Understanding Centrifugal And Diaphragm Pumps, And Hydraulic Systems

These (Asdal, 1997)are mechanical devices or equipment that are designed to mechanically pump fluids that is gases and liquids and sometimes slurries from one point to another. They are made of different components arranged in different forms making them to vary in their variety and how they work. These components are; the impeller, the shaft and seal, the motor, the backing plate and the casing. These components work together in bring the functionality of the pump system which are vital mechanical tools that are largely used around the world in different sectors of the economy. The most common pumps (VWS Westgarth wins SRP system contract, 2010) are water pumps which help in conveying water around buildings or from the source to the storage vessels and harvesting water from underground. However, they are classified into dynamic pumps and displacement pumps based on how they respond to change in discharge pressure as they function. This report focuses majorly on the centrifugal pump which is a perfect example of dynamic pumps. It however extends and elaborates an example of a displacement pump to outline the differences between them.

Centrifugal pumps (70 years of Bungartz special centrifugal pumps, 2017) consist open type impellers which rotates in a housing or casing that is a volute from which a discharge pipe is fixed. The impellers produce a relatively low pressure compared to closed type impeller hence its application in the centrifugal pumps which are moistly for water pumping, less viscous fluid. It is then connected to a motor that uses electricity to rotate the impeller inside the volute. The water or any other fluid enters the rotating impeller at a low pressure to the center of the impeller, the eye. Here, it is collected and rotated in the volute by the impeller’s shafts making it to accelerate radially until it gains maximum speed at which the shafts are moving, it is then discharged to the discharge pipe at a high pressure than it came in leaving the volute empty and with a low pressure around the shafts. Due to low pressure inside the casing (volute) the water or any other fluid enters again and the process repeats. These keeps a continuous flow of the fluid being pumped.

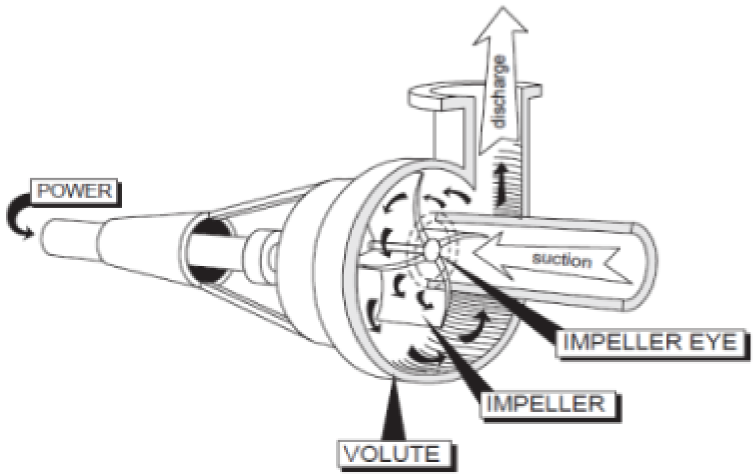
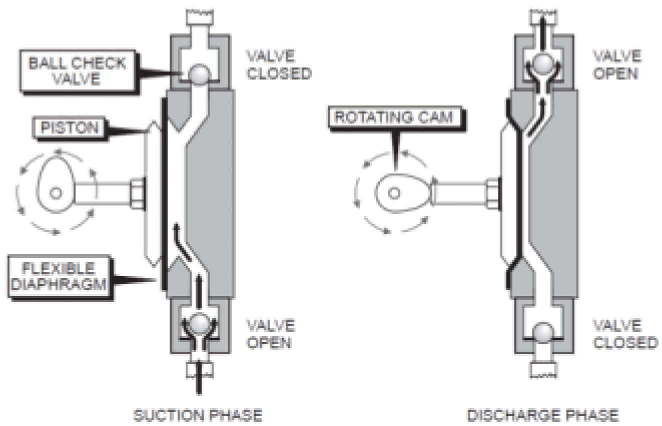


Image of a centrifugal pump system and its components.

1. Transfer –centrifugal pumps (Reliable centrifugal pumps, 2007) are used in the transportation of water from the source to storage tanks and from treatment plant to distribution systems.
2. Processing – these pumps are suitable for with low viscous fluids which can tolerate high flow rates without degrading in quality hence they are used in the industrial transfer of chemicals, paints in paint industries, hydrocarbons, sugar refining industries, pharmaceuticals and petrochemical industries.
3. Cleaning –they are used in transferring cleaning medium to surfaces and agents from the storage components of the medium in industries and large-scale cleaning requirements. Such industries include metal cleaning industries, bottle cleaning, crates cleaning and vehicle washing industries.
4. Irrigation – here, they are used in pumping water from reservoirs, streams, and wells. In addition, they are used as booster pumps in the irrigation pipelines especially where water is to be pumped over long distances.
5. Feed pumps. –they are usually connected to feeder pipes especially in residential supply of water to boost the flowrate of water as it circulates around the buildings.
6. Filtration process – they are used in petrochemical industries to pump out less viscous petrol elements leaving behind high viscous one which need to be channeled into other processes for further refinery.

On the other hand, the most common positive displacement pump (Reciprocating displacement pumps, 2002) is a diaphragm pump which is used in fluoride solutions and chlorine. It is driven mechanically by electricity and is made up of a chamber that I used to pump fluid and two valves (a suction valve and a discharge). Its diaphragm is pulled to create a vacuum forcing the discharge valve to close thus lowering the pressure in the volute. The high atmospheric pressure on the outside forces the fluid to enter through the suction valve which opens due to high atmospheric pressure on the outside. When the diaphragm is pushed back, the increased pressure in the chamber forces the suction valve to close and the discharge valve opened allowing the fluid to flow out and the process starts over again.

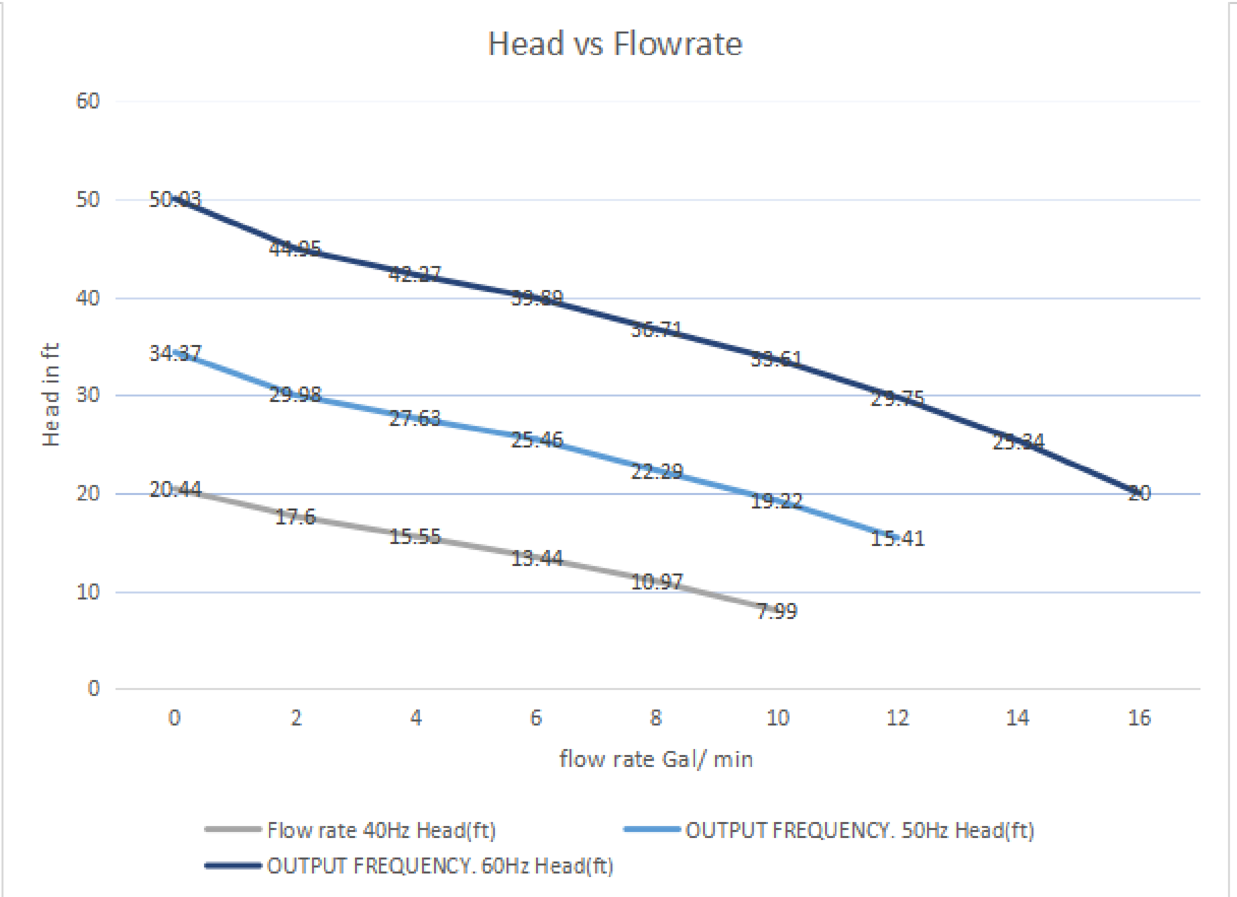


A simple diagram of a diaphragm pump.

1. They are used in water treatment industries for metering precise amount of liquids to be used in the treatment of drinking water, boiler water and swimming pool water.
2. They are also applied in pumping fluids in industries that deal with corrosive(Diaphragm pumps for hazardous liquids, 2017) chemicals, volatile solvents, viscous fluids, sticky fluids and abrasive slurry oils and gels. These because they can handle all types of fluids that is the viscous and less viscous fluids which require low pressure application as they flow at a low flow rate.

Flow rate			OUTPUT FREQUENCY.			
Gal US/min	40Hz		50Hz		60Hz	

	Pressure(psi)	Head(ft)	Pressure(psi)	Head(ft)	Pressure(psi)	Head(ft)
0	8.85	20.44	14.88	34.37	21.66	50.03
2	7.62	17.6	12.98	29.98	19.46	44.95
4	6.73	15.55	11.96	27.63	18.3	42.27
6	5.82	13.44	11.02	25.46	17.27	39.89
8	4.75	10.97	9.65	22.29	15.89	36.71
10	3.46	7.99	8.32	19.22	14.55	33.61
12			6.67	15.41	12.88	29.75
14					10.97	25.34
16					8.66	20



From the observation of the performance of the system on the graph above, it's clear that increase in the head value leads to a corresponding increase in the flow rate of the fluid being pumped. The higher the volume of the fluid the greater the pressure hence a corresponding increase in its flow rate. Similarly, with a higher output efficiency, the system's frequency increases.

Conclusion.

In summary, pressure and force are therefore observed to be directly related. Thus, increase in pressure produced corresponding force, however this depends on the viscosity of the fluid in use as a less viscous fluid is more effective as it transmits the pressure instantaneously compared to a less viscous fluid.

Hydraulic systems (YU, 2015)refer to systems that use enclosed pressurized incompressible fluid as a medium of transmission of energy to provide both linear and rotary motion. They mainly work on Pascal's principle applied in the design of their components. This part provides an overview of how active and passive components of any hydraulic system work together to transmit power thus hydraulic energy to mechanical energy required to drive other systems. Active components include hydraulic pumps, control valves and the actuators while on the other hand passive components includes fluid contactors and storage containers. Each component is vital to the system as they all contribute to the manipulation of pressurized hydraulic fluid for other systems to work. Their operation and components are extensively described in the following section of the report based on a configured hydraulic circuit which are largely used in industries to transmit power and operate machines such as vehicles as well in stationary machines like jerks.

Operation of a configured hydraulic circuit.

As discussed in the introductory part, the circuits transmit and control power from mechanical input to mechanical output via fluid (TAN, 2008). Hydrostatically high pressure makes the static forces to dominate over dynamic forces hence energy is transmitted. These circuits, however are made up of the following components which are connected to each other through pipes and direct connections to enable transmission and control of the fluid and power produced. It is through the description of the components and how they work that we get to understand to the circuit fully operates. These components are; -

Electric motor

They are electrical devices (Mahov et al., 2020) that are driven by electricity to convert the fluid pressure from pressurized fluid coming from the pump at a high pressure into rotary motion energy. This happens when the pressurized fluid pressure turns the shafts on the motor by pushing the gears and pistons which results to torque force sufficient enough to drive the applied system that is the actuators on the hydraulic system.

Pumps

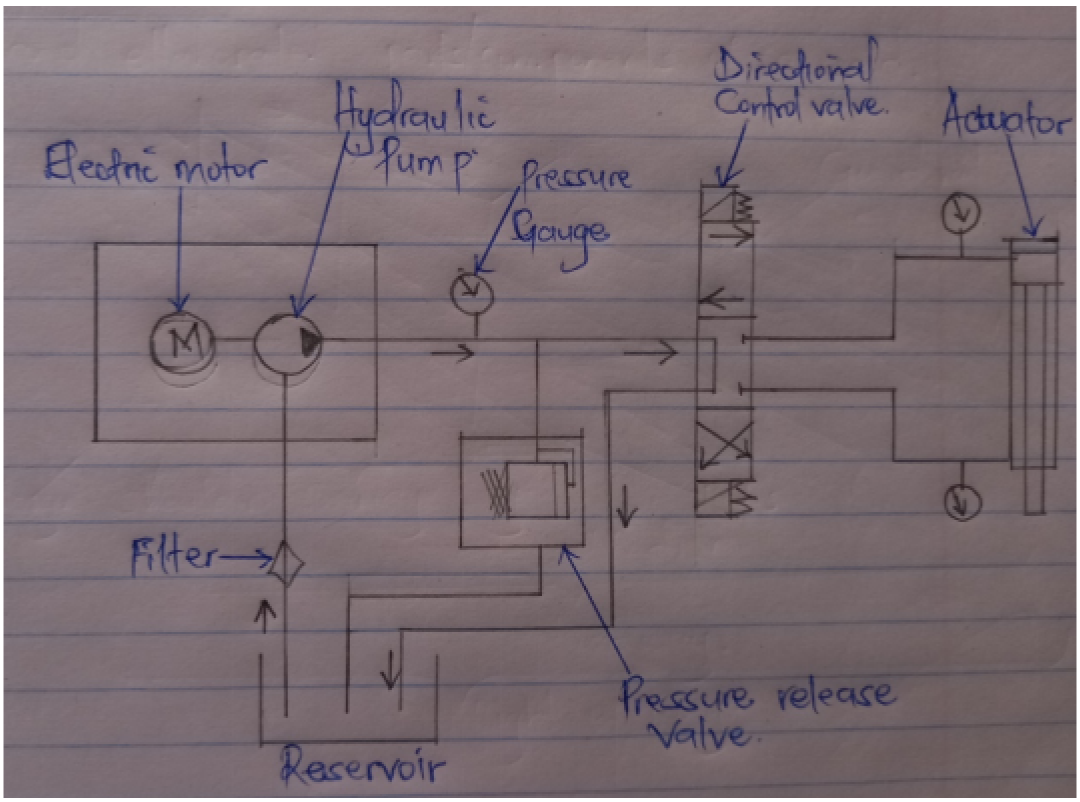
Pumps convert electrical energy into fluid pressure with the help of an electric motor. The fluid pressure produced is then delivered through cylinders to the motors and actuators in required volumes and controlled pressure. This process is usually necessary for all hydraulic pumps to be driven as well as the applied system.

They are used to measure the pressure of the fluid at different stages in the circuit as the system is usually designed to work in given set of pressure conditions. They are necessary to ensure that there are no leaks of the fluid medium and that the system works within the required conditions.

They control the flow of the fluid into and out of the cylinders. They are necessary for the flow path of the fluid from the pump to the reservoir and vice versa.

Flow control valves regulate the flow rate of the hydraulic fluid in the system thus controlling the speed of the applied component.

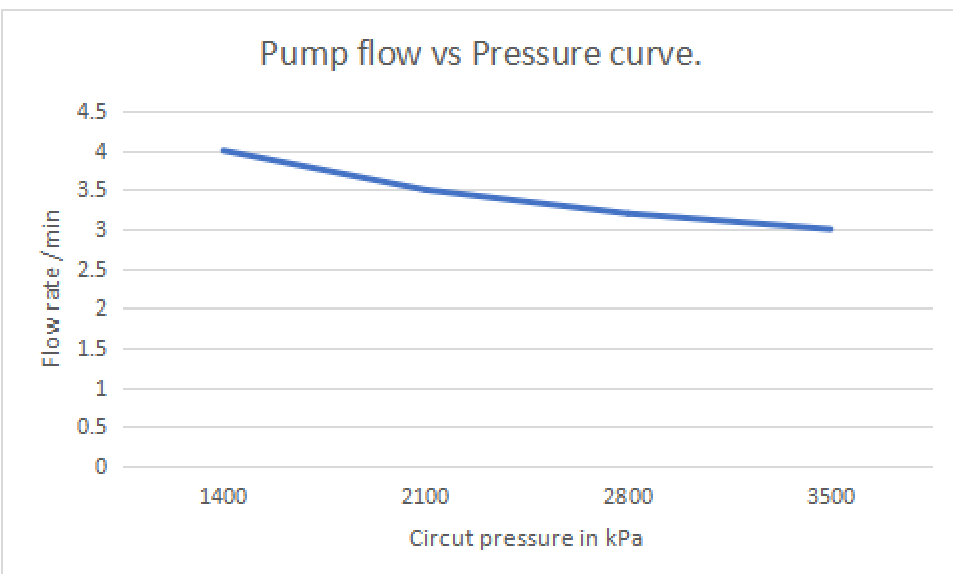
They convert hydraulic energy into mechanical energy which is useful for driving other components or the system in which they are applied. They are usually fitted with highly incompressible fluid so as to respond instantaneously upon compression by the applied pressure thus transmitting it immediately to the attached system.



A diagram of a hydraulic circuit with standard symbols.

Circuit pressure gauge A (kPa)	Flow rate l/min	Pressure at gauge B (kPa)	Pump output power	power dissipated by valve (W)

			(W)		
1400	4	75	93.33	88.3	
2100	3.5	75	122.5	118.1	
2800	3.2	75	149.33	145.3	
3500	3	75	175	171.3	



From the graph, the flowrate increases with increase in circuit pressure. This implies that when the fluid in the system is pumped at a high pressure, it flows at a high velocity which results to high pressure in the circuit. These could consequently produce a large force which drives the machine or the applied component more efficiently. This is however controlled by the level at with the fluid is compressed.

Conclusion.

As discussed, the system therefore needs to be filled with a more incompressible fluid for the system to work efficiently in transmitting the energy from one form to another.

These are measures that helps to improve the operation of hydraulic motors (Antonino-Daviu, 2020). Since they all work together for, that means that damage or failure in one component could cause failure of the whole system hence each component should be checked regularly and ensured that they are in the right conditions for them to perform their functions on the system. This maintenance measures include; -

Keep contaminants out of your hydraulic system. Clean the area around dipsticks, fill plugs and hydraulic filters before removing them to check or change the hydraulic fluid. Keep all fluid containers tightly sealed when stored and pour directly from the container into the system.

Change the fluid and filter after the initial 50 hours of use. Often, the manufacturing process allows contaminants to enter the hydraulic system. A fluid change after 50 hours will eliminate these particles. Thereafter, change hydraulic fluid and filters at regular intervals as recommended in the technical manual or shortened intervals dictated by the operating environment.

Check oil before each use. Verify that fluid levels are adequate and that the fluid is in good condition. An inadequate amount of oil can cause severe damage to pumps. If your oil appears foamy or milky, you may have a leak that is causing air to enter the system. Air will cause jerky and slow operation of the hydraulics. Locate and seal the source of any leak.

Regularly check the temperature of the hydraulic fluid during operation. Ensure the temperature of the oil is as required and that it is not burnt. Always check the hydraulic cooler and reservoir and ensure that they are clean and free from debris.

Check the pumps externally and also listen to cavitation from the inside which results from the pump not receiving enough amount of oil from the reservoir.

Maintain clean fluid to keep the valves in good condition as dirty oil carries debris which can clog at the valves making them ineffective

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