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A CASE STUDY ON PUMP OF HYDRO PNEUMATIC BOOSTER SYSTEM

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ABSTRACT

Water pressure is one of the major problems in domestic, agriculture and industrial sector. For boosting pressure in houses, high-rise buildings and all other purposes, hydro pneumatic pump are used. Maintaining a set pressure level, these pumps are highly energy efficient.In simple words, the main function of the hydro pneumatic pump is to manage or boost inadequate supply pressure to a higher consistent value so that a nonstop water supply is made available. The Hydro pneumatic pumps are designed with single or multiple pumps to provide constant water pressure and it consists of a pressure pump and a pressure vessel manufactured using most up-to-date technology. The hydro-pneumatic booster pumps have an easy operation and they produce a flow rate of up to 500 bar. In this paper we are discussing about the centrifugal pump used in hydro pneumatic system, and their various factors such as components, curves etc.

Keyword: Coupling, Hydro, Housing, Impeller, Seal.

I. INTRODUCTION

HYDRO PNEUMATIC PUMP: The pressure vessel of the pump contains water with a pressurized air space to provide pressure to the pumping system. The water gushes out from this pressure vessel with water demand which leads to an increase in air space and decrease in pressure. When this pressure is lowered, the pump starts. At this point, the air space reduces and pressure rises and when the upper level of pressure is achieved, the pump stops. Around 2-6 high pressure multistage centrifugal pumps are part of the hydro pneumatic systems. It also consist of suction and delivery manifolds, valves, base frame and a control panel that are assembled together and tested before installation at the required location. The manifolds eradicate dead corners that lower noise, reduce friction loss and prevent growth of bacteria in water pipes. The isolated valves offer low resistance and are easy to service. The control panel is used to manage the operation of the pump sets according to the pressure rate. To prevent repetitive starting and stopping of pump, this control panel helps by maintaining balance between the air charge and water level. The hydro pneumatic pumping system also consists of high quality pressure switches, pressure transmitter, pressure tank and other accessories. The Hydro pneumatic water system ensures a continuous flow of high pressure water to all the floors of a residential complex, high rise buildings and apartments, offices and other places and maintains a balanced pressure that is preset in the pump.

PRINCIPLE OF THE CENTRIFUGAL PUMP: An increase in the fluid pressure from the pump inlet to its outlet is created when the pump is in operation. This pressure difference drives the fluid through the system or plant. The centrifugal pump creates an increase in pressure by transferring mechanical energy from the motor to

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the fluid through the rotating impeller. The fluid flows from the inlet to the impeller center and out along its blades. The centrifugal force hereby increases the fluid velocity and consequently also the kinetic energy is transformed to pressure. The centrifugal pump is the most used pump type in the world. The principle is simple, well-described and thoroughly tested, and the pump is robust, effective and relatively inexpensive to produce. There is a wide range of variations based on the principle of the centrifugal pump and consisting of the same basic hydraulic parts.

II. HYDRAULIC COMPONENTS

The principles of the hydraulic components are common for most centrifugal pumps. The hydraulic components are the parts in contact with the fluid. Figure shows the hydraulic components in a single-stage inline pump. The subsequent sections describe the components from the inlet flange to the outlet flange.

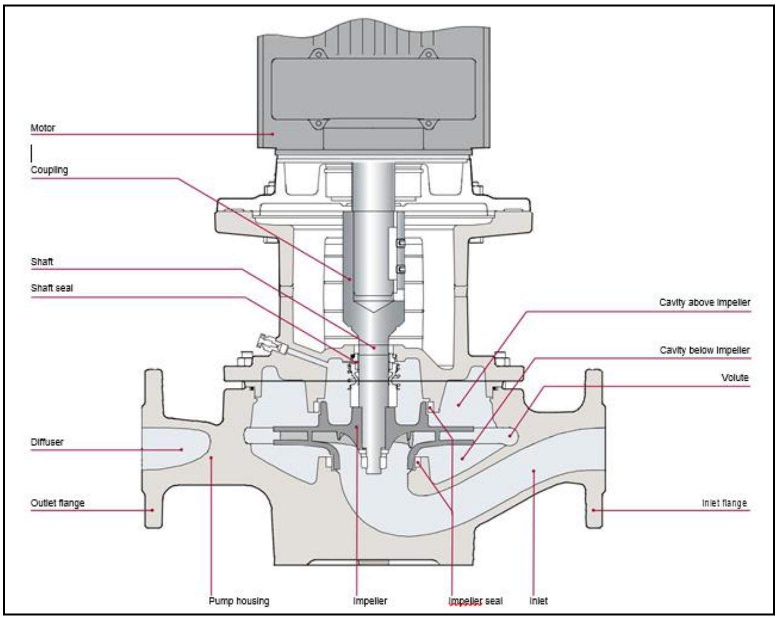

Figure: Hydraulic component

- Inlet flange and inlet: The pump is connected to the piping system through its inlet and outlet flanges. The design of the flanges depends on the pump application. Some pump types have no inlet flange because the inlet is not mounted on a pipe but sub-merged directly in the fluid. The inlet guides the fluid to the impeller eye. The design of the inlet depends on the pump type. The four most com-mon types of inlets are inline, end suction, double suction and inlet for submersible pumps.
- Impeller: The blades of the rotating impeller transfer energy to the fluid there by increasing pressure and velocity. The fluid is sucked into the impeller at the impeller eye and flows through the impeller channels formed by the blades between the shroud and hub. The design of the impeller depends on the requirements for pressure, flow and application. The impeller is the primary component determining the pump performance. Pumps variants are often created only by modifying the impeller.
- Coupling and drive: The impeller is usually driven by an electric motor. The coupling between motor and hydraulics is a weak point because it is difficult to seal a rotating shaft. In connection with the coupling, distinction is made between two types of pumps: Dry-runner pumps and canned rotor type pump. The advantage of the dry-runner pump compared to the canned rotor type pump is the use of standardized

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motors. The disadvantage is the sealing between the motor and impeller. In the dry runner pump the motor and the fluid are separated either by a shaft seal, a separation with long shaft or a magnetic coupling.

- Cavities and axial bearing: The volume of the cavities depends on the design of the impeller and the pump housing, and they affect the flow around the impeller and the pump's ability to handle sand and air. The impeller rotation creates two types of flows in the cavities: Primary flows and secondary flows. Primary flows are vortices rotating with the impeller in the cavities above and below the impeller. Secondary flows are substantially weaker than the primary flows.
- Volute casing, diffuser and outlet flange: The volute casing collects the fluid from the impeller and leads into the outlet flange. The volute casing converts the dynamic pressure rise in the impeller to static pressure. The velocity is gradually reduced when the cross-sectional area of the fluid flow is increased. This transformation is called velocity diffusion. The volute casing consists of three main components: Ring diffusor, volute and outlet diffusor.
- Return channel and outer sleeve: To increase the pressure rise over the pump, more impellers can be connected in series. The return channel leads the fluid from one impeller to the next. An impeller and a return channel are either called a stage or a chamber. The chambers in a multistage pump are altogether called the chamber stack. Besides leading the fluid from one impeller to the next, the return channel has the same basic function as volute casing: To convert dynamic pressure to static pressure. The return channel reduces unwanted rotation in the fluid because such a rotation affects the performance of the subsequent impeller. The rotation is controlled by guide vanes in the return channel. In multistage inline pumps the fluid is lead from the top of the chamber stack to the outlet in the channel formed by the outer part of the chamber stack and the outer sleeve. When designing a return channel, the same design considerations of impeller and volute casing apply. Contrary to volute casing, a return channel does not create radial forces on the impeller because it is axis-symmetric.

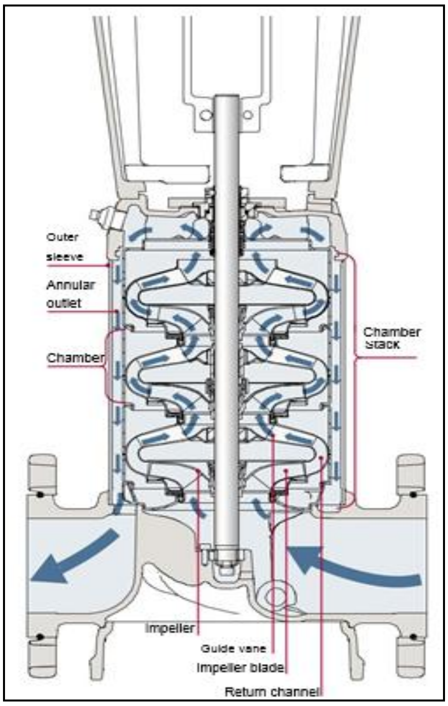

Figure: Hydraulic components in an inline multistage pump.

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III. PUMP TYPES

- UP pump: Circulation pumps are used for heating, circulation of cold water, ventilation and air-condition systems in houses, office buildings, hotels, etc. Some of the pumps are installed in heating systems at the end user. Others are sold to OEM customers (Original Equipment Manufacturer) that integrate the pumps into gas furnace systems. It is an inline pump with a canned rotor which only has static sealing. The pump is designed to minimize pipe-transferred noise.
- TP pump: The TP pump is used for circulation of hot or cold water mainly in heating, cooling and air-conditioning systems. It is an inline pump and contrary to the smaller UP pump, the TP pump uses a standard motor and shaft seal.
- NB pump: The NB pump is for transportation of fluid in district heating plants, heat supply, cooling and air conditioning systems, wash-down systems and other industrial systems. The pump is an end suction pump, and it is found in many variants with different types of shaft seals, impellers and housings which can be combined depending on fluid type, temperature and pressure.
- MQ pump: The MQ pump is a complete miniature water supply unit. It is used for water supply and transportation of fluid in private homes, holiday houses, agriculture, and gardens. The pump control ensures that it starts and stops automatically when the tap is opened. The control protects the pump if errors occur or if it runs dry. The built-in pressure expansion tank reduces the number of starts if there are leaks in the pipe system.
- SP pump: The SP pump is a multi-stage submersible pump which is used for raw water supply, ground water lowering and pressure boosting. The SP pump can also be used for pumping corrosive fluids such as sea water.
- CR pump: The CR pump is used in washers, cooling and air conditioning systems, water treatment systems, fire extinction systems, boiler feed systems and other industrial systems. The CR pump is a vertical inline multistage pump. This pump type is also able to pump corrosive fluids because the hydraulic parts are made of stainless steel or titanium.

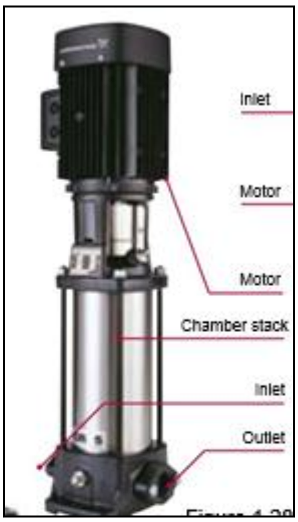

Figure: CR pump

- MTA pump: The MTA pump is used on the non-filtered side of the machining process to pump coolant and lubricant containing cuttings, fibers and abrasive particles.

IV. PUMPS OPERATING IN SYSTEMS

A pump is always connected to a system where it must circulate or lift fluid. The energy added to the fluid by the pump is partly lost as friction in the pipe system or used to increase the head. Implementing a pump into a system results in a common operating point. If several pumps are combined in the same application, the pump curve for the system can be found by adding up the pumps' curves either serial or parallel. Regulated pumps adjust to the system by changing the rotational speed. The regulation of speed is especially used in heating systems where the need for heat depends on the ambient temperature, and in water sup-ply systems where the demand for water varies with the consumer opening and closing the tap.

- Single pump in a system: A system characteristic is described by a parabola due to an increase in friction loss related to the flow squared. The system characteristic is described by a steep parabola if the resistance in the system is high. The parabola flattens when the resistance decreases. Changing the settings of the valves in the system changes the characteristics. The operating point is found where the curve of the pump and the system characteristic intersect. In closed systems, there is no head when the system is not operation. In this case the system characteristic goes through (Q, H) = (0, 0). In systems where water is to be moved from one level to another, there is a constant pressure difference between the two reservoirs, corresponding to the height difference. This causes an additional head which the pump must overcome. In this case the system characteristics goes through (0, Hz) instead of (0, 0).

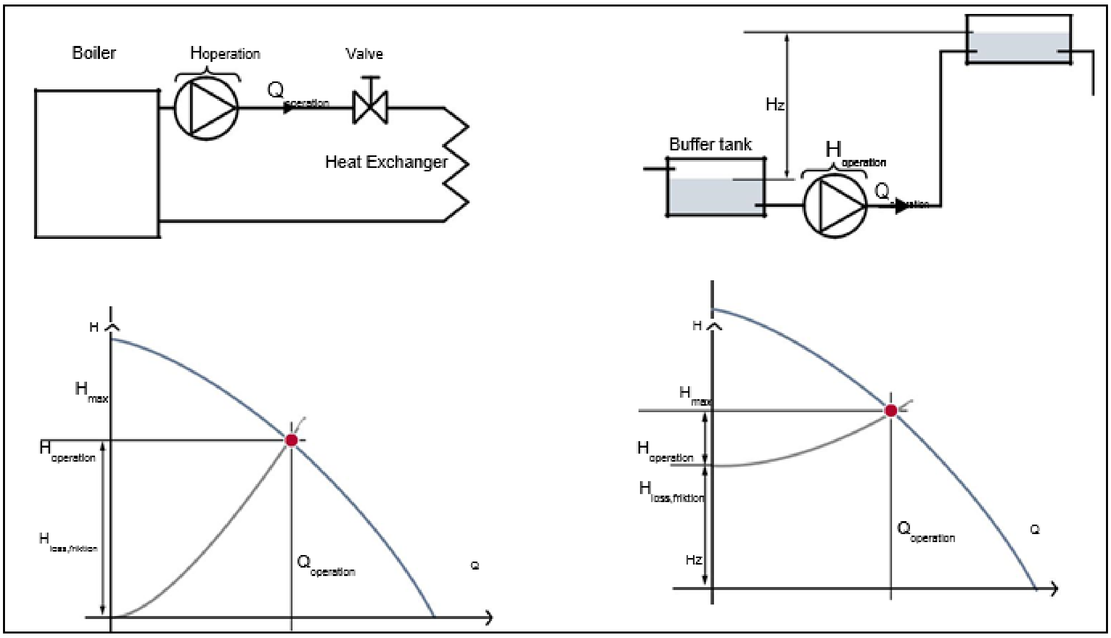

Figure: Closed system and open system

- Pumps operated in parallel: In systems with large variations in flow and a request for constant pressure, two or more pumps can be connected in parallel. This is often seen in larger supply systems or larger circulation systems such as central heating systems or district heating installations. Parallel-connected pumps are also used when regulation is required or if an auxiliary pump or standby pump is needed. When operating the pumps, it is possible to regulate between one or more pumps at the same time. A non-return valve is therefore always mounted on the discharge line to prevent backflow through the pump not operating. Parallel-connected pumps can also be double pumps, where the pump casings are casted in the same unit, and where the non-return valves are build-in as one or more valves to prevent backflow through the pumps. The characteristics of a parallel-connected system is found by adding the single characteristics for each pump horizontally.

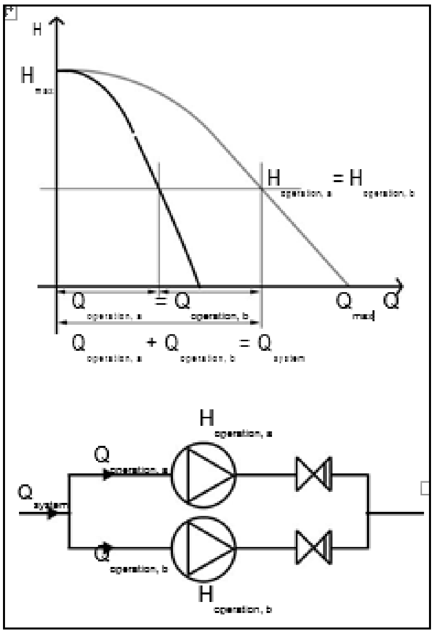

Figure: Parallel connected pump

- Pumps operated in series: Centrifugal pumps are rarely connected in serial, but a multi-stage pump can be considered as a serial connection of single-stage pumps. However, single stages in multistage pumps cannot be uncoupled. If one of the pumps in a serial connection is not operating, it causes a consider-able resistance to the system. To avoid this, a bypass with a non-return valve could be build-in. The head at a given flow for a serial-connected pump is found by adding the single heads vertically.

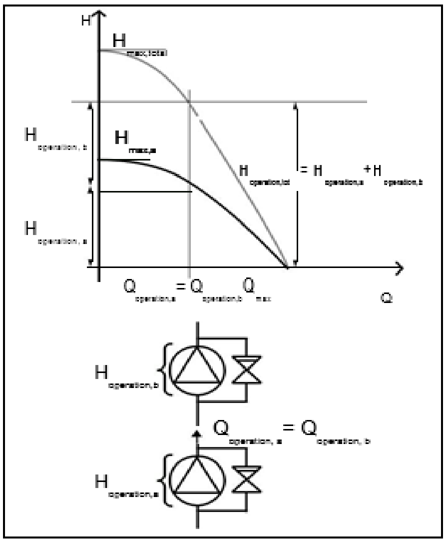

Figure: Pump operated in series

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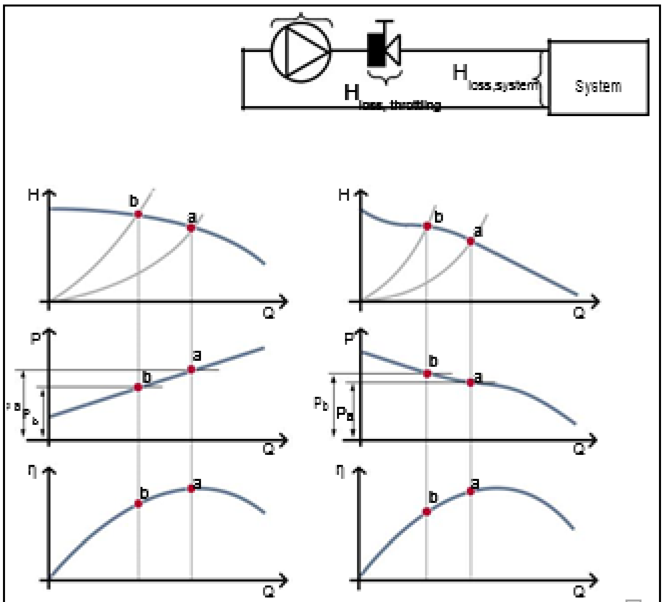
V. REGULATION OF PUMP

It is not always possible to find a pump that matches the requested performance exactly. A number of methods makes it possible to regulate the pump performance and thereby achieve the requested performance. The most common methods are:

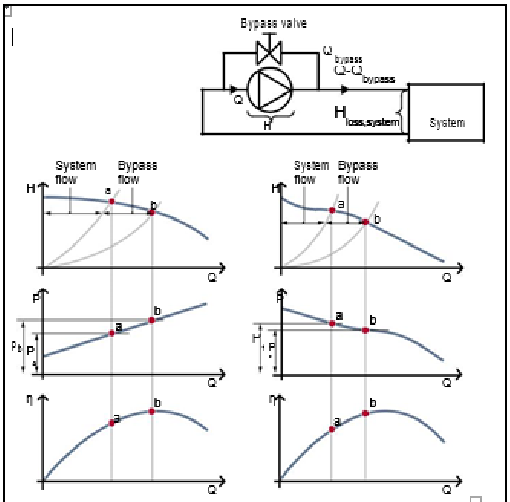
- Throttle regulation, also known as expansion regulation: Installing a throttle valve in serial with the pump it can change the system characteristic. The resistance in the entire system can be regulated by changing the valve settings and thereby adjusting the flow as needed. A lower power consumption can sometimes be achieved by installing a throttle valve. However, it depends on the power curve and thus the specific speed of the pump. Regulation by means of a throttle valve is best suited for pumps with a relative high pressure compared to flow.



The system characteristic is changed through throttle regulation. The curves to the left show throttling of a low n_q pump and the curves to the right show throttling of a high n_q pump. The operating point is moved from a to b in both cases.

Figure: Throttle regulation

- Regulation with bypass valve: A bypass valve is a regulation valve installed parallel to the pump. The bypass valve guide part of the flow back to the suction line and consequently reduces the head. With a bypass valve, the pump delivers a specific flow even though the system is completely cut off. Like the throttle valve, it is possible to reduce the power consumption in some case. Bypass regulation is an advantage for pumps with low head compared to flow (high $n_q$pumps).



The system characteristic is changed through bypass regulation. To the left the consequence of a low-n_q pump is shown and to the right the consequences of a high n_q pump is shown. The operating point is moved from a to b in both cases.

Figure: Bypass regulation

- Speed control: When the pump speed is regulated, the QH, power and NPSH curves are changed. The conversion in speed is made by means of the affinity equations.

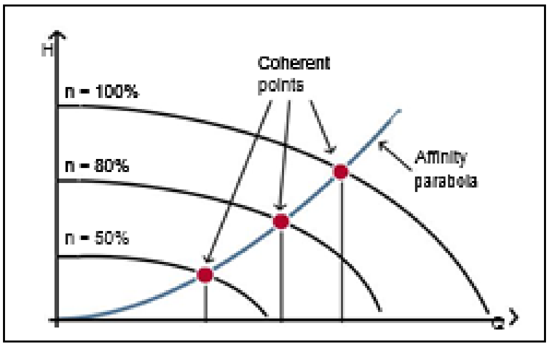
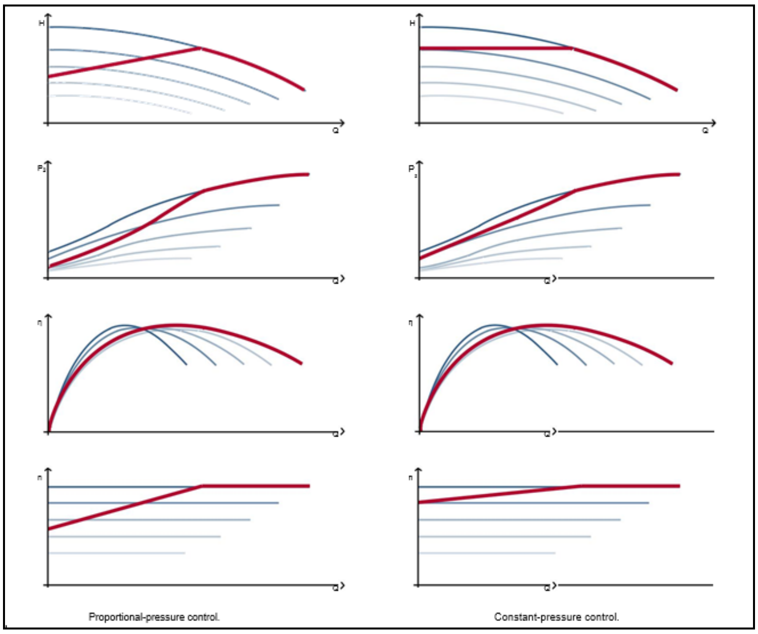


Figure: Speed control

- Proportional-pressure control: Proportional-pressure control strives to keep the pump head proportional to the flow. This is done by changing the speed in relation to the current flow. Regulation can be performed up to a maximum speed, from that point the curve will follow this speed. The proportional curve is an approximatively system characteristic as described where the needed flow and head can be delivered at varying needs. Proportional pressure regulation is used in closed systems such as heating systems.
- Constant-pressure control: A constant differential pressure, independent of flow, can be kept by means of constant-pressure control. In the QH diagram the pump curve for constant-pressure control is a horizontal line. Constant-pressure control is an advantage in many water supply systems where changes in the consumption at a tapping point must not affect the pressure at other tapping points in the system.



VI. LOSES IN PUMP

Distinction is made between two primary types of losses: mechanical losses and hydraulic losses which can be divided into a number of subgroups. Table shows how the different types of loss affect flow (Q), head (H) and power consumption (P_2).

	Loss	Smaller flow (Q)	Lower head (H)	Higher power consumption (P2)
Mechanical losses	Bearing			X
	Shaft seal			X
Hydraulic losses	Flow friction		X	
	Mixing		X	
	Recirculation		X	
	Incidence		X	
	Disk friction			X
	Leakage	X		

Table: Losses in pumps and their influence on curves

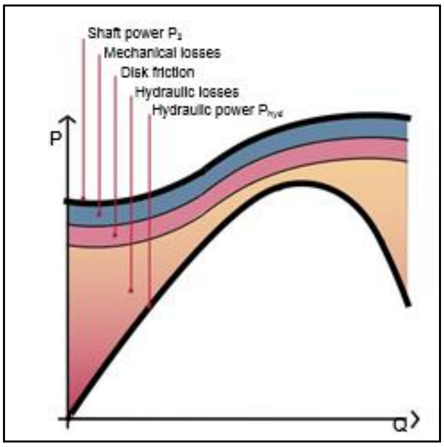


Figure: Increase in power consumption due to losses

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VII. CONCLUSION

From the case study made on the pump of hydro pneumatic booster system, it can be concluded that with the help of the above information we can do brief study of the performance of pump, Still research work is going on hydro pneumatic pump, with reference to the above factors further study will be made to improve the performance of the pump. This study will help us for design and development of hydro pneumatic booster system.

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