ISSN 1454 - 8003
Proceedings of 2016 International Conference on Hydraulics and Pneumatics - HERVEX
November 9-11, Baile Govora, Romania

METHODS OF DIAGNOSING MALFUNCTIONS IN HYDRAULIC ACTUATIONS

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Abstract: *Keeping hydraulic systems in optimal operating condition is one of the ways to obtain a high productivity and minimum energy consumption. However, even in situations where hydraulic components suffer damage, fast and accurate diagnosis will reduce losses. The article presents the most common diagnostic methods used in hydraulic systems, as well as some guidelines for the interpretation of the first signs of abnormal operation: increased noise and temperature.*

Keywords*: maintenance, malfunctions, noise, service, repair*

1. Introduction

Maintenance is a combination of all the technical actions, administrative and managerial taken during the lifecycle of the equipment in order to maintain or restore the ability to perform the desired function (acc. To European Standard EN 13306). From this definition it shows that maintenance activities that include the identification, measurement, control operation, testing, detecting faults, repair, adjustment or replacement of parts items and service [1]. The large number of activities and complexity of each of them, and the scientific and their high technical science, transforms maintenance into a very serious scientific branch with a strong theoretical and experimental character. Obviously that the repair or service work are part of a complex part called maintenance actions and should not be confused. An extremely important role in maintaining product quality is to maintain the good fabrication technology and technological equipment component manufacturing line, indicating that consideration should be given to maintaining the performance designed for components and subassemblies as and the whole machine.

2. The definition of malfunctions and causes of occurrence

One of the basic elements in maintenance, as in reliability, it represents the malfunction, which consists of a partial or total loss of the capacity or operating performance of the equipment or hydraulic system and can occur accidentally or while due to the changed operating parameters under allowable level. From this definition it appears a clear idea, namely that the equipment may be damaged even if still works, because essential is, if it’s in working parameters designed to keep productivity, product quality they execute and also the safety of personnel services which technology and equipment it deserve. Next we present several examples of malfunctions in the area of hydraulics in which the equipment still works, but the working parameters are below the level required of the equipment and given in the product data sheet.[1]
Hydraulic pumps and hydraulic motors which in a system take mechanical or electrical energy from thermal or electric motors and transfer it to a machine as mechanical energy represent the basic subassemblies of the entire machine, defining speeds, frequencies and I fact actually overall productivity. In case of increase of drainage losses or decreasing flow with an increase in pressure the hydraulic system still works, but with the slow rhythm and in a decreased of machine productivity.

Hydraulic distributors can increase during operation the response time by reducing the speed of the drawer, or to reduce its area crossing the working fluid, which ultimately leads to the same decreased in productivity.
Safety valves increase their on-off domain with flow around the pressure which is set, without getting totally stuck and therefore increase the total flow losses in certain phases and finally reach to a significant decrease in productivity line.
All previously described faults are caused by wear of components and wear and contamination of the working fluid.
The causes for malfunctions are found in all phases of the product life starting from the design passing through the execution phases and especially in phases of use. The type of malfunction determined by the equipment deviation from normal functional parameters it is based most often, processes that occur over time as wear, while accidental malfunctions are based, most often design errors or misuse without compliance to the manufacturer of work equipment. For malfunctions appeared by overcoming functional parameters the common remedy is the use of methods of preventive maintenance, while sudden accidental failures cannot be predicted and cannot be counted directly when making plans for preventive maintenance but only by statistical calculation. On the basis of over 70% of hydraulic systems malfunctions are the contaminating particles in working fluid, which during operation causes fast wear with serious consequences, sometimes resulting to total system crashes. General causes that lead to malfunctions are many, but the essential are abnormal noise, high temperature for working fluid and various components, and slowing down the action of the system.

3. Diagnosing malfunctions

Diagnosing or finding malfunctions it is a condition for general knowledge regarding hydraulic actuators, and a knowledge and understanding of the scheme of the installation defects, because this is the only way we can ensure the rapid removal with minimum effort of the failure. It is mandatory to start finding the malfunction from the effect that remove the equipment or system from the good operating condition. The malfunctions may be induce by one or more causes, which is acting independent or simultaneous and as usually we start to detect them from the warning symptoms which show as there is an exit from the accepted parameters. In the current practice it merges, often, the effect with the cause, which makes it difficult to analysis the defect and establishes an effective measure of remedial. In the diagnostic process, based on the effect observed and passing thru defining a series of effects associated, we get to the root of the primary cause. [3]
Superficial analysis of malfunctions found and the establishment of wrong or incomplete cases they have generated are likely to lead to the responsible fault from its initial phase or when the symptom accentuate and create negative effects associated.
At diagnosing malfunctions we mast need to analyze also the sound sources and abnormal temperature because in general the hydraulic system malfunctions are accompanied with this two phenomes. Once the malfunction is localized, establishment of the cause can be made through measurements of pressure and flow. For this, from the design phase of the installation is necessary to provide connections ports for pressure gauges and flow meters.
Finding malfunctions will be made thru successive checks of the components elements. An order verification, applicable in all cases it is not possible. In the first step the verification will be made only by means of gauges, they can obtain qualitative information on the fault found. For obtaining some quantitative information necessary to carry out measurements of flow it is requiring more complex equipment.
Analyzing defects is easier if the return routes and drainage tubes are made of transparent plastic. This way we visualize leakage and can appreciate the correctness of the distribution elements functions and losses to drainage. It is also useful to gather information on the operation mode, the volume of maintenance, defects and repairs on the period prior to failure. To determine the exact wear-related defects is necessary for the devices to be functional in order to determine how much the performance declined. Only after knowing the exact situation it is going to dismantling the

apparatus. The parts will be inspected visual and then measured with accurate precision dictated by producer. Usually it should be that these operations related to determine and then repair the defective apparatus to be done only by specialized firms, because is mandatory to test the unit on stands after repair or remediation.

4. Methods of diagnosing malfunctions of the hydraulic installations

For an accurate determination of malfunctions it needs that the hydraulic system to be controlled permanently depending on the importance of the system (subsystem) and the diagnostic method applied.[1]

4.1 Visualizations it represents the simple and the oldest method of finding fault and it's always applying, becoming the first in preventive maintenance obligation or any other variant. With this occasion we read the indication of the measure apparatus and control within the installation an checks the look and the integrity of the whole equipment. The finding can be done with the naked eye or using specific optical devices.

4.2 Functional Verification on stand is a specific method for hydraulic installations and is applied in the maintenance programs or when it's the case if signs appear which indicates a system deviation from the output parameters. The method is not available to all units as are needed the use of stands and specialists, therefore usually an outside company operate this work from the area of small and medium

4.3 The verification with penetrating fluids It's an old method appeared and used in the industry in the 30s of the 20th century, with little applicability in manufacturing of hydraulic equipment and very little application in maintenance of hydraulic systems. The detection of micro cracks are rarely checked and only to detect defects in housings, cylinder blocks or devices blocks that carry hydraulic circuits.

4.4 Magnetic control The method is less used in hydraulics, even if there castings and welded parts. For the small magnetic particles of iron to detect cracks in the verified part it must be executed from a ferromagnetic material.

4.5 Ultrasonic testing, According to Wikipedia this method is based on mechanical waves (ultrasound) generated by a piezo-magnetically element excited at a frequency of typically between 2 and 5 MHz. Control involves the transmission, reflection, absorption of ultrasonic waves that propagate in the part we need to verified. From where the beam is emitted inside the part and thru defects it returns to the fault detector that can be both transmitter and receiver. The defect positioning is done by interpreting the signals. Although the method has the advantage of finding defects in depth thanks to a high resolution, it is slow because of the need to scan multiple parts and is very used in the field of hydraulics production or maintenance.[5]

4.6 Electric control the method of testing using Eddy currents are rarely used in hydraulics and can only detect surface cracks or in the vicinity. It can be used somewhat effectively in pipes with great importance in the machine function.

4.7 Thermographic control it started from the fact that excessive temperature differences of benchmarks indicate faulty operation and as such it can be concluded that the area something is wrong. The method is for prospective in hydraulics because many of the faults are followed by additional friction of parts between themselves or the fluid and the metallic walls which care causes narrowing of the slots and passing holes. [2] The fact that is easy to measure and store information regarding the temperature area of interest makes infrared thermography become increasingly more interesting.

4.8 Vibration analysis. Although the method is used for some time in electromechanical systems in the field of hydraulics is at the beginning. Vibration spectra measured with an accelerometer it compares with initial spectrum and the differences is identified that could indicate defects occur in that area. The vibrations are generated not only by mechanical failure but also by the abnormal flow, which increases the area with problems that can be detected without intervention by stopping and dismantling the equipment.

5.The noise in hydraulic systems

In machinery with moving parts such as hydraulic equipment is occurring, shock and vibration that is transmitted directly to the entire system either creates oscillations of air, which is noise and that in any situation have a negative effect on the entire machine. These effects, with sometimes extremely serious consequences, can often be prevented if the specialists can determine the precise relationship between the type of noise and functional status of equipment.
Usually not all noises indicate a malfunction and therefore the limitations often have based the respect of rules for protecting people which is working with or around this equipment. In fact it will actually consider abnormal noise created by cavitation or air into the fluid. Air noise in the system is determined by the compression and decompression during the travel to a system at the same time with the working fluid. These aeration most often lead to foaming of the hydraulic oil that destroys the fluid, destroys lubrication, seals and ultimately destroy the equipment and hydraulic systems. Usually air enters in the system through suction line pump that can be mechanical failure, or when the oil level in the tank is below normal. Air can enter between the pump shaft when the seal it has problems.

5.1 The causes of noise in hydraulic systems

a.) The noise caused by the variation of pressure, pulse pressure and working fluid, determined first of all at the pump level, but also at the distribution level and control equipment.. Since redesigning the pump this noise cannot be stopped but eventually diminishes it is indicated to apply the solutions of silencers in predefined areas since the design phase.[5]

b.) The noise caused by the pumping unit which accumulates the noise from the drive motor, thermal or electrical with the noise of the pump.
If the drive motor is thermally we try by all methods to reduce noise by isolation and by limiting transmission.
If the motor is electrical in generally we cannot do much but anyway the noise in the system is only 15-20 dB. Problems with these engines are that their heating and cooling.
The noisiest equipment in the system is the pump and therefore from a design stage it is acting by selecting it on grounds of noise and vibrations. Best hydraulics pumps are that with screw and wheels, but unfortunately the most used are those with axial or radial pistons. In general volume pumps that open and close the displacement cameras with high speed creates pulsations that generate noise and that can be reduced only in the design phase. The most significant reduction in noise is still at the design stage of the system because then it can links through flexible tubes between the pump unit and basin on one hand and between the pumping unit and subassembly equipment control and adjustment.
A simple method, but not effective enough is that which introduces silencers based on the idea of limiting the reflection and not by absorption.

c.) Noise caused by fluid delivered by the system accumulator. If the accumulated energy is delivered suddenly creates massive drop of flow, and most of all of pressure which lead to an increase in dangerous levels of noise.

d.) The hammer strike effect which usually occurs in sudden closure or opening of hydraulic distributors is another reason for creating noise. The solution preferred by specialists involves inserting on the pipeline of a accumulator pneumo-hydraulic. Since this solution is insufficient, in recent years using hydraulics devices which can vary the speed of the fluid speed in open and close phases of the pipe.

e.) Noise emitted by an object is directly proportional to the radiant area and inversely proportional to its mass. If the mass of hydraulic systems subassemblies can act from the design phase by increasing or strengthening the support for electro pump, on the surface it can react insignificant. In practice it will remove the electric pump from the reservoir (at about 0,5m) or it can be used an electric pump submerged in reservoir.

f.) Another reason for developing noise is related to the performance of compression for the working fluid expressed through the module's Bulk. At compression, especially during changes in decompression volume of the fluid creates shocks and noises that can be predicted since the design phase that usually resolved by placing the flexible pipes through the use of accumulators placed in critical areas or simply by creating holes for. Everything must be done carefully because automation in hydraulic systems the flexibility of pipes lead to volume variation and therefore in a dynamical slowdown of the equipment.

g.) Cavitation occurs when the volume of hydraulic fluid required by the hydraulic circuit exceeds the amount received from the pump. This fact leads to lower the pressure in the area of the circuit, mining to the suction, under vaporization pressure of hydraulic fluid and leads to the formation of bubbles (cavities) that when compress it breaks and creating a characteristic noise. Consequences in system can be of metal erosion which contaminants the fluid and hydraulic components leads to fail. Most often malfunctions caused by cavitation occur in the pumps. You must be carefully to the suction line which it must be free of obstruction between tank and pump suction. The introduction of suction filters or valves will be under the supervision and indications from specialists and designers.

6. Too high temperature

The recommended temperature for working hydraulic system is between 35 and 60 degrees Celsius. When the temperature exceeds 75-85 degrees is danger of damage to the seals and the working fluid. Excess temperature is determined by the system's inability to dissipate heat and this happens either when the oil is below the level required, or when the system malfunctions, due to wear, increase energy losses. Also a major role it can have the appearance of malfunction at the heat exchanger both the working fluid circuit and to the cooling fluid (air or water). Another cause of heating is the increase in drainage at the equipment, meaning that an abnormal increase in the amount of fluid passing from the high pressure from pressure tank generate heat generation. Since heat is generated by compressing air, any aeration (increasing the of amount air in oil) leads almost automatically to unforeseen heating in design. Even by cavitation thru creating bubbles leads to increased warming of oil. Heat in excess can lead to the destruction of lubricator film and therefore to the destruction of mechanical-hydraulic component.[2]
Temperature measurement can be made both with temperature sensors of all kinds and infrared cameras. Thermography relies on the fact that anybody with temperature above or below zero emits heat, which can be monitored with infrared thermometers or thermal imager that can make even a map of the monitored equipment.

7. Working speed fell below the projected limits

Often it is found that at some point complex machinery start to reduce working speed and as a result their decrease productivity. Reducing machinery performance is an indication that the system has problems and that requires specialist’s intervention. Knowing that engine speed is given by the flow meaning that an decreased in it as result of external loss (most often the lines failure) or internal, usually caused by excessive wear, which makes that drainages to grow, or

pump flow to decrease. Starting from the idea enunciation above that internal losses occur if the temperature increases, means that we can detect the fault with an ordinary infrared thermometer.[5]
Finally we believe that a proactive monitoring of noise, temperature variation and the duration of a cycle can in time determine many causes of the most common faults. It is also increasingly used to analysis the temperature of working fluid, lubrication or cooling, analysis the type of noise in a new philosophy in predictive maintenance.

8. Conclusions

A hydraulic installation for command and/or driving represents most of the time the base operation for complex technological equipment and therefore correct operation and parameters are essential. Hydraulics malfunctions occur suddenly and usually manifests itself by total interrupting operation or in time it manifest by progressive loss of functional performance.
Detection, diagnosis methods are many, sometimes complex, but always to be applied by specialists.

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