Simulation Study of a Double-Acting Hydraulic Cylinder with Shock Absorber

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Abstract: *This paper focuses on the efficiency of the double-acting hydraulic cylinders with shock absorber at stroke end. In the present work, the simulation of two hydraulic circuits and an electro-hydraulic circuit with double-acting cylinders with shock absorber is studied. Thus, the first hydraulic circuit is made of the following components: tank, throttle check valve, 4/2-way hand lever valve with spring, filter, fixed displacement pump, and double-acting cylinder with shock absorber at stroke end (Dacs 1-1). The second hydraulic scheme has the following devices: pump unit, throttle valve, 4/3-way hand lever valve, and two double-acting cylinders with shock absorber at stroke end (Dacs 2-1 and Dacs 2-2). The third circuit studied is an electro-hydraulic scheme. The last scheme is made of the following components: tank, 4/3-way solenoid valve, nozzle, relay, valve solenoid, lamp, capacitive proximity switch, and double-acting cylinder with shock absorber (Dacs 3-1).*

Keywords: *Hydraulic, cylinder, shock, stroke, tank*

1. Introduction

Some hydraulic systems are equipped with double-acting cylinder with shock absorber at stroke end. Such systems are used in various fields of activity: telescopic hydraulic cylinders at trucks, metallurgical equipment, mining industry, military grade hydraulic cylinders, marine and shipyard use [1].
A double-acting hydraulic cylinder is built in two versions:

a) Without shock absorber.
b) With shock absorber.

Although the second option is more expensive, the quality is much better than the first option.
In the hydraulic actuator, the piston of the cylinder is controlled by the connected pressure loads. Also, the shock absorber can be adjusted by means of two adjustment screws [2].
Usually, a double-acting cylinder with shock absorber at stroke end used to stop a moving load smoothly and slowly. Such a model of hydraulic cylinder (OEM 48511-26040) was used at telescopic shock absorber for car (e.g. Toyota HiAce), Fig. 1.

Fig. 1. A double-acting cylinder with shock absorber

In these manuscript, the parameters of the hydraulic cylinders are presented in Table 1.

Table 1: The components from first scheme

Parameters	Value	Unit
Piston diameter	0.5	m
Piston rod diameter	0.4	m
Piston position	0.8	m
Coulomb friction force	5000	N
Break-away force	5000	N
Moving mass	10	kg
Damping length	0.05	m

In the design of hydraulic circuits, a double-acting cylinder with shock absorber at stroke end has a specific symbol, Fig. 2.

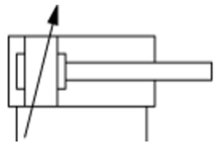

Fig. 2. Symbol of a double-acting cylinder with shock absorber

2. Simulation of a double-acting cylinder with shock absorber

The operation of a hydraulic and electro-hydraulic working circuit involves a continuous flow agent (oil) transported by the pump at certain values of the working pressure [3].
The layout of the circuits that have the double-acting cylinders with shock absorber at stroke end gives the hydraulic system high energy efficiency. Therefore, these schemes improve the internal instability of traditional hydraulic circuits [4].
First, hydraulic circuit made in this paper is designed as a simple scheme using only one double-acting cylinder with shock absorber at stroke end, Fig. 3.

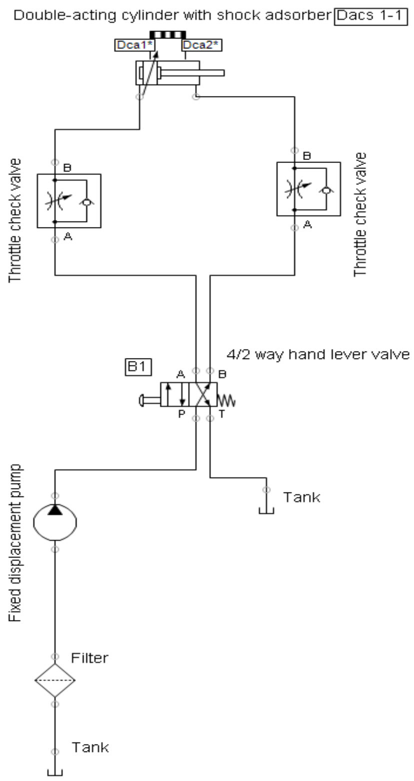

Fig. 3. Hydraulic circuit with a double-acting cylinder (Dacs 1-1)

In the first hydraulic circuit, operator must press the B1 button belonging to the 4/2-way hand lever valve with spring. Then, the piston rod moves from point Dca*1 to point Dca*2, Fig. 4.
After operator stops pressing the B1 button, the piston rod returns, because the 4/2-way hand lever valve has a spring, Fig. 4.

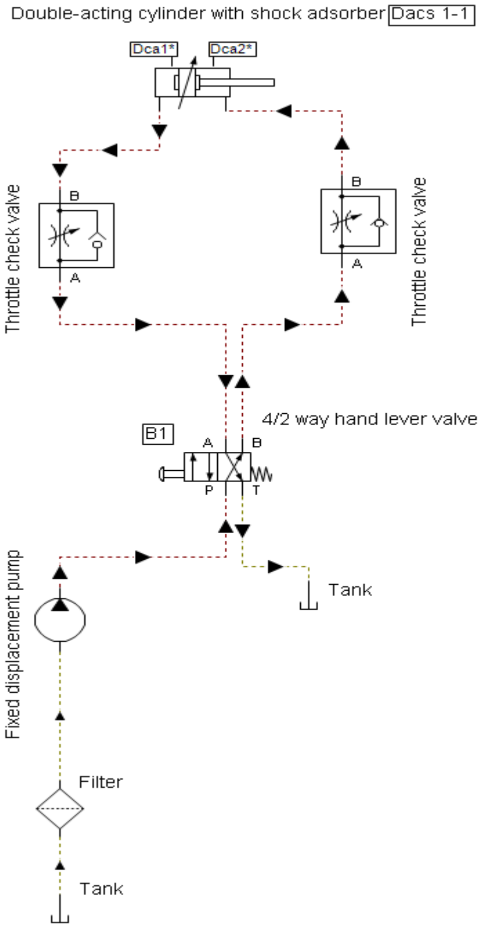

Fig. 4. Hydraulic circuit with a double-acting cylinder (Dacs 1-1). Simulation

The components which belong to the first hydraulic circuit are presented in the table below.

Table 2: The components from first scheme

Description	Number of components
Tank	2
Throttle check valve	2
Double-acting cylinder with shock absorber (Dacs 1-1)	1
4/2 way hand lever valve with spring	1
Filter	1
Fixed displacement pump	1

The diagrams show variation of the operating parameters of the double-acting cylinder with shock absorber at stroke end (Dacs 1-1). These operating parameters are: distance, velocity, and acceleration, Fig. 5.

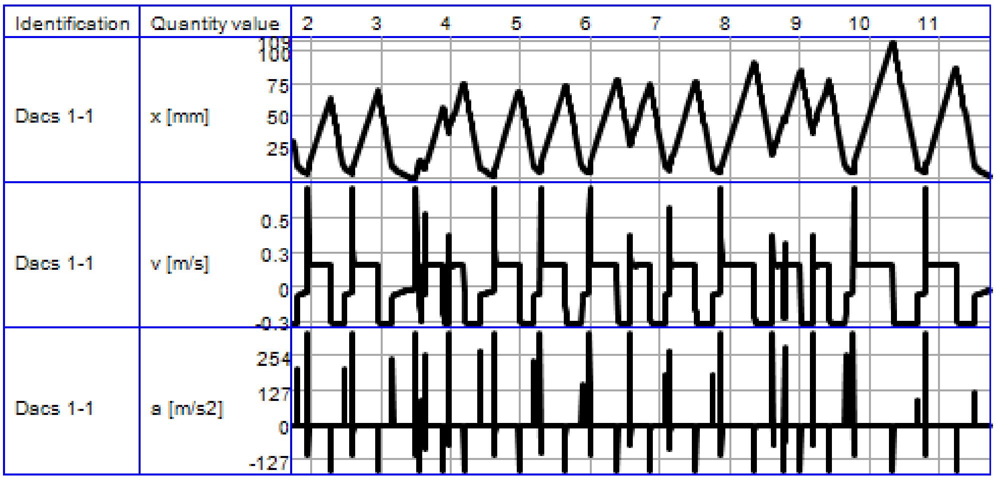

Fig. 5. Diagrams of the double-acting cylinder (Dacs 1-1)

Likewise, the second hydraulic circuit has two double-acting cylinders with shock absorber at stroke end (Dacs 2-1 and Dacs 2-2), Fig. 6.

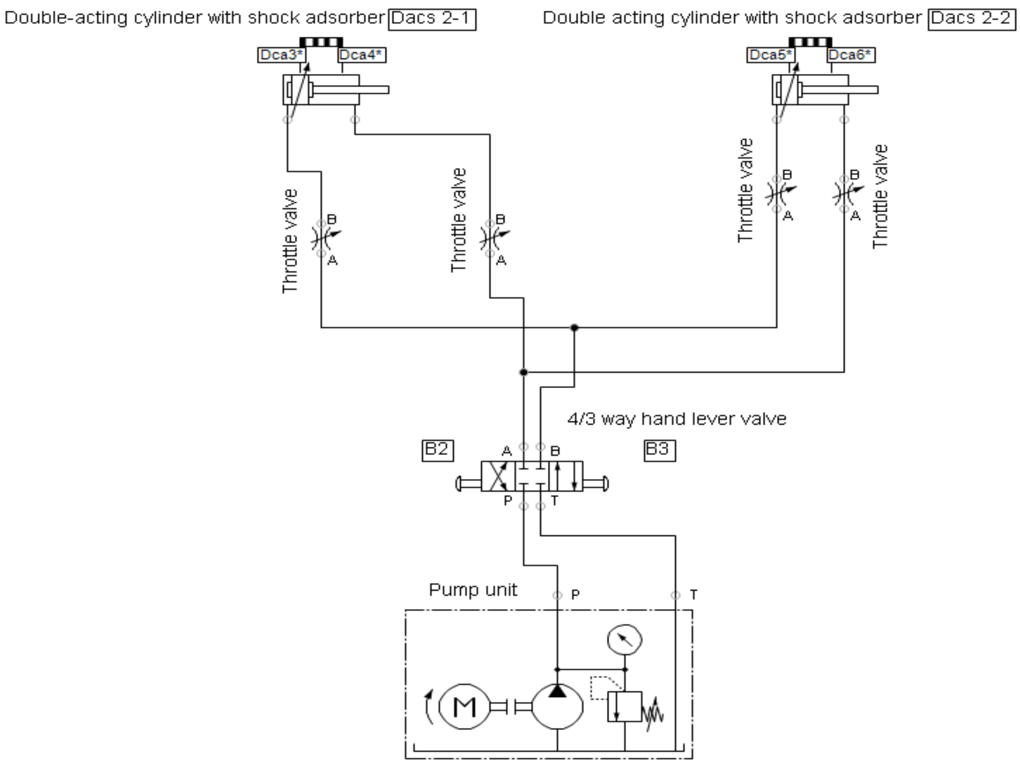

Fig. 6. Hydraulic circuit with double-acting cylinders (Dacs 2-1 and Dacs 2-2)

If operator presses the B2 button, then both piston rods of the double-acting cylinders (Dacs 2-1 and Dacs 2-2) move at the same; namely, the piston rod of the double-acting cylinder (Dacs 2-1) moves from point Dca3* to point Dca4*, and respectively the piston rod of the double-acting cylinder (Dacs 2-2) moves from point Dca5* to point Dca6*, Fig. 7.

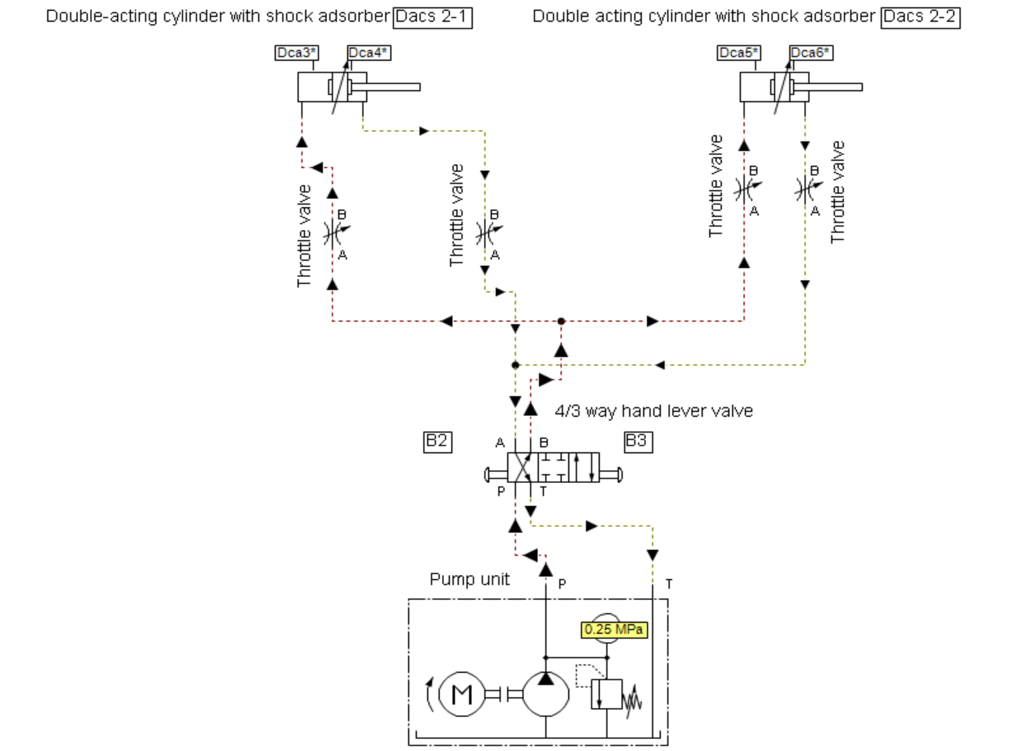

Fig. 7. Hydraulic circuit with double-acting cylinders. Simulation 1

But, if operator presses the B3 button, the piston rod of the double-acting cylinder with shock absorber (Dacs 2-1) returns from Dca4* to point Dca3*. Simultaneously, the piston rod of the double-acting cylinder with shock absorber (Dacs 2-2) returns from Dca6* to point Dca5*, as in second simulation, Fig. 8.

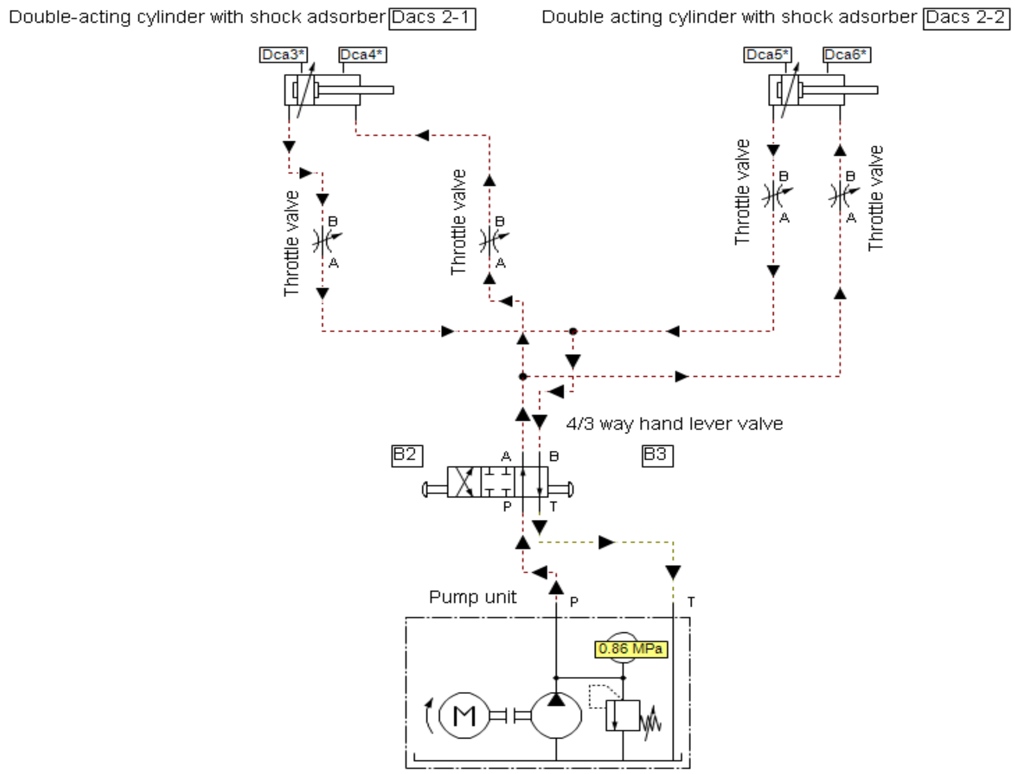

Fig. 8. Hydraulic circuit with double-acting cylinders. Simulation 2

Table 3 below shows six component devices used in the hydraulic scheme.

Table 3: The components from second scheme

Description	Number of components
Pump unit	1
Throttle valve	2
Double-acting cylinder with shock absorber (Dacs 2-1and Dacs 2-2)	2
4/3 way hand lever valve	1

Finally, an electro-hydraulic scheme that has a double-acting cylinder with shock absorber at stroke end is presented, Fig. 9.

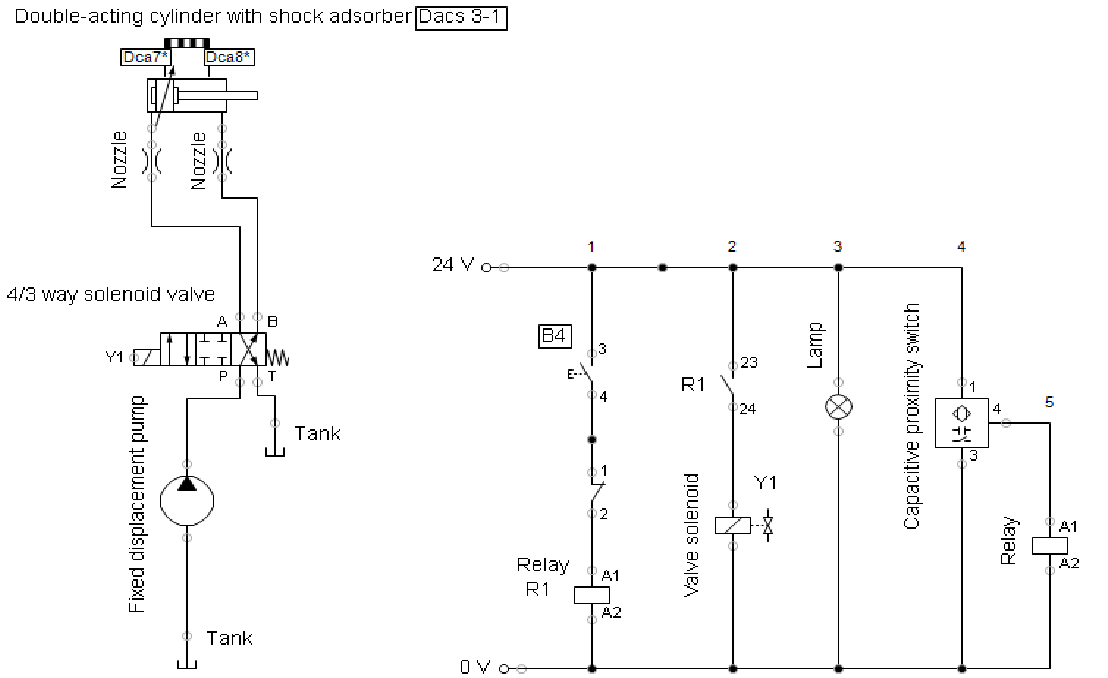

Fig. 9. Electro-hydraulic circuit with a double-acting cylinder

Table 4 below shows twelve component devices used in the hydraulic scheme, [5].

Table 4: The components from third scheme

Description	Number of components
Tank	2
Fixed displacement pump	1
Double-acting cylinder with shock absorber (Dacs 3-1)	1
4/3-way solenoid valve	1
Nozzle	2
Relay	2
Valve solenoid	1
Lamp	1
Capacitive proximity switch	1

Further, when operator presses the B4 button, the piston rod from double-acting cylinder with shock absorber (Dacs 3-1) moves from point Dca7* to point Dca8*.
In addition, a lamp shows a blue signal, Fig. 10.

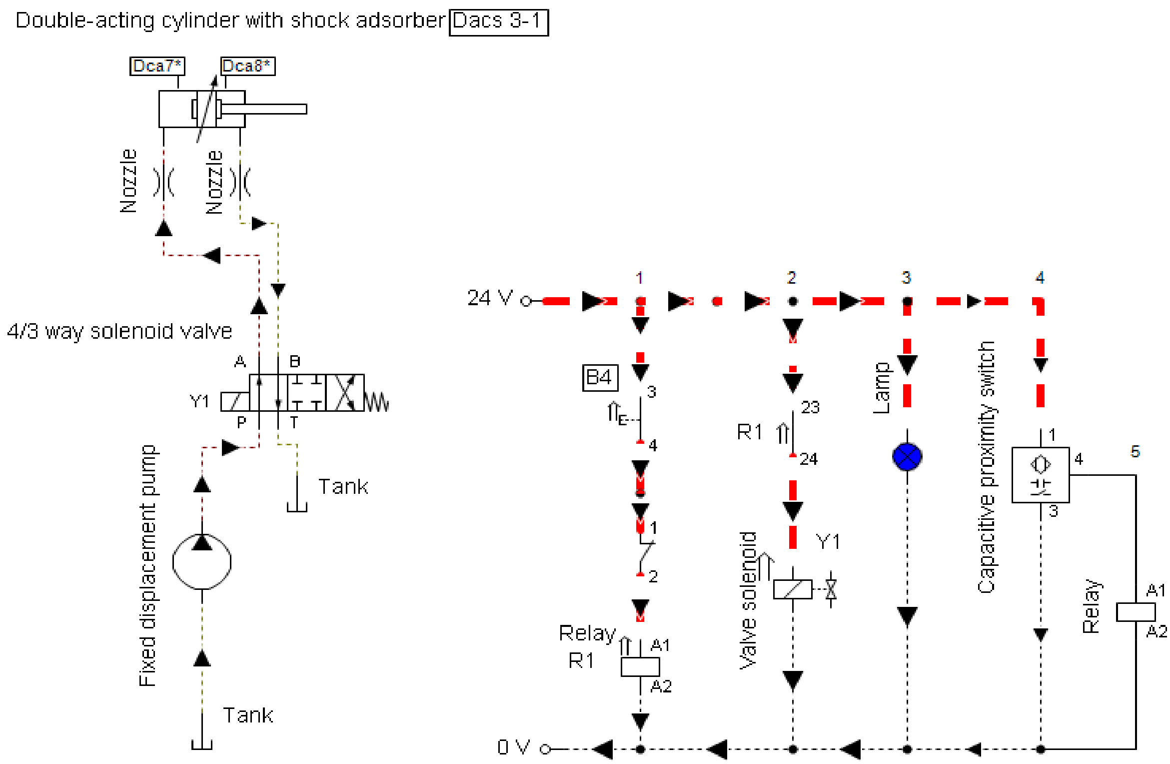

Fig. 10. Electro-hydraulic circuit with a double-acting cylinder. Simulation

The most commonly used actuators for pneumatic drives are cylinders (single acting and double acting). There are many applications that require a turning or twisting movement of up to 360 degrees. Only semi-rotary drives can be used for these pneumatic applications.

3. Conclusions

In fact, the double-acting cylinders with shock absorber at stroke end are actuators that are used in simulation of hydraulic and also electro-hydraulic installations.
Some benefits of the double-acting cylinder with shock absorber at stroke end:

- Safety in operation of double-acting cylinder.
- Faster reaction than hydraulic cylinders without shock absorber.
- Suitable for repetitive actions in a short time.
- Applies greater push and pull forces than a single-cylinder.

However, the double-acting cylinders with shock absorber at stroke end are often use for:

- Repetitive actions (e.g. jack and crib applications).
- When very long hoses are required.
- A controlled retraction time.
- Strong pushing and pulling uses.

In the future, we plan to develop electro-hydraulic schemes using double-acting cylinders with shock absorber at stroke end for research and education.

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