MULTIPLE HYDRAULIC DRIVES
LOAD SENSING

By

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I. HISTORY OF HYDRAULICS:

Hydraulics date back to the pyramids and Egyptians. It became popular during World War I and World War II, when it was mass produced for the military. What we will discuss today will be modern hydraulics, primarily hydraulics for the citrus industry.

II. EVERYDAY USE OF HYDRAULICS WE ARE ALL FAMILIAR WITH:

Hydraulic brakes on cars and other vehicles which at one time were completely mechanical. It was changed over to hydraulics in the 30's. Hydraulics is more flexible and much more reliable. Then later came hydraulic steering which is more popular today than any time in history. I venture to say that 99.9% of all the people here today have hydraulic steering and brakes on their cars. Other things using hydraulics for safety and reliability are big 747 jets on their steering, brakes and of course their landing gears. The guidance system of the big Saturn Missile was operated with hydraulics to put the first man on the Moon.

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So you can conclude that the most important parts of a system that need flexibility and dependability muscle uses hydraulics.

III. SIMPLE HYDRAULIC DRIVE (OPEN-LOOP) (Figure 1.)

(We will at a later time explain the difference between open-loop and closed-loop).

The simplest form of hydraulic drive consists of hydraulic pump, fixed displacement (which we will call "PF") which will take the rotary motion of any type of prime mover, (electric motor, diesel engine, gas engine etc.). The hydraulic pump will generate the pressure which is torque and volume which is R. P. M. (speed). The next important part of this system is the hydraulic motor, which is a fixed displacement we will call "MF", for "motor, fixed". In most concentrate drive applications, the speed will be from 0 - 350 R. P. M so our hydraulic motor will be low-speed, high-torque variety, which in turn will eliminate the need for a gearbox and chain drive that the electric motor would require. The next most important part of the system is the relief valve, which will determine the terminal pressure for maximum torque. Fluid power has automatic overload protection with the relief valve. If an electric motor is stalled it will probably burn out. The hydraulic system simply dumps over the relief valve while still maintaining maximum torque.

This simple hydraulic system has no provisions for speed control or directional control, this would compare with a high-speed electric motor with a gearbox and some means of a limiting-torque device. Note the hydraulic system is flexible and can be split and separated with flexible hoses, etc. The hydraulic system becomes self-lubricating and in most cases the hydraulic motor is explosion-proof and will be much smaller and compact at your concentrate pump.

IV. SIMPLE HYDRAULIC DRIVE - OPEN-LOOP - VARIABLE SPEED (Figure 2.)

The next system is basically the same as the first with added provisions for variable speed. You will note also that we have a second motor in series with the first motor. We will be using the terms "series" and "parallel" a great deal just as the electrical people will be using. "Series" drives will be using the same amount of flow as the first motor but the pressure-drop of the first motor will be deducted from the second motor. The "parallel" circuit will be the opposite of series; the flow will be independent and the pressure drop will be independent of each other. We will get into multiple drives later. We will not get into a basic course of fluid
power, but will try to get the idea of hydraulics without picking out a particular component for a particular application.

Since we are using fixed displacement pumps (PF) and (MF) motors, if we vary the flow to the hydraulic motors, the output speed of the motor will change. In this particular circuit we will use a priority flow regulator which will be pressure compensated (which means regardless of pressure the flow will remain approximately the same once it is set). This system has the same advantages and disadvantages as the first except it has variable speed and has the second motor in series. This circuit is a simple approach of synchronizing two drives.

V. SIMPLE HYDRAULIC DRIVE - OPEN-LOOP- VARIABLE DISPLACEMENT PUMP (Figure 3)

The third system (PV) pump which means variable displacement pump and fixed displacement motor (MF). In most cases, this system will be more efficient than (PF) pump and will require a piston pump in most cases. Input horsepower is determined by displacement times PSIG. With the variable volume pump, when we want to change the speed of the hydraulic motor we change the volume of the pump which reduces the input horsepower (GPM x Pressure equals Horsepower), so therefore we save input horsepower.

One of the most popular pumps on the market today is the pressure compensated, variable volume pump. (Figure 4) This means you set the maximum pressure and the pump changes the volume to maintain the maximum pressure. If you note the flow control valves are set for a certain volume for speed of hydraulic motor. Therefore the pump will maintain this volume within the limits of the pump. If you add a two-way valve into the pressure line of the hydraulic motor circuit you can start-stop the hydraulic motor without starting and stopping the hydraulic power unit. (Figure 5) With this type of circuit you can have several drives operating off of one hydraulic power unit. This is basically a good circuit if you have a lot of drives but aren't using them all at the same time.

VI. CLOSED-LOOP CIRCUIT; HYDROSTATIC TRANSMISSION DRIVE (Figure 6.)

This is what we call "one-on-one" - one variable volume pump and one fixed-displacement motor. Instead of the flow returning to the open reservoir only approximately 10% of the fluid returns. This means that 90% of the fluid stays in the loop, and is reused. Therefore the oil must be finer filtered for long life. The transmission always has a supercharge pump which will replenish the 10% flow for
**FIG. 5**

**SIMPLE HYDRAULIC DRIVE**

*Open Loop*

**VARIABLE DISPLACEMENT**

![Diagram of Simple Hydraulic Drive Open Loop]

**FIG. 6**

**HYDROSTATIC TRANSMISSION**

*CLOSING LOOP*

![Diagram of Hydrostatic Transmission Closing Loop]

**FIG. 7**

**MULTIPLE DRIVES - LOAD SENSING**

![Diagram of Multiple Drives Load Sensing]
cooling and also supply energy to stroke the pump for changing the displacement. This changes the RPM of the motor.

This system can be used for industrial drives but was primarily developed for mobile drives. The disadvantage of this type of drive for industrial use is that it requires a pump and electric motor for each hydraulic motor. Thus these drives do not have the advantages of multiple drives which will be discussed next. All of the previously discussed drives can be remotely controlled for computer control, etc.

VII. MULTIPLE DRIVES, LOAD-SENSING AND PROGRESSIVE LOADING (Figure 7)

This is a system that has been exclusively developed by Adams Air & Hydraulics Inc., of Tampa. We think this is the most advanced drive system available today. This system is most desirable in the citrus tank farm applications. The designing criteria of this system is usually determined by the number of drives that you would like to operate at any one time at the maximum speed. Let us assume you'll require twelve drives but you would never require more than six drives operating at maximum speed. This would determine the design criteria of the drive. This would also mean that you could operate all twelve drives at one time but at one-half of the maximum speed, or any ratios that would meet the maximum capacity of the system.

This system is flow and pressure compensated and load sensing. Note we are using more than one PV pump. When the power unit is running and there is no requirement for a concentrate pump drive, the pump will automatically destroke and maintain a minimum pressure at no-flow condition thus saving horsepower. If no. 1 drive is put in operation by opening a solenoid valve the flow and pressure will automatically respond to the load condition of the work load. There is direct communication between the work load and the pump controls at all times when in operation.

If the work load requires a higher starting torque, the pump will automatically sense this and meet the demand up to the maximum pressure of the system. When the work load requirements drop off the pressure will automatically drop off to maintain the torque required. Each drive has its own remote speed control for varying the speed of the concentrate pump. The hydraulic pump will maintain this condition at all times until the demand changes.
If a product valve is closed off accidentally and a drive is started, the hydraulic motor will reach the maximum torque of the drive which is controlled at its terminal maximum pressure. This will stall the hydraulic motor at its given torque and not destroy the product piping, the concentrate pump, or the hydraulic system. This hydraulic system can be instrumented to show this condition with a pressure switch, etc.

PROGRESSIVE LOADING:

By "Progressive loading" we mean that with this system, if you have several concentrate pumps on line and before you have fully taxed the volume of the first hydraulic pump, the second pump will automatically start and become part of the system. At this time both hydraulic pumps will be pumping only the volume and pressure of the work load, thus saving horsepower. If the load requirements decrease, the second pump will automatically shut off. This is Progressive Loading.

ADVANTAGES OF THIS SYSTEM:

The advantage of this system is we don't put all our fruit in one basket for it provides a back-up system should an electric motor burn out, etc. We can also use this power unit to operate hydraulic actuators at the same time on product valves which we have done in the past.

Objectives that can be accomplished with this hydraulic system:

1. Variable speed (larger range)
2. Variable torque
3. Constant torque
4. Progressive loading
5. Back-up and stand-by operations
6. A minimum of electric horsepower required. (Does not have an electric motor for each concentrate pump).
7. Not as much electrical control equipment needed such as motor starters, safety switches, etc.
8. Easily reversible
9. Totally enclosed
10. Self-lubricating
11. Explosion proof
12. Compact - Hydraulic motor at work load
13. Controls removed from damp area
14. Less moving parts ('Belts, Chains, Pulleys, etc.)
15. No gearboxes required
17. Soft Start, Soft Stop
18. More flexibility in design

We have tried to keep this presentation as simple as possible to provide you basically with what can be accomplished with this system. No doubt there are questions that we will be glad to answer at this meeting or at any time, please feel free to call.