IMPORTANCE OF HYDRAULICS AND ITS ROLE IN MECHANICAL AND AUTOMOBILE ENGINEERING

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ABSTRACT:
Hydraulics is a technology and applied science using engineering, chemistry, and other sciences involving the mechanical properties and use of liquids. At a very basic level, hydraulics is the liquid counterpart of pneumatics, which concerns gases. This paper mainly deals and tries to explain a brief about hydraulics and also the role of it in the stream of mechanical and automobile engineering. Hydraulic topics range through some parts of science and most of engineering modules, and cover concepts such as pipe flow, dam design, fluidics and fluid control circuitry. The principles of hydraulics are in use naturally in the human body within the vascular system and erectile tissue. Free surface hydraulics is the branch of hydraulics dealing with free surface flow, such as occurring in rivers, canals, lakes, estuaries and seas. Its sub-field open-channel flow studies the flow in open channels.

KEYWORDS: *Hydraulics, pneumatics, mechanical properties, vascular system, erectile tissue.*

INTRODUCTION:

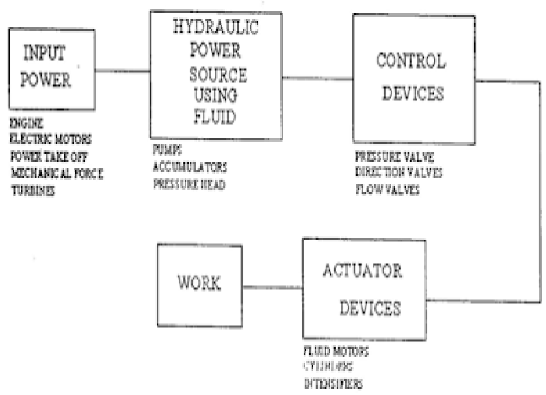
Hydraulics in Mechanical Engineering:

Hydraulics is the branch of physics having to do with the mechanical properties of water and other liquids and the application of these properties in engineering.

The word "hydraulics" comes from the Greek words "Hydro" means water and Aulics" means pipes. Hydraulics pertains to power transmitted and controlled through the use of a pressurized liquid. So hydraulics can be defined as a means of transmission and control of forces and movement of fluids.

Basic Elements of Hydraulic Power Systems:

A hydraulic system can be broken down into five main divisions. First, the power device; second, hydraulic power source using fluid; third, the control valves; fourth, the lines in which the fluid power flows and fifth, actuators devices.



Advantages of Using Hydraulic Power:

- Hydraulic power provides flexibility in the control of machines.
- Hydraulic power provides an efficient method of multiplying forces.
- Hydraulic power provides constant torque at infinitely variable

speeds in either direction with smooth reversals.

- Hydraulic power is compatible with other means of control, such as electrical, electronic, or Mechanical.
- Hydraulic power is accurate.
- Hydraulic power gives fast response to controls.
- Small forces can be amplified to control large forces.
- Oil fluid power provides automatic lubrication for lesser wear. .
- Hydraulic power provides freedom in machine design.
- Hydraulic power is simple and provides ease of installation and maintenance.
- Hydraulic power is economical.
- Hydraulic power is efficient and dependable.
- Hydraulic power gives predictable performance.
- Hydraulic power is readily available.

LITERATURE REVIEW:

Krivts, et.al.., (2006), Pneumatic Actuating Systems for Automatic Equipment: Structure and Design offers a modern treatment of the subject along with applied knowledge using practical examples and exercises to highlight the concepts. It is an ideal resource to bring you up to date on this critical component of automation. Automation is quickly becoming the standard across nearly every area of manufacturing. Pneumatic actuators play a very important role in modern automation systems, yet until now there has been no book that takes into account the recent progress not only in the pneumatic systems themselves but also in the integration of mechatronics, electronic control systems, and modern control algorithms with pneumatic actuating systems. Filling this void, Pneumatic Actuating Systems for Automatic Equipment: Structure and Design describes novel constructions along with many of the most commonly applied pneumatic actuating systems .

Fronczak, et.al.., (1988), This paper presents a hydraulic hybrid vehicle drive train to improve the fuel efficiency of a passenger car. The developed hydro-mechanical drive train enables independent control of the torque at each wheel. The motivation for developing this drive train is a hydraulic hybrid vehicle test bed for the Center for Compact and efficient Fluid Power at the University of Minnesota. The hydro-mechanical hybrid drive train is modeled and compared to a series hybrid drive train in operation on the EPA Urban Dynamometer Driving Schedule. The hydro-mechanical system demonstrates excellent fuel economy potential, yet requires development work in the area of pump/motors with high efficiency at low displacement fractions.

Bowns, et.al.., (1981), Hybridisation of hydraulic drive trains offers the potential of efficiency improvement for on – and off-road applications. To realise the advantages, a carefully designed system and corresponding control strategy are required, which are commonly obtained through a sequential design process.

Addressing component selection and control parameterisation simultaneously through simulation-based optimisation allows for exploration of a large design space as well as design relations and trade-offs, and their evaluation in dynamic conditions which exist in real driving scenarios. In this paper, the optimisation framework for a hydraulic hybrid vehicle is introduced, including the simulation model for a series hybrid architecture and component scaling considerations impacting the system's performance. A number of optimisation experiments for an on-road light-duty vehicle, focused on standard-drive-cycle-performance, illustrate the impact of the problem formulation on the final design and thus the complexity of the design problem. The designs found demonstrate both the potential of energy storage in series hybrids, via an energy balance diagram, as well as some challenges. The framework presented here provides a base for systematic evaluation of design alternatives and problem formulation aspects.

Kress, et.al.., (1968), The hydraulic hybridization of the hydromechanical transmission is an interesting solution to reduce fuel consumption in heavy duty machinery, thanks to the high power peaks recovered in the braking phase and the low cost technology involved. However, hybridization must be carefully considered, as there is no optimal configuration for all applications. For this reason, the design of a hydromechanical transmission must be developed on the basis of the specific data of the vehicle and must tend to optimization. Following this concept, the optimal layout of the hybrid Output Coupled configuration for a particular vehicle application, the reach stacker, was studied in this work. The study will be carried out in two steps: first the optimal layout will be sought based on the continuous formulation of the planetary gear. Subsequently, based on the design parameters obtained, the models of the non-hybrid and hybrid transmission will be simulated for a functional and energy comparison.

METHODOLOGY:

HYDRAUTICS IN CASE OF AUTOMOBILE ENGINEERING:

Low rider automobiles originated in Mexican American communities in Southern California. Car hydraulics were originally very expensive to have installed, and were only used to be shown at car shows. However, after WWII, more Mexican Americans were able to afford older, less expensive, automobiles. In the early 1960s, these automobiles, many times classics from the 1950s, began to be modified and customized to riding low to the ground. This however, was not favored by many police in Southern California and owners of these cars were ticketed. This is the reason behind why car hydraulics were installed. This enabled these car drivers to adjust these cars to the original height when put in a compromising position. This then began to spiral into a trend that spread to African American communities, as well as White American communities, throughout Southern California and many other western states. Today, low riders can be found anywhere, worldwide, however the greater percentage is in the Western States in the United States.

Car hydraulics are equipment installed in an automobile that allows for a dynamic adjustment in height of the vehicle. These suspension modifications are often placed in a low rider, i.e., a vehicle modified to lower its ground clearance below that of its original design. With these modifications, the body of the car can be raised by remote control. The amount and kind of hydraulic pumps being used and the different specifications of the subject vehicle will affect the impact of such systems on the height and orientation of the vehicle. With sufficient pumps, an automobile can jump and hop upwards of six feet off the ground. Enthusiasts hold car jumping contests nationwide, which are judged on how high an automobile is able to bounce.

All modern automobiles have this wonderful feature included that means the difference between life and death while out on the road – brakes.

Every day we use our brakes to prevent our vehicle from plowing into the whatever happens to be ahead of us, but we never stop to consider how those brakes do what they do. The way that brakes work, despite what you may think, are actually quite fascinating.

Brakes fail us all of the time. All mechanics understand this, and understanding a little about the hydraulic systems that make braking possible can help us grasp why they fail. This is useful to even the common driver, because if we can understand why they fail us, we can take steps to prevent their failure. That knowledge can save lives.

VEHICLE BRAKES ARE BASICALLY OUR FEET IN A DIFFERENT PLACE:

If you've ever used the emergency brake in your car, you'll know what I'm talking about. Operating a brake with your arm feels terribly unnatural.

The braking system in your car makes use of your natural tendency to stomp things dead. The harder you press down on the pedal, the faster your car stops. This is the work of competing pistons powered by a hydraulic system.

When you press down on the brake pedal, fluid is compressed by a piston in the chamber adjacent to the pedal. And, since the volume of liquids cannot change, that fluid is pushed towards the chamber next to your brake pad. That extra fluid pushes down on the piston in that chamber and that piston pushes your brake pad towards the tire. As a result of that pad rubbing up against the tire, the car's wheels are brought to a stop.

IF THERE ISN'T ENOUGH BRAKE FLUID, THE BRAKES CAN'T DO THEIR JOB:

This is why you should always keep brake fluid topped off. Hydraulic systems are fluid dependent. Without the fluid, the system fails. Many people are blissfully unaware that running a braking system on low fluid can lead to terrible, terrible accidents. Always take preventative measures when dealing with braking systems, not reactionary measures.

HYDRAULICS IN CASE OF MECHANICAL ENGINEERING:

The Hydraulic Power Unit

The basic hydraulic power unit consists a hydraulic pump, an oil reservoir with a cover, a suction strainer or filter, a motor coupling, an electric motor, pressure gage, pressure valves, hydraulic oil, and the necessary internal piping.

The Hydraulic Pump:

The heart of the power unit is the hydraulic pump. Pumps are used in hydraulic system to convert mechanical energy into hydraulic energy. The hydraulic energy delivered to the system by the pumps is in the form of a fluid flow.

There are two general classifications of pumps which are being used for transmission of hydraulic power:

- Non-positive displacement pumps.
- Positive displacement pumps.

Positive displacement pumps are most generally used for hydraulic power. The positive displacement pumps are generally four types:

- Gear type
- Vane type
- Piston type
- Screw type

Gear Type Pumps:

The gear type pump may be either of the external gear design or the internal gear design. The principle upon which this type of pump operates is that of a pair of gears being driven by an external means, the oil moving into the pump as a partial vacuum is formed and then being discharged by the meshing of the gear teeth on the discharge side of the pump. Oil is actually squeezed or forced out as the gear mesh. Various gear designs, such as helical, spur, spiral, or herringbone may be employed for the rotating element. Depending upon the type of service expected, the gears may be made of bronze, cast iron, or heat treated steel.

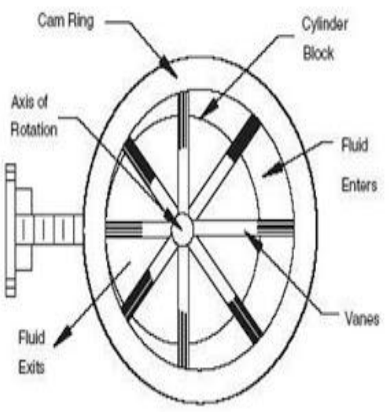
Advantages of gear type pumps are:

- They are inexpensive
- Have few moving parts, and
- Feature simplicity in design-and construction.the cam ring contour forces them back into the rotor and the hydraulic fluid must go out the discharge side of the pump.

There are several advantages to the vane type design:

- Simplicity in construction, high efficiency, and low cost.

- It is compact in design.



Vane type pump

Piston Pumps:

These are two types

- Rotary piston pumps and
- Reciprocating piston pumps.

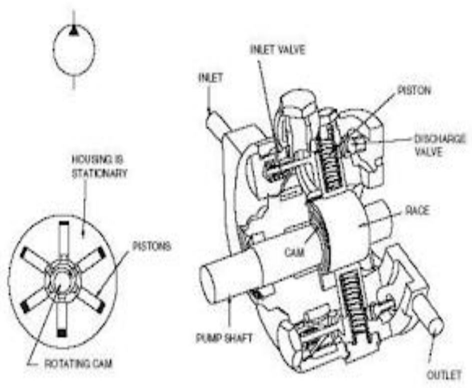
In rotary piston pumps the mechanism which actuates the piston has a rotary motion rather than a back and forth motion as in the reciprocating pumps. Rotary pumps may be of two types - radial type and axial type.

In the radial type, a number of pistons and cylinders are arranged radially around the rotor hub, while in the axial type they are located in a parallel position with respect to the rotor shaft.

In the radial type, each piston rides in its cylinder with the base of the piston pressing out against an eccentric ring or the eccentric surface of the casing. As the rotor revolves, the eccentricity of the ring or casing causes an in and-out or pumping motion of the pistons. In the axial type, the base of each piston is connected by a piston rod to the driving plate. The driving plate is free to tilt along any diameter through its center. Across the surface of this driving plate rotates a wobble or cam plate which is tilted at an angle to the shaft. The rotation of the wobble plate, produces an in-and-out motion of the pistons in their cylinders. Constant displacement rotary piston pumps contain no means of changing the volume of oil discharged at any given speed. Variable displacement rotary piston pumps, on the other hand, contain means of varying the length of piston stroke and hence the volume of discharge for a given speed by changing the eccentricity or angularity of the devices which actuate the piston plungers or connecting rods.

The advantages of the rotary piston pumps are;

- It is capable of delivering high operating pressures.
- It will handle oils in a wide viscosity range.
- It will provide a variable delivery of oil.



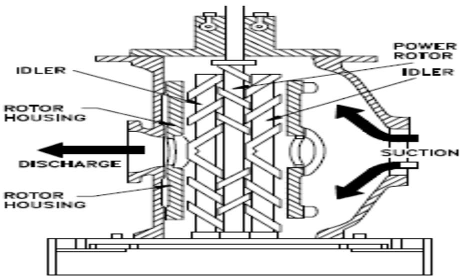
Rotary piston pump

Screw Pumps:

There are three types of screw pumps which are commercially available. These three types are the single-screw, the two-screw, and the three-screw pumps. A single screw pump consists of a spiraled rotor which rotates eccentrically in an internal stator. A two-screw pump consists of two parallel rotors with intermeshing threads rotating in a closely machined housing. These pumps use external or internal timing gears. A three screw pump consists of a central drive rotor with two meshing idler rotors; the three rotors are surrounded by a closely machined housing.

The flow through a screw pump is axial in direction of the power rotor. When the inlet side of the pump is flooded with a hydraulic fluid, a certain volume of the liquid that surrounds the rotors is caught as the rotors rotate. This fluid is pushed uniformly with the rotation of the rotors along the axis and is forced out the other end. In operation, when the power rotor is turning clockwise, the idler rotors are turning counter clockwise.

Other applications include hydraulic systems on submarines and other uses where noise must be controlled.



The Hydraulic Reservoir:

The hydraulic reservoir should contain enough fluid that its working level is always maintained during the system's operation. It should also have additional capacity to hold ,pll the fluid in the system during shutdowns. The reservoir capacity is generally between two and three times the capacity of the hydraulic pump. If a hydraulic system has a great number of cylinders operating simultaneously, more careful consideration should be given to the proper reservoir size by calculating the entire system's volume.

Other features of a well designed reservoir include the following

- Baffle plate
- Bottom drain
- Sight glass
- Filling cap and hole
- Breather air filter
- Clean out cover or door
- Return line
- Drain line
- Pump inlet line
- Drive mounting base
- Casters.
- Heat exchanger

The proper selection of a reservoir for any hydraulic system depends largely on the field of application and the type of duty under which the system must operate.

The Oil Filters:

The filter may be defined as "a device for the removal of solids from a fluid wherein the resistance to motion of such solids is in a tortuous path." Filters are listed under two types:

- Sump type
- Line type

The sump type or immersion type is placed in the oil reservoir and is connected to the intake of the pump. The line type filter is mounted outside of the tank either in the intake line or in the return line from the system.

Some of the basic designs of the filters are

- T type
- Pot type
- Y type
- In Line type

There are several basic types of filter media, such as paper, sintered metal powder, woven wire cloth, and certain kinds of ceramic or plastic. In the selection of a filter media, it is important to consider the type of fluid, chemical compatibility, temperature, and the ability to withstand high flow rates.

Hydraulic Accumulators:

An accumulator is essentially a pressure storage reservoir in which a non-compressible hydraulic fluid is retained under pressure from an external source. The fluid, under pressure, is readily available as a quick secondary source of fluid power. Accumulators are used in conjunction with hydraulic systems on large hydraulic presses, farm machinery, diesel engine, power brakes, and landing gear mechanisms on airplanes, hatch covers on ships and other devices. Accumulators are usually divided into three classes:

- The dead weight operated type
- The spring operated type
- The air operated type

Uses of Accumulator:

- As a Leakage compensator
- As secondary source of energy
- As fluid make-up device
- Synchronizing ram movements of two cylinders
- Provides emergency source of power
- Used as a holding device
- Used as shock suppressor
- Used in dual pressure circuit Used as lubricant dispenser

Hydraulic Actuators or Cylinders:

A hydraulic cylinder is a device, which converts fluid power into linear mechanical force and motion. It usually consists of a movable element, such as a piston and piston rod, plunger or ram, operating within a cylindrical bore.

The operating principle of the piston and piston rod type is that fluid entering one port drives the movable piston and the rod assembly in one direction. Fluid from the opposite side is exhausted back to the reservoir through a directional control valve.

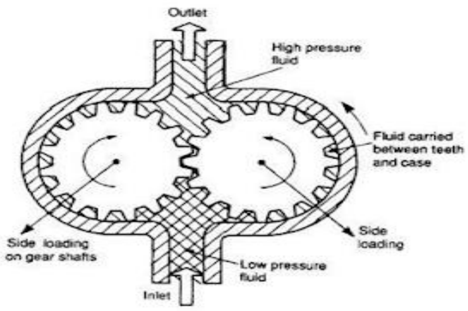
The ram or plunger type actuating cylinders have a movable element of the same cross-sectional area as the piston rod. The ram or plunger type of cylinder is generally powered in only one direction.

The opposed piston type produces a high turning force at low pressure. As the pistons extend or retract, they rotate the pinion gear, which is in mesh with each rack. It produces the same turning force in both directions.

The piston chain type has two cylinders in parallel. The large piston is used for powering the chain and drive sprocket, while the smaller cylinder provides a seal. Fluid entering one end operates against both pistons, but the large piston creates the greater force, so it moves, causing rotation of the output shaft. Flow directed to the other port reverses the operation.

Cushioning:

For the prevention of shock due to stopping loads at the end of the piston stroke, cushion devices are used. Cushions may be applied at either end or both. They operate on the principle that as the cylinder piston approaches the end of the stroke, exhaust fluid is forced to go through an adjustable needle valve which is set to control the escaping fluid at a given rate. This allows the deceleration characteristic to be adjusted for different loads.



Gear Type Pump

Vane Type Pumps:

This is a rotary type and also operates on the principle of increasing and diminishing volume. It consists of a shaft, rotor, vanes, cam ring, pump housing, bearings, and seals. Vane type hydraulic pumps may be either fixed delivery 'or variable volume units.

As the rotor is turned, centrifugal force causes the vanes to move out against the hardened and ground contour of the cam-shaped ring. Fluid is trapped between the rotating vanes when they pass over the inlet port. Because the vanes reciprocate in and out of the rotor as they rotate, while passing over the inlet port the vanes are extended out of the rotor and carry a maximum amount of fluid. As the vanes reach the outlet port .

CONCLUSION:

Throughout the history of automotive development hydraulics have played a critical role in the engineering of brakes, steering and gears, as well as suspension. Specialist functions on road going vehicles as well as vehicles designed for non-road use, such as tractors, other agricultural machinery and military vehicles, also use hydraulic power to effect movement of harvesting machinery, aerial ladders and artillery. Hydraulic engineering offers a tested and trusted way of effecting actions with a quick response time and most importantly, it is reliable, efficient, and easier to fix than electrical systems designed to do the same. Electrical systems are becoming more commonplace in road going vehicles, as the move to all electric or hybrid powered cars starts to take off in the mainstream. Electric actuators are starting to replace their hydraulic equivalent in some systems, especially those from manufacturers who are pro-actively making advances in alternative car design; self-driving cars and fully electric vehicles are pushing electric actuators to the fore of the minds of automotive designers. The appeal to designers is the easy integration of electrical components into an existing electrical system; if most of the controls are electric rather than mechanical it makes sense to extend the same technology as far as possible. Electric actuators are cheaper, easier to control and generally last as well as hydraulic actuators, and it is far easier to work these into the wiring and software system of a vehicle than to install a separate hydraulic system just to run the brakes, or the gearbox.

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