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Leakage and Its Effects In Various Hydraulics Driven System

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Abstract : This paper brings forward the various leakages and its effects which are associated with hydraulic system. Leakage is the main gradual leak in fluid power system, which is usually caused by the impurity in the oil and wear of matching surfaces between parts and lead to the change of the gap value. It results in reduction of system flow as well as the loss of system pressure, resulting in the decreasing of overall system efficiency. In fluid power system, internal leakage may occur in various components such as gear pump, reversing valve and hydraulic cylinder and external leakage at the shaft seal or the connecting parts. Effect of leakage on system can be observed using sensors.

Keywords : Hydraulic system, Leakage, External leakage, Internal leakage, Spool valves

1. INTRODUCTION

The hydraulic driven system has been widely used in industrial production ,construction and other mechanical equipment to produce high forces or torques with low inertia , fast time responses, reducing shock, smooth movement and easy to achieve automatic control. However, because of unstable quality of components and accessories on the objective, improper apply and maintenance on the subjective and the designing flaws of hydraulic system, it would inevitably give rise to various failures [1-2]. The faults in hydraulic system should be detected and recovered immediately while the system is still operating to prevent catastrophic failure. For hydraulic systems, faults cover a wide range, from component failure to leakage in system and material wear [3-4]. The leakage of hydraulic fluid is one of the major causes of faults and generally there are two types of leakages are exist in the system, depending on the location- Internal leakage and External leakage. Leakage in hydraulic system effects the performance of system as well as economically also. The cost of a drop of fluid may seem negligible , but the fluid drips from the leak several times per minute and a machine may suffer dozens of leaks , so it usually causing serious costs from downtime and maintenance. When the hydraulic fluid leaks from one chamber of the actuator cylinder to another, called internal leakage and when it leaks out of the cylinder, which is called external leakage Internal or external leakage or both can cause a substantial drop in hydraulic pressure and eventually decrease the velocity or controllability of the output shaft. Comparing the internal and external leakage, one finds that only external type is visible to the operator and can be detected easily [5].

2. GENERAL CONSIDERATION FOR LEAKAGE IN HYDRAULIC SYSTEM

In practical application, the main reason of hydraulic cylinder leakage is the damage of seal, which is a progressive failure. This gradually process can be described as a potential failure mode, i.e. the system performance declines with the fault development. If the features of leakage can be extracted, it can be diagnosed timely to avoid worse breakdowns of system [6].In general the leaks that are recognised and left in hydraulic system effects the company

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economically, and effects on the system performance. Due to no visual indication of leak the leaks are not identified until the system performance degrade. The component through which the leak occur are repaired unplanned or heuristics for the breakdown maintenance. Comprehensively and thoroughly approach required to keep record and oversight on the overseer leakage within the hydraulic system to control and identify the hydraulic system leakage. The overhauling the ground causes of the leaks and oversight the system upgrade the system performance and assured that the overhauled equipment efficaciously [6].

A. Internal leakage

Now these days generally the leaks are planned in the most of the hydraulic system. The equipment manufacturer frame the equipment of the system with specific function and with tolerable amount of leakage under normal running position. The planned internal leakage is ordinarily small orifices or pathways through which the high pressurised liquid flow to low pressurised zone to lubricate, clean or cool the particular equipment or area in the system. In internal planned leaks the fluids are not depart from the equipment of the hydraulic system, therefore internal leakage are not visible. Generally the excessive internal leakage claimed in the hydraulic system are done by wearing of the equipment during operation. The poor system framing, choosing incorrect equipments , poor quality control tolerances and repairing in incorrect manner leads to leakage in the hydraulic system. System performance , increased operating temperature and reliability indicates the excessive internal leakage [7]. In general, internal leakage cannot be detected until the actuator/cylinder seal is completely ruin and the actuator fails to respond to a control signal. A great deal of work has been carried out on development of fault detection systems in the past decade. Faults in fluid power systems and methods for detecting them have been documented in the book by Watton [8].

The internal leakage in pumps and motors leads to prime power losses in the hydraulic system. This leakage is due to excessive clearance and also degrade the volumetric efficiency.

The leakage of hydraulic cylinder is mainly related with the structural parameters of the hydraulic cylinder piston rod, seal forms, oil viscosity and wear situation of the piston. It can be divided into two cases: concentric and eccentric, they have different formula to calculate leakage flow. Leakage for concentric case calculated as in equation (*i*) and leakage for eccentric as in equation (*ii*)

$$Q_c = \frac{\pi d h^3}{12 \mu l} \times \Delta p \tag{1}$$

$$Q_c = \frac{\pi d^4}{128 \mu l} \times \Delta p \tag{2}$$

where d is the cylinder diameter; h is the height of the gap; l is the gap length; l is the fluid dynamic viscosity; Δp is the pressure difference between the high pressure chamber and the low pressure chamber.

Excessive heat reduced the viscosity of fluid and it enhances the internal leakage rate in the hydraulic system. Due to excessive heat the strength of fluid film decreases results untimely wear of components surface.

B. External leakage

The most apparent leakage of hydraulic system is external leakage. It can visualise by the naked eye as geyser. The external leakages are to be repaired immediately, to continue the system operation. The constant drop that drips from the equipment of hydraulic system as external leakage does not effects the system or production performance. For overhauling the external leaks of the equipment, location and leakage rate is to be known. In maximum case the leaks quantity and root cause of leaks on equipment are difficult to identify. For investigation of external leakage in hydraulic leakage, clean and wipe down components after few interval of time.

3. LEAKAGE THROUGH SPOOL AND HOUSING BORE

In case of spool valves, the control and stability concerning the hydraulic system are affected by certain factors such as increase in clearance ratio between spool and valve body. When the pressurised fluid traces its path

to the tank via spool valve, it sometimes leads to clearance issues and that is in terms of hydraulics is known as profit-robbing energy loss. Considering the case of faulty relief valve having the problem of jammed open condition, it will leads to loss of pressurised hydraulic fluid as fluid will easily bypass the main hydraulic circuit and return to tank.

Very often due to excessive clearance between spool bore and spool land, lot of leakage takes place. Depending on the nature of spool fitting the leakage path may be either (Figs.1 (*a*) and (*b*)) (*i*) concentric or (*ii*) eccentric. For a concentric spool with radial clearance (b)the maximum clearance passage is 2 b.

If the leakage path is eccentric, leakage area of a spool with a given radial clearance is almost 2.5 times larger than when it is concentric.

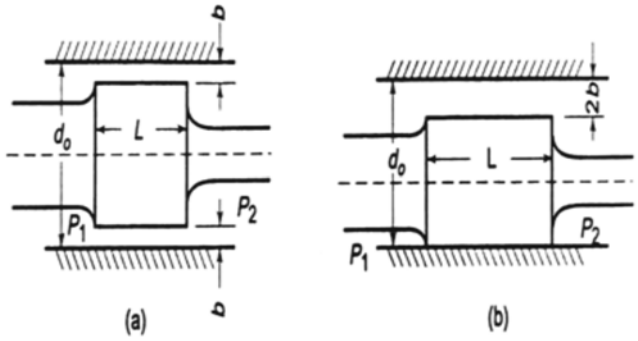

Fig. 1.

The center leakage for a new valve (Fig. 2*a*) around the neutral position is laminar. When spool moves away from the neutral position, leakage reduces drastically (Fig. 3). For an old valve, the leakage flow is laminar and the leakage flow curve is similar to that of a new valve. But the central leakage flow is slightly bigger, which is caused by the wear-out of the edges of spool and sleeves (Fig. 2*b*). To take account of this feature, an experimental function is formed.

The external leakage flow is influenced by two factors: (*i*) pressure, which implies that the leakage of the laminar flow type is related to the pressure drop; and (*ii*) the valve orifice area [9], which can be represented as a function of the spool position (or the relative spool position).

The external leakage flow has the following features : (*i*) it is most significant at the spool's neutral position; (*ii*) the leakage flow and its derivative get smaller when the spool moves away from the neutral position; and (*iii*) the leakage flow and its derivative will be very small or zero when the spool shifts to the largest displacement.

On the basis experiment done by C Wang [9], a new leakage model considering both the pressure and the valve orifice area is proposed. The central leakage for a new valve (Fig. 2*a*) at the neutral position can be defined as:

$$Q_c = \frac{\pi C_r^2}{32\mu l} \times \Delta p \tag{1}$$

where , Qc is the central leakage flow, w the area gradient of orifice, Cr radial clearance between spool and sleeve, the dynamic viscosity, and p pressure drop.

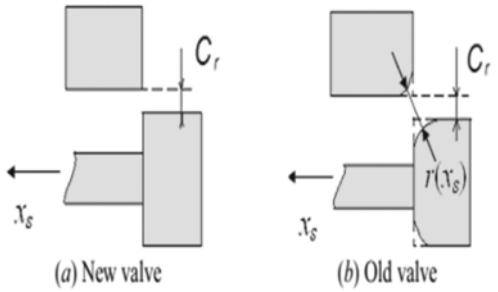

Fig. 2.

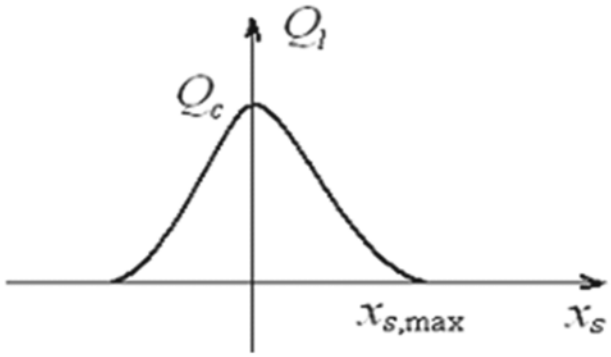

Fig. 3. Typical Leakage Curve

4. LEAKAGE IN CYLINDER OF HYDRAULIC SYSTEM

The leakage of hydraulic cylinder is mainly related to the structural parameters of the hydraulic system within cylinder piston rod, seal forms, oil viscosity and wear situation of the piston. Yang found the leakage could be detected accurately by the pressure rise time [10]. Werlefors applied nonlinear observation model and established by static feedback to diagnose the leakage successfully by measuring the piston position and piston speed [11].

The experiment for hydraulic cylinder internal and external leakage is done by Xiuxu Zhao , Shuanshuan Zhang , Chuanli Zhou , Zhemin Hu, Rui Li , Jihai Jiang [6]. In that experiment, variable orifice is applied to simulate at different leakage level of hydraulic cylinder, which is shown in Table 1. System load pressure was set in 5 MPa; gear pump output flow is 23.6 L/min. And Leakage of orifice can be calculated by the equation (ii).

Table 1 : Leakage At Different Orifice size.

Number	***1***	***2***	***3***	***4***	***5***	***6***
Orifice diameter (mm)	0.25	0.30	0.35	0.40	0.45	0.50
Orifice length (mm)	3	3	3	3	3	4
Leakage (L/min)	0.0049	0.0104	0.0192	0.0327	0.0524	0.0599

And hence the leakage varies as the orifice diameters length changes. During the process of piston rod retracting and stretching , the changes of piston position and pressure over time with no leakage and different levels of leakage are recorded by the pressure sensor and the position sensor.

5. CONCLUSION

Leakages in hydraulic systems are expensive and potentially hazardous. The hydraulic system failure /leakage directly affects its efficiency, and even can-not work But like any leak, they can be mended or prevented. Leakage, however, they can lead to system contamination and shutdown if they are not handled with precision – and the right materials. In general, most of the leakage can be traced to a fault in design, assembly, operation, or repair. Some leakage in the hydraulic system are planned for lubrication, cooling and cleaning purpose. And overall the leakage in hydraulic system effect the system performance due pressure drop and error in displacement.

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