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Introduction

These researchers were asked to take apart an unknown hydraulic device and determine its use and how it worked. We disassembled this device in N1363, the Advanced Manufacturing Lab, at Purdue Polytechnic New Albany, IN on 23 January 2014, and are confident it is a hydraulic vane motor. [1].

Literature Review

In general, hydraulic motors extract energy from a fluid and convert it to a mechanical energy to perform work. Instructions were provided after testing to aid in the identification of the hydraulic vane motor. [2] [3]

"Vane motors develop torque by the hydraulic pressure acting on the exposed surfaces of the vanes, which slide in and out of the rotor connected to the drive shaft. As the rotor revolves, the vanes follow the surface of the cam ring because springs are used to force the vanes radially outward. No centrifugal force exists until the rotor starts to revolve. Therefore the vanes must have some means other than centrifugal force to hold them against the cam ring." [1, pp. 237]

"Vane motors provide good operating efficiencies, but not as high as those of piston motors. However, vane motors generally cost less than piston motors of corresponding horsepower ratings. The service life of a vane motor usually is shorter than that of a piston motor, though. Vane motors are available with displacements of 20 in^3/rev. Some low-speed/high-torque models come with displacements to 756 in^3/rev. Except for the high-displacement, low-speed models, vane motors have limited low-speed capability." [2]

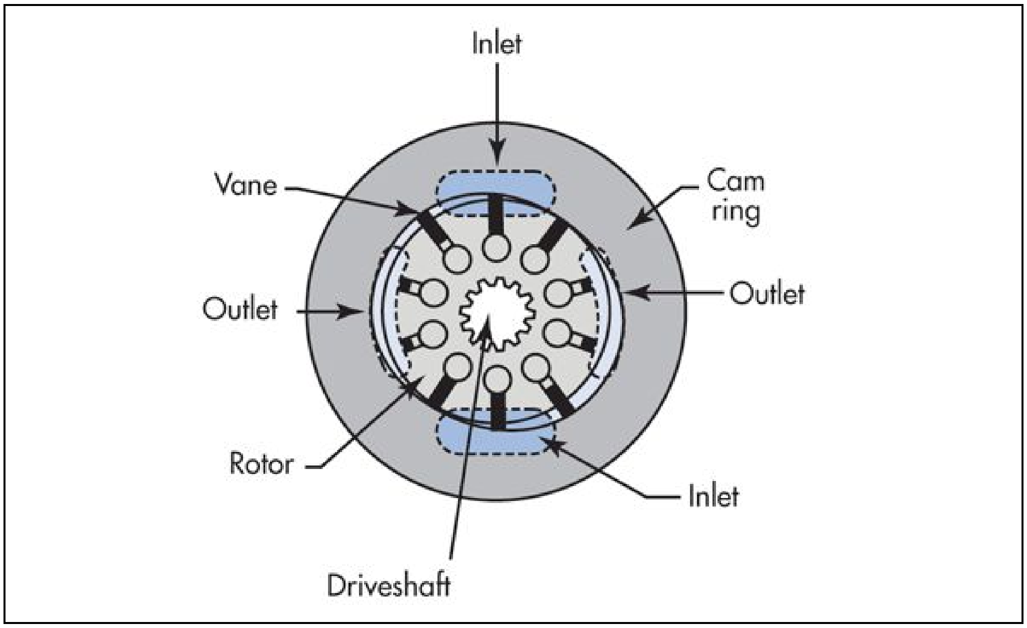

Fig 1. Vane motors (balanced type shown) have vanes in a slotted rotor. [2]

Method

We disassembled the vane motor by removing four large bolts and two small bolts. Upon removal of the four large bolts, the shaft came apart from the motor housing. This process exposed the cam ring, the two fluid inlets, the two fluid outlets, the vanes, the vane springs, and the rotor. This allowed us to observe how the device operates.

Upon observation, we discovered that as the fluid enters into the inlet ports, its pushes the vanes in a counterclockwise [2] rotation causing torque to spin the driveshaft. We also observed that the borehole within the cam ring was an elliptical shape rather than the traditional circular shape.

We found out that this shape allows the fluid to exit the motor [2], and it also allows the springs to press against the vanes causing the vanes to press against the cam ring to prevent leakage while the motor isn't in operation. The researchers find it interesting to note that vane motors are often found in the usage of paddle drives on steamboats. [1, pp. 237]

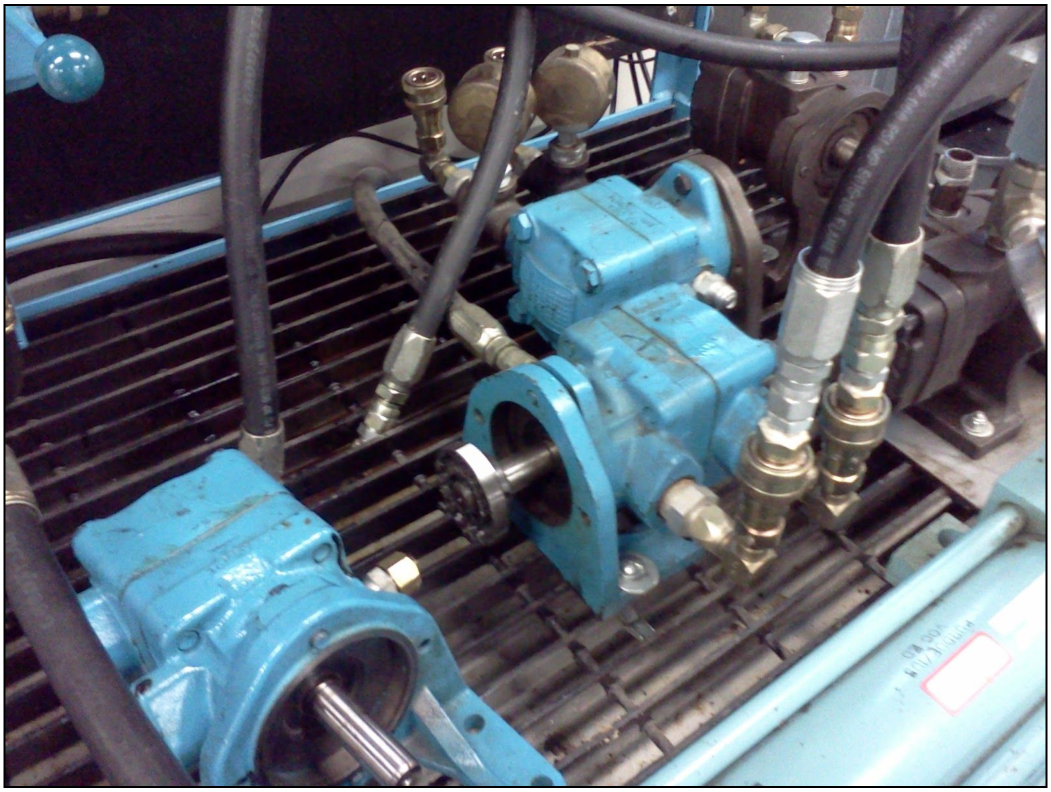

Fig 2. Photo of test rig, on the left is the actual unit that was taken apart, on the right is one of the same model that was used to gather data.

Results

Lever Direction	Flow Rate (gpm)		Pressure (psi)		Speed (rpm)	
Right	4.44	4.44	230	220	660.5	660
Left	4.45	4.45	240	230	659.4	660
Neutral	4.48	4.48	80	80	0	0
Average	4.46	4.46				

*gpm = gallons per minute, psi = pounds per square inch, rpm = revolutions per minute

After conducting the test of running the vane motor on the provided test stand, it was concluded that the flow rate of the motor while at rest, was 4.44 gpm. Once the hydraulic pump was activated the rate increased to 4.45 gpm. The working pressure of the pump was also recorded while at rest and the pressure was at a constant 80 psi, however once the pump was activated, the pressure increased rapidly to 230 psi. The final test that was performed was recording the speed using a digital tachometer by aiming a laser at reflective tape attached to the rotating shaft for increased accuracy. When the pump was activated the running speed was recorded to be 660 rpm.

Along with the measured data, the researchers were also asked to calculate the internal volume. To find the internal volume, we used the formula:

$$Q = \frac{DN}{231\,Ev}$$

Where Q is the flow rate, D is the displacement, N is the revolutions per minute, and Ev is the internal volume. Note that since the displacement wasn't measured in this procedure, we used the published statement, "Vane motors are available with displacements of 20 in.3/rev." [3]. The internal volume was calculated to be 13.48 cubic inches.

$$Ev = DN/231Q = (20)(660) / (231)(4.46) = (13\ 680) / 1\ 027.95) = 13.48\ in^3.$$

Conclusion

Through this lab and experiment we the researchers learned that it is possible to calculate internal volume of a hydraulic vane motor by recording the flow rate, displacement, and speed of a rotating shaft.

References

[1] Esposito, Anthony. Fluid power with applications. Upper Saddle River, N.J: Pearson Prentice Hall, 2014, 7th edition. Print, pp. 164 - 170, 237 - 240.

[2] Fundamentals of Hydraulic Motors
http://www.hydraulicspneumatics.com/hydraulic-pumps-motors/fundamentals-hydraulic-motors

[3] Cooley, Timothy R. "Spring-2018-MET-23000-08T: Hydraulic motor information". 24 Jan 2018. E-mail.