Simulation of Hydraulic Motor Controlled by the Control Valve

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Abstract: *The paper presents an overview of the importance of installations with hydraulic motors. In this manuscript, we are studying two hydraulic circuits and one electro-hydraulic circuit, which contains 4/2-way hand-lever valves. Thus, the first hydraulic circuit contains the following devices: fixed displacement pump, three tanks, 4/2-way hand-lever valve, two throttle valves, pressure relief valve, and hydraulic motor (HM 1-1). Next, the second hydraulic circuit contains the following components: a pump unit, two tanks, a 4/2-way hand-lever valve, 3-way pressure regulators, two check valves, two throttle valves and hydraulic motors (HM 2-1 and HM 2-2). Finally, the last circuit, which is actually an electro-hydraulic system, contains the following devices: a fixed displacement pump, three tanks, a 4/2-way solenoid valve, two throttle check valves, a hydraulic motor (HM 3-1), two relays, valve solenoid and a magnetic proximity switch.*

Keywords: *System, hydraulic, energy, motor, valve*

1. Introduction

Hydraulic motors are resistant devices that convert hydraulic energy into mechanical energy in a short time.
One of the first rotary hydraulic motors to be developed was that constructed by William Armstrong in 1850. But since then, the hydraulic motors have developed a lot.
These devices are used in a variety of applications, including conveyors, metalworking machines, mining machinery, construction equipment, transportation, agricultural installations, etc.
In practice, hydraulic motors are usually more efficient than electric motors because they can operate in a wider range of conditions (e.g., temperature, pressure, etc.) [1].

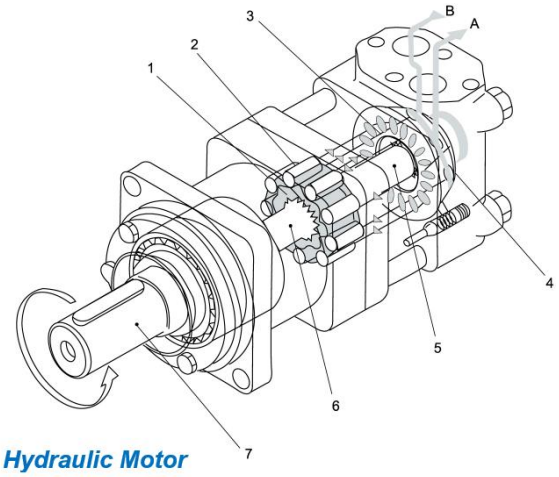

Fig. 1. The main components of the hydraulic motor

Moreover, there are three types of hydraulic motors:
• Vane motor: is used to generate the rotational force.
• Piston motor: pistons are used to generate the rotational force.
• Gear motor: gears are used to transfer hydraulic pressure into rotational force.
Anyway, these components are shown in the figure above, Fig. 1.

The main components of the hydraulic motor are:
1) Orbit cam
2) Roll
3) Distributor
4) Auxiliary plate
5) Distributor shaft
6) Transmission shaft
7) Output shaft.

In the hydraulic systems, the fluid is controlled directly or automatically by a motor and distributed through hoses, tubes or pipes [2].

In any technical documentation, the hydraulic motor has the symbol below, Fig. 1.

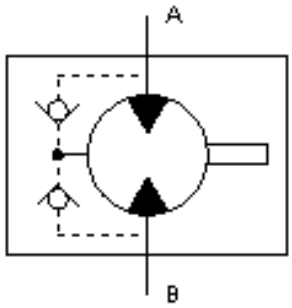

Fig. 2. Symbol of hydraulic motor

MS series hydraulic motors are suitable for hydraulic systems because they operate under difficult operating conditions (high pressures, thin oil, etc.) [3].

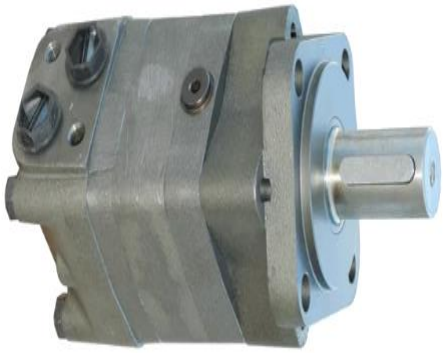

Fig. 3. MS 80 - Hydraulic motor

Technical data for MS 80 hydraulic orbit motor are shown in Table 1.

Table 1: Technical data

Feature	Value
Max. speed	800 rpm
Max. torque	225 Nm
Max. output	16 kW
Max. pressure drop	205 $\cdot 10^5$ Pa
Max oil flow	1083.33 $m^3 \cdot s^{-1}$
Max. inlet pressure	250 $\cdot 10^5$ Pa
Weight	9.8 kg

2. The role of hydraulic motors

The design of hydraulic motor systems has a direct effect on flow rates, friction losses in piping and other plant components.
Hence, the hydraulic devices in the presented installations are selected based on the available dimensions of the components in the product catalogs. In this case, the circuits must be designed to achieve the required flow and pressure in a hydraulic installation [4].
The following equations provide specialists with the basic relations needed for sizing hydraulic motors used in industry:

$$N = \frac{\eta_v \cdot q \cdot 1000}{D} \quad (1)$$

Where:
- N – speed.
- η_v – volumetric efficiency.
- q – hydraulic fluid flow.
- D – displacement.

$$M = \frac{\eta_m \cdot \Delta p \cdot D}{63} \quad (2)$$

Where:
- M – output torque.
- η_m – mechanical efficiency.
- Δp – differential pressure.

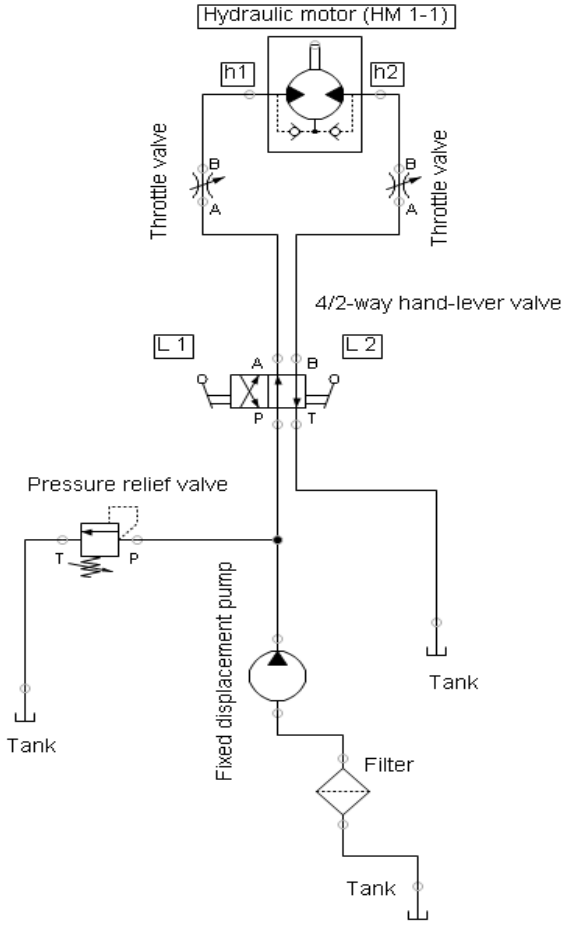

Fig. 4. First hydraulic circuit with HM 1-1

$$P = \frac{\eta_t \cdot \Delta p \cdot q}{600} \quad (3)$$

Where:

- P – output power.
- η_t – overall efficiency.
- Δp – differential pressure.

If the operator pushes lever L1, then the output shaft from hydraulic motor (HM 1-1) rotates counterclockwise from point h2 to point h1, Fig. 5.

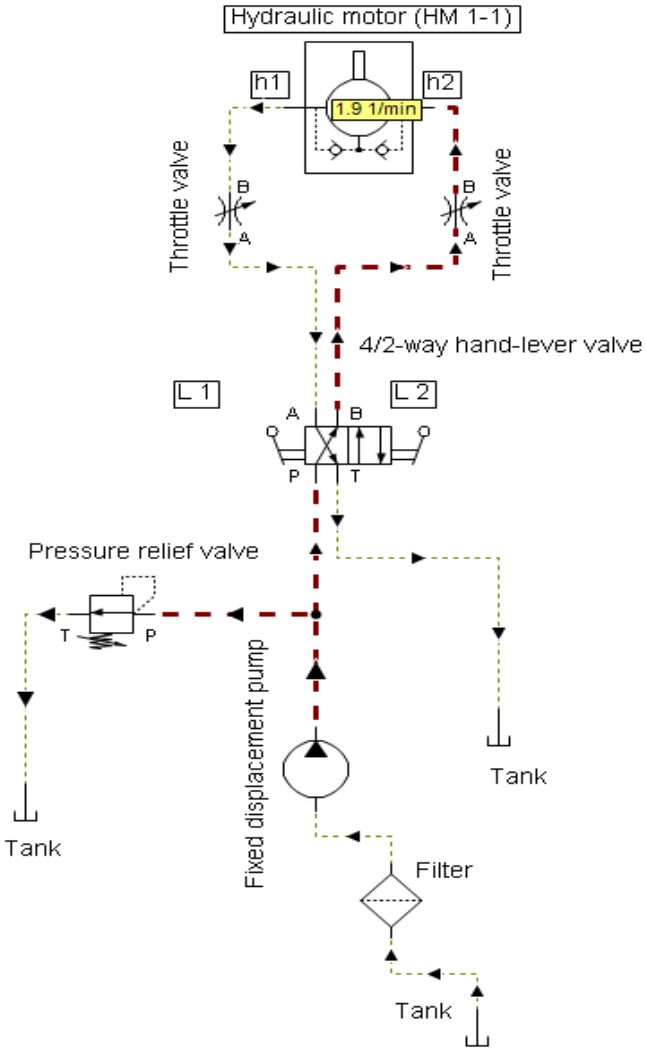

Fig. 5. First hydraulic circuit. Simulation I

But, if the operator pushes the L2 lever to the left, then the output shaft from hydraulic motor (HM 1-1) rotates clockwise from point h1 to point h2, Fig. 6.

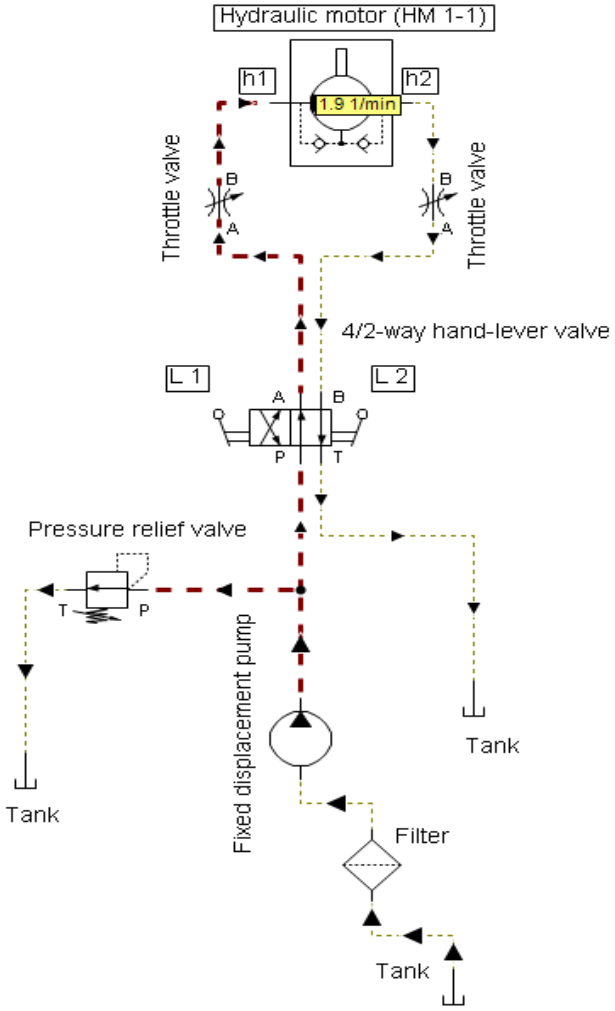

Fig. 6. First hydraulic circuit. Simulation II

Depending on the 4/2-way hand-lever valve, the parameters of the hydraulic motor: revolutions per minute (rpm) and volume flow rate (q), Fig. 7.

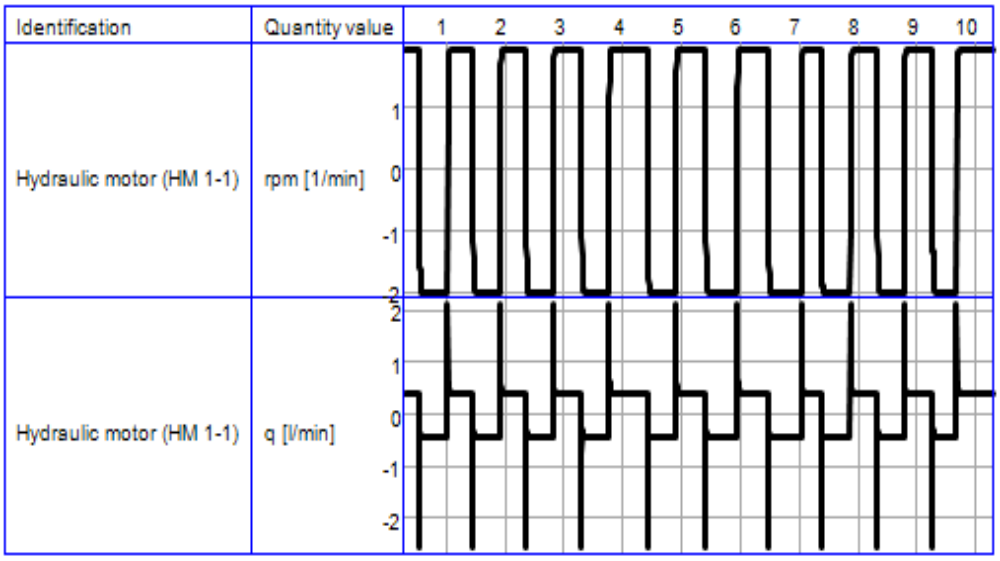

Fig. 7. Diagrams of parameters rpm and q

The second installation has two hydraulic motors (HM 2-1 and HM 2-2), Fig. 8.

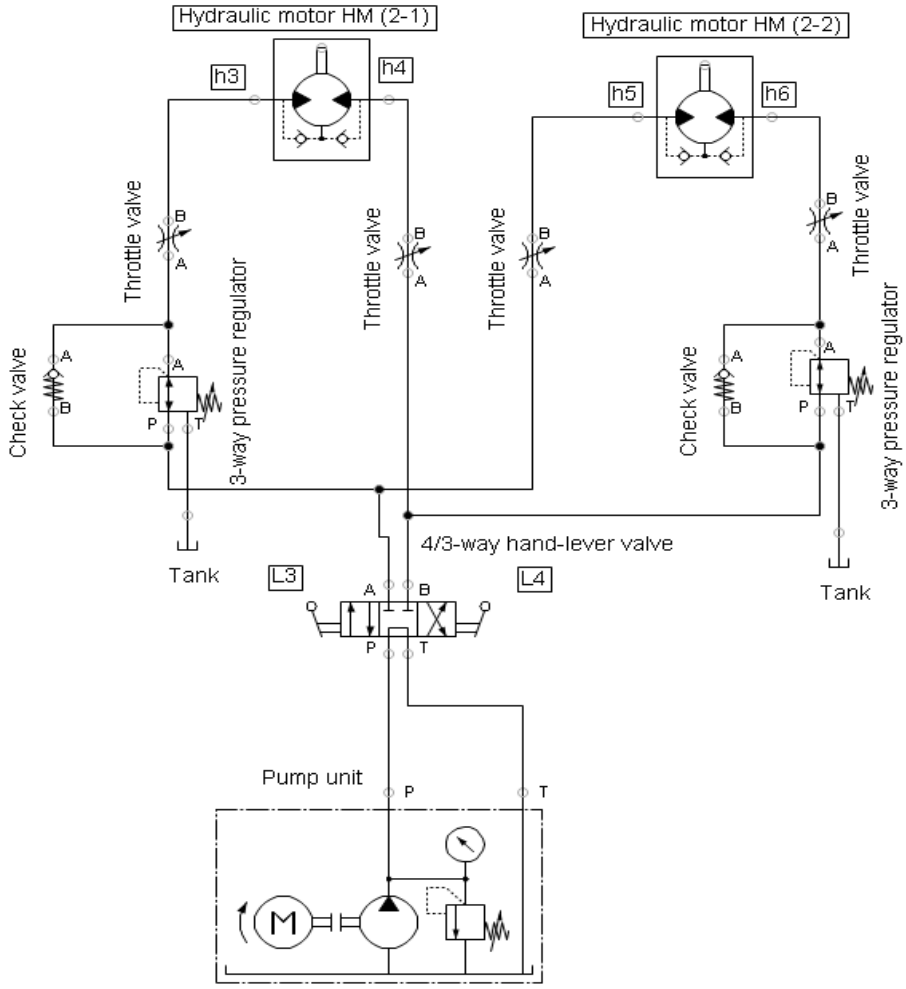

Fig. 8. Second circuit with two hydraulic motors

The second hydraulic system has the following eleven devices, listed in the table below [5].

Table 2: Devices of second electro-pneumatic scheme

Description	Number of components
Hydraulic motor (HM 2-1 and HM 2-2)	1
Throttle valve	2
Check valve	2
3-way pressure regulator	2
4/3-way hand-lever valve	1
Tank	2
Pump unit	1

The second hydraulic circuit with two hydraulic motors opens if the operator pushes L3 to the right. Then, output shafts from hydraulic motors (HM 2-1 and HM 2-2) rotate together clockwise at the same time, Fig. 9.

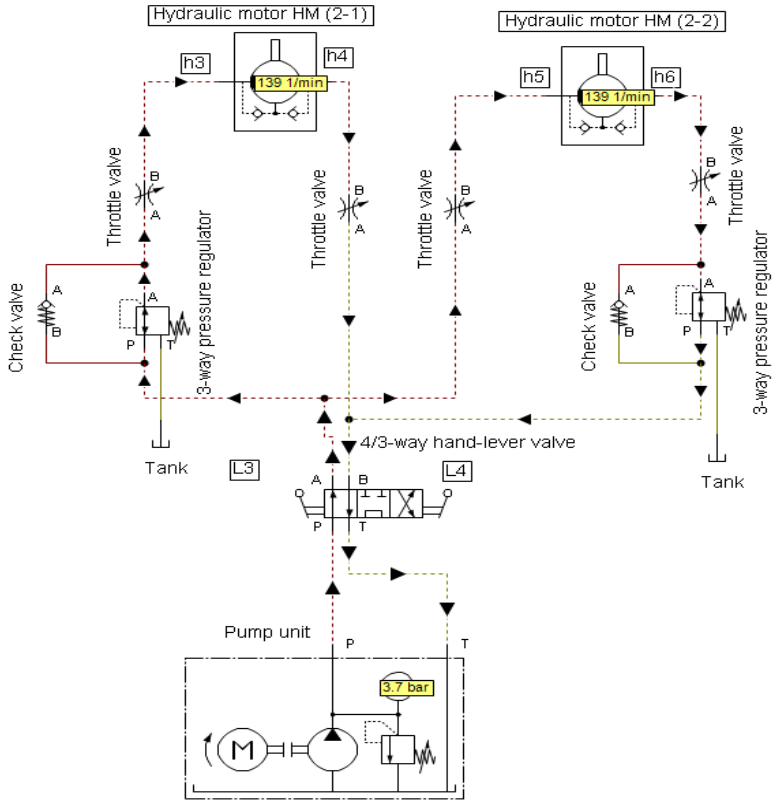

Fig. 9. Second hydraulic with two hydraulic motors. Simulation

Afterwards, in order to close the installation, the manipulator must pull the lever L2 to the left. The third installation is an electro-hydraulic circuit with the hydraulic motor HM 3-1, Fig. 10.

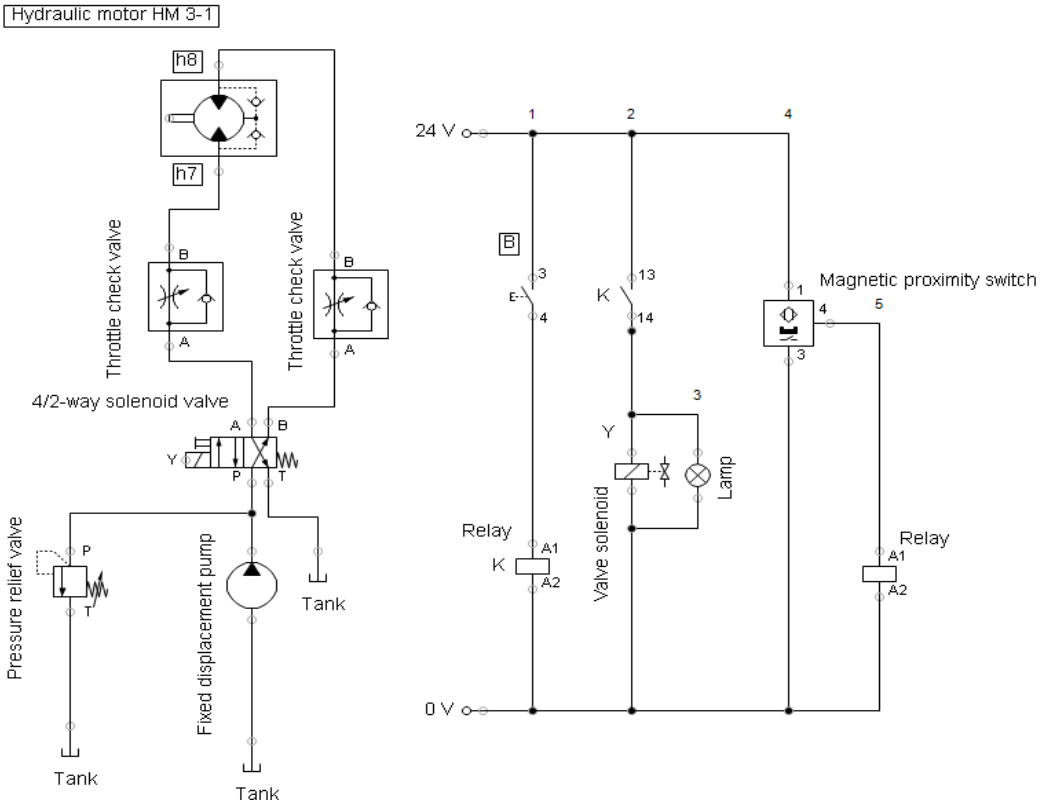

Fig. 10. Electro-hydraulic circuit with one hydraulic motor HM (3-1)

The last of electro-hydraulic system with hydraulic motor HM (3-1) has the following twelve devices, listed in the table below [5].

Table 3: Devices of second electro-pneumatic scheme

Description	Number of components
Fixed displacement pump	1
Tank	3
Throttle check valve	2
4/2-way solenoid valve	1
Hydraulic motor	1
Relay	2
Valve solenoid	1
Magnetic proximity switch	1

In addition, an electro-pneumatic circuit with a 4/2-way solenoid valve has a return spring [6]. When the manipulator presses B button, then output shaft from hydraulic motors (HM 3-1) rotates clockwise from point h7 to point h8 and a lamp shows an orange signal, Fig. 11.

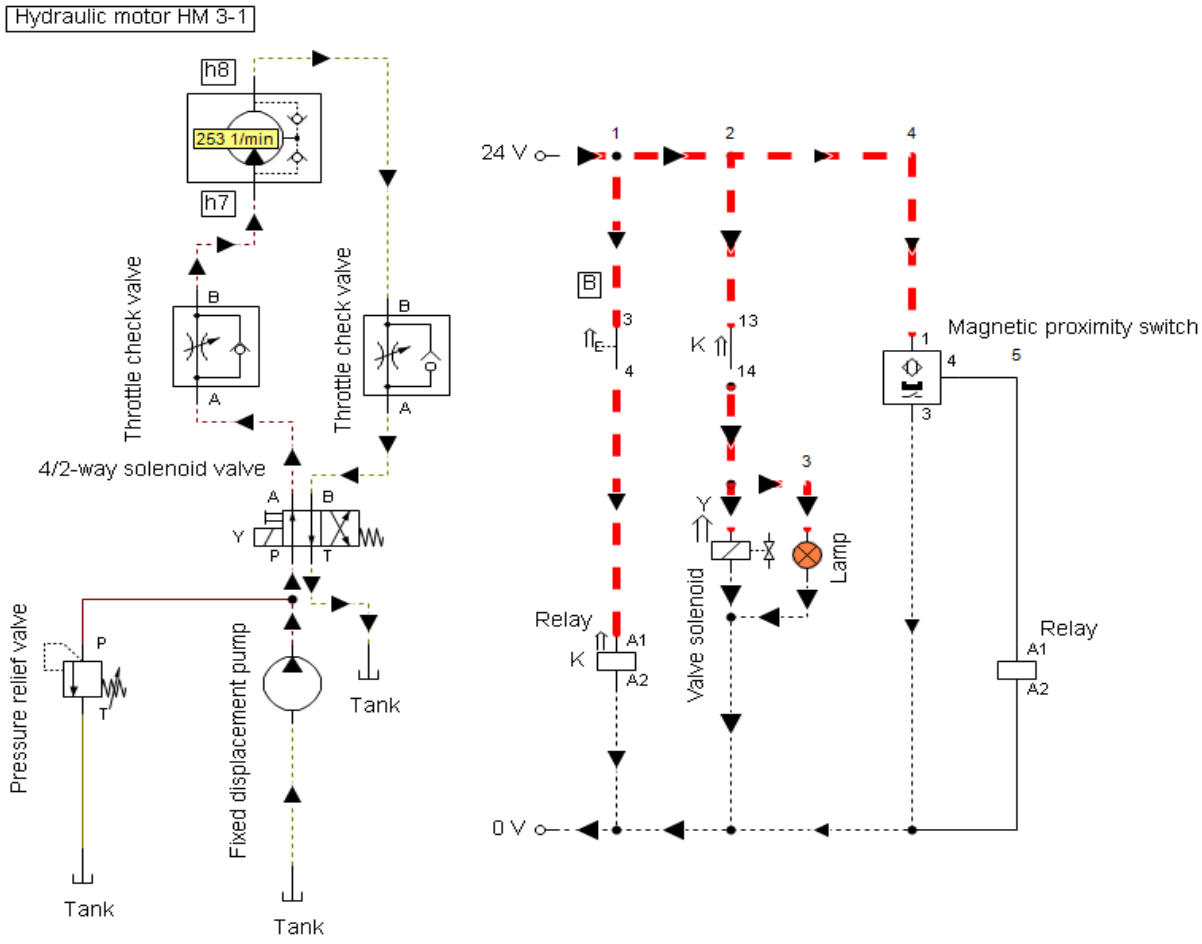

Fig. 11. Electro-hydraulic circuit with hydraulic motor HM (3-1). Simulation

At the end, when the operator stops pressing the button, then the lamp stops lighting up and output shaft rotates counterclockwise from point h8 to point h7.

3. Conclusions

Systems using hydraulic motors are a common choice for various engineering applications.
Nevertheless, the hydraulic motor installations form the basis for many industrial upgrades in the modern era.
The main advantages of hydraulic motors are: high torque, low output speed, simpler than piston engines, more durable than vane motors, do not pollute, low vibrations, easy to maintain, etc.
In stationary industrial applications, the following factors of hydraulic motors are more important: performance, durability and cost, than its size or position in the installation.
In order to choose hydraulic motors according to the objectives they have to fulfill, the specialists must consider the following characteristics: operating temperature, estimated life of the motor, contamination potential and type of control. Consequently, specialists are advised to contact the hydraulic motor manufacturers to discuss the requirements of their application.

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