Fluid Clutch Motor-Driven Centrifugals

JOSEPH HERTRICH[1]

General

The Fluid Clutch motor is applied on a centrifugal in the same manner as a direct connected electric motor.

Schematically, the drive consists of an electric motor connected to the centrifugal by means of a fluid clutch. The motor is always running at top speed and the power connection is made or broken by filling or emptying the fluid clutch. The rate of power transmission is determined by the quantity of oil in the fluid clutch. The quantity of oil at any time circulating in the clutch is controlled by suitable outside controls, such as torque, speed and filling controls.

The application of slip clutches on centrifugals is well known. In certain characteristics the fluid clutch compares with the centrifugal type friction clutch, in other characteristics it deviates so far from the friction clutch that in practical application the results are quite different. The fluid clutch lends itself particularly for high speeds and high power transmission.

Principle of Operation and Characteristics of Fluid Clutch

The Fluid Clutch consists of an impeller which is connected to the drive motor (equivalent of a centrifugal pump) and the runner which is connected to the centrifugal (equivalent of a turbine) which are operating concentrically and adjacent.

When oil is introduced into the coupling the impeller, which is rotating at a relatively constant speed, imparts a velocity to the oil which is then transferred to the slower revolving runner inside of which some of the oil velocity is absorbed. This results in an oil vortex inside the coupling where the oil continuously enters the impeller near the center at slow velocity and leaves it near the circumference at high velocity. It then enters the runner near the circumference at high velocity and leaves the runner at low velocity near the center. This change in velocity of the oil entails a change in kinetic energy of the oil which is proportional to the square of the velocity change. Consequently the impeller imparts kinetic energy to the oil while the runner absorbs kinetic energy from the oil. About 90% or more of the power is transmitted by exchange of kinetic energy while 10% or less is transmitted by hydraulic friction. The amount of power transmitted then depends on the amount of oil circulating in the coupling (rate of filling) and the vortex velocity which changes with the slip in the coupling.

The characteristics of a fluid clutch are generally as follows:

a) The torque capacity varies approximately in proportion to the square of the impeller speed.

b) The torque capacity varies, within certain limits, in proportion with the slip, that is, the difference in speed between impeller and runner.

c) The input torque and output torque are equal.
d) The energy lost in the coupling is proportional to the slip. This energy is absorbed as heat by the oil which in turn must be cooled.

Design Features

Fig. 3 shows a section through a vertical fluid clutch motor. The unit with the drive shaft extending downwards connects to the centrifugal head in the same manner as a direct-connected vertical motor. The fluid clutch arranged above the hollow shaft motor makes a compact design possible with good bearing supports for both shafts.
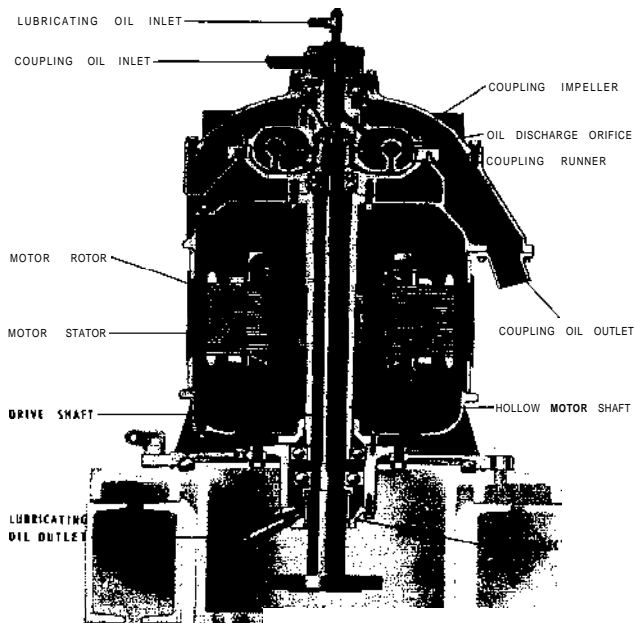
40 HP FLUID CLUTCH MOTOR

FIG. 3
THE WESTERN STATES MACHINE COMPANY
HAMILTON, OHIO

The machine is composed of:

a) The stationary unit—comprising motor stator, lower end shield with flanged base, upper end shield with oil collecting chamber, upper endshield cover and bearing cartridges.
b) The primary revolving unit — comprising the motor rotor

mounted on the hollow shaft, the coupling housing and fan bolted to the hollow shaft, the impeller and the two supporting ball bearings.

c) The secondary revolving unit composed of the runner and flanged drive shaft and the supporting ball and roller bearings.

The motor is a conventional single speed squirrel cage motor with standard windings and power characteristics. It is started by a reduced voltage or an across the line starter and then runs continuously at high speed. The heat produced in the motor is comparable to the heat produced in any standard motor under full load. The motor is cooled by the air flow produced by the fan on the coupling housing.

The oil is introduced into the clutch through the oil inlet pipe on top of the unit. While the clutch is filled with oil, there is a continuous stream discharged through four discharge orifices in the impeller which collects in the oil collector housing from where it flows to the oil cooler.

The required filling of the coupling is obtained by the regulated oil flow into the coupling as determined by the outside controls.

All bearings are lubricated by a continuous oil flow through the lubricating oil inlet line on .top of the motor. The same oil supply is used for the lubrication and for the power transmission. Part of the lubricating oil discharges through the lubricating oil outlet pipe below the lower bearings.

Oil Flow Controls

The oil flow to the fluid clutch is controlled as follows:

1) Manually by the operator to start and stop the machine and to regulate the discharge speed.
2) By the automatic cycle control which shuts the oil off at the end of the drying cycle and applies the brake.
3) By the torque control which regulates the oil flow so as to obtain the desired acceleration torque.
4) By the speed control which shuts the oil supply off at a desired speed below the maximum speed of the unit.

The machine can be furnished with manual control only, eliminating the other 3 controls where they are not required.

Manual Control

The manual control consists of an "oil:solenoid valve in the oil supply line which is controlled by a master switch which interlocks the oil valve with the brake so that the fluid clutch and brake can not be energized at the same time. The master switch has three positions, namely "Brake," "Off" and "Run."

Automatic Control

The automatic control is added to the manual control by adding one or more electric timers which time all desired functions such as "Washing," "Separator Trip," "Stop" and any other desired timed function.

The master switch now has four positions, namely, "Brake," "Off," "Plow" and "Run." In "Plow" position the oil solenoid valve is energized, thus engaging the fluid clutch. In "Run" position the electric timer is also energized and times the automatic functions of the cycle. This timer controls the application of the brake at which time also the oil solenoid valve is closed and the fluid clutch disengaged.
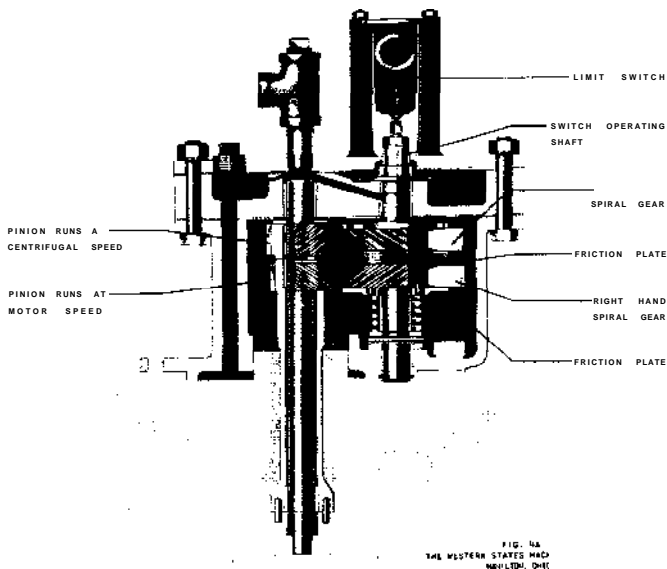
Speed Control

Two types of controls are used:

  a) The differential governor type for fixed top speed.

  b) The oil governor type for variable top speed.

Fig. 4a shows a section through the differential type governor, which was designed especially for this application.

The normally closed limit switch of the governor is wired into the

SPEED CONTROL UNIT

control circuit of the oil solenoid valve. The switch is operated by an axially shiftable gear assembly, consisting of a shaft with a right hand and a left hand spiral gear, held together by spring and washers in such a way that there is some frictional resistance to the relative rotation of the two gears. These gears are driven by left and right hand pinions which are connected to the motor shaft and centrifugal shafts respectively. The gear ratios selected determine the speed of the centrifugal. The spiral gears produce an end thrust either downward or upward, depending on whether the right hand or the left hand spiral gear is driven faster. As long as the centrifugal operates below the controlled speed the thrust is downward. When the centrifugal operates at the controlled speed, there is no thrust because both

gears are driven at the same speed. When the centrifugal operates above controlled speed the thrust is reversed to upward so that now the shaft moves up, trips the limit switch and shuts off the oil supply to the fluid clutch.

The machine now coasts until the speed gets below controlled speed and the oil solenoid valve is again energized.
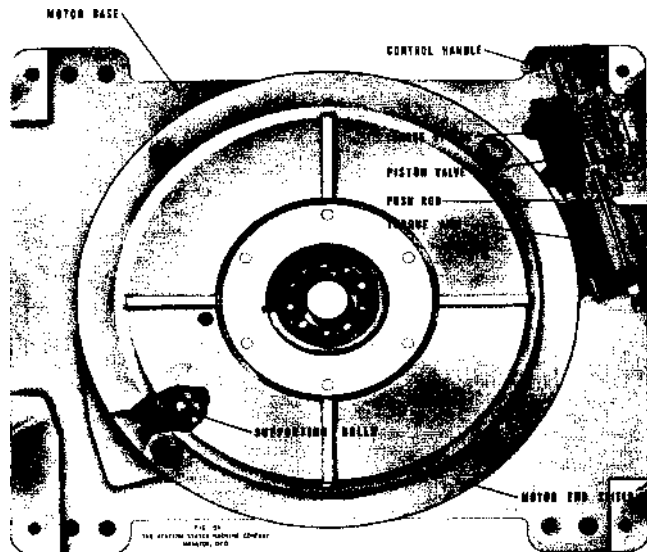
The oil governor type speed control consists essentially of the control pump driven at the speed of the centrifugal which pumps oil at the rate of its driven speed. This oil is discharged through an adjustable orifice in a speed control valve. For a given setting of the control valve the oil pressure will then vary with the square of the speed of the machine.

This oil pressure is used to operate a diaphragm-operated oil valve which is inserted in the oil supply line in series with the oil solenoid valve. With this speed control any speed from 300 RPM to top speed can be selected merely by turning the control valve.

The oil governor type of speed control is used in the chemical industry where variable speeds are many times required.

For the sugar industry where high production is required and the speed

is generally fixed for a given product the differential type governor is used. This insures a definite top speed of all machines *in* a battery which can not be altered without introducing new gears in the speed control.

Torque Control

The power transmitted by the fluid clutch is controlled by the torque

100 H.P. FLUID DRIVE SPEED / POWER / TIME PERFORMANCE CURVES
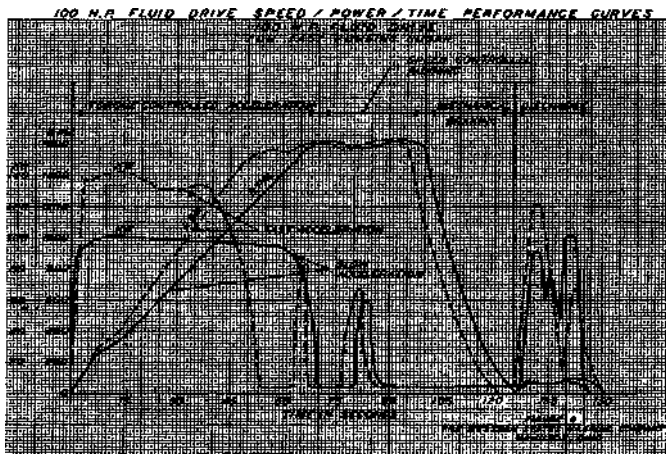
control valve of which Fig. 5a shows a horizontal section through the center. This valve is inserted in the oil supply line in series with the oil solenoid valve. It is normally held open by an adjustable spring and is closed by the torque reaction of the motor in the following manner:

The inotor is supported on a row of balls and is free to swivel within a small arc. The torque valve is bolted to the fixed motor base and is connected to the movable motor frame by an arm and push rod in such a way that the spring in the torque valve pushes the motor frame in the direction of rotation. When oil is introduced into the coupling the torque increases until the torque reaction on the frame is strong enough to compress the spring and partly close the torque valve. The stator and valve will automatically assume the position in which the oil flow to the coupling is sufficient to produce the torque for which the torque spring has been adjusted. A handle is provided on the torque valve for regulating the torque by changing the spring pressure.

Sizes

Fluid Clutch motors have been made in ratings of 30 HP, 40 HP, 50 HP, 60 HP, 75 HP, 100HP and 125 HP and are operating at speeds from 1,400

40 H.P. FLUID DRIVE SPEED/POWER/TIME PERFORMANCE CURVES
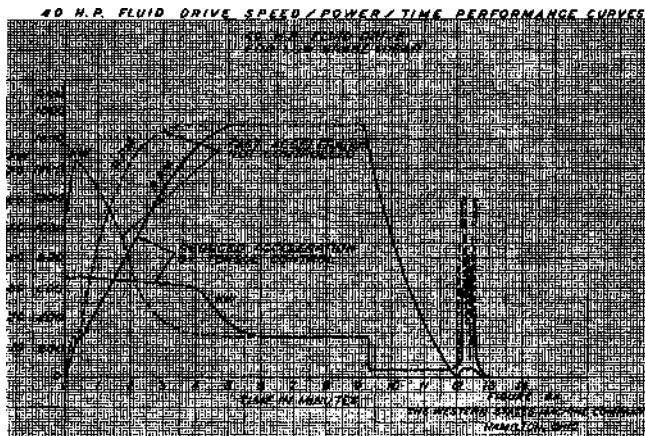
to 2,200 RPM. The speeds above 1,800 RPM are obtained by a stepup of the frequency.

Advantages

Some of the advantages of the fluid drives are:

1) **Smooth power connection between motor and centrifugals resulting in lower** stresses **in the working parts.**
2) **Continuously running electric motor eliminating high** starting stresses **in the motor and violent fluctuations in the power supply lines. Resulting in longer life of the motor, starter and other machinery.**
3) **Cool running motors insuring a long life of the motor winding without using special insulating materials.**
4) **Motors are of standard type, using standardized ratings.**
5) **With torque and speed control available the units can be selected for the best process advantages. The acceleration rate can be altered to suit requirements.**
6) **The torque control produces an almost straight line acceleration and a constant power pull from the line during acceleration. High power peaks are eliminated.**

Power and Speed Curves

Fig. 8 shows two sets of power and speed curves taken on a 100-HP Fluid Drive with torque control and differential speed control driving a 40" x 24" x 6" centrifugal at a top speed of 1,600 RPM, processing white sugar in a beet sugar factory.

The two curves were picked out of a series of graphs made with different torque control settings. Note the constant power pull during acceleration and the corresponding straight line acceleration.

With the first setting the motor pulls an average of 135 KW and accelerates the machine to 1,600 RPM in 50 seconds. The second torque setting produces a power pull of approximately 100 KW and accelerates the machine to 1,600 RPM in 67 seconds.

Note that the top speed is maintained by small intermittent power impulses, resulting in a slightly wavy speed curve.

Fig. 8a shows two sets of power and speed curves taken from a series of test graphs made on 40-HP fluid drives with torque controls (no speed control) driving 40" x 24" x 6" low grade centrifugals in a beet sugar factory.

The first curve shows the fastest acceleration rate with the maximum torque setting. The machine reaches 1,600 RPM in $2^1/_4$ minutes and accelerates slowly from there on up. Note that the torque control valve is only active for approximately $^1/_2$ minute and that from then on the power capacity of the coupling is less than the torque setting. The maximum power pulled is 73 KW.

The second set of curves indicates an acceleration to 1,600 RPM in approximately 4 minutes with a steady power pull of about 32 KW for the greater part of the acceleration period.

In cases where a still longer acceleration is desired it is found that the torque produced is not enough for satisfactory discharging operation. An additional oil valve is then used to bypass the torque control valve.

Conclusion

It is not the purpose of this discussion to convey to you a conviction that this type of centrifugal drive is superior to all others. Rather, we attempted merely to give you some idea of the design and construction with the resulting operating characteristics.

We manufacture five different types of centrifugal drives and there are conditions prevailing at different factories which can properly indicate each one of these drives as superior for a specific situation.