctionPipe**

Suctionpipeconnectsthesourceofliquidtothecylinderofthereciprocatingpump. Theliquid is suck by this pipe from the source to the cylinder.

2. **SuctionValve**

Suctionvalve is non-returnvalvewhichmeansonlyonedirectionalflow is possible inthis type of valve. This is placed between suction pipe inlet and cylinder. During suctionof liquid it is opened and during discharge it is closed

3. **DeliveryPipe**

Deliverypipeconnectscylinderofpumptotheoutletsource.Theliquidisdeliveredtodesired outlet location through this pipe.

4. **DeliveryValve**

Deliveryvalvealsonon-returnvalveplacedbetweencylinderanddeliverypipeoutlet.Itisin closed position during suction and in opened position during discharging of liquid

5. **Cylinder**

Ahollowcylinder madeofsteelalloyorcastiron. Arrangementofpistonand pistonrodis inside this cylinder. Suctionand release ofliquid is takes place in thisso, bothsuctionand delivery pipes along with valves are connected to thiscylinder.

6. **PistonandPistonRod**

Piston is a solid type cylinder part which moves backward and forward inside thehollow cylinder to perform suction and deliverance of liquid. Piston rod helps thepiston to its linear motion.

7. **CrankandConnectingRod**

Crank isasolidcirculardiscwhichisconnectedtopowersourcelike motor, engineetc.for itsrotation. Connecting rodconnectsthecranktothe pistonasaresult the rotationalmotion of crank gets converted into linear motion of the piston.

8. **Strainer**

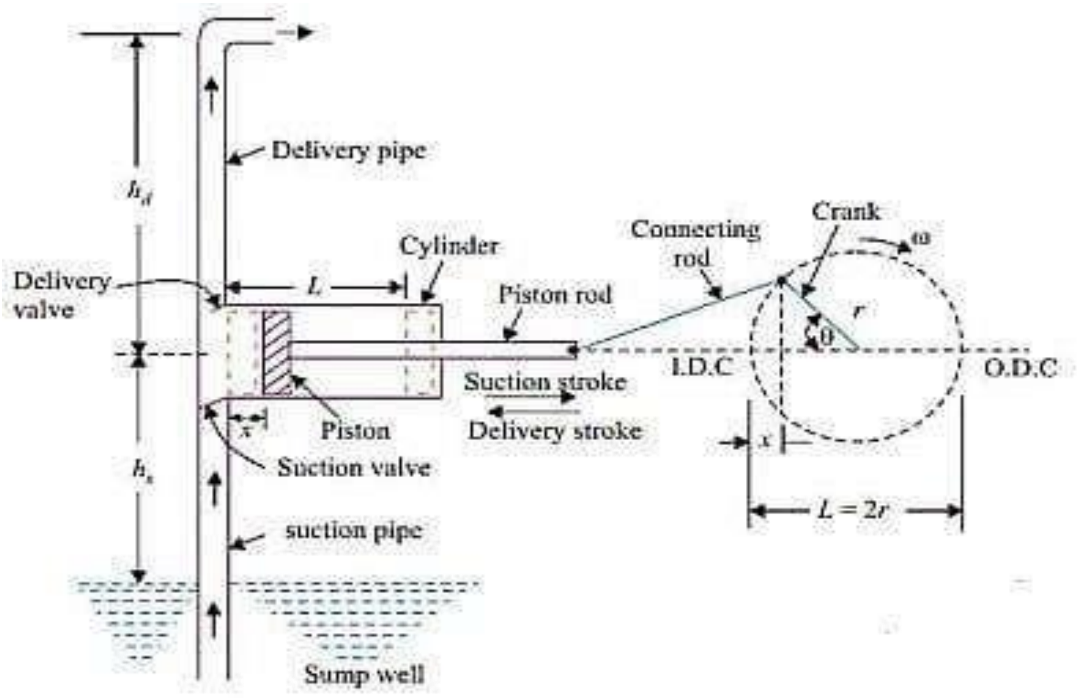
Strainer isprovided attheendofsuctionpipetoprevent theentranceofsolidsfromwater source into the cylinder.

9. **AirVessel**

Airvesselsareconnectedtobothsuctionanddeliverypipestoeliminatethefrictionalhead and to give uniform discharge rate.

WorkingofReciprocatingPump

Theworkingofreciprocatingpumpisasfollows:



- Whenthepowersourceisconnectedtocrank,thecrankwillstartrotatingand connecting rod also displaced along with crank.
- Thepistonconnectedtotheconnectingrodwillmove inlinear direction.Ifcrank movesoutwardsthen thepiston movestowardsitsright and create vacuum in the cylinder.
- Thisvacuumcausessuctionvalvetoopenandliquidfromthesourceis forcibly sucked by the suction pipe into the cylinder.
- Whenthecrank movesinwardsortowardsthecylinder,thepiston willmove towards its left and compresses the liquid in the cylinder.
- Now,thepressuremakesthedeliveryvalvetoopenandliquidwilldischarge through delivery pipe.
- Whenpistonreachesitsextremeleftpositionwholeliquidpresentinthecylinder is delivered through delivery valve.
- Thenagainthecrankrotateoutwardsandpistonmovesright tocreatesuction and the whole process is repeated.
- Generally the above process can be observed in a single acting reciprocating pump where there is only one delivery stroke per one revolution ofcrank. But when it comestodoubleactingreciprocatingpump,therewillbetwodeliverystrokesperone revolution of crank.

N=revolutionsofcrank perminute

WORKDONE BYRECIPROCATINGPUMP

Single acting pump:- Inthe single acting pump, as explained earlier, it has onlyone suction strokeandonedeliverystrokeforonerevolutionofthecrank. It deliversthe liquidonlyduring the delivery stroke. Hence, the flow rate of the liquid delivered per second.

$Q=ALN/60$ (1)

L=lengthofstroke

=2rr=radius ofpiston

A=Cross-sectionofcylinder.
Thetheoreticalworkdonebythepump

$W_{net}=\rho gQ(H_s+H_d)$ (2)

Hs=suctionheadHd

=deliveryhead

$W_{net}=\rho g(ALN)(H_s+H_d)/60$

PROBLEM-01

Asingleactingreciprocatingpump,runningat50rpm,delivers0.01m^3/sofwaterthediameter of the piston is 200mm and stroke length 400 mm.Determine:

(a) Thetheoreticaldischargeofthe pump
(b) Coefficientofdischargeand
(c) Slipandthe percentageofslipofthe pump?

DatagivenN=50

rpmQ=0.01m^3/s

D=200 mm

L=400 mm

Areaofthepump(A)=$(\pi/4)xD^{2=}(\pi/4)x0.2^{2=}0.0314m^2$Theoretical discharge

ofa single acting pump (Q_{th})= ALN/60

$=0.0314\times0.4\times50/60=0.0104m^3/s$

Coefficientofdischarge(c_d)=Q_{act}/Q_{th}=0.01/0.0104

=0.955(ans)

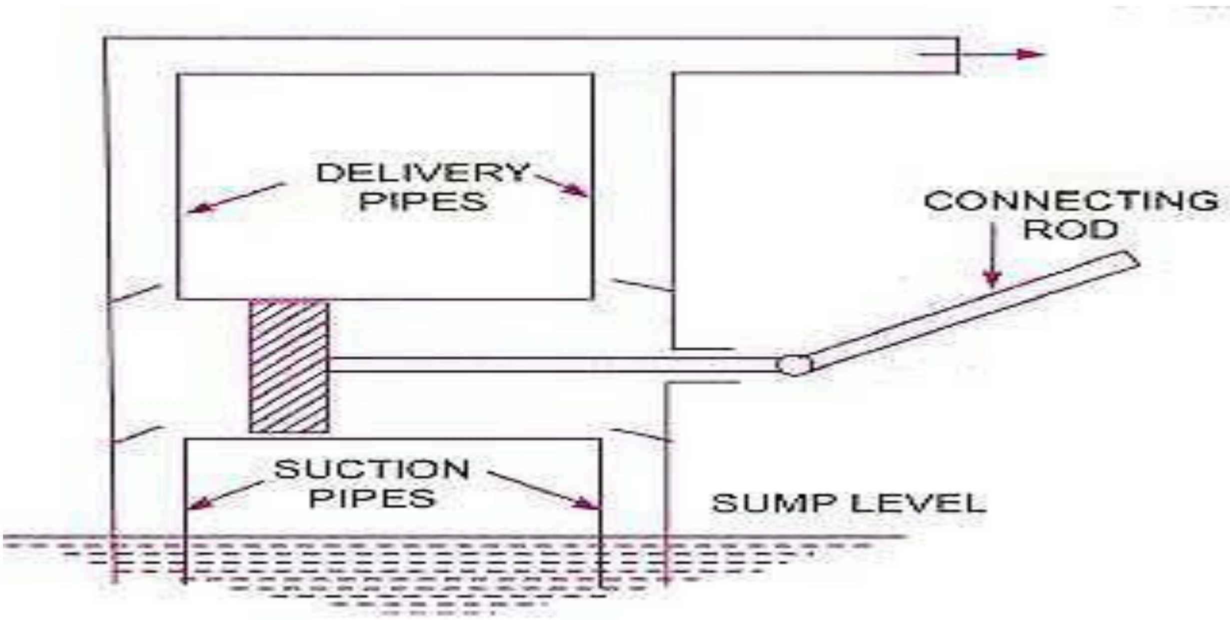
Slip=Q_{th}-Q_{act}=0.0104-0.01=0.0004m^3/s(ans)

Percentageofslip=$(Q_{th}-Q_{act})/Q_{th}\times100$

=0.0004/0.01×100=4.4percent(ans)

CONSTRUCTIONANDWORKINGPRINCIPLEDOUBLEACTINGRECIPROCATING PUMP

Water will be acting on both side of the piston in case of double acting reciprocating pumpasdisplayedhere inbelowfigure.Therefore,therewillbetwo suctionandtwodelivery pipes for double acting reciprocating pump as shown in below.



Whentherewillbeasuctionstrokeononesideofthepiston, sametimetherewillbea delivery stroke at the other side of the piston.

Hence, incaseofdoubleactingreciprocatingpump, therewillbetwo suctionstrokesandtwo deliverystrokes foronecomplete revolutionofcrankandwaterwillbedischarged throughthe delivery pipes during these two delivery strokes.

Letusconsiderthefollowingtermsasmentionedbelow$D$= Diameterofthepiston

d =Diameterofthe pistonrod

Area ononeside ofthepiston,$A=(\pi/4)\times D^2$

Areaonother sideofthepistonwherepistonrodisconnected withpiston, $A_1=(\pi/4)\times[D^2 - d^2]$

Dischargeofthedoubleactingreciprocatingpump

Volumeofwaterdeliveredinonerevolutionofthecrankwillbedeterminedasmentioned below

$V=A\times$Lengthofstroke$+A_1\times$Lengthofstroke

$$V = AL + A_1L = (A + A_1)L = \left[\frac{\pi}{4}D^2 + \frac{\pi}{4}\left(D^2 - d^2\right)\right] \times L$$

Discharge of pump inone revolution of the crank will be determined asmentioned below

Dischargeofpump=Volumeofwaterdelivered inonerevolutionXNo.ofrevolutioninone second

$$\text{Discharge of pump} = \left[\frac{\pi}{4}D^2 + \frac{\pi}{4}\left(D^2 - d^2\right)\right] \times L \times \frac{N}{60}$$

Ifdiameterofthe pistonrodi.e. disverysmallascompared tothe diameterofthepistoni.e. D, then we can neglect it and discharge of the pump could be written as mentioned below.

$$\text{Discharge of pump per second } Q = \left(\frac{\pi}{4}D^2 + \frac{\pi}{4}D^2\right) \times \frac{L \times N}{60} = 2 \times \frac{\pi}{4}D^2 \times \frac{L \times N}{60} = \frac{2ALN}{60}$$

$$\text{Discharge of pump per second } Q = \frac{2ALN}{60}$$

Aboveequationistheequationforthedischargeofthedoubleacting reciprocating pump. We can say that, discharge ofthe double acting reciprocating pump will be double of the discharge of the single actingreciprocating pump.

Workdonepersecond bythe pump

$$w=(2\rho gALN(hs+hd))/60$$

powerdeveloped

$$p=(2\rho gALN(hs+hd))/60000$$

Problem-02

A double acting reciprocating pump running at 40rpm, is discharging at 1.0 m^3ofwater per minute. The pump has a stroke of 400mmthe diameter of the piston is 200mm, the delivery andsuctionheadare20m&5 mrespectively find theslipofthe pumpandpower requiredto drive the pump?

Solution datagiven

N=40rpm

Q = $1m^3/m=0.016\ m^3/s$L=

400mm=0.4mD=200mm=

0.2m

H_d=20m

H_s=5m

Areaofthepump=$(\pi/4)\ xD^{2=}(\pi/4)x.2^2=0.0166m^3/s$Theoretical discharge of

the pump (Q_{th})=2ALN/60

=2×0.0166×0.4×40/60=0.01675m^3/sSlip=Q_{th}-

Q_{act}=0.01675-0.016=0.00075 m^3/s

Powerrequiredtodrivethedoubleacting pump

$$p = (2 \rho g A L N(hs + hd))/60000$$

=2x1000 x9.81 x0.0166x0.4x40 x25/60000

=4.109 kw(Ans)

POWERREQUIREDTODRIVETHEPUMP

Powerrequiredtodrivethesingleactingpump

$$p = (\rho g A L N(hs + hd))/60000$$

Powerrequiredtodrivethedoubleacting pump

$$p = (2 \rho g A L N(hs + hd))/60000$$

3.4 &3.5SLIPOFRECIPROCATINGPUMPANDPERCENTAGEOFSLIP

- Slipofpumpisdefinedasthedifferencebetweenthetheoreticaldischarge(Qth)and actual discharge(Q_{act}).

Slip=(Qth Qact)

Percentage Slip = (Q th Qact)/Q_{th}×100where

Cd = Co-efficient of discharge

Percentageslip=(1-Cd)×100

Negative Slip: In most ofthe cases, the slip is positive. But in some cases, the actual discharge ofthe pump may be more than the theoretical discharge in which case Cd will be more thanone and the slip will be negative, whichis knownas negative slip. This occurs in pumps having long suctionpipeand low deliveryhead, especiallywhenthesearerunning at high speed. This is due to the reasonthatthe inertia pressure inthe suctionpipe becomesso large that itcauses the delivery valve to open before the suction stroke is completed. Thus, some liquid is pushed directly into the deliverypipe even before the delivery stroke is commenced. This results inmakingtheactualdischarge morethanthe theoreticaldischarge.

Relationbetweenpercentageslipandcoefficientofdischarge

Percentageslip=(1-Cd)×100

3.6PROBLEM–03

The cylinder bore diameterofa single acting reciprocating pump is 150 mmand itsstrokeis 300 mm. The pump runs at 50 r.p.m. and lifts water through a height of25 m. The delivery pipe is 22m long and 100mm in diameter. Find Thecylinder bore diameter ofa single acting reciprocatingpump is150 mmand its strokeis300mm.Thepumprunsat 50r.p.m.and lifts waterthrougha height of25 m. The deliverypipe is22mlong and 100mm indiameter. Find the theoretical discharge and theoretical power required to run the pump. If the actual discharge is 4.2 liters/s, find the percentage of slip**.**

vthetheoreticaldischargeandtheoreticalpower requiredtorunthepump.Iftheactual discharge is 4.2 liters/s, find the percentage of slip.

DATAGIVEN

Diameterofcylinder,D=150mm=0.15mArea,A=

$\pi/4\times D^2=\pi/4\times0.15^2=0.01767m^2$

Stroke,L=300mm=0.3m

Speedofthepump,N=50r.p.mTotal

height lifted, H= 25m Length of

delivery pipe, L_d= 22m

Diameterofdeliverypipe, D_d=100mm=0.1mActual discharge,

Q_{act}= 4.2liters/s = 0.0042m^3/sTheoretical discharge of the pump

Q_{th}=ALN/60=O.O1767×0.3×50/60=0.0044175m^3/s=4.4175litres/sec

<u>Theoreticalpower</u>

Theoreticalpower=Theoreticalweightofwaterlifted/s×Totalheight/1000

$=\rho\times g\times Q_{th}\times H/1000$

= 1000×9.81×0.0042×25/1000= 1.0833kw

<u>ThePercentageofSlip</u>

%slip=((Q_{th}-Q_{act})/Q_{th})/100=((4.4175 –4.2)/4.4175)×100=4.92%(ans).

SHORTQUESTIONSWITH ANSWER

1. Whatisslipinpump?2018(s), 2019(s)

- slip maybedefinedasthedifferencebetweentheoreticaldischargetotheactual discharge.
- Generallyitisexpressedaspercentageofslip.
- Mathematically

  %slip=theoreticaldischarge-actualdischarge/theoreticaldischarge

2. Defineaboutnegativeslip?2019(s)

Ans- Whentheactualdischarge is morethanthetheoreticaldischargethennegativedischarge occurs. It is possible when the suction pipe is short and deliverypipe is long and the pump is running at high speed.

3. what iscavitation?2019(s)

Ans-cavitationisthephenomenonofformationofvaporbubblesandcavitiesaroundthe impeller when the pressure around the impeller falls below the vapor pressure.

LONG QUESTIONS

1. Differentiatebetweenreciprocatingpumpandcentrifugalpump?2018(s)
2. Asingleactingreciprocatingpumprunningat60R.P.M.delivers0.015m^3/sofwater.The

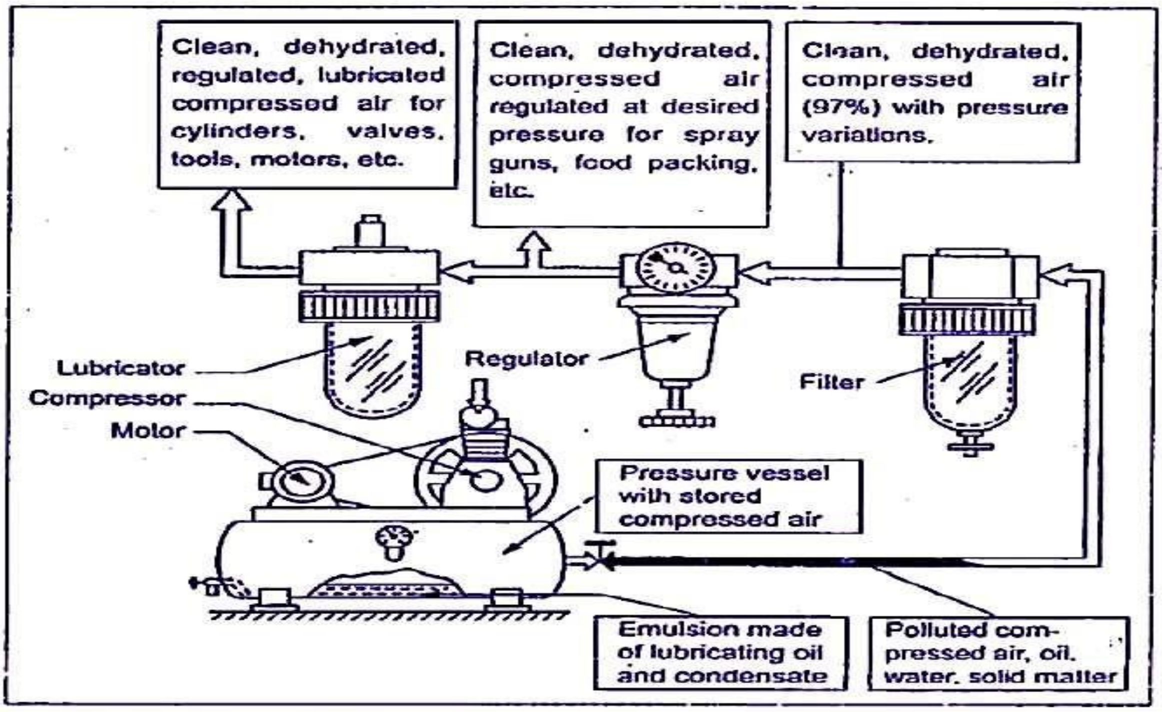
diameterofthe pistonis200 mmandstrokelength400mm. determinetheoreticaldischarge of the pump, Coefficient of discharge and slipof the pump.2018(s)

CHAPTER NO - 04PNEUMATICCONTROLSYSTEM

ELEMENTS–FILTER-REGULATOR-LUBRICATIONUNIT:

Filter,PressureRegulator,andLubricatorarecombined inaunit.Thesethreeunits together are called FRL units or Service units.

Compressedair fromcompressorcomesinFRLunit wherein,theair isfiltered,controlled, and lubricated. Such prepared and controlled air is delivered to the pneumatic system.



Compressed air generation and distribution system showing a FRL unit.

ConstructionAndWorkingoftheFRLunit:

FRC unit means Filter Regulator Combine unit. Most of the pneumatic system uses FRL unit. The main elements of the FRL unit are Filter, Regulator, and Lubricator.

1. Filter:

Air enters the inlet port of the air filter through angled louvers. The centrifugalaction of therotatingaircausesthe largerpiecesofdirt and waterparticlesto bethrownagainst the innerwallofthe filterbowl. These contaminantsthenflowdownintothebottomofthe filter bowl. Abafflepreventsturbulent airfromsplashingwaterontothefilterelement.Theairthen passes throughthe filter element, where the fine dirt particles are filtered out. The compressed air then exits through the outer port to the regulator.

2. RelievingorVentingTypePressureregulator:

Outlet pressureissensedbyadiaphragmpreloadedwithanadjustablepressuresettingspring. The compressed air, which flows through a controlled cross-section at the valve seat, acts on theother sideofthediaphragm. Thediaphragmhasa largesurfacearea exposed to secondary (outlet) pressure and is quite sensitive to its fluctuations. The movement of the diaphragm regulates the pressure.

3. Lubricator:

As air enters the lubricator, its velocity is increased by a venture ring. The pressure at the ventureringwillbelowerthantheatmosphericpressureandthepressureontheoil isatmospheric.Duetothispressuredifferencebetweentheupperchamberandlowerchamber, oilwillbedrawnupinarisertube.Oildropletsmixwiththeincomingairandformafinemist. The needle valve is used to adjust the pressure difference across the oil jet and hence the oil flowrate.Theairtheoilmixtureisforcedto rotateasit leavesthecentralcylindersothatlarge particles of oil goes back to bowl and only the mist goes to outlet.

PRESSURECONTROLVALVES:

- A pneumatic flow control valve circulates air throughout a larger pneumatic system by eitherallowingorinhibitingthe flowofpressurizedair,whoseforce isthenusedto power a device. Because valves can have varying numbers of entryways for air, creating different flowpatterns, valvesareclassifiedaccordingtothenumber ofportstheypossess and the flow-paths theycreate. Additionally, because theycan move air in a varietyof ways, they can suit a variety of applications.
- Aside from the commonly used directional control valves, there are valves that are designed to serve more specific purposes, such as pressure regulator, venting-type regulatorvalves,andneedlevalves.Pressureand venting-typevalvesbothhelpcontrol pressure, whereas needle valves help control the flow within a pneumatic pressure system.
- Thereare varioustype ofpressure controlvalves

1-Pressureregulator

2-ventingregulator

3-Needlevalves

4-Twovalves

PRESSURERELIEFVALVES:

- Pressurereliefvalvesarethequitecommonvalvesusedinpneumaticindustriesfor performing two important functions as mentioned here-

  1. Protectionagainstoverloadforvariouscircuitcomponents.

  2. Limitingtheforceortorqueapplied byactuators

- Pressurereliefvalvewillhavetwosectionsi.e.bodysectionandpilotvalvesection.Body section of relief valve will have a piston or seat due to the action of spring force. Pilot valve section will control the piston movement with the help hydraulic force.

- We cansee one simple type ofpressure relief valve in following fig. oneofthe pressure reliefvalvewillbeconnectedwithpumpdeliverylineorpressurelineandotherportwill be connected with pneumatic reservoir. Poppet will be positioned to its seat due to the spring force, one adjusting pressure of relief valve.

- If pressure at the inlet of relief valve is not enough to overcome the spring force in that situation poppet will be remain seated over its seat and will not allow the flow of fluid through it and therefore relief valve will be closed and will not allow flow through it.

- Whenpressureattheinletofreliefvalveincreasesandovercomesthespringforcewhich wasadjustedwiththehelpofpressureadjustingscrewdisplacedatthetopofreliefvalve inthat situationpoppetwillleavetheseat andwillpermit theflowoffluidthroughrelief valve.

- Hence,ifpressureatinletofreliefvalveovercomesthesettingpressure,poppetwillagain positioned to its seat duetothe actionofspring force and relief valve willbe closed and will not allow the flow through it.

- Crackingpressureinreliefvalveoperationisdefinedasthepressureatwhichreliefvalve operation isdefined asthe pressure at whichrelief valve first permit the flow throughit. Pressureatwhichreliefvalveallowstoflowthefullratedcapacitywillbetermedasvalve full flow pressure.

PRESSUREREGULATIONVALVES:

- The principalparts ofthe pressure regulationvalve arethe main valve, anupward-seating valve that has a piston on top of its valve stem an upward seating auxiliary valve, a controlling diagram and an adjusting spring and screw.
- Apressureregulationvalveusesaspringloadedspooltocontrolthedownstreampressure. Ifthedownstreampressure isbelowthevalvesetting, thefluid flows freelyfromthe inlet to the outlet.
- Regulationvalveoperationiscontrolledbyhighpressureatthevalveinletandtheadjusting screw on the top of the valve assembly. The pressure entering the main valve assists the main valve spring in keeping the reducing valve closed by pushing upward on the main valve disk.
- However, someofthe highpressure is bled to anauxiliaryvalveontopofthe main valve. The auxiliary valve controls the admission ofthe high pressure to the pistonon top ofthe main valve. Thepistonhasa largesurfaceareathanthe main valvedisk, resulting ina net downward forcetoopenthe main valve. The auxiliaryvalve iscontrolled bya controlling diaphragm located direction over the auxiliary valve.
- The controlling diaphragm transmits a downward force that tends to open the auxiliary valve. The downward force is exerted by the adjusting spring, which is controlled by the adjusting screw. Reduced pressure from the main valve outlet is bled back to a chamber beneath the diaphragm to counteract the downward force of the adjusting spring.

DIRECTIONCONTROLVALVES

- Inthepneumaticworld,valvesaretheequivalentofrelayscontrollingtheflowofelectricity in automation systems. Instead of distributing electric power to motors, drives and other devices, pneumatic valves distribute air to cylinders, actuators and nozzles.

- Pneumatic valves, also called directionalcontrolvalves, are activated ina varietyofways includingmanually,solenoidoperatedandairpiloted.Intheirsimplestform,2-wayand3- way valves can be normally open (NO) or normally closed (NC), terms that refer to their normalstateswithout power applied. Another verycommonvalve is a4-wayvalvewhich switches supply and exhaust between two outlet ports.
- Manually activated valves are typically switched open and closed by a foot pedal, toggle actuator, handle, knob or push button. An operator controls the activated position of the valve, and a spring or the operator returns the valve to its home position.

- Solenoid operated valves use an electrical coilto controlthe position ofa poppet, plunger or spool to open or close a valve. Typical solenoid control voltages are 12VDC, 24 VAC/DC, 120VAC or 240VAC.
- Air piloted valvesare operated byanexternalair source suchasa solenoid operated valve inaremotelocation. The valvecanalso be internallyair piloted, enablinguseofasmaller integrated electric solenoid to provide an air pilot signalto controlthe larger valve spool.

3/2DCV,5/2 DCV,5/3DCVVALVETYPES:

- With pneumatic valves, the configuration or valve type indicates how air is connected to thedeviceandswitchedthroughthevalve.Thisconfigurationhasastronginfluenceonthe device the valve is controlling, and understanding this is critical for specifying the proper valve for the application.

- The pneumatic symbol for a valve has three parts: actuation (how the valve is actuated), position (the number of positions and ports) and flow (how the air flows through the device). Theactuationmethodsareonthe left and rightof thesymbol, andcanbethought of as pushing the boxes left or right.

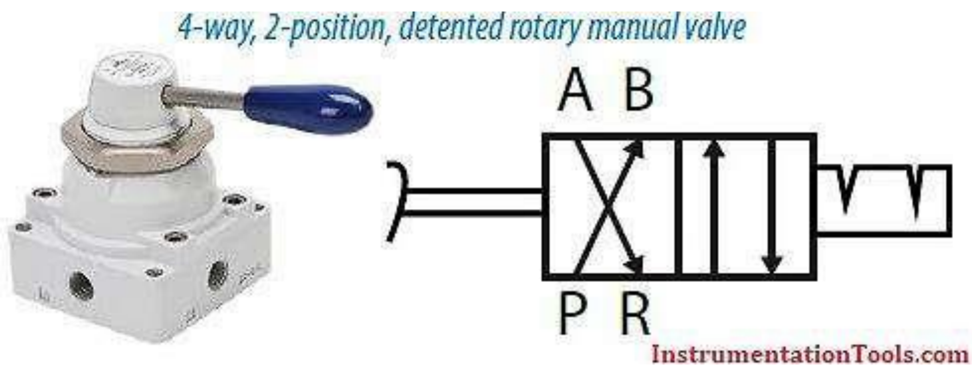
- The number of boxes indicates the number of positions, typically two or three. Flow of supply air or exhaust, for each position, is defined bythe information in each box.

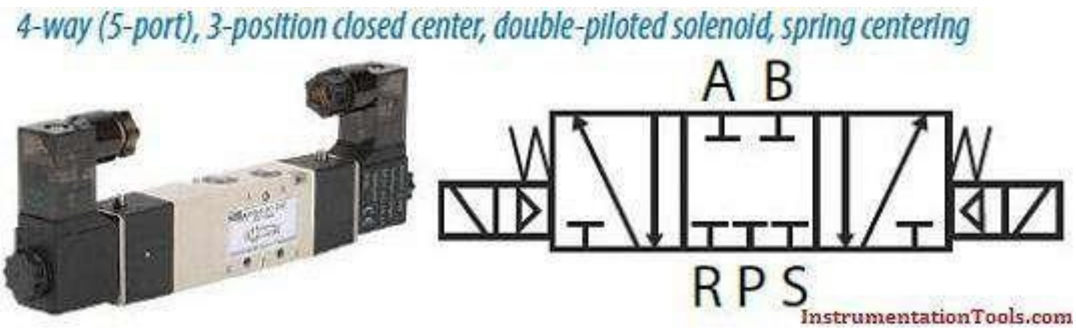
- Eachvalvepositionhasoneormoreflowpaths,andthearrowsineachboxrepresent flow of air and exhaust. The point where each path touches a box is called a port, and to determine the number ofports, one must count a single boxofthe symbol. The flow path can also be blocked, indicated by a “T” symbol.
- The number of ports and positions define the type of work a valve is designed for, so selectingtheseoptionsisacriticaldesigndecision.A2-portor2-way,2-positionvalvehas one inlet port and one outlet port. that is its only function.

- The number of different pathways for air to travelin or out ofthe valve are referred to as “ways” while the different available states are called “positions”. Valves commonly used in industrial applications are either a 2-, 3- or 4-way configuration, 2- and 3-way valves have 2 positions while 4-way valves can be either 2- or 3-position.

Commonpneumaticvalvetypes:

- 2-port(2-way), 2-position
- 3-port(3-way),2-position
- 5-port(4-way),2-position
- 5-port(4-way),3-position





- Byadding a third port, the 3-port or 3-way, 2-position valve can both supplyand exhaust pressure. The three ports are air in, air out and exhaust. While exhausting pressure is important for cylinder movement, this type of valve onlyworks well in applications such as single-acting cylinders with a spring return, or in air blow off applications such as blowing chips in a machining process.
- Adding two more ports turns the valve into a 5-port (4-way), 2-position valve. A 5-port valve is technically a 4-way valve since there are two ports open to ‘Exhaust’. This is mainly done to simplify valve construction.
- Thisisthemostpopulardirectionalcontrolvalvebecauseitcanextendandretractdouble-actingcylinders,providingawiderangeofcontrolcapabilities.Thistypeofvalveincludes an inlet port, two outlet ports and two exhaust ports.
- In a 2-position configuration, one output is flowing air from the inlet and the other is flowingairto anexhaust port.Whenthevalve isswitched, thetwooutputsareinopposite modes. This is the most common way to extend and retract a double-acting pneumatic actuator, pressurizing one side of the cylinder while exhausting the other.
- Keep in mind that 2-position, single solenoid valves have a spring return. So with an energized valve, ifthe double-acting cylinder it’s connected to is extending, that cylinder will retract if electricalpower is lost (such as when an emergency stop is pressed) but air remainson.Iftheemergencystopalsodumpsairpressureinthesystem,asrecommended, the cylinder will retract once pressure is restored unless the valve is re-energized.
- If a 2-position, double solenoid valve has a detent feature, the valve spool is held at whichever position it was at the moment the emergency stop was pressed.
- If the cylinder was at mid-stroke when the emergency stop was pressed, when air is reapplied,thevalvewillcommandthecylindertocontinuemotiontotheoriginalenergized position, even with both solenoids on the valve de-energized. This motion, due to the maintained valve position, can cause issues.
- Forexample,unintendedcylinder motionafteranemergencystopcandamagetooling and should be examined during design.

Flowcontrolvalves:

Flow Control Valves are used to reduce the rate of flow in a section of a pneumatic circuit, resulting in a slower actuator speed. Unlike a Needle Valve, a Flow Control Valve regulates air flow in onlyone direction, allowing free flow in the opposite direction.

PneumadyneAirFlowControlValves

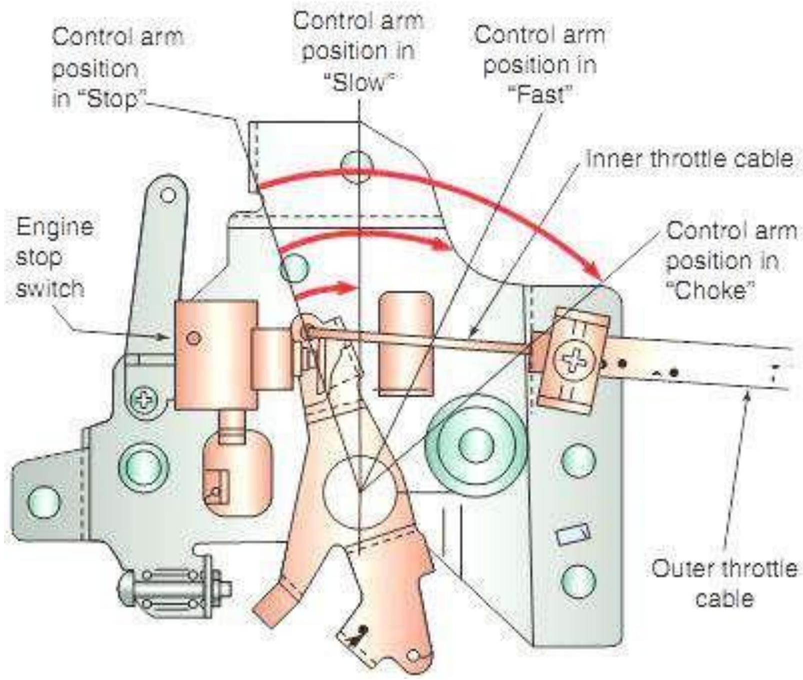
Pneumadyne's inline Flow Control Valves feature finely threaded stems that allow for gradualadjustmentofthecontrolled flowpassingthroughthevalve. Thepneumaticsystem's air flowentersviathe input port,travelsthroughanorificesized bythetaperedstem, andout via the output port. Our pneumatic flow controlvalves include a bypass check which allows rapid free flow from the output through the input port.

Weoffertwotypesofair flowcontrolvalves.Theirselectionandplacement withina pneumatic circuit will greatly affect the function of an actuator.

- Ameter-inflowcontrolvalve(also knownasareverse flowcontrolvalve)restricts the flow *to* an actuator.
- Ameter-outflowcontrolvalveregulatestheexhaust flow *from*anactuator.Theseare the most commonly used air flow control valve

THROTTLE VALVE

Throttle valve is one ofthe most simple and widelyused as flow controlvalve and often equipped with a pressure relief valve to compose a varietyof throttle speed in pneumatic circuit orsystem. ThrottleValvesThe flowofthrottlevalvesisrelatedtothepressuredropat the throttle position, i.e. a larger p results in a larger flow. The equation for the resistance coefficient shows the relationship to the viscosity. The shorter the throttle length I, the less noticeable is a change is viscosity. It should also be notedthat the flow increases at the fluid becomesthinner. Whether avalve isdependent ontheviscosityor ispracticallyindependent, dependsonthe constructionofthe throttle position. Throttle valvesare used, when: - there is constant working resistance - change in speed is irrelevant or desired with changing load.

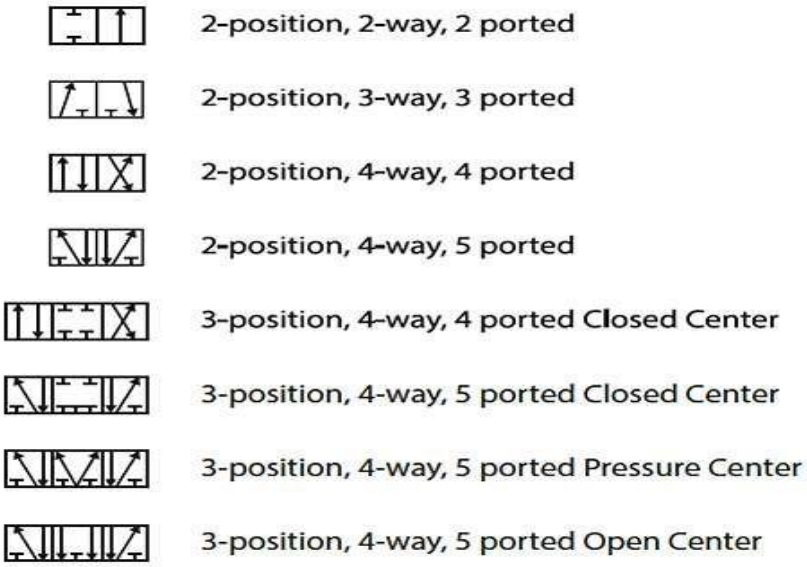


These throttle valves are related to pressure and viscosity. Oilreaches the throttle position3 by means of side bores 1 in the housing 2. These are formed between the housing and the adjustablesleeve4. Byturningthesleeve, thering-shapedsectionatthethrottlepositioncan be altered steplessly. There is throttling in both directions (fig.1). Ifthrottling is required in onedirectiononly, anadditionalcheck valve isnecessary. Inthrottledirection, fluid reaches the rear side 1 ofthe valve poppet 2. The poppet ofthe check valve is pushed on its seat. Throttling procedure is as per type MG (fig 2). In the opposite direction, (right to left) the flow actson the face surface ofthe check valve. The poppet is lifted from its seat. Oil flows unthrottledthroughthevalve.Atthesametime,partofthefluidpassesovertheringslot and thus the desired self-cleaning process is achieved.

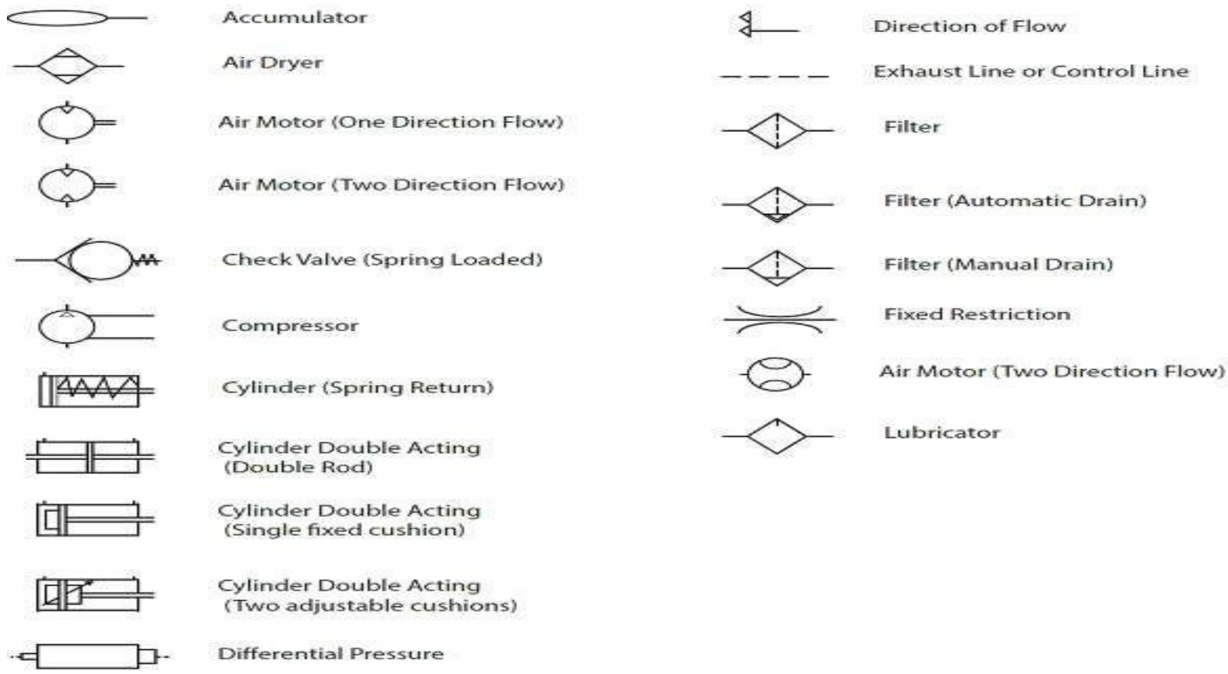
ISOSYMBOLSOFPNEUMATICCOMPONENTS

Pneumatic systems are still popular in old as well as modern plant. Pneumatic diagram representsthepneumaticsystemindefinedwaystheyarerepresented. Followingarethe different symbols for different pneumatic components.

Pneumaticdirectionalcontrolvalve



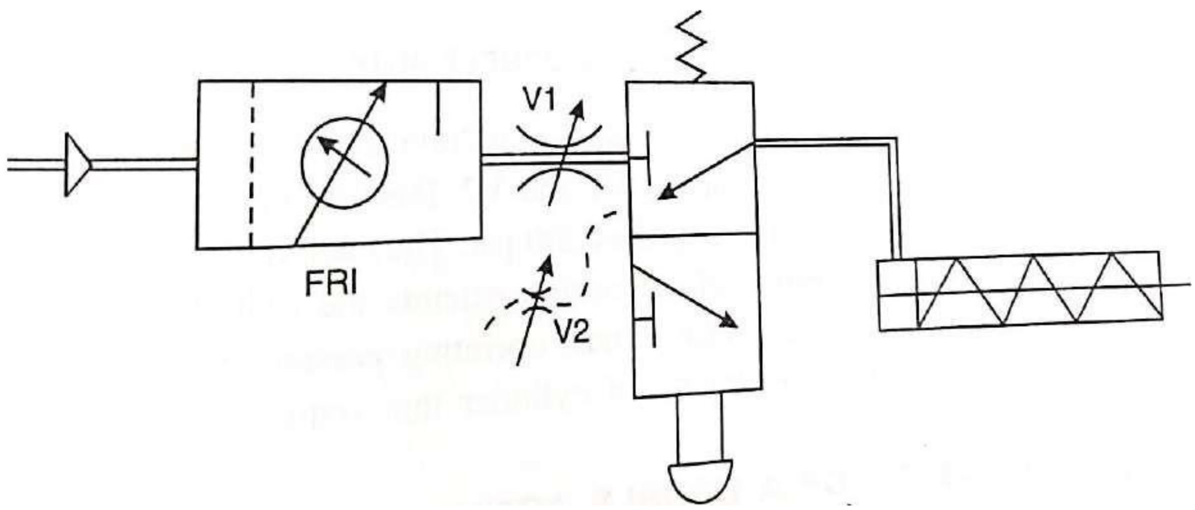
Symbolsofcommonequipmentusedinpneumaticcircuits



PNEUMATICCIRCUIT

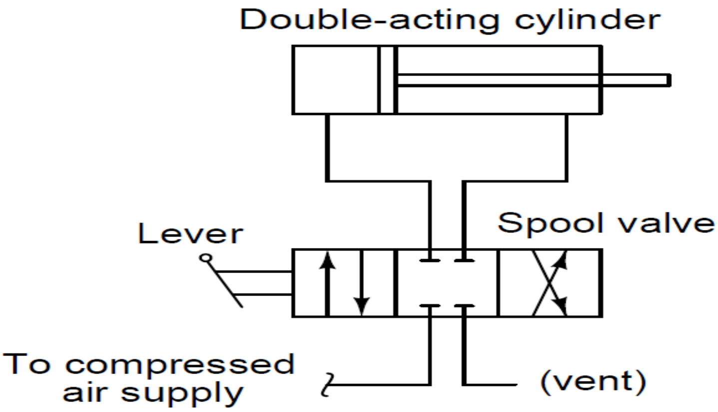
DIRECTCONTROLOFSINGLEACTING CYLINDER

- Thecircuit consistsofa3/2waypushbuttonoperatedDCVtocontrolasingleacting cylinder.
- Initially the flow is blocked and when the push button is operated the cylinder extends andwhenthebuttonisreleasedthecylinder retractsbythecompressionspring locatedat the rod end of the cylinder.
- Theadjustable flowcontrolvalvesV_1andV_2cancontroltherateofextensionand retraction of the cylinder.



OPERATIONOFDOUBLEACTINGCYLINDER

- Itispossibleto achieveautomaticretractionofthecylinderwhenthecylinderhas completed its functionduring its extensionstroke.The below circuit show sucha possibility of semi-automating a cylinder.
- Inthebelowcircuit the5/2waypilot operatedDCVV_2controlsthecylinder movement. The DCV is controlled by the two push buttons $V_3$and V_4.



- The flow is allowed after metering through the flow control valve V_1. When the push buttonV$_3$ is operatedto spring offset position, it pilot actuatestheDCV V$_2$to allow the pushbuttonV$_3$isoperatedtospringoffset position, it pilot actuatestheDCVV$_2$toallow the compressed air to enter the piston side of the cylinder to extend.

- At the end ofthe extensionstroke,the pistoncam operatesthe push buttonV$_4$.This pilot actuatestheDCVV$_2$to shift itspositionandallow theairtoentertherodsideandretract the cylinder.

- Thus in application which require automatic retraction of the cylinder the above circuit designifused it ispossibletoachievethecontrol. Thetimingofextensionandretraction can be achieved by keeping a flow control valve in the upstream of the actuator.

OPERATIONOFDOUBLEACTINGCYLINDERWITHMETERING IN AND METERING OUT CONTROL

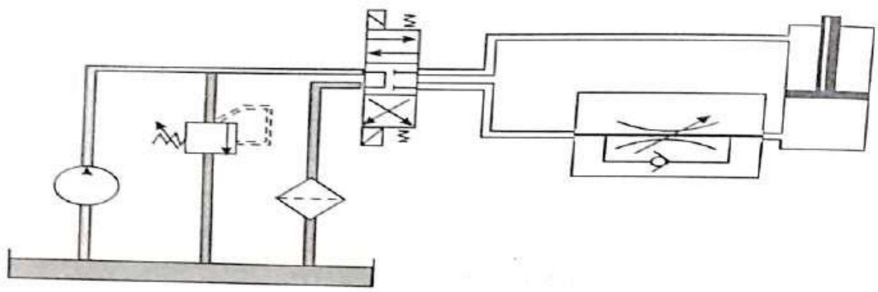
Meterincircuitforextension

- Inmeterincircuit,therateofflowofoilorairgoingintothecylinderiscontrolledbyflow control valve.

- FCV is placed at inlet ofthe cylinder. Cap end port “C” is inlet for extensionand rod end port “R” is inlet for retraction.

- In first position of4/2 DCV air under pressure flows fromP to A and B to T. this flow is through flow control valve, the flow is controlled and hence piston extension slowly.

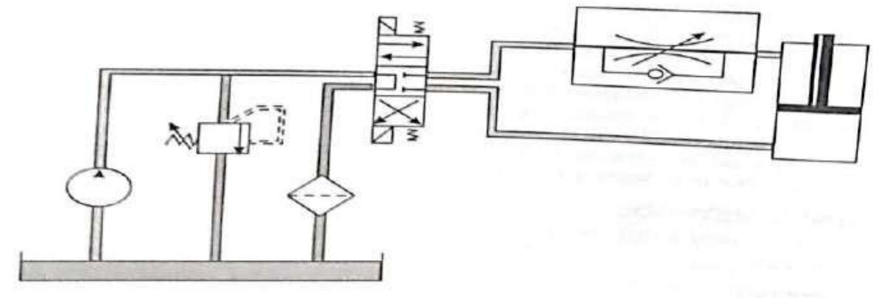
- Insecondposition4/2DCV,oilunderpressureflowsfreefromPtoBandAtoT.Theflow isthroughthecheckvalve,thisisfreeflow.Hencethepistonretractsathigherspeedwhich is not control.



FLOW CONTROL VALVE TO CONTROL EXTENSION STROKE

Meterincircuitforretraction

- Infirst positionof4/2DCV, air under pressure flows fromPto AandBto T.This flow is throughthe check valve. This is free flow hence the pistonextends at higher speed which is not controlled.
- Insecondpositionof4/2DCVair under pressure flows fromPto BandAto T.This flow is through flow control valve. The flow is controlled and hence piston retracts slowly.
- Meter in control is used for opposing load only. It can n't prevent running away loads, because the return line from the cylinder is a free path towards reservoir. Running away load will pull the piston and piston can n't resist that.



FLOW CONTROL VALVE TO CONTROL RETURN STROKE

METER IN CIRCUITS

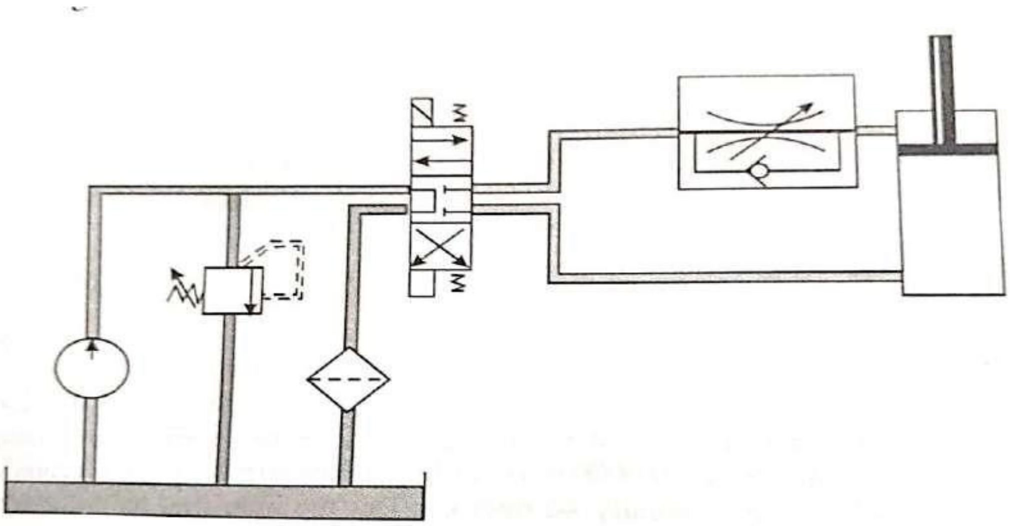
METER-OUTCIRCUIT

Meteroutforextension

- In meter out circuits, the rate of flow of oil under pressure coming out of the cylinder controlledbyflowcontrolvalve.FCVisplacedatoutletofthecylinder. RodendportRis outlet for extension and cap end port C is outlet for retraction.
- In first position of4/2 DCV air under pressure flows fromP to A and B to T. this flow is throughtheflowcontrolvalve, theflow iscontrolledandhencethepistonextendsslowly.
- Inthesecondposition4/2DCV,air underpressureflowsfromPtoBandAtoT.thisflow isthroughthecheck valve,and free flowhencethepistonretractsathigherspeedwhichis not controlled.

Meteroutforretraction

- In first position of 4/2 DCV air under pressure flows from P to A and B to T, hence the piston extends at higher speed which is not controlled.
- Insecond positionof4/2 DCV air under pressure flows fromP to B and Ato T.this flow is through flow controlvalve hence the flow is controlled and piston retracts slowly.
- Meterout controlcan be used for bothopposing load as wellas running away load. It can hold running awayloadsbecause there is FCV at outlet ofcylinder, which maintainshigh pressure air at cylinder outlet.



The above circuit meters the oil coming from the Rod Side

METER-OUT CIRCUIT

Bothmeter-inandmeter-outcircuitsareeffectivebutnotefficientastheexcesscontrolledflow passes through the relief valve back to the tank.

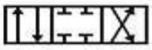
POSSIBLESHORTQUESTION

01. WhatisthepurposeoflubricatorinFRLUnit.

Ans-lubricatorisadevicewhichmixesoiltothehighvelocityhigh pressureairsothatamistformed andlubricateallthemovingparts of the pneumatic system

02. Draw4/3and4/2DCVinpneumaticsystem.

Ans-



3-position, 4-way, 4 ported Closed Center

2-position, 4-way, 4 ported

LONGQUESTIONS

1. Describefollowingpneumaticdevices

Elements–filter-regulator-lubricationunit
Pressurecontrolvalves
Pressurereliefvalves
Pressureregulationvalves
Directioncontrolvalves
3/2DCV,5/2DCV,5/3DCV
Flowcontrolvalves
Throttle valves
ISOSymbolsofpneumaticcomponents
Directcontrolofsingleactingcylinder
Operationofdoubleactingcylinder
Operationofdoubleactingcylinderwithmeteringinandmeteringoutcontrol

CHAPTER – 05HYDRAULICCONTROLSYSTEM

HYDRAULICSYSTEM

Thehydraulicsystemisdefinedasthedevice inwhichpoweristransmittedwiththehelp ofa fluid which may be liquid (water oroil) or a gas(air) under pressure. most ofthese devices are based on the principle of fluid statics and fluid kinematics.

MERITSOFHYDRAULICSYSTEM

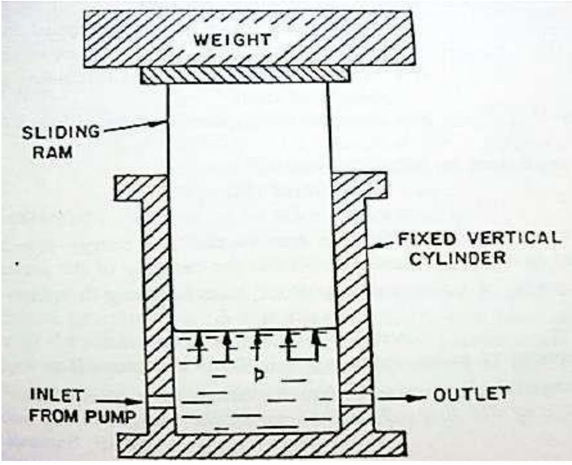
1. Smallsizeand lightweight;
2. Highstiffness,highprecisionand fastresponse;
3. Largedriving force,suitable forheavyloaddirectdriving;
4. Widespeed controlrange and variousspeed controlmodes;
5. Self-lubrication,self-coolingandlonglife;
6. Easyto realize securityprotection.

DEMERITSOFHYDRAULICSYSTEM

1. Poorresistancetoworking fluidpollution.
2. Sensitivetotemperature changes.
3. Hiddendangerofleakage.
4. Difficultmanufacturingandhighcost.
5. Itisnot suitableforlong-distancetransmissionandrequireshydraulicenergy.

5.2HYDRAULICACCUMULATORS

- Thehydraulicaccumulatorisadeviceused forstoringtheenergyofa liquid inthe form of pressure energy, which may be supplied for any sudden or intermittent requirement.
- Incaseofhydraulic lift orthehydrauliccrane,a largeamount ofenergyisrequiredwhen lift or crane is moving upward. This energy is supplied fromhydraulic accumulator, but when the lift is moving in the downward direction, no large externalenergy is required and at that time, the energy from the pump is stored in the accumulator.
- Thisfigureshowsahydraulicaccumulatorwhichconsistsofafixed verticalcylinder containing a sliding ram. A heavy weight is placed on the ram.
- The inlet ofthe cylinder is connectedto the pump, whichcontinuouslysupplies water underpressuretothecylinder.Theoutlet ofthecylinder isconnect isconnectedtothe machine (which may be lift or crane etc.)
- The ramis at the lower most position inthe beginning. The pump supplies water under pressurecontinuously.Ifthewaterunderpressureisnotrequiredbythe machine(lift or crane), the water under pressure will be stored in the cylinder.
- This will raise the ramon which a heavyweight is placed. When the ram is at the uppermost position,thecylinder isfullofwaterandaccumulatorhasstoredthemaximum amount ofpressure energy. When the machine (lift or crane) requires a large amount of energy, the hydraulic accumulator will supply this energy and ram will move in the downward direction



CAPACITYOFHYDRAULICACCUMULATOR

Itisdefinedasthe maximumamount ofhydraulic energystoredintheaccumulator.The expression for the capacity of accumulator is obtained as,

Let A= Area of the sliding ram

L=Strokesorliftoftheram

P=intensityofwaterpressuresuppliedbythepump W=

Weight placed on the ram

W=Intensityofpressure×Areaofram

Then p × A

Thework donein liftingtheram= W×liftofram= WL

=p×A×L

Theworkdone inliftingtheramisalso theenergystoredintheaccumulator andenergy stored is equal to the capacity of the accumulator.

Capacityoftheaccumulator= workdoneinlifting the ram

=p×A×L

ButA×L=volume ofaccumulator

Capacityofaccumulator=p×volumeofaccumulator

PRESSURECONTROLVALVE

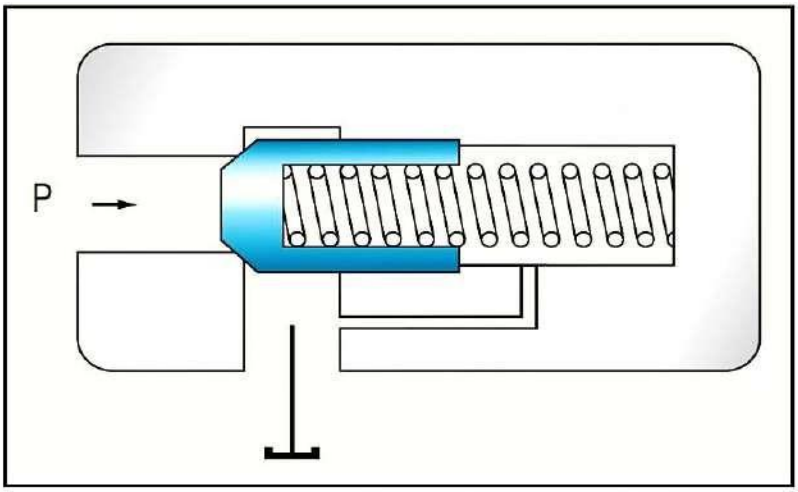
- Pressure-controlvalvesarefoundinvirtuallyeveryhydraulicsystem,andtheyassist ina varietyoffunctions, fromkeepingsystempressuressafelybelowadesiredupper limit to maintaining a set pressure in part of a circuit.

- Typesincluderelief,reducing,sequence,counterbalance,andunloading.Alloftheseare normally closed valves, except for reducing valves, which are normally open.

RELIEFVALVES

- Mostfluidpowersystemsaredesignedtooperatewithinapre-set pressurerange.This range is a function of the forces the actuators in the system must generate to do the requiredwork.Withoutcontrollingorlimitingtheseforces,thefluidpowercomponents (and expensive equipment) could be damaged. Relief valvesavoid this hazard. They are the safeguards which limit maximum pressure in a system by diverting excess oil when pressures get too high.

- Reliefvalvesareeitherdirect-actingorpilot-operated.



- Figure1.Simple,direct-actingreliefvalvehasno adjustingscrewandthereforeopensata fixed, pre-set pressure as controlled by setting of compression spring.

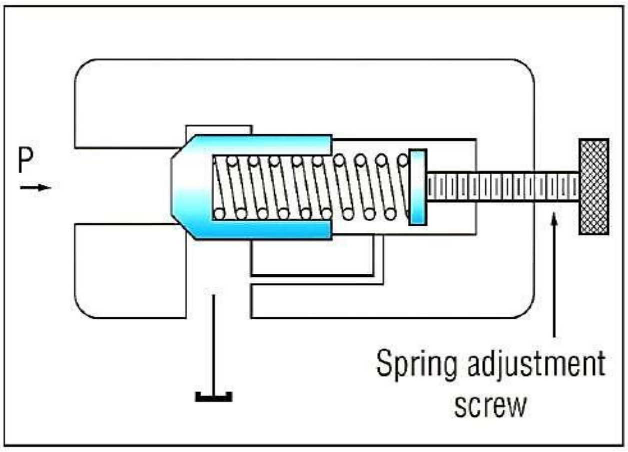
- A direct-acting valve mayconsist ofa poppet or ball, held exposed to systempressure on one side and opposed bya spring of pre-set force onthe other. In a fixed, non-adjustable, normallyclosedreliefvalve,Figure1,theforceexertedbythecompressionspringexceeds theforceexertedbysystempressureactingontheballor poppet.Thespringholdstheball or poppet tightly seated. A reservoir port on the spring side of the valve returns leakage fluid to tank.

- Whensystempressurebeginstoexceedthesettingofthevalvespring,thefluidunseatsthe ball or poppet, allowing a controlled amount of fluid to bypass to reservoir, maintaining system pressure at the valve setting. The spring re-seats the ball or poppet when enough fluid is released (bypassed) to drop systempressure below the setting ofthe valve spring.

- Because the usefulness of a fixed relief valve is limited to the single setting of its spring, mostreliefvalvesareadjustable.Thisiscommonlyachievedwithanadjustingscrewacting on the spring, Figure 2. By turning the screw in or out, the operator compresses or decompresses the spring respectively. The valve can be set toopenat anypressure within adesiredrange.Asidefromtheadjustablefeature,thisvalveworksjustlikethefixedvalve in Figure 1.

- Spring-loadedpoppet valvesare generally used for small flows. They don't leak below cracking pressure and respond rapidly, making them ideal for relieving shock pressures. They often are used as safety valves to prevent damage to components from high surge pressures, or to relieve pressure caused by thermal expansion in locked cylinders. The differentialbetweencracking and fullopenpressureonspring-loaded poppetreliefvalves is high. For this reason they are not recommended for precise pressure control.

5.2.2PRESSURERELIEFVALVE



- direct-acting relief valve blocks flow through the valve until force of system pressure on the poppet overcomes the adjustable spring force and downstream pressure.

- Relief valvesare also made to relieve flow in either direction. Fluid pressure at the other portactsonashoulderontheplungertoopenthevalve.Anothertypeofdirect-actingrelief valve has a guided piston. In this valve a sliding piston, instead of a poppet, connects the pressure and reservoir ports. System pressure acts on the piston and moves it against a spring force. As the piston moves, it uncovers a reservoir port in the valve body.

- These valves have a fast response but may be prone to chatter. They can be damped to eliminate chatter, butthis also slows their reactiontime. Theyare reliable and canoperate with good repetitive accuracy if flow does not vary widely. Valves with hardened-steel pistons and sleeves have a very long service life. They may leak slightly below cracking pressure unless the pistons are sealed.

- Avariationoftheguided-pistonreliefvalveisthe differential-pistonreliefvalve.Here,the pressure acts on an annular area (the difference between two piston areas). This annular areaissmallerthanthevalve'sseatarea.Thispermitstheuseofalighterspringthanwould be needed if pressure acted on the entire seat area. These valves have a lower pressure differential than poppet or guided-piston relief valves.

5.2.3PRESSUREREGULATIONVALVES

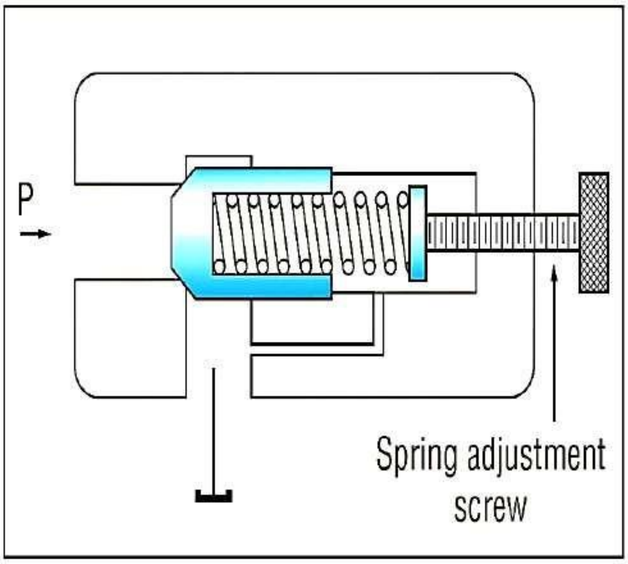
- Apressureregulatorisavalvethatcontrolsthepressureofafluidorgastoadesiredvalue. Regulators are used for gases and liquids, and can be an integral device with a pressure setting,arestrictorandasensorallintheonebody,orconsistofaseparatepressuresensor, controller and flow valve

- Therearetwotypesofpressureregulationvalve-:Thepressurereductionregulatorandthe back-pressure regulator.
- Apressurereducingregulatorisacontrolvalvethatreducestheinputpressureofafluidor gases to adesired value at itsoutput. It is a normally-openvalve and is installed upstream of pressure sensitive equipment.
- Aback-pressure regulatoror back-pressure valve, is acontrol valvethat maintains the set pressure at its inlet side by opening to allow flow when the inlet pressure exceeds the set value.
- It is a normally-closed valve which may be installed in parallel with sensitive equipment or after the sensitive equipment to provide an obstruction to flow and thereby maintain upstream pressure.

- Both types of regulator use feedback of the regulated pressure as input to the control mechanism, and are commonly actuated by a spring loaded diaphragm or piston reacting tochangesinthefeedbackpressuretocontrolthevalveopening,andinbothcasesthevalve should be opened only enough to maintain the set regulated pressure.

PRESSUREREDUCINGVALVE

- Apressure reducing regulator'sprimaryfunction isto matchthe flowofgasthroughthe regulatortothedemandforgasplaceduponit,whilemaintainingasufficientlyconstant output pressure.



If the load flow decreases, then the regulatorflowmustdecreaseaswell.Ifthe loadflowincreases,thentheregulatorflow must increase in order to keep the controlledpressurefromdecreasingdueto a shortageofgas inthe pressure system. It is desirable that the controlled pressure doesnotvarygreatlyfromthesetpoint for a wide range of flow rates but it also desirablethat flowthroughtheregulatorisstableandtheregulatedpressureisnot subject to excessive oscillation.

Schematicdiagramofpressurereducing regulator(A)andback-pressure regulator(B).

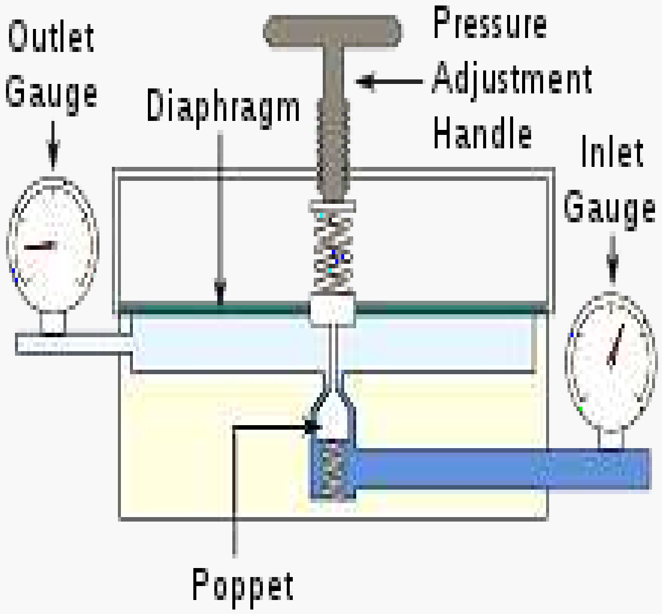
- Theupperdiagramsshowthenormalstatefor thevalves, whichisnormallyopenforpressure reducers and normally closed for back-pressure valves.

- 1.Pressuresettingscrew
- 2.Spring
- 3.Actuator
- 4.Inletport(highpressure)
- 5.Outletport (lowpressure)
- 6.Valve body
- 7.Valvecrownandseat

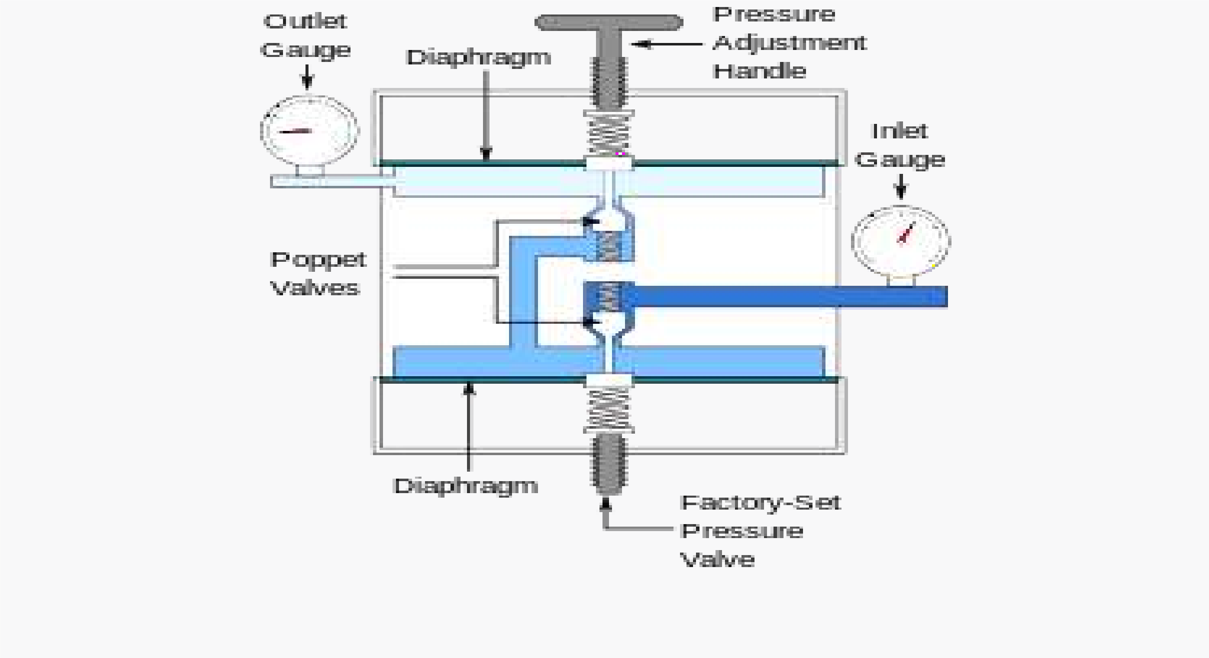
Apressureregulatorincludesa restrictingelement,a loadingelement,anda measuring element:

- Therestrictingelement isavalvethatcanprovideavariablerestrictiontotheflow,suchas a globe valve,butterfly valve,poppet valve, etc.
- The loadingelementisapartthatcanapplytheneededforcetotherestrictingelement.
- Thisloadingcanbeprovidedbyaweight,aspring,apistonactuator,orthe diaphragm actuator in combination with a spring.
- The measuring element functions to determine when the inlet flow is equal to the outlet flow.Thediaphragmitselfisoftenusedasameasuringelement;itcanserveasacombined element.

SINGLESTAGE REGULATOR



DOUBLESTAGE REGULATOR



5.3DIRECTIONCONTROLVALVES

As the name implies directional controlvalves are used to controlthe direction of flow in ahydrauliccircuit.Theyareusedto extend,retract,positionorreciprocatehydrauliccylinder and other components for linear motion.

Valvescontainsportsthat areexternalopeningsforfluidtoenterand leaveviaconnecting pipelines, The number ofportsona directionalcontrolvalve (DCV) is usually identified by the term“way”. For example, a valve with four ports is named as four-wayvalve.

Directionalcontrolvalvescanbeclassifiedinanumberofways:

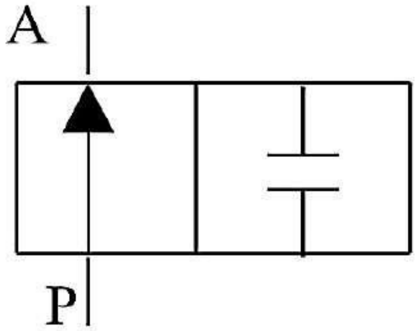
1. Accordingtotypeofconstruction:
   - Poppet valves
   - Spoolvalves
2. Accordingtonumberofworking ports:
   - Two-wayvalves
   - Three–wayvalves
   - Four-wayvalves.
3. AccordingtonumberofSwitching position:
   - Two–position
   - Three – position
4. AccordingtoActuatingmechanism:
   - Manualactuation
   - Mechanicalactuation
   - Solenoid(Electrical)actuation
   - Hydraulic(Pilot) actuation

- Pneumaticactuation

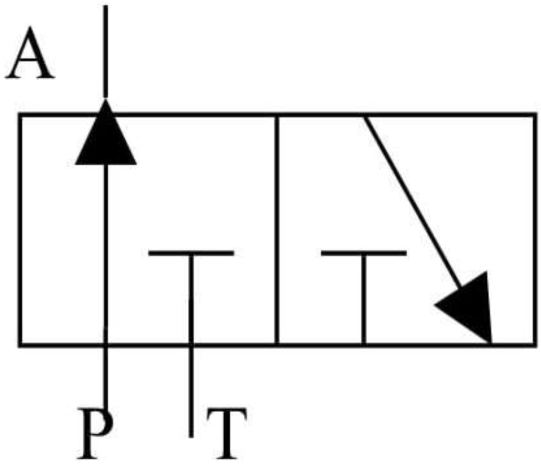
- Indirectactuation

Thedesignationofthedirectionalcontrolvalvereferstothenumber ofworking portsandthe number of switching positions.

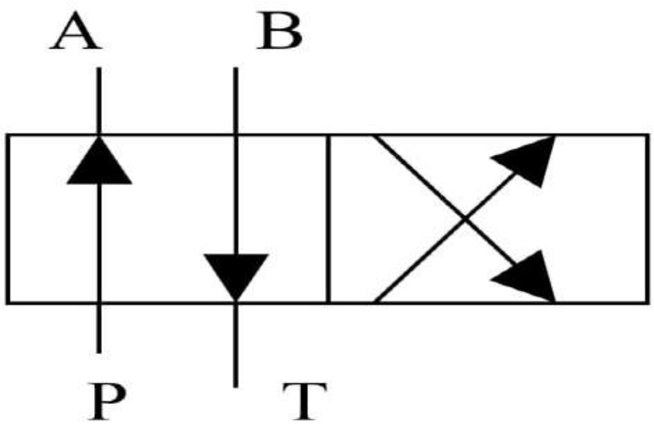
Thusavalvewith2serviceportsand2switchingpositionsisdesignatedas2 /2wayvalve.



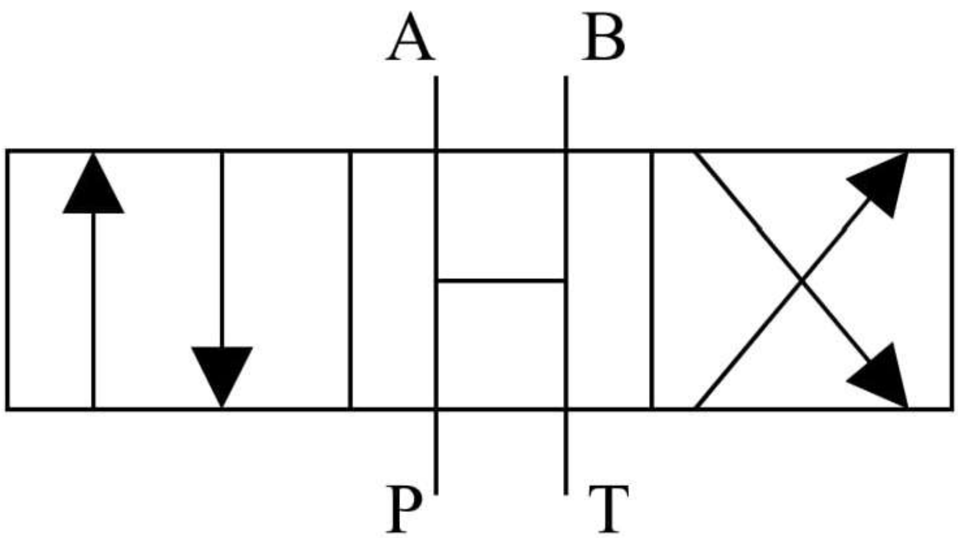
Avalvewith3 serviceportsand 2position isdesignated as2 / 3wayvalve



Avalvewith4 serviceportsand 2position isdesignated as2 / 4valve.



Avalvewith4 Serviceportsand 3 Switchingposition isdesignated as3 /4wayvalve



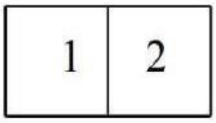
A valve with 2 spool position is shown and also a valve with 3 spool positions. In directionalcontrolvalveswith3 spoolposition, thecentralposition istheneutralposition(or mid position or zero or null position). The neutral position is the position in which the moving parts are assumed to be inactive, but affected bya force (e.g. spring)

Theportsaredesignatedasfollows: P

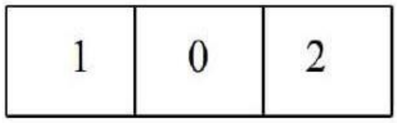
= Pressure Port (Pump Port)

T=TankPort

A,B=UserPorts



2- Position valve



3- Position valve

5.3.2FLOWCONTROLVALVE

Flowcontrolvalvesareusedto regulatetheflowrateandpressureofliquidsor gasesthrough a pipeline. Flow controlvalves are essential for optimizing systemperformance, relying on a flow passage or port with a variable flow area.

FunctionofHydraulicFlowControlValve

The purpose of a flow control valve is to regulate the flow rate in a specific portion of a hydraulic circuit. In hydraulic systems, they're used to control the flow rate to motors and cylinders, thereby regulating the speed of those components.

Hydraulic flow controlvalvesalso controltherateofenergytransfer at agivenpressure. This is based on the physics concept surrounding work, energy and power.

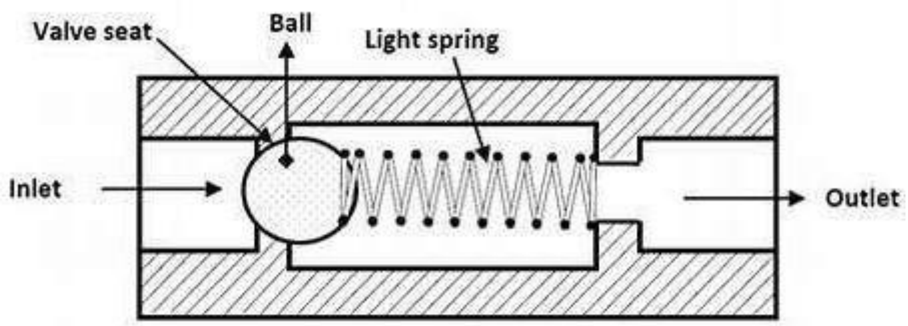
The energy transfer must be equal to the total work done. Because the actuator speed determines the rateofenergytransfer, speed is a functionofthe flow rate. Directionalcontrol valvesserveadifferentpurpose,directingtheenergytransfersystemtotheappropriatelocation at the appropriate time, although some pressure and flow rate control may be achieved using directional control valves, as they can throttle the flow of fluid.

There are a variety of flow control valve designs, with most intended for specific applications. Therefore, understanding how hydraulic flow control valves work is crucial in selecting the right valve for an application.

The mostcommontypesofflowcontrolvalvesinclude:

- Ball
- Diaphragm
- Needle
- Butterfly
- Plug

Thesimplestflowcontrolvalveshaveanaperturewhichopensorclosesinordertoincrease or slow down the flow rate. Ball valves are among the simplest options, consisting of a ball attachedtoahandle. Theballhasaholethroughthecentre,andwhenthehandle isturned,the hole is aligned with valve openings in order to permit flow. In order to shut off the flow, the handle is used to turnthe hole perpendicular to the valve openings, which obstructsthe flow.

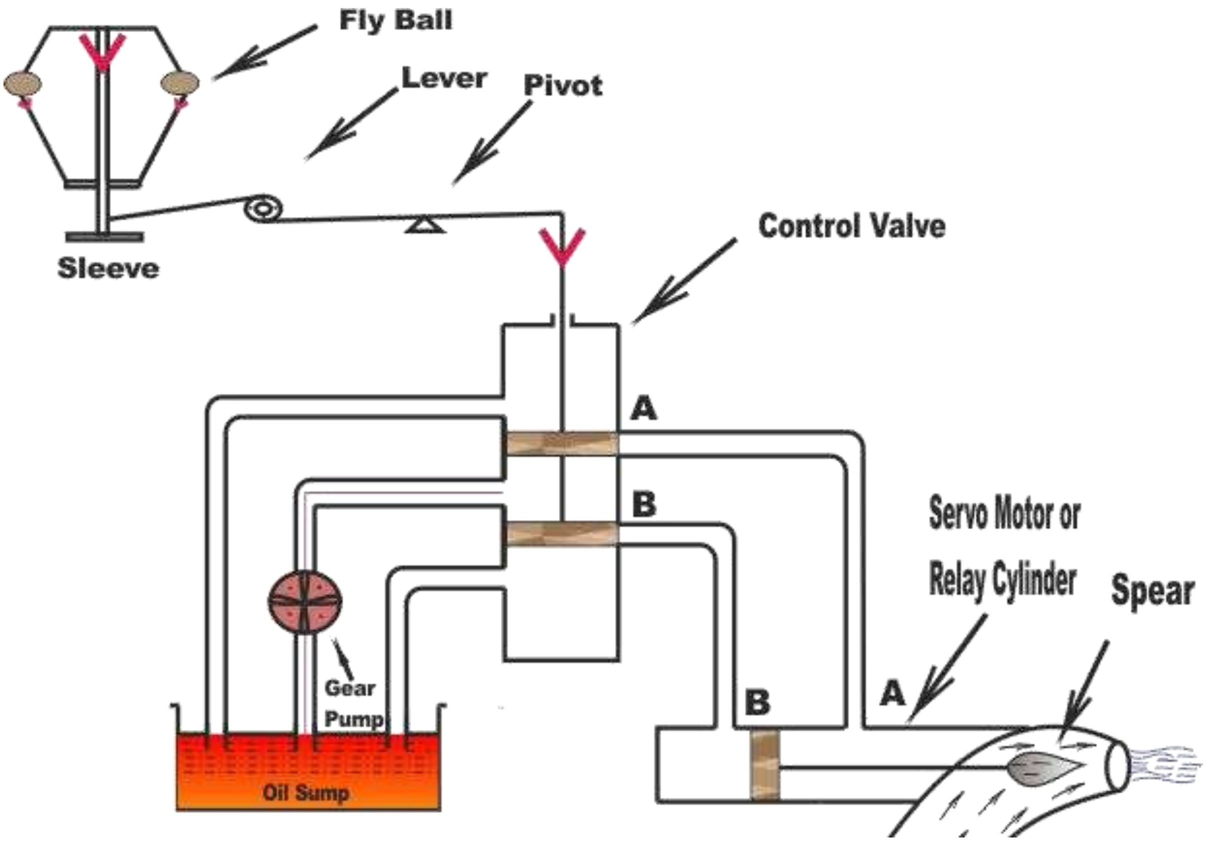


: Ball-type check valve.

Othervalvetypes functioninasimilarwaywithsome mechanismforeitherpermittingor blocking flow.Abutterflyvalve,forinstance,hasaninternalmetalplateattachedtoaturning mechanism. The plate opens or closes when the mechanism is turned. Needle valves, which are among the more precise valve options, have an adjustable needle and a valve stemwhich restricts or allows the flow of liquid. The needle can be adjusted to block the flow of fluid completely, allow the free flow of liquid, or partiallyobstruct the flow to varying degrees, therefore allowing for greater and more precise control over the flow rate.

5.3.3THROTTLEVALVE

- ThrottleGoverningofsteamTurbineismostpopularandeasiestwaytocontroltheturbine speed. Whensteam turbine controls its output speed by varying the quantity of steam enteringtheturbine iscalledThrottleGoverning.Itisalso knownasServomotormethods.
- In this system, a centrifugal governor is driven from the main shaft of turbine by belt or gear arrangement.
- Acontrolvalve is used to controlthe directionofoilflow whichsupplied bythe pipe AA or BB.
- The servomotor or relay valve has a piston which moves towards left or right depending uponthe pressure of oil flow through the pipes AA or BB. This cylinder has connected a needle which moves inside the nozzle.
- Whentheturbineisrunningatnormalspeed,everythingintheturbinesuchassuchcontrol valve, servomotor, pistonposition, flyballsofcentrifugalgovernorwillbe intheirnormal positionasshowninthefigure.ThemouthofbothpipesAAorBBisclosedintothecontrol valves.
- Assumethat theturbine'sload increases.It willdecrease itsspeedwhichwilldecreasethe centrifugal force of the turbine.
- Now fly balls of the governor will come down thus decreasing their amplitude. These fly balls also bring downthe sleeve. The sleeve is connected to a control valve rodthrougha lever pivoted on the fulcrum. This down word sleeve will raise the control valve rod.
- Now oil is coming from the from the oil sump, pumped by gear pump is just stay at the mounts of both pipes AAor BB which are closed by the two wings ofcontrol valves. So, raise of control valve rod will open the mouth of the pipe AA but BB is still closed.
- Now the oil pressure is coming from the pipe AA. This will rush from the control valve whichwillmovetherightsideofthepiston.Asaresult,thesteamsflowrateintotheturbine increaseswhichwillbringthespeedoftheturbinetothenormalrange. Whenspeedofthe turbine will come to its normal range, fly balls will come into its normal position. Now, sleeve and control valve rod will back to its normal position.



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5.4FLUIDPOWERPUMPS

Thepumpsaretheheartofthehydraulicsystem. Pumpstransferthemechanicalenergythey receive from the prime mover (electric motor) into fluid energy.

PUMPINGTHEORY:

Allpumps operate onthe principle that a partial vacuum is created at the inlet of the pump duetointernaloperationofthepump. Thisallows atmosphericpressuretopushthefluidout ofthe reservoir and into the pump intake. The pumpthen mechanically pushes the fluid out into the discharge line.

PUMPCLASSIFICATION

Therearetwo typesof Pump

(1) Positivedisplacement pumps
(2) Nonpositivedisplacementpumps

Positive displacement pumps

Ex–Rotarypumps(gear,screw,lobe),Reciprocatingpump(Radial, inline,axialtype) Non

positive displacement pumps

Ex–Centrifugalpumps(impeller type),Axialpump(propeller type)

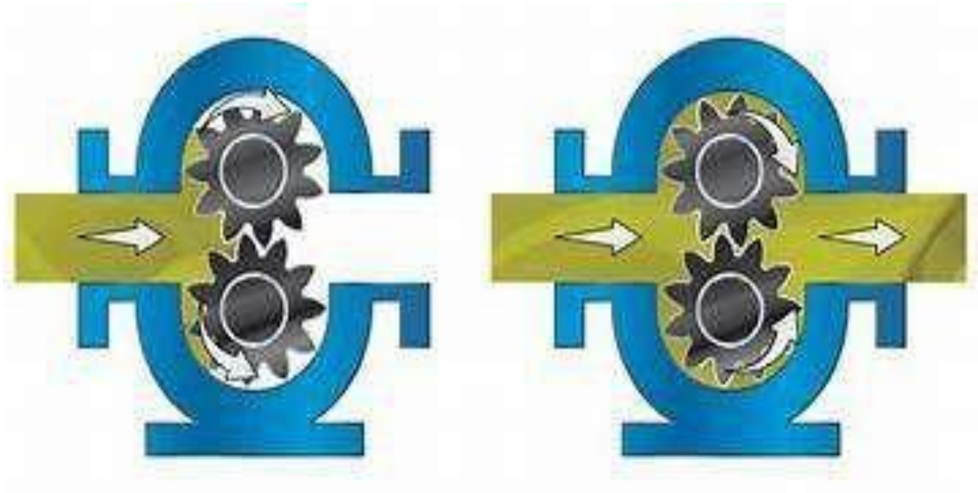
5.4.1GEARPUMP:(external&internalgearpump)

Therearetwotypes ofgearpumps-

(1) Externalgearpumps
(2) Internal gear pumps

EXTERNALGEARPUMPS

Externalgear pumps are the most popular hydraulic pumps in low-pressure ranges due to their longoperating life,highefficiencyand lowcost.Theyaregenerallyused inasimple machine. The most common form of external gear pump is shown in Figs.



Theyhave meshing gearsofequalsize. Thedrivegear iscoupled withthedriveshaft of the electric motor. This gear drives the other gear. As theyrotate the fluid is trapped and carried between teeth ofthe driver and driven gears and externalcasing, which is in close contact withthegears. Thepumpcreates flowand astheypassthroughthecomponentsof the systems, pressure is generated and transmits it to flow and as theypass through the components of the systems, pressure is generated and transmits it to the actuator. the displacement of the gear pump increases with an increase in input rpm.

VOLUMETRICDISPLACEMENTANDTHEORITICALFLOWRATE

LetD_o=addendumcirclediameterofthegearteeth, D_I =

base circle diameter of the gear

W=widthofthegear

N = speed ofthe prime mover

Q_t=theoreticalpumpflowrate

V_D=displacedvolumeofthepump

Volumetricdisplacement$V_D=\pi/4\ (D_o^2-D_I^2)W\ mm^3$

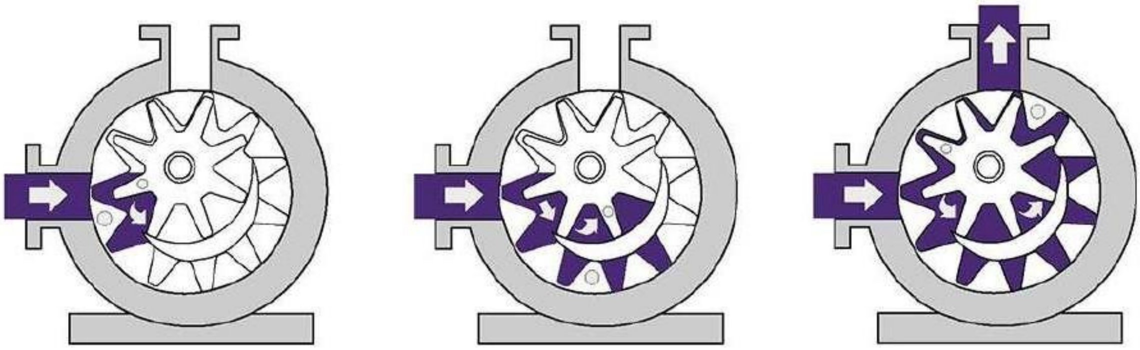
Theoreticalflow rate$Q_t=V_DN\ mm^3/min$

Volumetricefficiency, η_v=actualdischarge/theoreticaldischarge

$=Q_A/Q_T\times100$

The high pressure are created when a large load or resistance to flow is encountered. The actual discharge depends on the discharge pressure. As the discharge pressure increases the amount of internal leakage increases thus decreasing pump outlet volume. Hence the pump should beoperatedat pressure lessthanthepressure,whichwillcause mechanicaldamageto the pump.

INTERNALGEARPUMP



Inthistypeofgearpumpboththegearrotateinsamedirection. Asthegears moveaway nearthe inlet,theoilistrappedinthegearspaceandtravelsaroundthecrescent sealand near the outlet asthe two gears come closer pressure rises and the oil is pushed into the outlet port.

5.4.2VANEPUMP

Therearetwotypesofvanepump. Theyare-

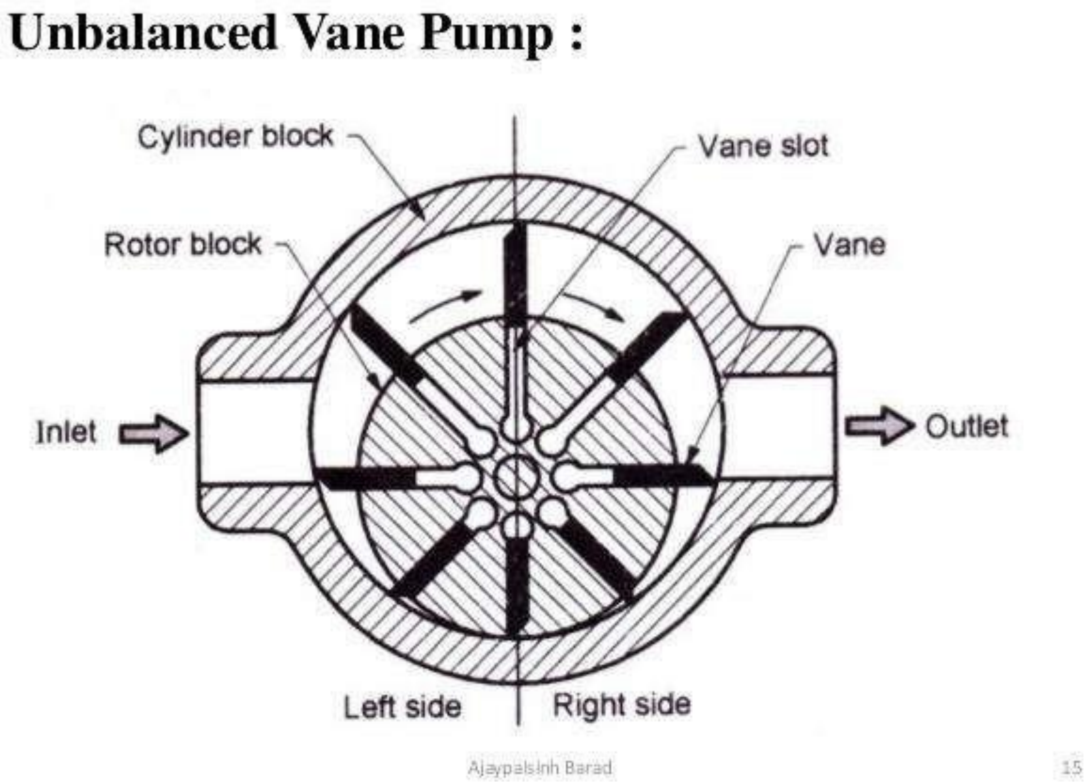
Unbalanced vane pump

Balancedvanepump

UNBALANCEDVANEPUMP

The unbalanced vane pumps have a rotor connected to the rotating shaft which is coupled with the prime mover. The rotor has radial slots into which there are vanes that that move in andoutwhilerotatingdueto centrifugalforce.Thecamring iscircular inshape,whichlimits the outward movement

oftherotors.At inletthevanes moveoutcreatingthesuctionoffluidandastheyrotatethe fluid travels entrapped between the radial vanes and the cam ring. Nearing the outlet the vanes are pushed in by the camring resulting in high pressure. This results in pushing or discharge of liquids out into the discharge line.



<u>Advantages:</u>

Theadvantageoftheunbalancedvanepump isthatastheeccentricitybetweencam ring and rotor is changed the volume of fluid pumped can be proportionately changed.

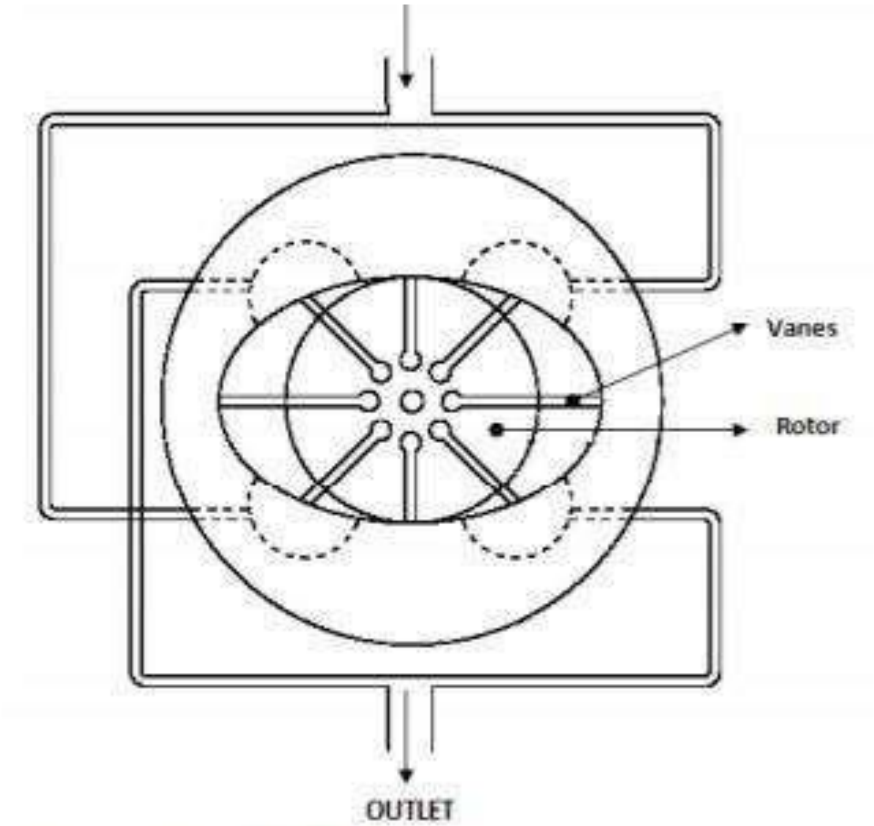
<u>Disadvantages:</u>

Thesuctionsideofthe fluid isat atmosphericpressure.but atthedischargeendthe fluid is at systempressure and as a result in imparts the side axial thrust onthe rotor. This unbalanced force creates changes in the displacement volume and failure of the rotor.

<u>BALANCEDVANEPUMP</u>

- The disadvantage of the unbalanced vane pump is that it experiences axial thrust. Changingtheshapesofthecamringellipticalinsteadofcircular caneliminatesidethrust. In addition if there are two suction and discharge ports placed at equal and opposite quadrants, the two pressure or discharge port cancelout their forces and thus side thrust eliminated.
- The displacement of fluid and the basic operation of the pump are similar to the unbalanced pump except that there are two suction and discharge pressure. the pump remainsaconstant volumedischargepumpandhencetheycannotbeusedasavariable

dischargepump.But mostofthe industrialapplicationuseonlyconstant volumepositive displacement balanced vane pumps.



Operation of a balanced vane pump

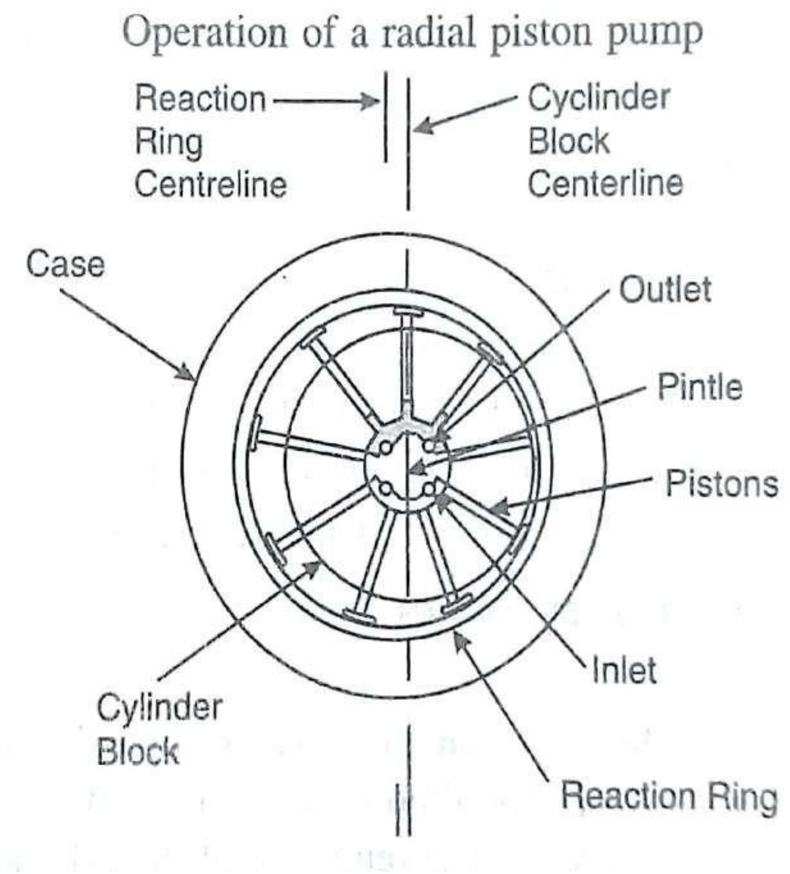
PISTONPUMP

Thepistonpumpsarereciprocatingpumps.theyarebroadlyclassifiedas-

(1) Axialpistonpump
(2) Inline piston pump
(3) Radialpiston pump

5.4.3RADIALPISTON PUMP

- Inthistypethepistonremainsincontact withthereactionringdueto centrifugal force and back pressure on the pistons.
- To providepumpingaction,thereactionring moveseccentricallywithrespecttothe pintle or shaft axis. As the cylinder barrelrotates, the pistonon one side move out. This draws fluid as each cylinder passes the maximum port.
- Whenthepistonmovestomaximumeccentricity,it isforcedbackbythereaction ring. This forces the fluid into the discharge port of the pintle.

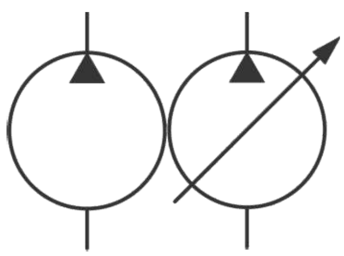


5.5ISOSYMBOLSFORHYDRAULICCOMPONENT

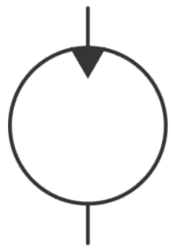
HydraulicReservoir

Ahydraulicreservoirstoreshydraulicfluid.Thisisa must-havecomponent inanyhydraulic system. Allhydraulic reservoirs are opento the atmosphere except inthe case ofthose used in aircraft and submarines.

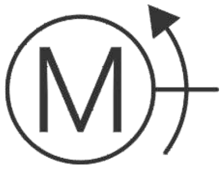
HydraulicPumpand Motor



Ahydraulicpumpconvertselectricaland/ormechanicalenergy into hydraulicenergy.The lowerend(suctionside)ofapump isconnectedtothehydraulicreservoir,theupperend is connected to the remaining circuit. The dark upper triangle in these hydraulic symbols indicates fluid going out of the system and hence represents a pump.



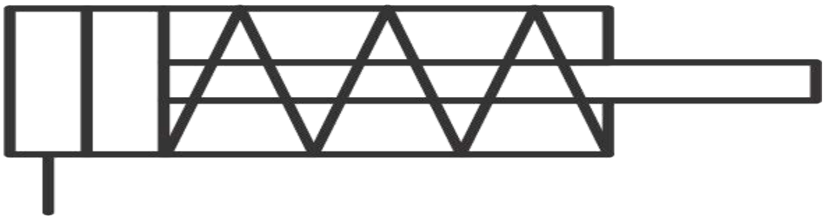
Inthecaseofthehydraulic motor,thedarktriangle isinvertedindicatingthatthefluid is entering into the system. A hydraulic motor converts hydraulic energy into mechanical energy**.**



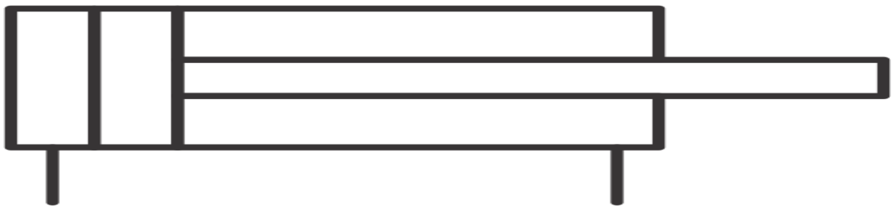
Systemoutputisrepresentedbyanarrowat 450–thiscanbeadjusted, Inother words,that the pump/motor can deal with variable flow rate per shaft rotation. Most industrial applications use electric motors as prime movers to rotate hydraulic pumps. The electric motor is represented bythe letter M inside of a circle. The curved arrow represents the direction of shaft rotation.

HydraulicCylinders

Hydrauliccylinderscanbecategorizedassingleactingcylindersanddoubleactingcylinders.

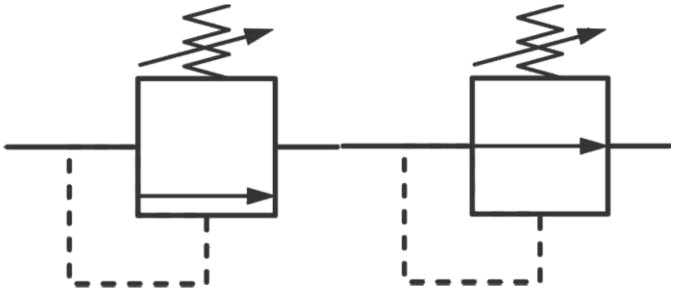


Singleactingcylinderscanperformoperations inonlyonedirectionandreturntothe initial position by spring.



Doubleactingcylinderscanactuateineitherdirectiondependinguponthepositionofthe direction control valve

Controllingvalves



PressureReliefValve
A pressure relief valve is a NC (normally closed) type safety valve which operates when systempressure increasesabovea maximumworkingpressure.Thenormallyclosedposition is indicatedbythearrowawayfromthecentreline. Thedashed line indicatesthatthesystem pressure acts against spring force for valve actuation.

5.6ACTUATORS

Theactuatorsarethedevices,whichconvertthehydraulicenergyinto mechanicalenergy. Thehighpressurised fluidwhenpassesthroughtheactuatorconvertsthefluidenergyinto linear or rotary motion. When it converts the energy into reciprocating motion theyare termed as cylinders and when they rotate and produce torque they are named as motors.

CYLINDERS

1. Thesearelinear actuators
2. Theoutputmotionisstraightline
3. Thehydraulicpowerisconvertedinto linearmechanicalpower.
4. Theyareusedbasicallyforpushing,pulling,tiltingand pressing.

Typesofcylinder

Ram: this is the simplest type ofcylinder. Usually these cylinders are verticaltype. The fluid ispassed onbottomsideofthecylinderto pushupand do work.Theretractionofthe cylinder isachievedbygravity.Ithasonlyonefluidchamberandtheapplicationisontheothersideof the ram. It can carry heavy load and has a large stability on heavy load.

Singleactingcylinder:

Thiscylinder type hasone fluid chamber and may be placed either verticalor horizonalor at anyposition. The fluid ispressurisedonthepistonside andontherodside it ispushed bythe spring.

Thefluidpushedthepistonouttodoworkanditretractbythespringforce.

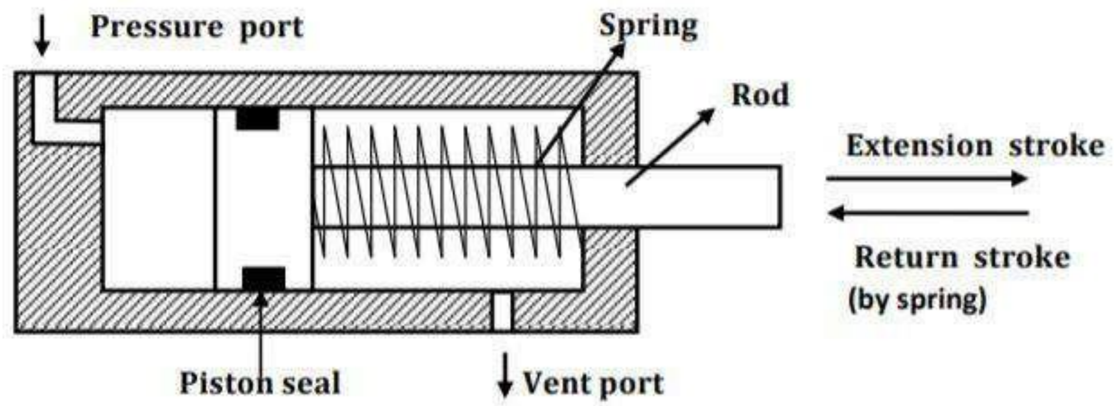


Figure 1.1 Single-acting cylinders

Doubleacting cylinder

- Thiscylindertypehastwofluidchambersandboththeextensionandreturnofthecylinder is by the fluid power. These are also called as differential cylinder.
- Thepressureisappliedonboththesidesofthepiston.Thevolumeonboththesideofthe piston are different.
- The volume onthe pistonside is more and ontherodside the rodarea reducesthe actual area andthusthe area,whichcarriesthe fluid pressure, is lessonthe rodside. Thisresults in different pressure levels on either side and is called as differential cylinders.

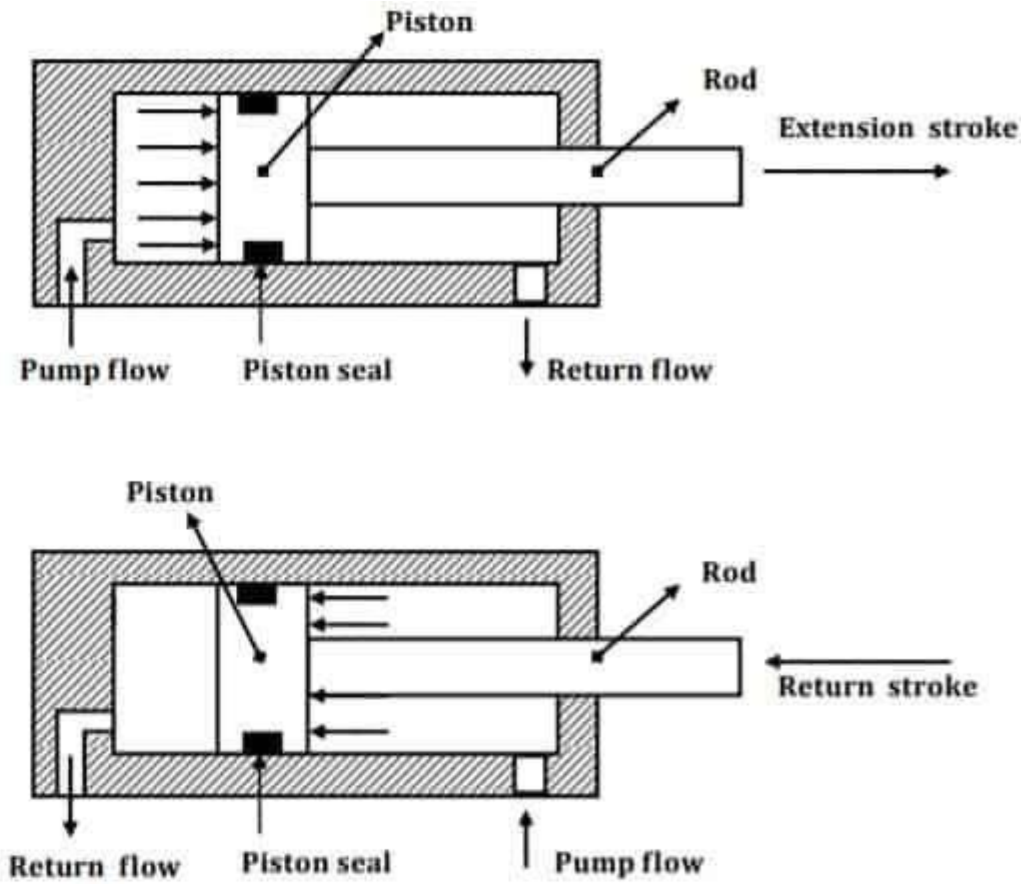


Figure 1.4 Double-acting cylinder with a piston rod on one side

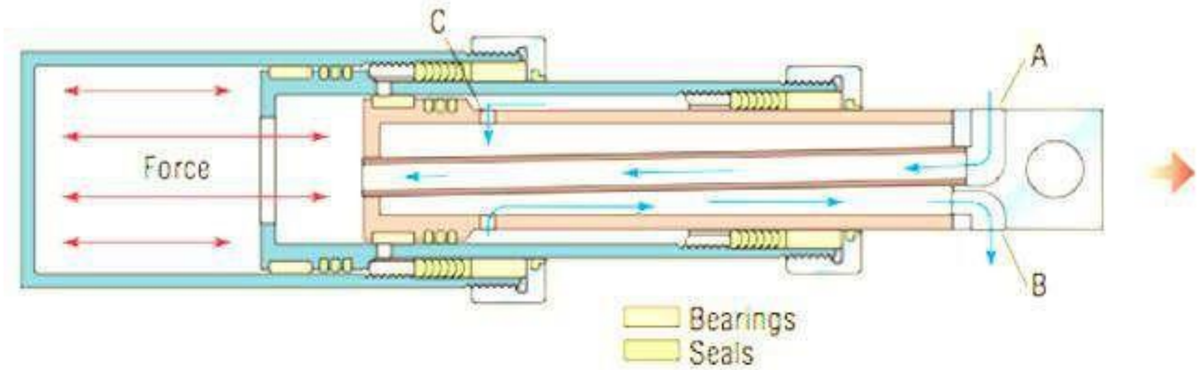
Double rodcylinder

Thiscylindertypealsohastwofluidchambersandboththeextensionandreturnofthecylinder isbythefluidpower.Thesearecalledasnon-differentialcylinders.Thepressureisappliedon boththesideofthepiston.Thevolumeandareaonboththesideofthepistonareequal.Equal force can be generated in bothextension/returnstrokes. These cylinders are used whenequal force and equal speed on both the strokes are required.

Telescopiccylinders

These cylinders are used in application, which require a lengthyoperation. Some ofthe applicationsofthistypearetheonesused inautomobilestolift thechassistounloadthe vehicle. The extension of these type of cylinders occurs one after the other.

Extension of a double-acting telescopic cylinder



MOTORS:

1. Theseare calledrotaryactuators.

2. Thisconstructionissimilartothepumpconstruction.

3. Theirfunctionalityisjustreverseofthepumps.

4. Theirprincipleofoperationisinsteadofpushingthe fluidaspumps,pressurized fluid push the internal surface area that develops torque and rotation.

5. Boththeinput andoutput arepressurizedand hence mostofthe motorsareinternally drained.

6. The mostcommonmotorsare

   (a) Gearmotors

   (b) Vanemotors

   (c) Pistonmotors

   (d) Bentaxispistonmotors

7. The motorsareratedbasedonthedisplacementandtorques generated.

8.Largedisplacementandlargeradius motorsproducemoretorque.

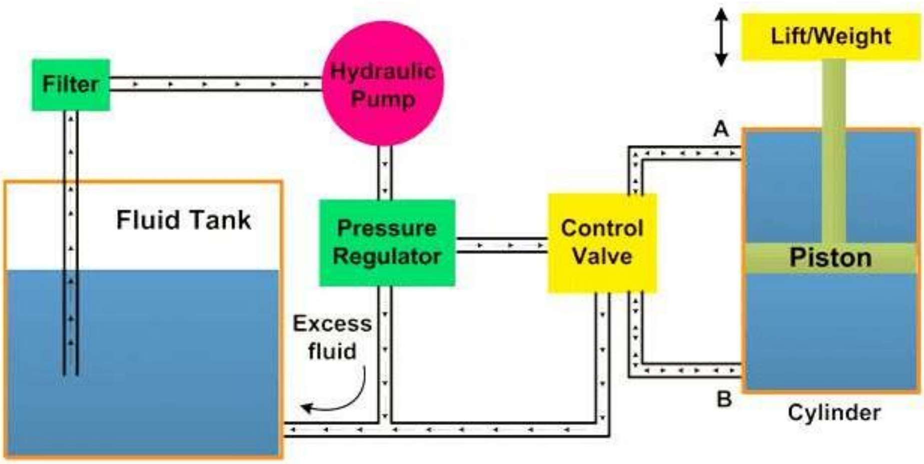
Torque = force×radius

Forsamepressure, iftheradiusofthemotors,internalcomponent isincreased,then can produce large toque.

5.7HYDRAULICCIRCUITS:

The controlled movement of parts or a controlled application of force is a common requirement intheindustries.Theseoperations areperformedmainlybyusingelectrical machines or diesel, petrol, and steam engines as prime movers.

Theseprime moverscanprovide variousmovementstotheobjectsbyusingsome mechanical attachments like screw jack, lever, rack and pinions etc. However, these are not the only prime movers.



- Theenclosedfluids(liquidsandgases)canalsobeusedasprimemoversto provide controlled motion and force to the objects or substances.

- The specially designed enclosed fluid systems can provide both linear as well as rotary motion.Thehighmagnitudecontrolledforcecanalsobeappliedbyusingthesesystems.

- Thiskindofenclosed fluid-basedsystemsusingpressurized incompressible liquidsas transmission media are called as hydraulic systems.

- Thehydraulicsystemworksontheprinciple ofPascal’slaw whichsaysthatthe pressure inanenclosedfluidisuniforminallthedirections.

- Thehydraulicsystemsconsist anumberofpartsfor itsproperfunctioning. These include storagetank, filter, hydraulic pump, pressure regulator, controlvalve, hydraulic cylinder, piston,and leak-prooffluid flowpipelines.Theschematicofasimplehydraulicsystemis shown in figure.
- Itconsistsof:
  - a movablepistonconnectedtotheoutputshaftinanenclosedcylinder
  - storage tank
  - filter
  - hydraulicpump
  - pressureregulator
  - controlvalve
  - leak proofclosed-looppiping
- Theoutputshaft transfersthe motionorforcehoweverallotherpartshelpto controlthe system. Thestorage/fluidtank isareservoir fortheliquidusedasatransmissionmedia.
- The liquid used is generally high-densityincompressible oil. It is filtered to remove dust oranyother unwanted particlesand thenpumped bythehydraulicpump. Thecapacityof the pump depends on the hydraulic system design.
- These pumps generally deliver constant volume in each revolution of the pump shaft. Therefore,thefluidpressurecanincrease indefinitelyatthedead-endofthepistonuntil the system fails.
- Thepressureregulatorisusedto avoidsuchcircumstanceswhichredirecttheexcessfluid back tothe storagetank.The movement ofthe pistonis controlled bychanging the liquid flow from port A and port B.
- The cylinder movement is controlled by using a control valve which directs the fluid flow. The fluid pressure line is connected to the port Bto raise the piston and it is connectedto port Ato lowerdownthepiston.Thevalvecanalso stopthe fluid flow in any of the ports.
- The leak-proof piping is also important due to safety, environmental hazards, and economic aspects. Some accessories such as flow control system, travel limit control, electric motorstarter,andoverloadprotectionmayalso beused inthehydraulicsystems which are not shown in the figure.

ComponentsofHydraulicSystem

Basic hydraulicsystemhasthe followingcomponents:

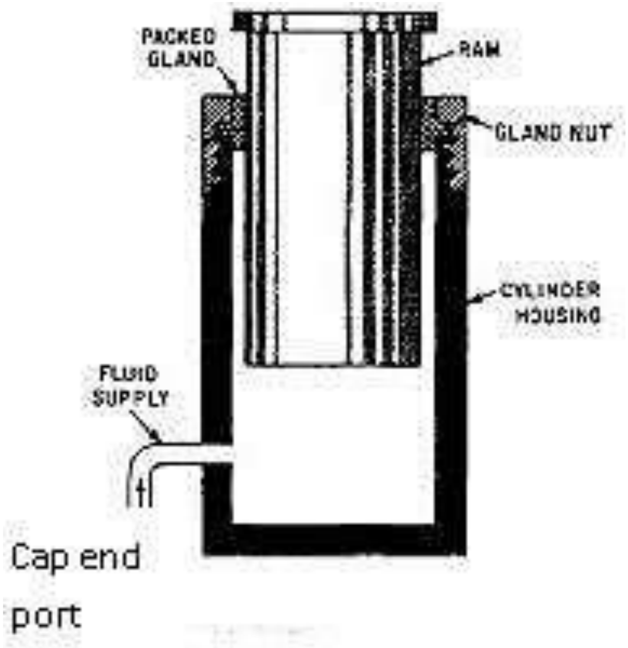
1) Oilreservoir
2) Rotarypump
3) Pressurereliefvalve
4) Directioncontrolvalve
5) Flowcontrolvalve
6) Double-actingcylinder
7) Pressure gauge
8) Filter

DIRECTCONTROLOFSINGLEACTINGCYLINDER

- Single acting hydraulic cylinders are the simplest form of hydraulic cylinder which is used forpulling,lifting, movingand holdingthe load.Singleactingcylinder,asshown infigure,willhaveoneport i.e.capendport.Singleactingcylinder,asname indicates, will be operated hydraulically in one direction only.

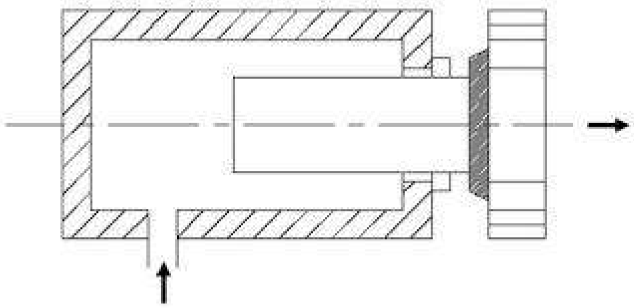
- Singleacting hydrauliccylinderwillhaveonepistonwithinacylindricalhousing.When hydraulicoilwillbesuppliedto itscapendport,hydraulicpressure forcewillbeapplied over the piston or plunger and hence piston will be extended and this stroke of cylinder will be termed as forward stroke.

- For return strokeor during retraction of cylinder, piston or plunger will be returned due toitsownweightorbyanymechanicalmedia i.e. spring force. Whenpistonwillstart its retraction i.e. return stroke due to its self weight or spring force, oilwill flow back to reservoir during retraction of cylinder.

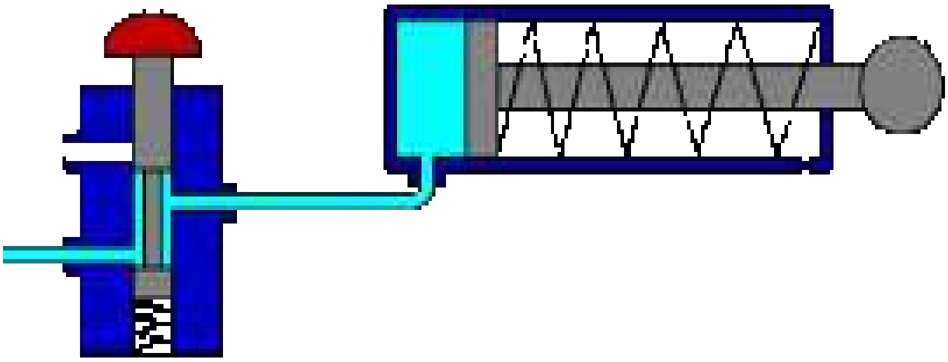


- Hencepistonwillbeoperatedhydraulicallyonlyinonedirectioni.e. duringextensionor forwarddirection. Retractionofcylinder will notbeoperatedbyhydraulic forcebut also it will be operated by mechanical force such as spring force or piston may also returns due to its self weight on the basis of design of cylinder.

- Singleactingcylindersareclassified intwotypesonthebasisofmechanismofretraction of cylinder.
    1. Singleactingcylinder- Gravityreturn



2. Singleactingcylinder-Springreturn

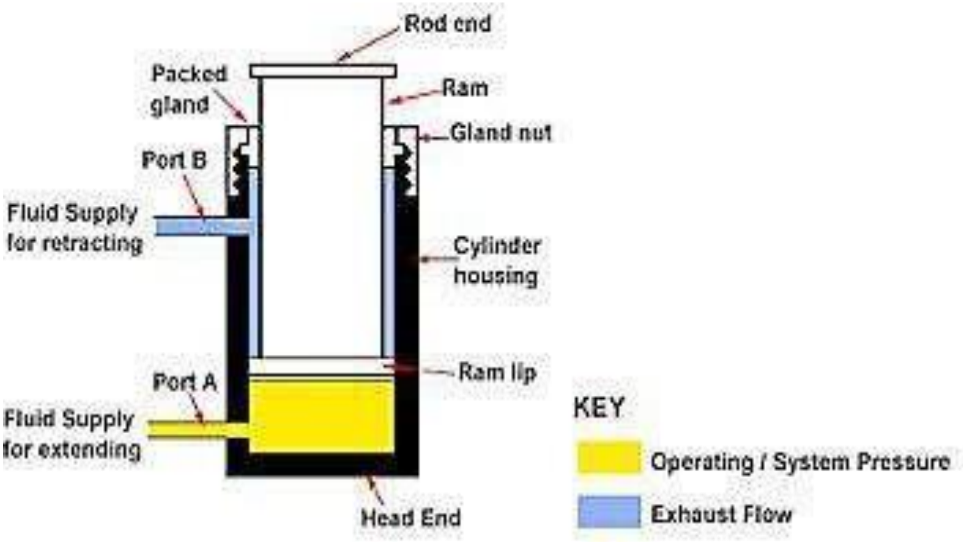


5.7.2OPERATIONOFDOUBLEACTINGCYLINDER

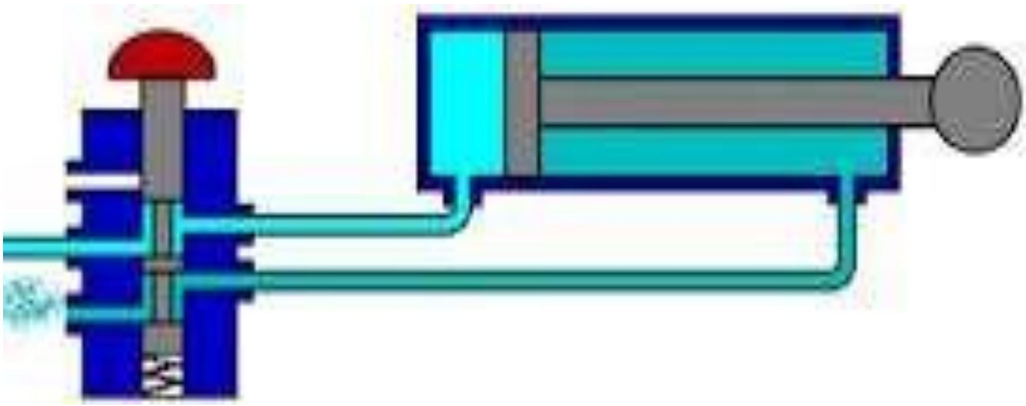
- Double acting hydraulic cylinder isalso onetype ofhydraulic cylinder which isused for pulling, lifting, movingandholdingtheload.Doubleactinghydrauliccylinder,asshown in figure, will have two ports i.e. cap end port and rod end port.
- Doubleactinghydrauliccylinder,asnameindicates,willbeoperatedhydraulicallyin both direction i.e. forward direction and return direction.

- Doubleactinghydrauliccylinderwillhaveone pistonwithinacylindricalhousing.When hydraulic oilwill be supplied to its cap end port, hydraulic pressure force will be applied over the piston or plunger and hence piston will be extended and this stroke of cylinder will be termed as forward stroke.

- Duringextensionofthecylinderpistonorplunger,hydraulicoilat rodendsidewillbe pushed out and will be directed towards reservoir.



- For returnstrokeorretractionofcylinder, hydraulicfluiddirectionwillbereversedwiththehelp of direction control valve.
- During return stroke, hydraulic oil will be supplied to its rod end port and therefore hydraulic pressure forcewillbeappliedoverthepistonorplunger fromrodendsideand hencepistonwill be retracted and this stroke of cylinder will be termed as return stroke.
- Duringretractionofthecylinderpistonorplunger,hydraulicoilat capendsidewillbepushed out and will be directed towards reservoir.



<u>Workingofdoubleactinghydrauliccylinder</u>

- Hencedoubleactinghydrauliccylinderswillbeoperatedhydraulicallyinbothdirections i.e. during extension or forward direction and also during retraction or return stroke. Direction of hydraulic oil will be changed with the help of double acting directional controlvalveorreversiblepumpcouldalso beusedforchangingthedirectionofflowof fluid.

5.7.3OPERATIONOFDOUBLEACTINGCYLINDERWITHMETERING IN AND METERING OUT CONTROL

METER-INCIRCUIT

With this circuit, a flow control valve is installed In a pressure line that leads to a work cylinder.Allflowenteringaworkcylinderisfirstmeteredthroughaflowcontrolvalve.Since this metering action involves reducing flow from a pump to a work cylinder, a pump must deliver more fluid than is required to actuate a cylinder at desired speed. Excess fluid returns to atankthroughareliefvalve. To conservepowerandavoidundue stressonapump, arelief valve's setting should be only slightly higher than a working pressure's, which a cylinder requires.

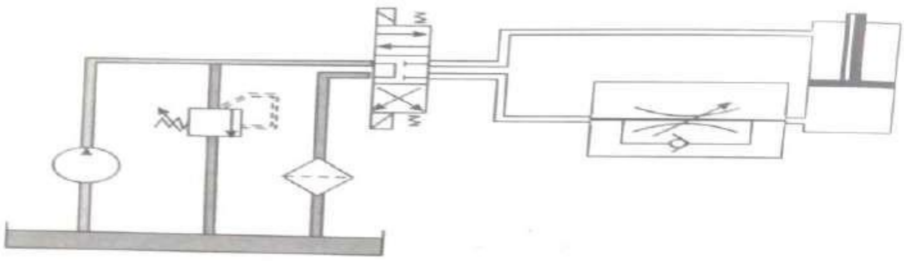
Application

A meter incircuit is idealin applicationswhere a load alwaysoffersa positive resistance to flow during a controlled stroke. Examples would be feeding grinder tables, welding machines, milling machines, and rotary hydraulic motor drives.

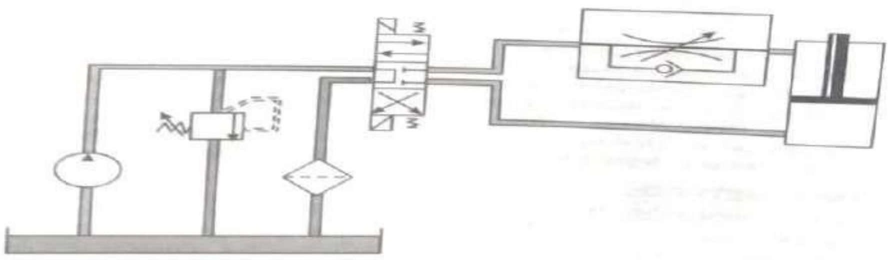
A flow controland check valve used in this type ofcircuit would allow reverse free flow for the return stroke of a cylinder, but it would not provide controlof return stroke speed.

Drawback

The meter in circuit is circuit is advantageous and accurate only for positive loads. For loads that are overrunning the actuator does not control the speed of extension. This overrunning load creates cavity and vacuum.



FLOW CONTROL VALVE TO CONTROL EXTENSION STROKE



FLOW CONTROL VALVE TO CONTROL RETURN STROKE

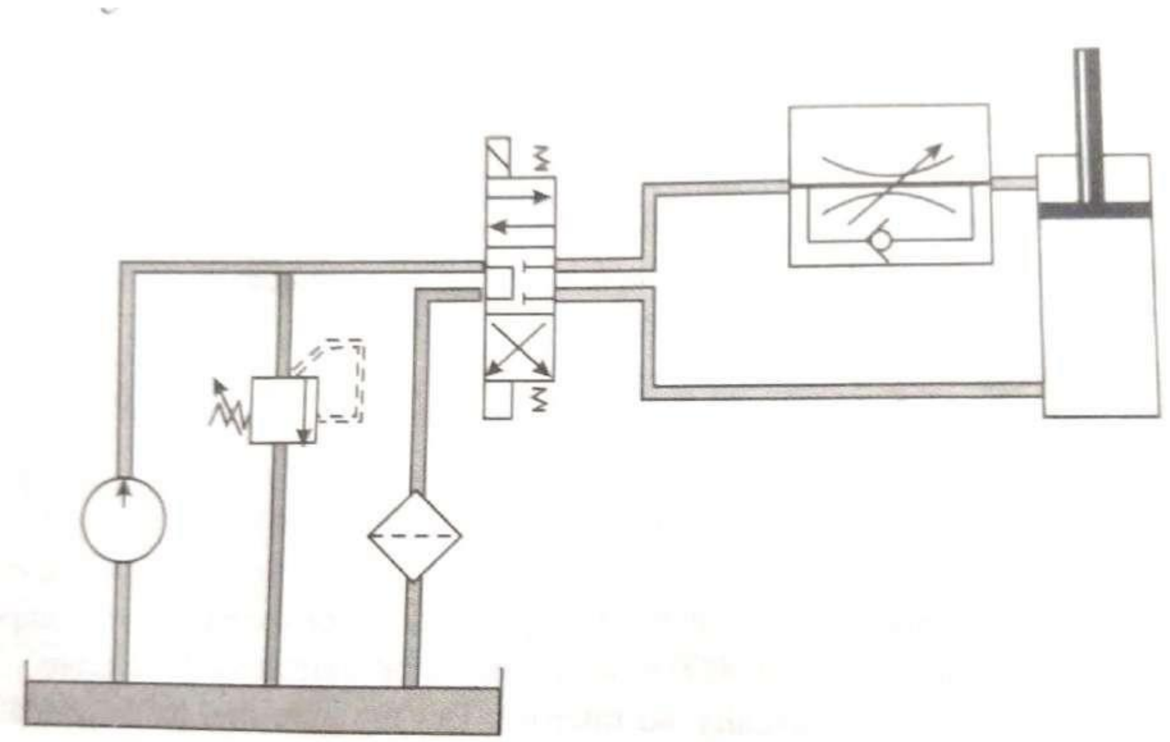
METER IN CIRCUITS

METER-OUT CIRCUIT

With meter-out circuit, a flow controlvalve is installed onthe returnside ofa cylinder so thatit controlsacylinder’sactuationbymetering itsdischargeflow.Areliefvalveisset slightly above the operating pressure that is requires by the type of work.

Application

Thistypeofcircuit isidealforoverhaulingloadapplicationsinwhichaworkloadtendstopull an operating piston faster than a pump’s delivery would warrant. Examples would be for drilling, reaming, boring, threading, tapping, cutting off and cold sawing machines. A flow control and check valve used in this circuit would allow reverse free flow, but it would not provide a control of return stroke speed.



The above circuit meters the oil coming from the Rod Side

METER-OUT CIRCUIT

Drawback

These types of circuits though they protect cylinder from overrunning, there is pressure intensification ifthe flow controlvalve is onthe rod side ofthe cylinder and this damages the rod seals.

Note

Have a close look at the positioning of the control valve and check valve in the meter-in and meter-out circuits. Only change would be in the waythe check valves are connected.

Bothmeter-inandmeter-outcircuitsareeffectivebutnotefficientastheexcesscontrolledflow passes through the relief valve back to the tank.

5.8COMPARISONOFHYDRAULICANDPNEUMATICSYSTEM

ISSUES	HYDRAULICSYSTEM	PNEUMATICSYSTEM
power	Hydraulic tools are more powerful,becausetheyuse pressurized liquid.	Can not deliver the same pressureespeciallywhenthe torqueisrequiredbecause if only uses pressurized air.
maintenance	Very little maintenance is required,asinternalpartsare always bathed in oil	Moremaintenanceisrequired including draining moisture fromairtanks,andconstantly keeping tools oiled.
noise	Hydraulictoolsarequiet.	Pneumatic tools are accompaniedbyloud compressor.
temperature	It will operate in sub-zero temperatures.Theywillnot freeze up.	Due to moisture in the air, pneumatictoolscanfreezeup.
cost	Abouttwicethecostof pneumatic tools.	Pneumaticsystemsischeaper and easier to construct.

Shortquestions

1. Whatisthefunctionofpump?

Ans-pumpisahydraulicdevicewhichconvertkineticoffluidintopressureenergy.

2. Whatthefunctionofhydraulicaccumulator?

   Ans- thefunctionofhydraulicaccumulatoris to storeenergyincaseofexcessenergy supply and release this energy when required

Longquestions

Explainabout followingdevices-

Hydraulicaccumulators
Pressurecontrolvalves
Pressurereliefvalves
Pressureregulationvalves
Directioncontrolvalves
3/2DCV,5/2DCV,5/3DCV
Flowcontrolvalves
Throttle valves
Fluidpowerpumps
Externalandinternalgear pumps
Vanepump
Actuators
Hydrauliccircuits
Directcontrolofsingleacting cylinder
Operationofdoubleactingcylinder
Operationofdoubleactingcylinderwithmeteringinandmeteringoutcontrol
Comparisonofhydraulicandpneumaticsystem
ISOSymbolsforhydrauliccomponents.