COMPARATIVE ANALYSIS OF SECONDARY AND PRIMARY ADJUSTMENT IN FLUID POWER SYSTEMS

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This paper underlines several aspects regarding functionality and energy consumption in fluid power systems with secondary adjustment, based on coupling hydraulic motors to constant pressure, respectively in fluid power systems with primary adjustment, based on coupling hydraulic motors to constant flow.

In the article there are presented numerical simulations, developed in MATLAB-SIMULINK, on hypothetical fluid power systems with secondary adjustment, respectively fluid power systems with primary adjustment.

Keywords: secondary adjustment, primary adjustment.

1. Introduction

Simulations, developed mainly with MATLAB-SIMULINK software, are characterized by: (a) Simulation schematic diagrams have been developed for constituent subsystems of the two basic diagrams of hydraulic transmissions, respectively of primary and of secondary adjustment. They can be improved from a functional perspective; (b) Simulations prove the necessity for development into practice of the two stands (of secondary and primary adjustment) with a modular structure, with as few interconnections of their modules as possible; (c) During simulations is very important the way of developing the resistant load, especially when this one is intended to become active (secondary adjustment). It is easy to maintain at zero rotational speed of a hydraulic motor in case of a purely inertial load (winch), but for an elastic load (hydraulic pumps or motors) there can occur oscillation within the system; (d) It is recommended to use adjustable hydraulic pumps and motors with dedicated electronics, as this one is specific and optimum.

2. Hydraulic Transmissions of Secondary Adjustment

2.1. Simulation of Operation of a Hydro Accumulator

In figure 1 is shown the basic schematic diagram of a hydraulic installation provided with a hydro accumulator. It is considered that this installation supplies simultaneously several consumers. To determine the dynamic behaviour of the

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hydro accumulator there have been performed numerical simulations under the following conditions: capacity of hydro accumulator V_0=25l; time constant of hydro accumulator T=2s; maximum pressure inside the installation = 100 bar; minimum pressure inside the installation = 80 bar; initial pressure of the gas inside the hydro accumulator = 30 bar. It is considered that the pressure source has a limitted flow, while the hydro accumulator is used as a power source.

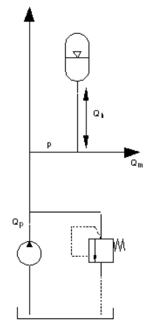

Fig. 1. Basic diagram of a pressure source provided with hydro accumulator

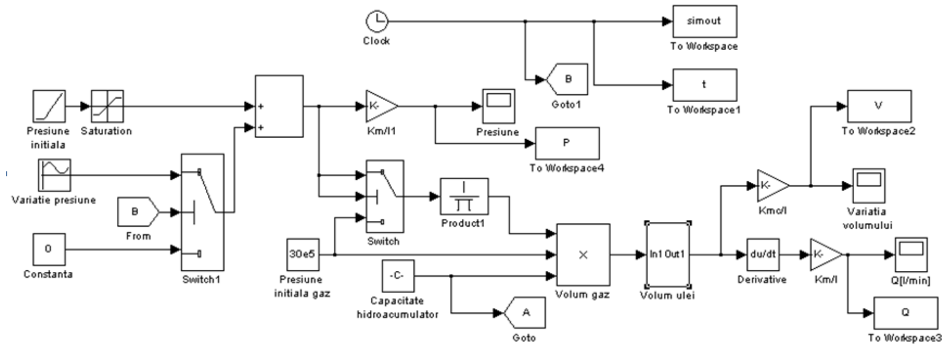

Fig. 2. Simulation network used to determine dynamic behaviour of a supply system provided with hydro accumulator

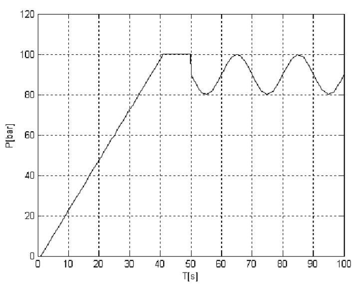

Fig. 3. Variation over time of pressure inside the outlet pipe of pump

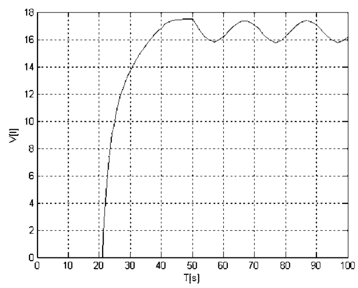

Fig. 4. Variation over time of oil volume inside the hydro accumulator

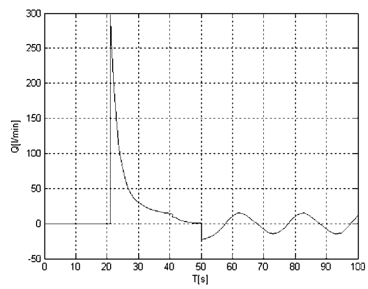

Fig. 5. Variation over time of flow supplied by the hydo accumulator

To performe numerical simulations we have used Matlab-Simulink sofware suit. Simulation network is shown in figure 2. Results of simulations are presented in figures 3, 4 and 5. Positive values of flow in figure 5 correspond to flow towards the hydro accumulator.

2.2. Response of the system that adjusts capacity of hydraulic motor to simoultaneous variations of pressure and resitant torque

Response of the adjustment system has been analyzed under conditions of constant rotational speed of hydraulic motor, by adjusting capacity of the motor.

In figure 6 is shown the basic diagram of a hydraulic installation which is supplied at almost constant pressure. There is traced the response of the adjustment system to simoultaneous variations of pressure and resitant torque.

The aim of simulations is to determine the system's response to simoultaneous variations of pressure and resitant torque, under conditions of constant rotational speed.

To performe numerical simulations we have used Matlab-Simulink sofware suit. Simulation network is shown in figure 7. Results of simulations are presented in figures 8, 9, 10 and 11.

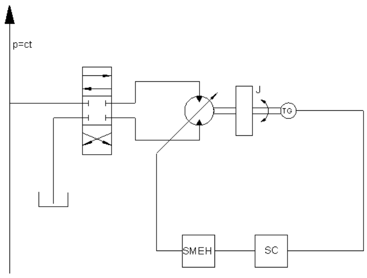

Fig. 6. Basic diagram of a hydraulic installation supplied at almost constant pressure

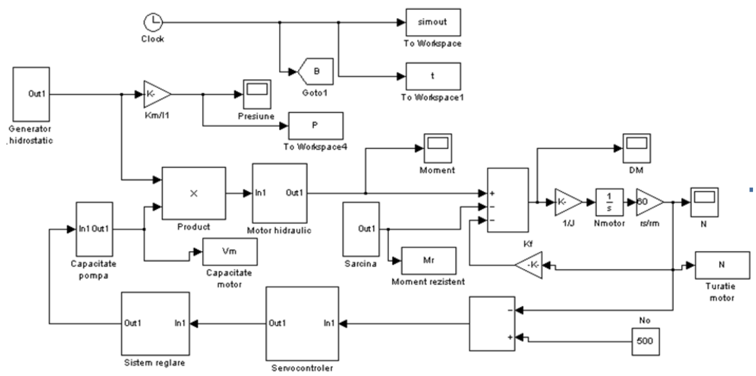

Fig. 7. Simulation network used to determine dynamic behaviour of a hydraulic installation supplied at almost constant pressure

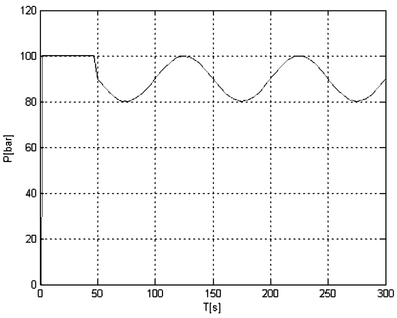

Fig.8. Variation over time of pressure inside the supply pipe of motor

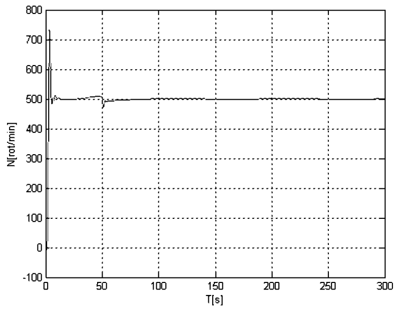

Fig.10. Variation over time of rotational speed of hydraulic motor

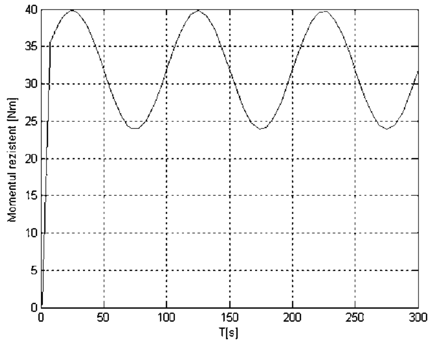

Fig.9. Variation over time of resistant torque

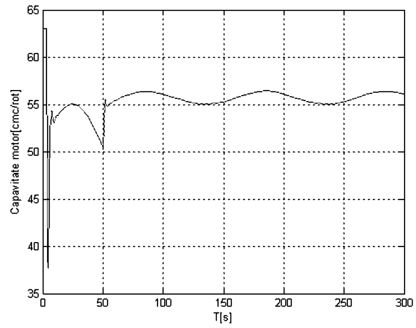

Fig.11. Variation over time of capacity of hydraulic motor

2.3. Simulation of operation of a system with secondary adjustment at pressure stages

Basic diagram of a hydraulic installation supplied at almost constant pressure is shown in figure 6, while Matlab-Simulink simulation newtwork - in figure 7. The aim of simulation is to determine system's response to stage-type variations of supply pressure, under conditions of constant rotational speed of hydraulic motor. Results of simulations are shown in figures 12, 13 and 14.

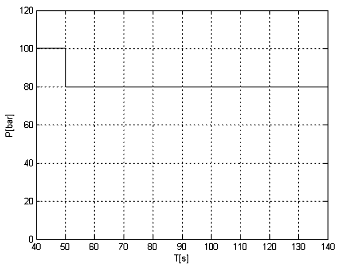

Fig.12. Variation over time of pressure inside the supply pipe of motor

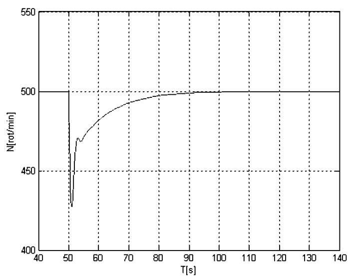

Fig.13. Variation over time of rotational speed of hydraulic motor

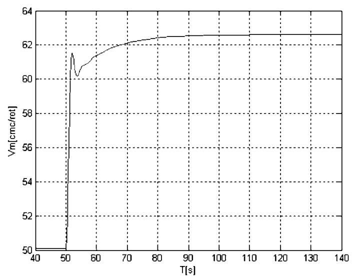

Fig.14. Variation over time of capacity of hydraulic motor

2.4. Simulation of operation of a system with secondary adjustment at resistant torque stages

Basic diagram of a hydraulic installation supplied at almost constant pressure is shown in figure 6, while Matlab-Simulink simulation newtwork - in figure 7. The aim of simulation is to determine system's response to stage-type variations of resistant torque, under conditions of constant rotational speed of hydraulic motor. Results of simulations are shown in figures 15, 16 and 17.

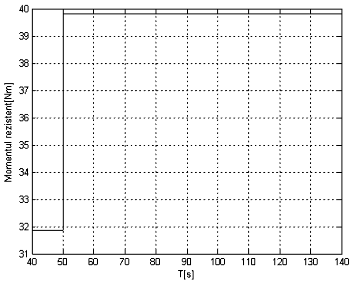

Fig.15. Variation over time of resistant torque

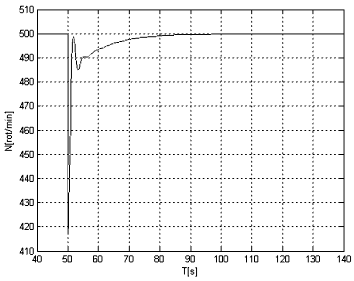

Fig.16. Variation over time of rotational speed of hydraulic motor

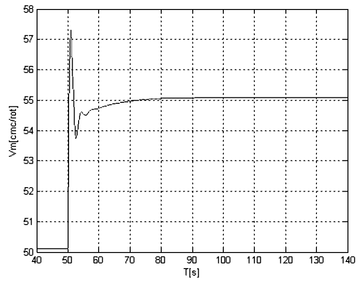

Fig.17. Variation over time of capacity of hydraulic motor

2.5. Simulation for secondary adjustment with transforming of hydraulic motor into a generator

Simualtion conditions are: resistant torque equals active torque; rotational speed is null. Basic diagram of a hydraulic installation supplied at almost constant pressure is shown in figure 6, while Matlab-Simulink simulation newtwork - in figure 18.

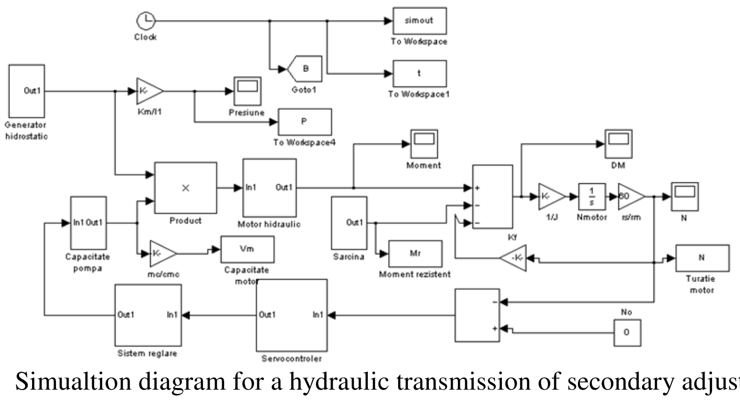

Fig.18. Simualtion diagram for a hydraulic transmission of secondary adjustment. Hydraulic motor turns into a generator.

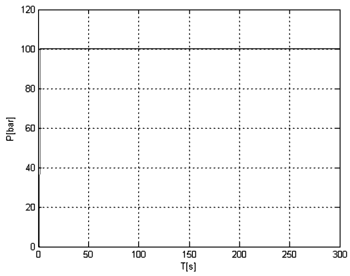

Fig.19. Variation over time of pressure inside inlet coupling of motor

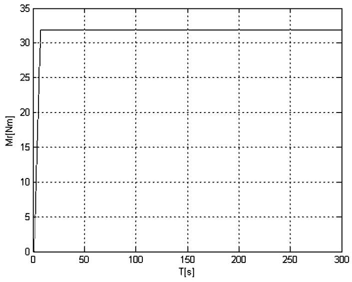

Fig.20. Variation over time of resistant torque

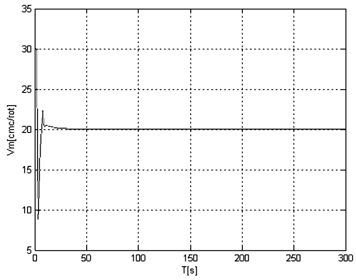

Fig.21. Variation over time of capacity of hydraulic motor

This simulation shows how a hydraulic motor can be turned into a generator (pump) by varying capacity. This simulation proves that rotational speed of the motor can be maintained null and, at the same time, have an active torque. Practically, we can maintain a mass actuated by a winch at a fixed point. Results of simulations are shown in figures 19, 20 and 21.

3. Hydraulic transmissions of secondary adjustment

3.1. Response of sinusoidal variations of the load

Pump is actuated at a constant speed and its flow changes due to changes of its capacity. There is traced the response at sinusoidal variations of load under conditions of a constant rotational speed of hydarulic motor, by adjusting capacity of pump. To overcome the resistant torque, pressure has to pass through uncontrolled automatic variation. Basic diagram of a hydraulic installation supplied at almost constant pressure is shown in figure 22, while Matlab-Simulink simulation newtwork - in figure 23.

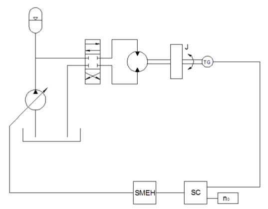

Fig.22. Basic diagram of a hydraulic transmission of secondary adjustment

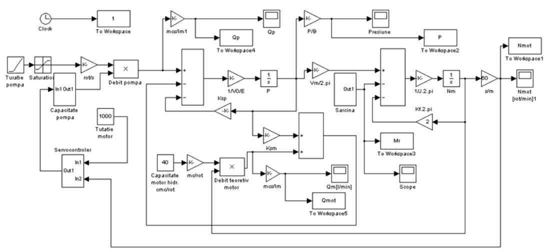

Fig.23. Simulation diagram of a hydarulic transmission (pump-motor) with no adjustment

Rezultatele simulărilor sunt prezentate in figurile 24, 25 şi 26.

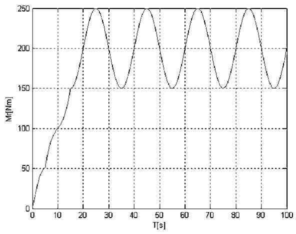

Fig.24. Variation over time of resistant torque of hydraulic motor

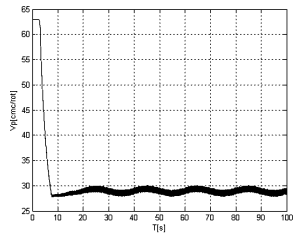

Fig.25. Variation over time of capacity of pump (detail)

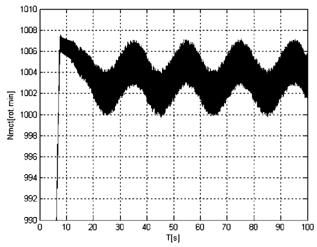

Fig.26. Variation over time of rotational speed of hydraulic motor (detail)

3.2. Response to stage-type variations of the load

In this case, pump is actuated at constant speed, and its flow changes due to changes of its capacity. In simulation motor's rotational speed is maintained at a constant value, by adjusting pump's capacity, while in order to overcome the resistant torque, pressure passes through uncontrolled (automatic) variation.
Basic diagram of a hydraulic installation supplied at almost constant pressure is shown in figure 22, while Matlab-Simulink simulation newtwork - in figure 23. Results of simulations are shown in figures 27, 28 and 29.

4. Conclusions

Hydraulic actuation systems of secondary adjustment, based on adjusting capacity of volumetric servomotors, supplied at constant pressure, have a low energy consumption and advantages from a functional perspective, compared to hydraulic actuation systems of primary adjustment, based on volumetric servopumps, that adjust automatically their capacity so that they supply constant flow to volumetric motors of constant capacity.

These advantages, considered from energetic and functional perspectives, of secondary adjustment, are better noticed in case of long lines, provided with hydraulic accumulators, where just one fixed hydraulic pump supplies flow, at constant pressure, for several adjustable, rotary or linear, volumetric servomotors.

Advantages, considered from energetic perspective, of secondary adjustment result from the fact that, depending on the operation cycle diagram of a hydraulic drive installation, that operates on such adjustment, servomotors can turn into generators of hydraulic energy, that is pumps, which can supply hydraulic accumulators or they can turn into generators of electric energy.

Advantages, considered from functional perspective, of secondary adjustment result mainly from diminishing the effect of compressibility of hydralic oil, given the fact that hydarulic servomotors are supplied at almost constant pressure.

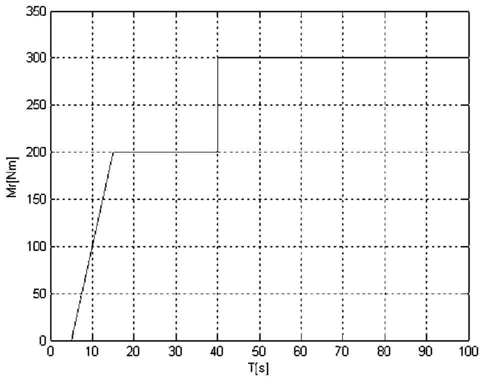

Fig.27. Variation over time of resistant torque of hydraulic motor

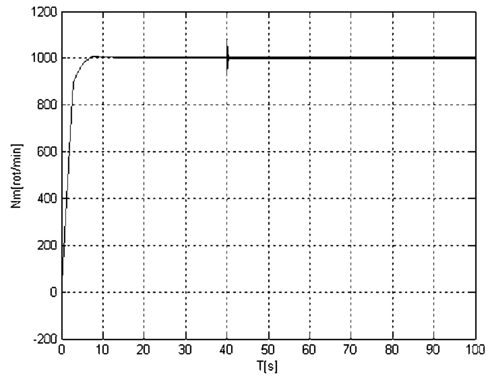

Fig.29. Variation over time of rotational speed of hydraulic motor

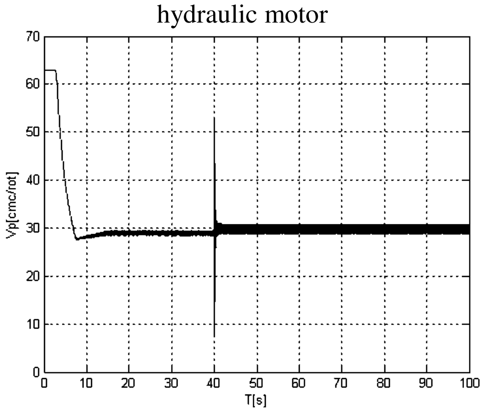

Fig.28. Variation over time of capacity of pump

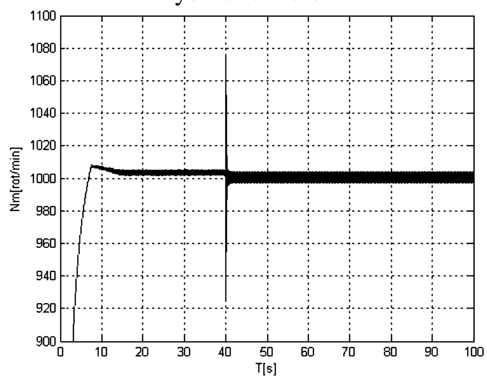

Fig.30. Variation over time of pressure inside inlet coupling of hydraulic motor (detail)

The grate disadvantage of secondary adjustment consits in the fact that, many times, variation of load at one cosummer, in the secondary structure of drive installation, can influence variation of load at the rest of consummers. In practice a mixed adjustment of hydraulic drive installations is used, based on adjusting capacity of hydraulic pumps and motors, performed in such a way that, regardless variation of load inside the system, rotational (displacement) speed of rotary (linear) volumetric motors stays constant, with low energy consumption.

R E F E R E N C E S

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