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Simulation of Dynamic Characteristics of Circuit with Linear Hydraulic Motor and Mass Load

Adam BUREČEK[1], Lumír HRUŽÍK[2]

[1] Ing. Adam Bureček, VŠB-TU Ostrava, 17.listopadu 15/2172, 70833, Ostrava Poruba, adam.burece.st@vsb.cz
[2] doc. Dr. Ing. Lumír Hružík, VŠB-TU Ostrava, 17.listopadu 15/2172, 70833, Ostrava Poruba, lumir.hruzik@vsb.cz

Abstract: *Contribution deals with the numerical simulation of a hydraulic circuit with a linear hydraulic motor, a long pipeline and mass load. Discuss with about a circuit stroke removing load plates. Numerical model in Matlab SimHydraulics has been verified experimentally. Numerically is simulated effect piston diameter of hydraulic motor with mass load on the dynamic behavior of a circuit.*

1. Introduction

Numerical simulation of hydraulic circuit can properly optimize its parameters. Using the simulation was optimized hydraulic circuit with linear motors with a mass load, a proportional directional valve and a long supply pipe. The submitter was required to verify the effect of the increased hydraulic motors on the dynamics of a hydraulic circuit i. e. to compare the amplitude of vibration of the piston stroke end position. In addition, try to shorten the cycle time to a minimum [1], [3].

2. Description of experimental device

The task is to create a mathematical model to simulate the dynamics of a hydraulic circuit in Fig. 1. Given circuit is part of the hydraulic line and its task is to lifting and lowering mass load. This motion is realized by linear hydraulic motor with dimensions of piston 63 mm, piston rod 45 mm and piston stroke 330 mm. His actuating provides a proportional directional valve 14.7. During the drawing-out piston rod i. e. lowering load to activate a one-way valve 30.2, and consequently also pressure relief valve 17.2, which branch of the A1 lighten and load lowering slowly. Into supply branch P is supplied pressure fluid hydraulic unit and piston accumulator, drain is outlet branch T. Minimess for pressure measurement are marked as 80.19 and 80.20. Branch A1 and B1 is made of steel pipe with a length of 35 m, internal diameter 12 mm and wall thickness 2 mm. Hydraulic motor is connected to the pipeline by hydraulic hoses with a length of 3 meters and internal diameter of 12 mm [2].

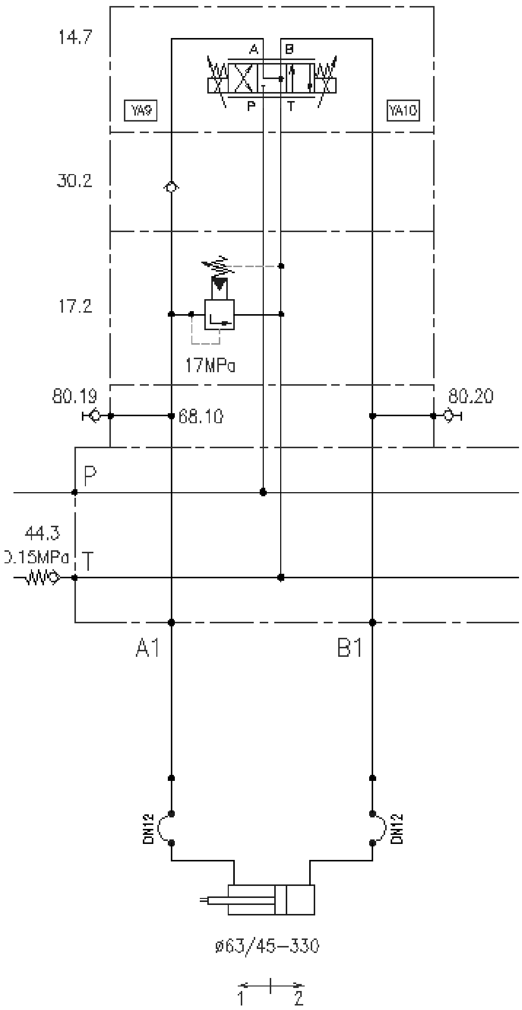

Figure 1: Diagram of hydraulic circuit

3. Description of adverse effects

Linear hydraulic motor is loaded with a load a mass about 1,800 kg. This means that the influence of mass load and compressibility of liquids there is the vibration piston of hydraulic motor in the end positions. The hydraulic line has two modes slow and fast. During the slow mode it take cycle 45 s, vibration in end positions has no effect. Fast cycle time is 24 s, but already there are undesirable vibrations. These cycle times are dependent on the velocity of drawing-out and inserting piston rod of hydraulic motor. For modeling was then chosen and modeled hydraulic motor with the slowest velocity of stroke [4].

4. Description of simulation model

In compiling the simulation model shown in Fig. 2 was necessary to introduce a number of simplifications, including the adaptation of each set of blocks.

The source of pressure energy is hydraulic generator with regulated to a constant pressure. Constant pressure is also ensured gas accumulator. Hydraulic generator is driven by subsystem Motor, which consists of a constant value input turns and the appropriate adjustment to the angular velocity. The output port is marked as a mechanical shaft, which is connected to a hydraulic generator. The whole subsystem is named as the Source consists of a hydraulic power unit, which is connected, supply pipeline P.

At the other end of the pipeline is connected to valve of PV, he is in charge of managing the flow to a hydraulic motor HM. Subsystem Control is in charge of managing directional valve. Includes Signal Builder SB and proportional control, which creates of a step signal a continuous signal called start-up ramp. The output of block SB is dimensionless, so the transfer of the physical signal was assigned to the meter, which represents the value average opening corresponding to flow area of directional valve.

Behind the directional valve is a one-way valve OV1 followed by relief valve RV1. RV1 lighten the branch A during drawing-out piston rod. Furthermore is connected subsystem for measuring flow and the subsystem for pressure measurement. These subsystems are equipped with data records Workspace Ws and plotting graphs Scope. After pressure liquid goes a long pipeline A and hydraulic hose A1, which is connected to itself the hydraulic motor HM.

Hydraulic motor HM is on the side of the cylinder attached to a fixed point FP and on the side of the piston rod to subsystem Load. This subsystem would create a load the piston rod during its stroke. The values of this load are generated signal SB1 and transferred to Newton [N]. Between the hydraulic motor HM and subsystem Load is connected to a system for measuring velocity and distance the piston.

To the circuit must be connected Solver block and the block to define the working fluid. Pressure sensors sense the pressure signal between the sampling point and tanks. This signal is then converted to Pascal [Pa] and merged into a one graph. Flow Sensors are connected directly into pipelines and sense the signals that are consequently transferred to $dm^3.min^{-1}$ and merged into one graph. The output of motion sensor MS, are values piston velocity and piston track [1], [3], [4], [5].

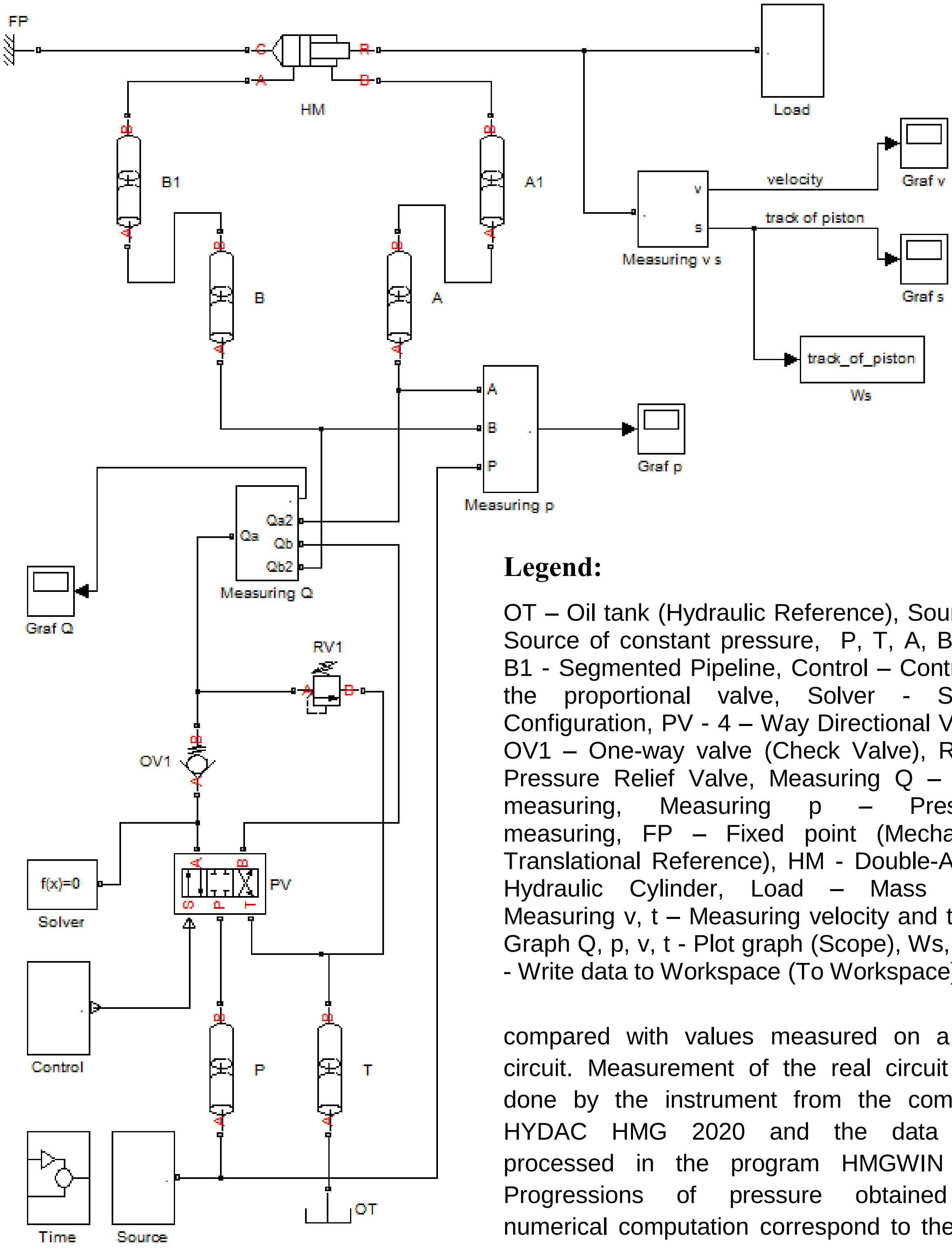

Figure 2: Diagram of simulation model

Legend:

OT – Oil tank (Hydraulic Reference), Source – Source of constant pressure, P, T, A, B, A1, B1 - Segmented Pipeline, Control – Control of the proportional valve, Solver - Solver Configuration, PV - 4 – Way Directional Valve, OV1 – One-way valve (Check Valve), RV1 - Pressure Relief Valve, Measuring Q – Flow measuring, Measuring p – Pressure measuring, FP – Fixed point (Mechanical Translational Reference), HM - Double-Acting Hydraulic Cylinder, Load – Mass load, Measuring v, t – Measuring velocity and track, Graph Q, p, v, t - Plot graph (Scope), Ws, Ws1 - Write data to Workspace (To Workspace)

5. Simulation results and comparison with measurements

The values obtained by simulation on the mathematical model in Matlab have been adaptation by Excel to the graph and compared with values measured on a real circuit. Measurement of the real circuit was done by the instrument from the company HYDAC HMG 2020 and the data was processed in the program HMGWIN 1.0. Progressions of pressure obtained by numerical computation correspond to the real measured values. Figure 3 shows a comparison of frequency and amplitude of pressure oscillation on the branch A1 during insertion piston rod to end position. Progressions of the pressure measured are slightly distorted by another higher frequency, which was not taken into account in the simulation model. The period of the piston stroke is 2 s [4].

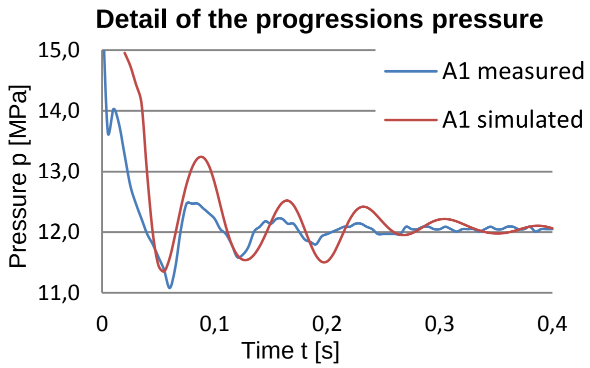

Figure 3: Detail of comparing the frequency and amplitude of pressure

6. Optimization of hydraulic circuit

The first adjustment was needed to reduce cycle time, i. e. faster drawing-out and inserting piston rod of the original hydraulic motor. Faster mode was achieved by increasing the flow, the time of stroke was reduced from 2 seconds to 0.7 seconds, but the amplitude of vibration increased from 2.2 mm to 9 mm, which is undesirable see fig. 4 and table 1.

The second adjustment was designed to eliminate this vibration, and consisted in a change from the original hydraulic motor 63/45 - 330 to a larger 100/63 – 330. Piston diameter was increased from 63 mm to 100 mm diameter piston rod from 45 mm to 63 mm. Increasing the diameter of hydraulic motor piston was achieved a reduction amplitude of vibration from 9 mm to 1.3 mm. Time the stroke in this solution was 1.65 s.

The third modification was the election of a compromise between size of vibration of the and speed the stroke i. e. was elected the hydraulic motor by size 80/50 – 330. The period of the piston stroke was reduced to 1.1 s compared with the original 2 s, the amplitude of vibration increased only slightly to 2.7 mm compared to the original 2.2 mm [4].

Table 1: The numerical comparison of results

Hydraulic motor - state	Time of stroke [s]	Amplitude of vibration [mm]
63/45 - original	2	2,2
63/45 short cycle	0,7	9
100/63 short cycle	1,65	1,3
80/50 short cycle	1,1	2,7

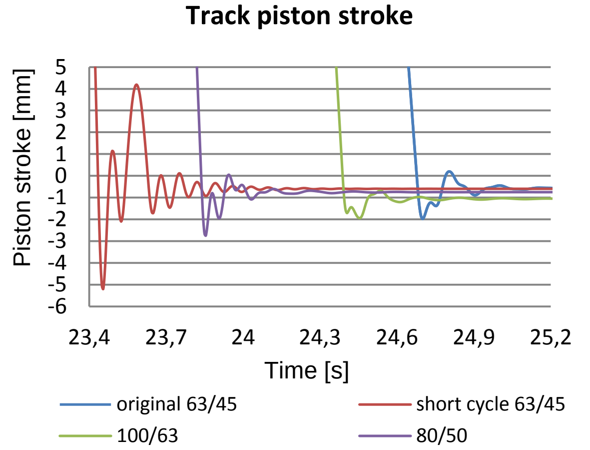

Figure 4: Comparison of the piston stroke tracks

7. Conclusion

Numerical simulations were optimized hydraulic circuit. Optimization was achieved by reducing cycle time and reduced amplitude of vibration of the hydraulic piston loaded mass loads. Progressions vibrations piston in end position for different size variants of hydraulic motor and duration stroke are compared in Fig.4.

8. Literature

[8] BEATER P.: ENTWURF HYDRAULISCHER MASCHINEN: MODELLBILDUNG, STABILITÄTSANALYSE UND SIMULATION HYDROSTATISCHER ANTRIEBE UND STEUERUNGEN, BERLIN, HEIDELBERG, NEW YORK: SPRINGER, 1999

[9] MANNESMANN REXROTH: PŘÍRUČKA HYDRAULIKY, SVAZEK 2, PROPORCIONÁLNÍ TECHNIKA A SERVOTECHNIKA, 1986

[10] KOZUBKOVÁ M.: DYNAMIKA HYDRAULICKÝCH SYSTÉMŮ, OSTRAVA: VŠB-TU OSTRAVA, 2005

[11] BUREČEK A.: OPTIMALIZACE PROPORCIONÁLNÍHO ŘÍZENÍ SOUSTAVY PRO ODEBÍRÁNÍ FOREM, OSTRAVA: VŠB-TU OSTRAVA, 2010

[12] PALIKOVÁ B.: DYNAMICKÉ VLASTNOSTI OBVODU S DLOUHÝM POTRUBÍM, DIPLOMOVÁ PRÁCE, OSTRAVA: VŠB-TU OSTRAVA, 2008