# THEORETICAL AND EXPERIMENTAL RESEARCH REGARDING MALFUNCTIONING DETECTION FROM HYDRAULIC SYSTEMS

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**Abstract**
In this paper is presented a method to track the malfunctioning from hydraulic systems. This method aloud the identification of causes, even apparatus with malfunctions, not being needed to dismantle the system.
The method of detection the inappropiate function of installation is based on establishing the temperatures from the whole system.

**Keywords**: hydraulic systems, detection of malfunctioning.

## 1. THEORETICAL ASPECTS

If a liquid transits from pressure $p_1$ to pressure $p_2$ ($p_1 > p_2$) as shown in figure 1, its temperature will be changed.

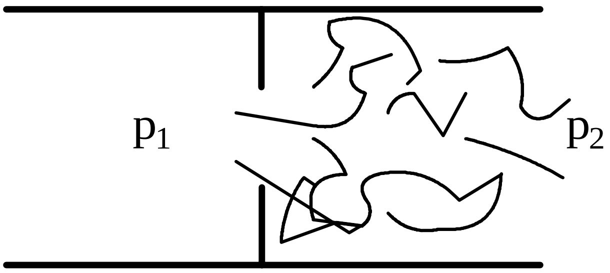



Fig. 1

Between these areas of different pressure it can be written:

$$\rho \frac{(\Delta V)^2}{2} = \Delta p = p_1 - p_2 \tag{1}$$

$$m \frac{(\Delta V)^2}{2} = mc\Delta T_1 \tag{2}$$

In relations (1) and (2) we notate:

$\rho$ - oil density $\Delta V$ – flow speed variation $\Delta p$ – pressure variation
m – oil weight $\Delta T_1$ – temperature variation c – oil specific heat

From previous relations we obtain:

$$\Delta T_1 = \frac{\Delta p}{\rho c} \tag{3}$$

Besides heating fenomenon caused by pressure variation, we must take in consideration the temperature diminution. The diminution value is:

$$\Delta T_2 = 1.21 \cdot 10^{-2} \Delta p \quad (4)$$

The final temperature variation is:

$$\Delta T = \Delta T_1 - \Delta T_2 \quad (5)$$

For usual oils and materials it can be considered:

$$\Delta T = \frac{\Delta p}{16.8} \quad (6)$$

If $\Delta$p is constant, then $\Delta$T is the same.

## 2. LOCAL HEATING IN HYDRAULIC SYSTEMS

Hydraulic apparatus usually used in tool-machine domain, is characterized by the fact that the oil crosses them through active edges generated by construction. We talk about pressure valve, distributors, regulators etc. Liquid flow through these edges generates local heating. Local heating appears the same in case of apparatus with drain circuit. The pumps are under the same heating effect because of the friction happened while functioning. Distributor's electromagnets change their temperature during functioning. In case of normal functioning, after a period of time, the temperature is stabilizing. Starting from these presumptions, we may consider for a system with normal functioning, we have "a map" of temperatures distribution. We may consider this distribution a system reference. If a certain element from the hydraulic system has a malfunction, there will appear local changes of temperature. These changes can be detected by realizing a periodic distribution of temperatures. The blockage of a pressure valve or a distributor, the same as a pump usage, will be detected.
For temperature measuring different apparatus can be used, starting with classical thermometer, finishing with infrared systems.

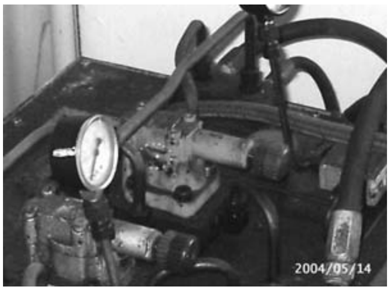
## 3. EXPERIMENTAL RESEARCH

For experimental research we used two hydraulic system placed in department's laboratory.
First system is used for "step by step hydraulic system" studying, and the second is represented by a robot's hydraulic action system. For local temperature measurement we used a laser thermometer, presented in figure 2.
This apparatus can measure temperatures between: -30…..900°C, with errors of 1°C. For temperature's measurement we localize the measurement point with laser ray and read directly on display the associated value, like in figure 3. In this faze of research we wanted to detect malfunctions from a hydraulic system using temperatures measurement. Two malfunctions were simulated on these systems.


Fig. 2

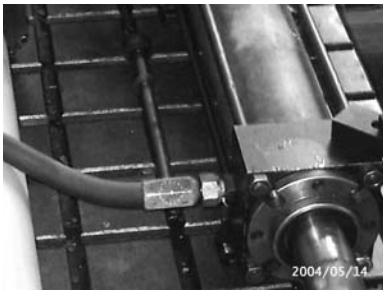

Fig. 3

**3.1.** On "step by step hydraulic system" we presumed the system works on low pressure, then on high pressure and at a certain moment the following piston is being blocked. Temperature was measured in three points: on pressure valve – [Point **A**], in area with malfunction – [Point **B**], and in system's retour area – [Point **C**], like in figure 4.




a. POINT A


b. POINT B




c. POINT C

Fig.4

The system worked 25 minutes on low pressure, then 5 minutes on high pressure without malfunctions. The malfunction was simulated after 30 minutes. Measurement results are presented, for these three points, in figure 5.

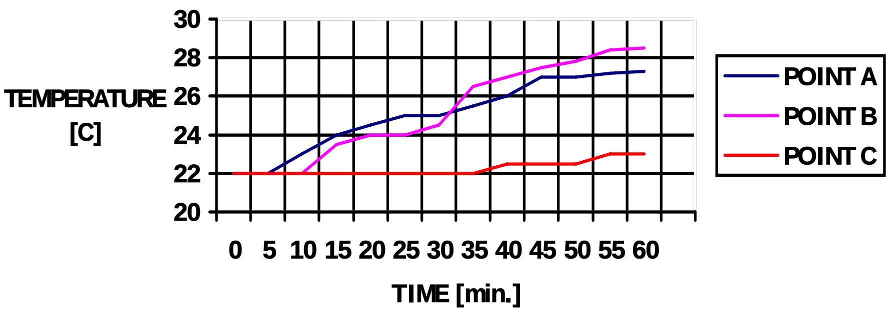



Fig. 5

At start temperature grown faster on pressure valve, [Point **A**]. Caused by local resistance modification, at time where malfunction appears, temperature became higher in [Point **B**] area.

The oil from return circuit, flowing on low resistance area, is almost not affected, [Poin **C**]. Heating appeared in this area is normal, caused by oil circulation.

**3.2.** For robot's hydraulic action system we presumed that the usual malfunction is stuck followed by blockage of pressure valve. After 25 minute of normal activity we simulate the blocking of pressure valve.

The temperature was measured on the exterior surface of valve, [Point **D**], like in figure 6.

Measurement results are presented on figure 7.

We observe that the blocking valve is detected because of a fastness heating. This fact is explained by a flow difference. On step by step action the pump has 6,3 l/min flow. For robot is used a double pump with approx. 22 l/min flow.

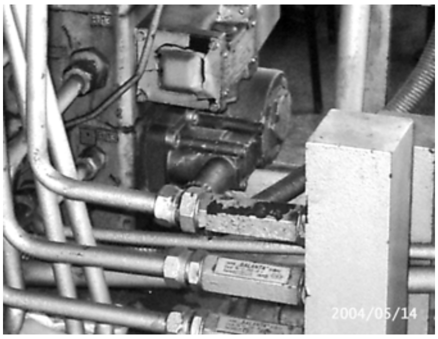


Fig. 6

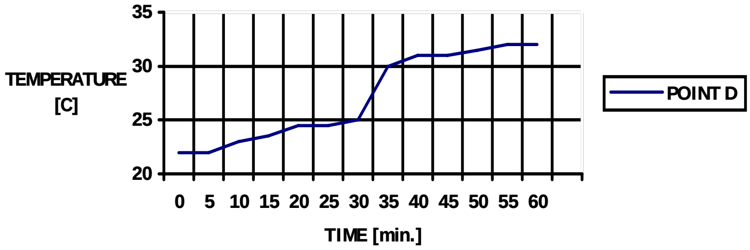



Fig. 7

In this both cases, malfunction appears after 30 minutes and the temperature becomes higher in affected area. We observe that this temperature variation is faster than normal heating.

## 4. CONCLUSIONS

In both cases, simulated malfunction produced the heating of affected area. Temperature variation is more obvious and faster than in the case of normal activity. This variation is caused by pump's pressure and flow. By measuring temperature is possible to detect eventual malfunctions that appear in reality, and localize them. In these conditions the repair time becomes shorter by eliminating the searches used for in maintaining activity. By constant observation, it is possible to predict a major malfunction that would require replacement of some system parts.

This research will be followed by other studies regarding the temperature observation using infrared monitoring systems.

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