International Journal of Engineering Technology, Management and Applied Sciences

IJETMAS

www.ijetmas.com June 2017, Volume 5, Issue 6, ISSN 2349-4476

Design and Fabrication of Piston Operated Water Pump

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ABSTRACT

The technology of pneumatics has gained tremendous importance in the field of automation from old fashioned timber works, machine shops and space robots .Certain characterizes of air have made this medium quite suitable for used in modern manufacturing and production industries. It is therefore important that technicians and engineers should have knowledge on pneumatic systems air operated valves accessories. Pneumatic system consists of a compressor plant, pipe lines control valves and drive members. The air is compressed in an air compressor and from the compressor plant the flow media is transmitted to the pneumatic cylinder through a well laid pipe line system. So keeping in mind about the importance of pneumatic system are introducing a project called Automatic pneumatic water pumping system. Here all need is a compressor pneumatic cylinder, pneumatic cylinder, piston pump. The aim of the project is pneumatic operated piston water pump. The piston is reciprocated with the help of a pneumatic cylinder solenoid valve. There are two cylinders are used in this project, one for pneumatic cylinder and another one for hydraulic cylinder. This pumping system also can be used in pumping of water supply in agriculture lands, Industrial pumping and also in domestical applications.

1. INTRODUCTION

The aim of the project is pneumatic operated water pumping system. Radial plunger pneumaticoperated water pumping system are pump in which the piston is provided for the pumping action. The piston is reciprocated with the help of a pneumatic cylinder.

A pump is a Mechanical device which converts mechanical energy into hydraulic energy. This pump is classified into two types;

1.1 TYPES OF PUMP

i. Positive Displacement and

ii. Non-Positive Displacement pump

In positive displacement pump is the one, in which the liquid is transferred positively from one stage to another stge by the to and from motion of the plunger or piston of the pump .

In non-positive displacement pump the liquid is transferred by the centrifugal force. This force is cause due to the rotary movement of an impeller in this, our project, pneumatic water pump is of positive displacement pump. The salient features of a pneumatic water pump have been retained in our project model and this has been achieved with great care.

Due to high precision work involved in producing pneumatic water pump besides higher cost these pumps are not widely manufactured by most of the industries. The very name itself indicates that it works with the help of a piston. This piston is reciprocated with the help of a solenoid valve and electronic timing control unit.

1.2 RECIPROCATING PUMP

Reciprocating pumps are those which cause the fluid to move using one or more oscillating pistons, plungers or membranes (diaphragms).

To 'Reciprocate' means 'To Move Backwards and Forwards.Areciprocating pump therefore, is one with a forward and backward operating action.The simplest reciprocating pump is the 'piston Pump', which everyone at some time or other will have used to re-inflate their bike tyres.Reciprocating-type pumps require a system of suction and discharge valves to ensure that the fluid moves in a positive direction. Pumps in this category range from having "simplex"one cylinder, to in some cases "quad" four cylinders or more. Most reciprocating-type pumps are “duplex” (two) or "triplex" (three) cylinder.This type of pump was used extensively in the early days of steam propulsion (19th century) as boiler feed water pumps. Reciprocating pumps are now typically used for pumping highly viscous fluids including concrete and heavy oils, and special applications demanding low flow rates against high resistance.

Fig. 1.2 Reciprocating Pump

1.3 CENTRIFUGAL PUMP

Reciprocating pump is a positive displacement pump, which causes a fluid to move by trapping a Fixed amount of it then displacing that trapped volume into the discharge pipe. The fluid enters a pumping chamber via an inlet valve and is pushed out via a outlet valve by the action of the piston or diaphragm. They are either single acting; independent suction and discharge strokes or double acting; suction and discharge in both directions. During the suction stroke the piston moves left thus creating vacuum in the Cylinder. This vacuum causes the suction valve to open and water enters the Cylinder. During the delivery stroke the piston moves towards right. This increasing pressure in the cylinder causes the suction valve to close and delivery to open and water is forced in the delivery pipe. The air vessel is used to get uniform discharge.

Reciprocating pumps are selfpriming and are suitable for very high heads at low flows. They deliver reliable discharge flows and is often used for meteringduties because of constancy of flow rate. The flow rate is changed only by adjusting the rpm of the driver.

The piston pump is one of the most common reciprocating pumps and, prior to the development of high speed drivers which enhanced the popularity of centrifugals, it was the pump of choice for a broad range of applications. Today, they are most often seen in lower flow, moderate (to 2000 PSI) pressure applications. Its close cousin, the plunger pump, is designed for higher pressures up to 30,000 PSI.

The major difference between the two is the method of sealing the cylinders. In a piston pump the sealing system (rings, packing etc) is attached to the piston and moves with it during its stroke.

The sealing system for the plunger pump is stationary and the plunger moves through it during its stroke.

A centrifugal pump is of a very simple design. The two main parts of the pump are the impeller and the diffuser. Impeller, which is the only moving part, is attached.a shaft and driven by a motor. Impellers are generally made of bronze, polycarbonate, cast iron, stainless steel as well as other materials. The diffuser (also called as volute)converted to pressure by specially designed passageways that direct the flow to the discharge of the pump, or to the next impeller should the pump have a multi-stage configuration.

The pressure (head) that a pump will develop is in direct relationship to the impeller diameter, the number of impellers, the size of impeller eye, and shaft speed. Capacity is determined by the exit width of the impeller. The head and capacity are the main factors, which affect the horsepower size of the motor to be used. The more the quantity of water to be pumped, the more energy is required

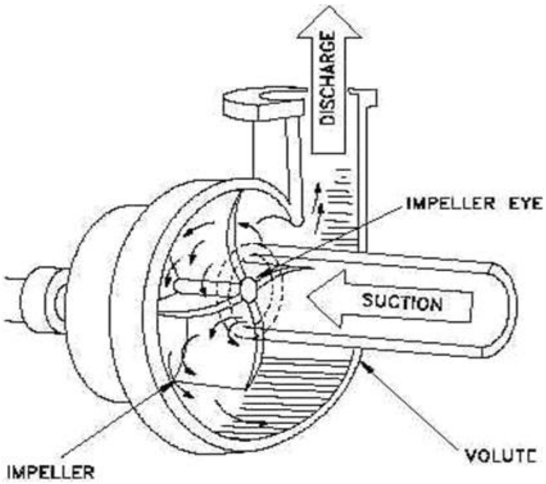

Fig. 1.3Centrifugal Pump

2. CONCEPTOF MECHANISM

The air is compressed in an air compressor and from the compressor plant the flow media is transmitted to the pneumatic cylinder through a well laid pipe line system. So keeping in mind about the importance of pneumatic system are introducing a project called Automatic pneumatic water pumping system. Here all need is a compressor pneumatic cylinder, connecting links and a control system. The aim of the project is pneumatic operated water pumping system, radial plunger pneumatic water pumping system are reciprocating pump is provided for the pumping action. The piston is reciprocated with the help of a pneumatic cylinder solenoid valve. There are two cylinders are used in this project, one for pneumatic cylinder and another one for hydraulic cylinder.

The two outlet ports are connected to an actuator (Cylinder). The pneumatic activates is a double acting, single rod cylinder. The cylinder output is coupled to further purpose. The piston end has a water horning effect to prevent sudden thrust at extreme ends. The end of the cylinder two Non return valve is connected for both of the side. One Non return valve for suction side and another one non return valve are for delivery side.

2.1 WORKING PRINCIPLE

These pumps deliver a highly pulsed flow. If a smooth flow is required then the discharge flow system has to include additional features such as accumulators. An automatic relief valve set at a safe pressure is used on the discharge side of all positive displacement pumps.

The performance of a pump is characterized by its net head h, which is defined as the change in Bernoulli head between the suction side and the delivery side of the pump. h is expressed in equivalent column height of water.

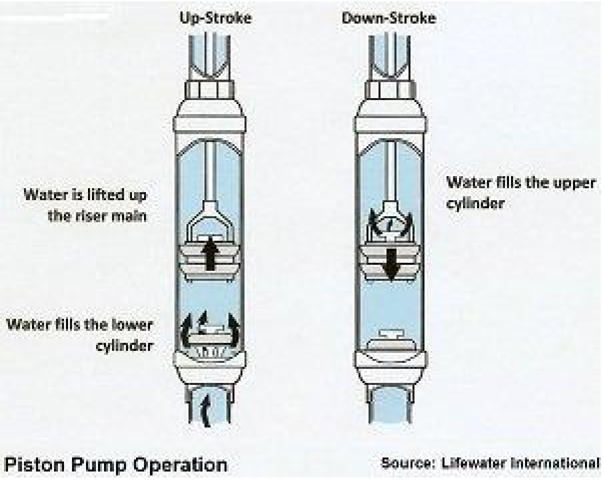

Fig.2.1DIAPHGRAM PUMP

A reciprocating pump is a class of positive-displacement pumps which includes the piston pump, plunger pump and diaphragm pump. When well maintained, reciprocating pumps will last for years or even decades; however, left untouched, they can undergo rigorous wear and tear.

2.2SINGLE ACTING CYLINDER

Single-acting cylinders (SAC) use the pressure imparted by compressed air to create a driving force in one direction (usually out), and a spring to return to the "home" tion. More often than not, this type of cylinder has limited extension due to the space the compressed spring takes up. Another downside to SACs is that part of the force produced by the cylinder is lost as it tries to push against the spring.

One major issue engineers come across working with pneumatic cylinders has to do with the compressibility of a gas. Many studies have been completed on how the precision of a pneumatic cylinder can be affected as the load acting on the cylinder tries to further compress the gas used. Under a vertical load, a case where the cylinder takes on the full load, the precision of the cylinder is affected the most. A study at the National Cheng Kung University in Taiwan, concluded that the accuracy is about ± 30 nm, which is still within a satisfactory range but shows that the compressibility of air has an effect on the system

2.3DOUBLE ACTING CYLINDER

Double-acting cylinders (DAC) use the force of air to move in both extend and retract strokes. They have two ports to allow air in, one for outstroke and one for instroke. Stroke length for this design is not limited, however, the piston rod is more vulnerable to buckling and bending. Additional calculations should be performed as well.Oninstroke, the same relationship between force exerted, pressure and effective cross sectional area applies as discussed above for outstroke. However, since the cross sectional area is less than the piston area the relationship between force, pressure and radius is different. The calculation isn't more complicated though, since the effective cross sectional area is merely that of the piston surface minus the cross sectional area of the piston rod.

2.4MULTI STAGE TELESCOPING CYLINDER

Telescoping cylinders, also known as telescopic cylinders can be either single or double-acting. The telescoping cylinder incorporates a piston rod nested within a series of hollow stages of increasing diameter. Upon actuation, the piston rod and each succeeding stage "telescopes" out as a segmented piston. The main benefit of this design is the allowance for a notably longer stroke than would be achieved with a single-stage cylinder of the same collapsed (retracted) length. One cited drawback to telescoping cylinders is the increased potential for piston flexion due to the segmented piston design. Consequently, telescoping cylinders are primarily utilized in applications where the piston bears minimal side loading

In a momentum transfer pump, gas molecules are accelerated from the vacuum side to the exhaust side (which is usually maintained at a reduced pressure by a positive displacement pump). Momentum transfer pumping is only possible below pressures of about 0.1 kPa. Matter flows differently at different pressures based on the laws of fluid dynamics. At atmospheric pressure and mild vacuums, molecules interact with each other and push on their neighboring molecules in what is known as viscous flow. When the distance between the molecules increases, the molecules interact with the walls of the chamber more often than with the other molecules, and molecular pumping becomes more effective than positive displacement pumping. This regime is generally called high vacuum.

Molecular pumps sweep out a larger area than mechanical pumps, and do so more frequently, making them capable of much higher pumping speeds. They do this at the expense of the seal between the vacuum and their exhaust. Since there is no seal, a small pressure at the exhaust can easily cause backstreaming through the pump; this is called stall. In high vacuum, however, pressure gradients have little effect on fluid flows, and molecular pumps can attain their full potential.

The two main types of molecular pumps are the diffusion pump and the turbomolecular pump. Both types of pumps blow out gas molecules that diffuse into the pump by imparting momentum to the gas molecules. Diffusion pumps blow out gas molecules with jets of oil or mercury, while turbomolecular pumps use high speed fans to push the gas. Both of these pumps will stall and fail to pump if exhausted directly to atmospheric pressure, so they must be exhausted to a lower grade vacuum created by a mechanical pump.

As with positive displacement pumps, the base pressure will be reached when leakage, outgassing, and backstreaming equal the pump speed, but now minimizing leakage and outgassing to a level comparable to backstreaming becomes much more difficult.

Fig 2.2PNEUMATIC CYLINDER

2.6 ENERGY LOSSES IN PIPE FITTINGS

When a fluid flows through a pipe line consisting of straight pipe and fittings, there is a definite loss of pressure due to friction, This loss of head is often considerable and has been investigated many times.There two types of

Energy losses.

- Major energy losses
- Minor energy losses
  - sudden expansion
  - sudden contraction
  - bond in pipe
  - pipe fitting
  - An obstruction in pipe

2. 7 SELECTION OF PNEUMATICS

Mechanization is broadly defined as the replacement of manual effort by mechanical power. Pneumatic is an attractive medium for low cost mechanization particularly for sequential (or) repetitive operations.

Many factories and plants already have a compressed air system, which is capable of providing the power (or) energy requirements and the control system (although equally pneumatic control systems may be economic and can be advantageously applied to other forms of power).

The main advantage of an all pneumatic system are usually economic and simplicity the latter reducing maintenance to a low level. It can also have out standing advantages in terms of safety.

2.8 THE SIZE (INSIDE DIAMETER) OF THE PIPE

Smaller pipe causes a greater proportion ofthe water to be in contact with the pipe, which creates friction. Pipe size also affects velocity. Given a constant flow rate, decreasing pipe size increases the water's velocity, which increases friction.

2.9 THE ROUGHNESS OF THE INSIDE OF THE PIPE

Pipe inside wall roughness is rated by a"C" factor, which is provided by the manufacturer. The lower the C value, the rougher the inside and the more pressure loss due to friction

2.9.1FABRICATED MODEL DIAGRAM

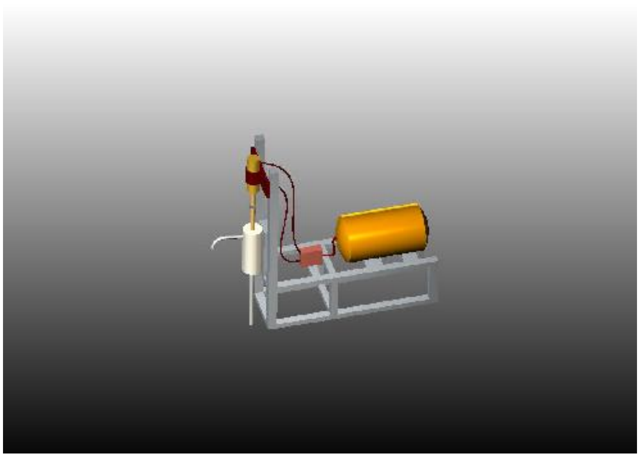

Fig 2.3FABRICATED DIAGRAM

3. RESULTS AND DISCUSSION

3.1 SPECIFICATIONS

Pumps are commonly rated by horsepower, flow rate, outlet pressure in feet (or metres) of head, inlet suction in suction feet (or metres) of head. The head can be simplified as the number of feet or metres the pump can raise or lower a column of water at atmospheric pressure. From an initial design point of view, engineers often use a quantity termed the specific speed to identify the most suitable pump type for a particular combination of flow rate and head.

Positive displacement designs are the ones which deliver a fixed amount of flow through the mechanical contraction and expansion of a flexible diaphragm. These pumps are ideal in many industries that manage high viscosity liquids, or where sensitive solids are also present. Recommended water pumps to be used for low flow and high-pressure combination or other applications.

Positive displacement water pumps or rotary pump are very efficient, due to the fact that they remove air from the lines, thus eliminating the need to bleed the air from the lines.In addition, these pumps are great when dealing with high viscosity liquids.

As any equipment, positive displacement water pumps also present some drawbacks. These types of pumps require that the clearance between the rotating pump and the outer edge must be very close. This causes that the rotation occurs at very slow speeds; otherwise, if the pump is operated at higher speed, the liquids might erode and will eventually reduce the efficiency of the water pump

There are two general types of water pumps: centrifugal pumps and positive displacement design type. Both types follow the same purpose, which is to move water from one point to another continuously. These two major components have a wide variety of options that might be used depending on your project specific needs

3.2 PUMP MATERIAL

Pump material can be of Stainless steel (SS 316 or SS 304) , cast iron etc. It depend upon the application of pump. In water industry for pharma application, SS 316 is normally used. As at high temperature stainless steel give better result.This column presents a discussion between myself and pump users regarding some of their questions, concerns and preferences about materials of construction that they consider for their applications. Some of this feedback comes from previous articles published in Pumps &Systems.I enjoyed your recent article about using a specialty material to help improve the efficiency and reliability of a multistage pump. I was interested in your selection of the Graphalloy material. I have used Vespel CR6100 to reduce running clearances for efficiency gains and rotor stability improvements. Do you have experience using Vespel? If so, what comparisons can you make between this and Graphalloy? When would you recommend one over the other? Any experiences you can share would be greatly appreciate.

A great multitude of materials can be used for pump bushings, including metals (bronze, hardened steels), hard coatings, non-metals (thermoplastics, thermosets, composites) and ceramics. All have benefits and shortcomings, such as resistance to temperature, thermal or mechanical shock, machinability, galling resistance, dimensional stability, swelling, chemical resistance, abrasive resistance and price.

It would be good to have a three-dimensional tabulation listing these materials on one column (say, horizontal), versus properties on the other (vertical), and application (pumped fluid) inside the table, for some sort of visual pick-and-choose guide. I am not aware of such table.

In practice, it is difficult to select an all-around best choice. The main reason is unfamiliarity of the end users with the multiple products that exist and users being cautious against over-zealous salesman trying to sell them a bushing material for their application which may not be appropriate for what they pump.

3.3 PUMPING POWER

The power imparted into a fluid will increase the energy of the fluid per unit volume. Thus the power relationship is between the conversion of the mechanical energy of the pump mechanism and the fluid elements within the pump. In general, this is governed by a series of simultaneous differential equations, known as the Navier-Stokes equations.

However a more simple equation relating only the different energies in the fluid, known as Bernoulli's equation can be used. Hence the power, P, required by the pump

where ΔP is the change in total pressure between the inlet and outlet (in Pa), and Q, the fluid flowrate is given in m^3/s. The total pressure may have gravitational, static pressure and kinetic energy components; i.e. energy is distributed between change in the fluid's gravitational potential energy (going up or down hill), change in velocity,or change in static pressure. η is the pump efficiency, and may be given by the manufacturer's information.

3.4 PUMP CAPACITY,

Q = Volume of liquid delivered by pump per unit time,m/sec

Q is proportional to N, where N- rotational speed of the pump

3.5 TOTAL DEVELOPED HEAD,

h = The difference of discharge and suction pressure 99

The pump head represents the net work done on unit weights of a liquid in passing from inlet of the pump to the discharge of the pump.

There are three heads in common use in pumps namely 1. Static head 2. Velocity head3. Friction head.

The frictional head in a system of pipes, valves and fittings varies as a function (roughly as the square) of the capacity flow through the system.

3.6PUMP EFFICIENCY

To determine pump efficiency, three key parameters are required: Flow, Head andPowerOf these, flow measurement is the most crucial parameter as normally online flow meters arehardly available, in a majority of pumping system. The following methods outlined below canbe adopted to measure the flow depending on the availability and site conditions.Fluid power and useful work done by the pump divided by the powerinputin the pump shaft

PUMP EFFICIENCY= $\frac{\text{H} \quad \text{P(} \quad \times 1}{\text{P(} \quad \text{I]} \quad \text{T} \quad \text{T} \quad \text{P|} \quad \text{S}}$

WHERE,

P_h=Hydraulic power

HYDRAULIC POWER

$P_h(kw)=[Q\times(H_d-h_s)\times\rho\times g]/1000$

WHERE,

- Q=Volume flow rate (m^3/s),
- P=Density of fluid (kg/m^3),
- G= Acceleration due to gravity(m^3/s)
- (h_d-h_s)=total head in metres

3.6.1DETERMINATION OF TOTAL HEAD,

3.6.1.1 SUCTION HEAD (h)

This is taken from the pump inlet pressure gauge readings and the value to be converted in to meters (1kg/cm2 s = 10. m). If not the level difference between sump water level to the centerline of the pump is to be measured. This gives the suction head in meters.

3.7 DISCHARGE HEAD

This is taken from the pump discharge side pressure gauge. Installation of the pressure gauged in the discharge side is a must, if not already available.

3.8 TROUBLESHOOTING PUMP PROBLEMS

3.8.1 PUMP FAILS TO DELIVER REQUIRED CAPACITY

- air leaking into pump
- liquid cylinder valves, seats, piston packing, liner, rods.
- pump not filling
- makeup in suction tank less than displacement of pump
- capacity of booster pump less than displacement of power pump
- vortex in supply tank
- one or more cylinders not pumping
- suction lift too great
- broken valve springs
- stuck foot valve
- pump valve stuck open
- clogged suction strainer
- relief, bypass, pressure valves leaking
- internal bypass in liquid cylinder

3.8.2 SUCTION AND/OR DISCHARGE PIPING VIBRATES

- piping too small and/or too long
- worn valves or seats
- piping inadequately supported

3.8.3 PUMP VIBRATES

- gas in liquid
- pump not filling
- one or more cylinders not pumping

3.9 DESIGN CALCULATION

Maximum pressure applied in cylinder (P)=10 bar

PNEUMATIC CYLINDER

Diameter of pneumatic cylinder = 80mm = 8 cm Applied pressure = 5 bar

= 50 N /cm2

Stroke length(L) = 160mm

Piston rod dia (d) = 25mm = 2.5 cm

FORWARD STROKE FOR DOUBLE ACTING CYLINDER

Force (F) = π4×D2×P = π4× (8)2×50 = 2513.27 N

RETURN STROKE FOR DOUBLE ACTING CYLINDER

Force (F) = π4× (D2-d2) ×P = π4× (82-2.52) ×50

= 2267.83 N

HYDRAULIC CYLINDER

Diameter of hydraulic cylinder (D) =56mm =5.6cm

Stroke length =160mm

Piston rod dia (d) =25mm =2.5 cm

F= 2513.27 N (forward stroke for double acting cylinder)

F=2267.83 N(return stroke for double acting cylinder)

We know that F= A×P

P=F/A = (4×2513.27)×5.62 = 102.04 N/cm^2

=10.2 Bars (forward stroke)

We know that F= A×P

P=F/A = (4×2267.83)×(5.62−2.52)

=114.99 N/cm^2 =11.4 bars (return stroke)

Velocity of water flow from hydraulic cylinder

Pressure developed in hydraulic cylinder (p) = 10×104 kg/m^2

Radius of hose pipe = 4mm = 4×10^{-3} m

We know that force (F) =p ×A

= 10×104 × π × (4×10^{-3})^2 = 5.026 kg

We know that force (F) =M×A

Here M=mass of the piston = 0.3 kg;

a = acceleration

There Fore Acceleration (a) =F/M = (5.026)/ (0.3) =16.753 m/sec^2

HEAD OF WATER RAISED

Pressure (P) =ρgh

Here (h) =head of water raised

Therefore (h) =P/ρg= (**10**×**104**)(**103**×**10**)= 10mts

DISCHARGE OF WATER FROM HYDRAULIC CYLINDER

We know that velocity (V) =L×N

Where L=stroke length =160×10^{-3}mts

N= number of strokes per minute

Therefore N=VL =2.315160×10^{-3} =14.468 strokes/sec

=868.12 strokes/minute

Discharge (Q)=A×L×N60

= π/4×(56×10^{-3})^2 × 160×10^{-3}×(868.12)60

=0.0057m^3/sec

WORKDONE BY HYDRAULIC CYLINDER

Work done (W) $=\rho g\times ALN$ $60\times(hs+hd)$

Here hs=suction head = 0

hd= discharge head = 10 m

$Q=103\times10\times\pi^4\times$ $(56\times10^{-3})^2$ $\times$ $160\times10^{-3}\times$ $(868.12)/60\times$ $(0+10)$ = 570.18 watt

- excessive pump speed
- worn valves or seats
- broken valve springs
- loose piston or rod
- unloaded pump not in synchronism
- loose or worn bearings
- worn crossheads or guides

3.10TURNING

Turning is a machining process in which a cutting tool, typically a non-rotary tool bit, describes a helix toolpath by moving more or less linearly while the workpiece rotates. The tool's axes of movement may be literally a straight line, or they may be along some set of curves or angles, but they are essentially linear (in the non mathematical sense).

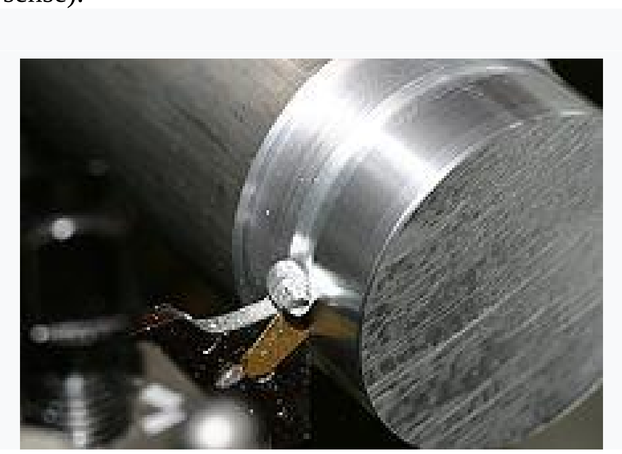

Fig3.1:TURNING PROCESS

3.11 WELDING

The manufacture of virtually all sophisticated modern products involves joining together many individual components. Where a permanent join is required, welding is often a good option. Other possible processes such as brazing, soldering, and use of adhesives will are considered in the Design module.

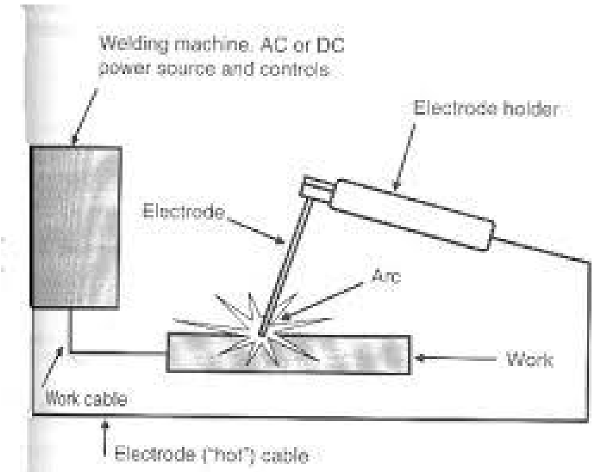

FIG 3.2:WELDING PROCESS

3.12 ADVANTAGES

- This is of compact in size
- .Less Maintenance is enough
- The oil or water pumped is of higher pressure
- Quite running and smooth operation is achieved.
- Higher efficiency
- Full efficient positive displacement pump
- Effective working principle
- It does not have any Prime mover, like electric motor related to the unit.
- As the air is freely available, we can utilize the air to pumping the water and hence it is economical.
- Less Maintenance.

4. CONCLUSION

It is concluded that, this system is very useful in the area where there is less amount of electricity is available. By using less amount of electricity we can able to suck the water from the ground by this system. By increasing the pressure can able to raise the head of water with less amount of electricity than the motors which use for sucking of water from ground.

In this system the discharge of water increases with increase in pressure but takes less amount of electricity as compared to electric motors which depends upon electricity for increase in discharge of water i.e. discharge of water increases by increasing of electricity consumed. But only things take care in this system is about the leakages.

4.1 BILL OF MATERIALS

NAME OF THE PRODUCT	QUANTITY (Nos)	COST (Rs)
CLINDER	1	1200
FRAME MATERIAL	Solid Rods Of Different Sizes	1000
PIPE FITTINGS	3 -90 Elbows 5-Sraight Pipes	250 250
SOLENOID VALVE	1	250
PNEUMATIC CYLINDER	1	1500
PAINT	1 Litre	275
OTHER EXPENCES	Transportation And Assemly	1800
TOTAL	Six Thousand Five Hundred And Twenty Five	6525

Table 4.1 Bill of Materials

REFERENCES

1. Atul.P.Ganorkar, K.S.Zakiuddin, H.A.Hussain, “An Experiment on Development of Pedal Operated Water Pump”, IOSR, e-ISSN:2278-1684,(2014).
2. Vishal Garg, NeeleshKhandare, GautamYadav, “An Experimental Setup and Design of Pedal Powered Water Pump”, International Journal of Engineering Research and Technology (Vol.2, Issue.1)(2013).
3. Ademola Samuel Akinwonmi, Stephen KwasiAdzimah, Fredrick Oppong, “An Experiment on Pedal Powered Centrifugal Pump for Purified Water Supply Device” ISDE (Vol.3, No.11) (2012).
4. Bryan Lee, “A Design of Simple Human Powered Water Pump”, International Journal of Technology(2007).