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A BEHAVIOR STUDY OF AN ADJUSTABLE HYDRAULIC DRIVING SYSTEM WITH SECONDARY CONTROL SUBJECTED TO LOAD VARIATIONS

BY

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Abstract. The paper contains the results of the experimental research of a hydraulic system with secondary control. It shows the overview of the experimental stand and the secondary control module. The stand allows experimental tests in transient state of the hydraulic system with secondary control. It follows the evolution of the output signal, respectively hydraulic motor rotational speed when load is varied at the motor shaft. The system responses are analyzed and some conclusions concerning the quality of transient state are drawn.

Key words: secondary control, hydraulic system, transient state.

1. Introduction

Hydraulic drives are means of transmitting the hydraulic energy from the source to the working body. Beside the high and fully controlled of energy values, they have the advantage to easily achieve continuous variation, precise and in wide range of the forces, torques, speed and position of the hydraulic motor shaft.

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These variations are obtained through pressure control or a flow control.

In a hydraulic system the flow control is done by resistive or volumetric way (Călăraşu, 1999; Călăraşu, 2002; Huian *et al*., 2012).

The adjustment is applied to the pump (primary control) or to the hydraulic motor (secondary control).

In a hydraulic system with secondary control, the control of mechanical parameters of the hydraulic motor is performed at the output by controlling hydraulic parameters. The speed control can be achieved by adjusting the pump-motor unit hydrostatic capacity (Călăraşu, 1999; Huian *et al*., 2012). The power developed by the hydraulic motor and therefore the speed are proportional to the flow at constant load.

The method is economically, but has a number of disadvantages such as: the speed of the hydraulic drives with volumetric control is limited; the control time depends on the control system performance; the control system is complex and difficult to be manufactured.

2. The Structure of Hydrostatic System with Secondary Control

In Fig. 1 is presented an overview of the experimental stand which was used to study the behavior of the hydraulic system with secondary control in transient state at load changes on hydraulic motor shaft.

Fig. 1 – Hydraulic system with secondary control:
3, 10 – safety valve, 4, 11, 28 – pressure gauge, 5 – way valve , 6 – hydro pneumatic accumulator, 17 – servo valve, 18 – displacement transducer, 19 – hydraulic linear motor, 20 – hydraulic rotational motor with adjustable capacity, 22 – pump, 23 – valve block, 24 – filter, 25– pressure transducer, 26 – proportional valve, 27 – adjustable throttle, 30 – tap.

In Fig. 2 two views from different angles of the secondary control module are presented.

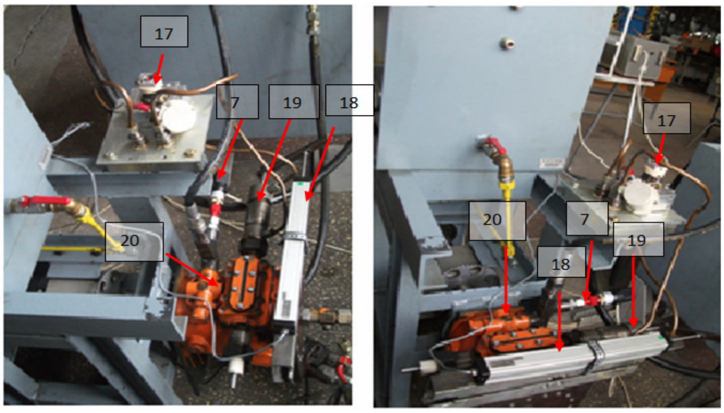

Fig. 2 – Secondary control module:
7 – pressure transducer, 17 – servo valve, 18 – displacement transducer, 19 – linear hydraulic motor, 20 – hydraulic rotatory motor.

3. The Experimental Results Obtained by Varying the Load at Hydraulic Motor Shaft

The tests were conducted for one reference speed (660 rpm) of the motor shaft imposed by the size of the reference voltage *Ur*. At the imposed reference speed, load variation was applied to the motor shaft by a pressure change Δp of the pump 22, Fig. 1, obtained by adjusting the throttle 27, Fig. 1. Three step responses for three values of the pressure variation were determined.

Experimental values for this series of experiments are presented in Table1.

Table 1
Experimental Values

Reference speed at hydraulic motor shaft, [rpm]	Pressure variation Δp, [bar]
660	5
660	8
660	10

Each experiment given in Table 1 was done as follows:

− The system pressure is set;

− The speed of the hydraulic motor shaft is brought to the prescribed reference value (660 rpm);

– The load of hydraulic motor shaft is changed at the second 2 as can be seen in Figs. 4-6.

The block diagram of the control loop and data acquisition used in the experiment is shown in Fig. 3.

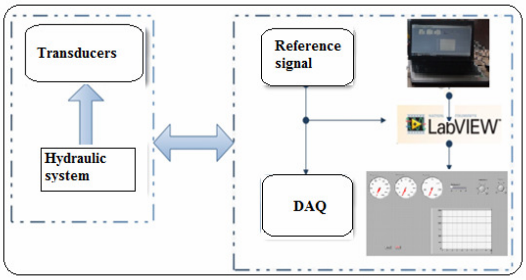

Fig. 3 – Block diagram of the control loop and data acquisition.

Virtual instrumentation associated with the hydraulic stand was developed using graphical programming software LabVIEW mainly used for signal acquisition and analysis.

Acquisition board converts electrical values to analog signals by its basic component the analog-to-digital converter. Converter associates a numerical value to a voltage value, making possible by this association the computer based analyze.

Step responses of the system at the load variations are shown in Figs. 4-6.

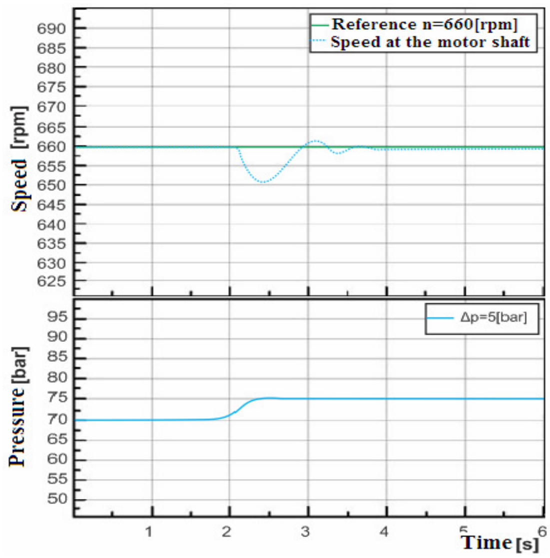

Fig. 4 – Step response of the system to $n_{ref} = 660$ [rpm] and $\Delta p = 5$ [bar].

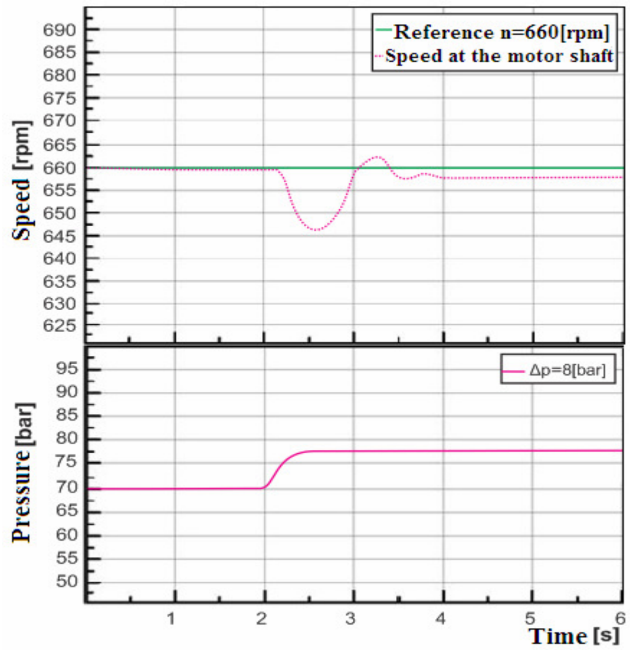

Fig. 5 – Step response of the system to
n_{ref} = 660 [rpm] and Δp = 8 [bar].

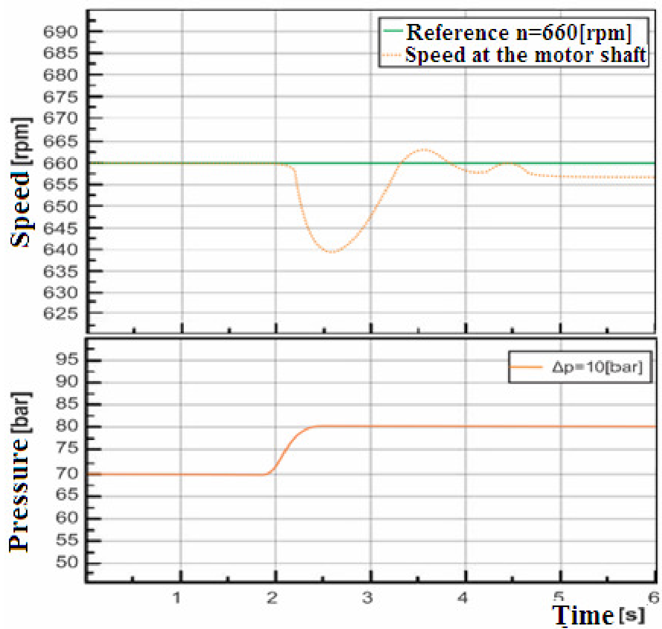

Fig. 6 – Step response of the system to
n_{ref} = 660 [rpm] and Δp = 10 [bar].

The step responses analysis of the input signal size changes, shown in Figs. 4-6, shows that the transfer factor *k, t*he transient state duration and the override *δ* increase with the input signal size increasing.

4. Conclusions

A new kind of hydraulic system with secondary control system was designed. The experiments performed by using this system with different loads at the hydraulic motor shaft, show the following behavior of the main parameters:

1. The transfer factor *k* shows an error within acceptable limits with the increasing of the input signal size.
2. The transient state duration increases with the increasing of the input signal size.
3. The override *δ* increases with the increases of the input signal size.

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STUDIUL COMPORTĂRII UNUI SISTEM CU REGLARE SECUNDARĂ LA VARIAȚII DE SARCINĂ

(Rezumat)

Lucrarea prezintă rezultatele cercetării experimentale pentru un sistem cu reglare secundară de concepție proprie. Se prezintă vederea generală a standului experimental precum şi a modulului cu reglare secundară. Standul experimental a permis testarea în regim tranzitoriu a sistemului cu reglare secundară. S-a urmărit evoluția mărimii de ieşire *n* (turația motorului hidraulic) la variația sarcinii la arborele motorului hidraulic. În urma analizei răspunsului sistemului cu reglare secundară la variația sarcinii, se constată că:

1. Acest sistem hidraulic cu reglare secundară se comportă ca un sistem de reglare.
2. Sistemul asigură o evoluție de scurtă durată a regimului tranzitoriu a mărimii de ieşire care este turația motorului hidraulic.
3. Suprareglarea, factorul de transfer şi timpul de răspuns al sistemului cresc odată cu creşterea mărimii de intrare care este sarcina la arborele motorului hidraulic.