EXPERIMENTAL RESEARCHES REGARDING THE POSSIBILITY OF AUTOMATION OF A CONVENTIONAL GEARBOX

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KEYWORDS - actuating, logic, gear box, electrovalves, test bench.

ABSTRACT - The goal is to establish an actuating logic, the minimum necessary actuators and electrical driving unit. On the power train, a sequential self-acting, quadratic cycle Huffmann type device are implemented to act the clutch and the levers of gearbox to shift speed.
The number of actuators was minimized by using a combinational logic, which with the help of a "step by step" relay circuit was build-up. The acting energy is a pneumatic one, which activates a number of command electrovalves for pneumatic cylinders. The conclusions will be validated by experimental researches to the engine's test bench.

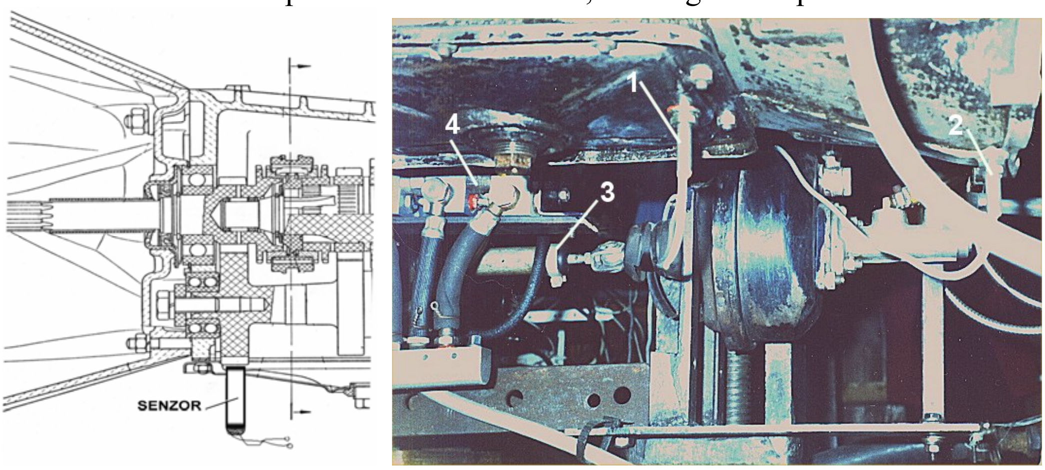
THE OBJECTIVES

The paper describes the experimental researches on a standard power train equiped with a conventional 4 step gearbox, subject to an automation.
For an optimal desired transmission ratio it will be used a sequential command of a gearbox.

THE RESEARCH CONDITIONS

Standard atmospheric conditions;

1. The elastic mounting of a powertrain to the test bench, using a hydraulic brake, 200 kW / 5500 rpm.
2. The following parameters were measured:
    - The rotational speed of the engine, brake and primary gear of the gearbox, shown in figure 1.
    - The linear displacement of the clutch, and angular displacement of the throttle.



a b

Figure 1 a – cross section, b – 1 the same sensor like a, 2 the engine sensor, 3 the clutch displacement, 4 the electrovalves.

THE RESEARCHES

On the test bench it's determined the torsion torques for all speed steps, based on the relation:

$F_R = \frac{M_{mot} i_{cv} i_0}{r_d} \eta_{tot}$,where: i_{cv} = ratio gear;i_0 = 4.1 – ratio gear of the main transmission; r_d = 0.28 m – wheel dinamic radius; η_{tot} = 0.95 – the transission efficiency.

THE SYSTEM

The goal is to find an actuating logic, starting from the command grid which combines two motions, one of step selection, second for the synchronize and engagement of the desired speed step. It is shown in figure 2 the two lever gearbox acting.

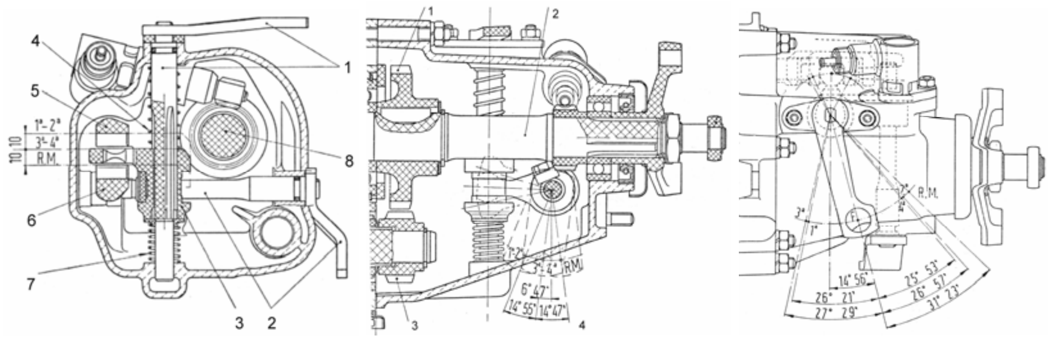


Fig.2 The two lever gearbox acting
1 – shift lever; 2 – selecting lever; 3 - selector; 4 – turn-on spring I-II;
5 – coupling fork I-II; 6 – stroke back fork; 7 - stroke back spring; 8 – output shaft.

THE GEARBOX AUTOMATION SOLUTION

Two air-driven cylinders are provided for driving the gearbox levers: one, stroke up-and-down for gear coupling, a simple stroke for selector, as shown in figure 3.

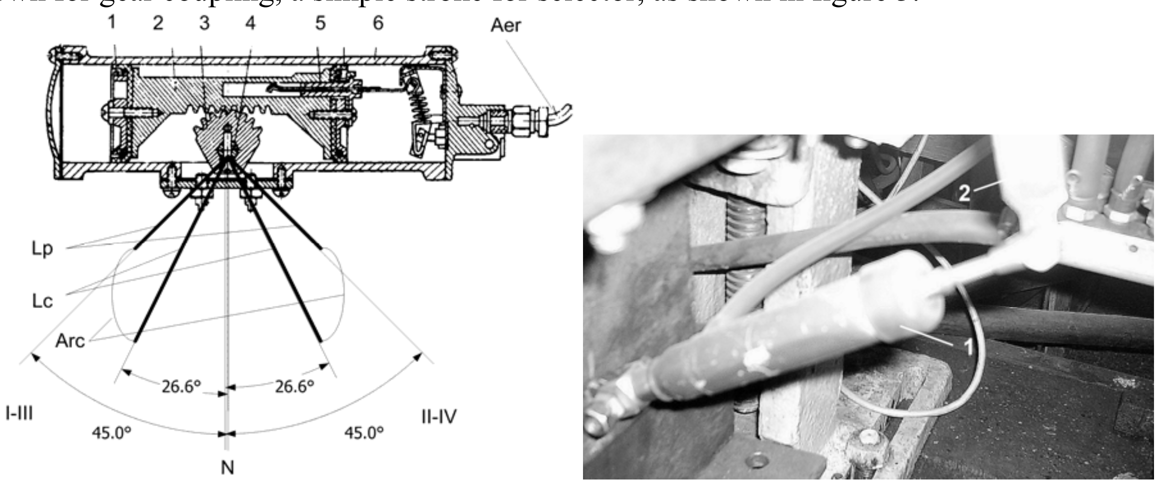


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Fig. 3 a – The air-driven cylinders, a 1 - stuffing; 2 - piston; 3 - cradle; 4 – toothed sector; 5 – stroke turn-on ; 6 - cylinder; Lp – command lever; Lc – coupling lever; Arc - spring,
b – Selecting actuator 1 –selecting cylinder Cil2; 2 - selecting lever

A general view of the actuators assembly it shown in figure 4.

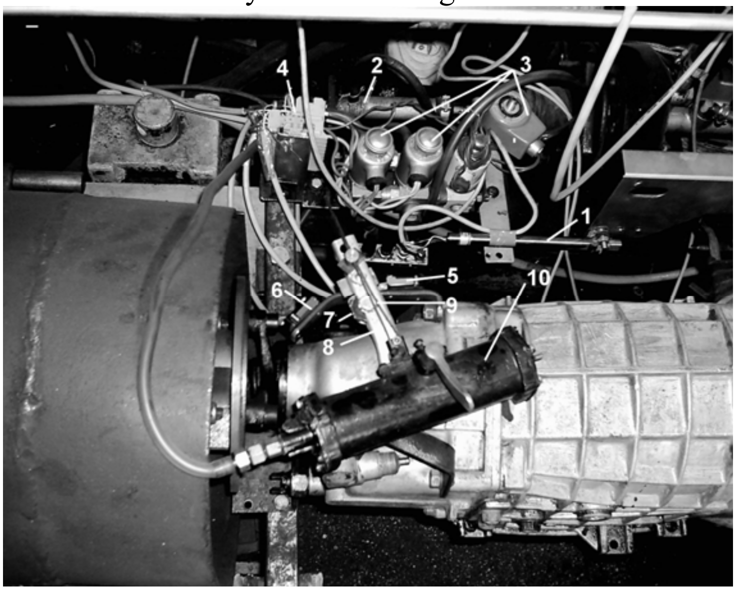

Fig. 4 View of the instrumented gearbox
1 – displacement sensor of clutch; 2 - the clutch air-driven cylinder; 3 – command electrovalves v1, v2, v3; 4 – electrical connexions; 5 - microswitch K1; 6 - microswitch K2; 7 – coupling lever; 8 – coupling lever arm; 9 - spring; 10 – coupling cylinder Cil1.

WORKING ELEMENTS

For shifting the gears it's proposed a sequential air-driven gearbox automation, shown in figure 5. The shift gear command it's achieved by two press buttons, B1 for shift up, and B2 for shift down. The microswitch K5 validate by a flag the end of disengagement of clutch.

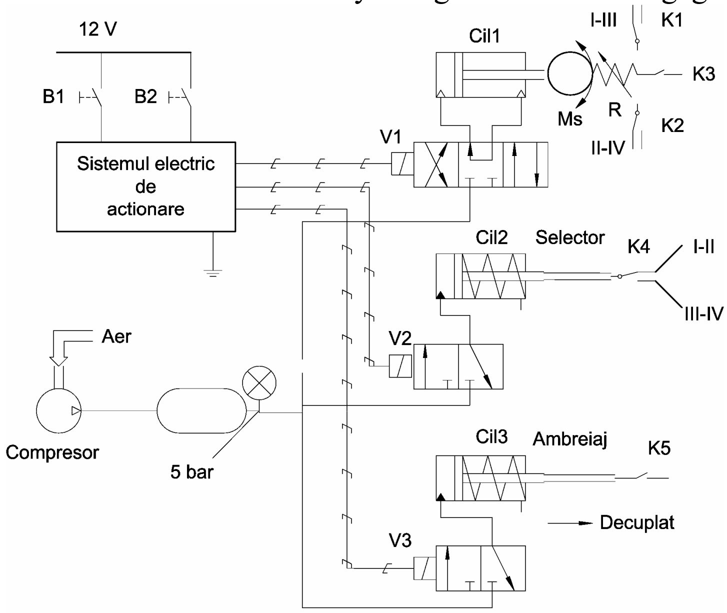

Fig. 5 The electrical air-driven system
B1 – shift up switch; B2 – shift down switch; v1 – acting electrovalve for coupling the steps I-III, respectiv II-IV; v2 – the selector electrovalve; v3 – the clutch electrovalve; Cil1 – stroke turn-on cylinder; Cil2 – selecting cylinder; Cil3 – the clutch cylinder; Ms – turn-on device ; R – lamelar spring; K1…K5 – coupling validation switchs.

GENERAL ELECTRICAL DIAGRAM

A sequential self-acting "step by step" reversible circuit it's ended by a relay configuration for driving the electrovalves as shown in figure 6.

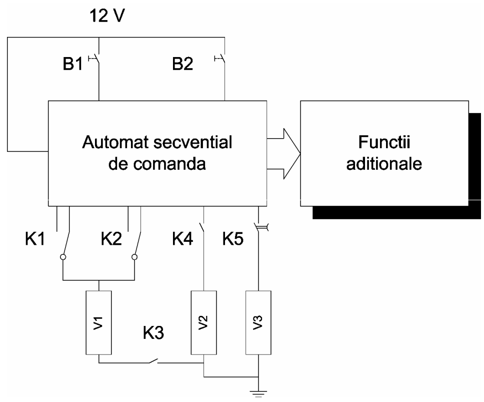

Fig. 6 General electrical diagram.

DRIVEN LOGIC

It's established the following conventions:

- Primary variables due by B1 and B2;
- Output variables due to K1...K5, without K3, corresponding to the four gear positions;
- Secondary variable, by K3 state;
- Only one variable is in „1" state each moment.

The commands generated follow the electronic logic achieved by a simulated process, shown in figure 7.

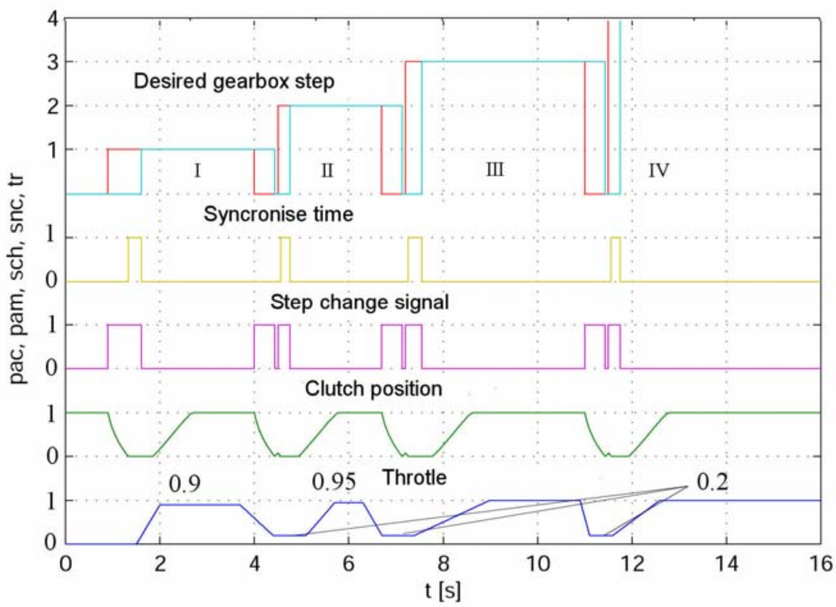

Figure 7 Electronical logic obtained from a simulated process.

Each B1 pushing leads to one unit "modulo 4" progression of the index of the output, reciprocaly for B2. Note that Ki – closed contact, $\overline{\text{Ki}}$ – open contact, where i = 1...5.
The sequential self-acting proposed is a Huffmann type, shown in figure 8, and the coupling conditions due to Ki switches presented in table 1.

Table 1 Coupling conditions

B1 /B2	I	II	III	IV
V1	$K1, \overline{K2}, \overline{K3}$	$\overline{K1}, K2, \overline{K3}$	$K1, \overline{K2}, \overline{K3}$	$\overline{K1}, K2, \overline{K3}$
V2	$K4$	$K4$	$\overline{K4}$	$\overline{K4}$
V3	$K5$	$K5$	$K5$	$K5$

For example, for shifting I-st gear, must accomplish the following relation:
$B1 \cup K1 \cdot K4 \cup K5_{\tau}$,
and by shifting from I-st to II-nd:
$B1 \cup \overline{K1} \cdot K2 \cdot \overline{K3} \cdot K4 \cup K5_{\tau}$.

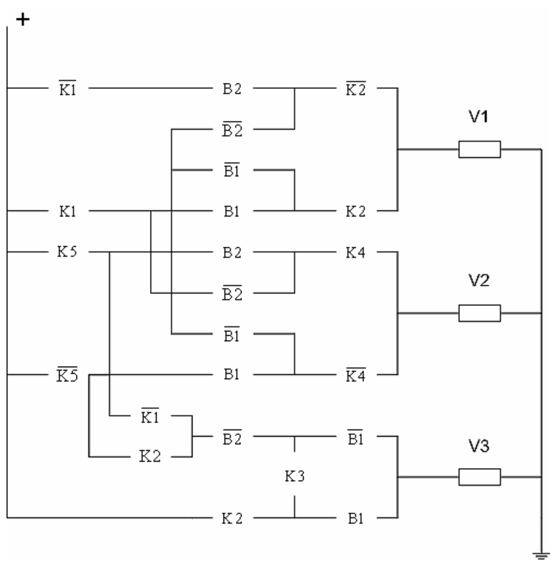

Figure 8 Huffmann type circuit.

SOME EXPERIMENTAL RECORDINGS

Figures 9…11 presents the recordings of different shift gear, obtained by testing on the test bench.

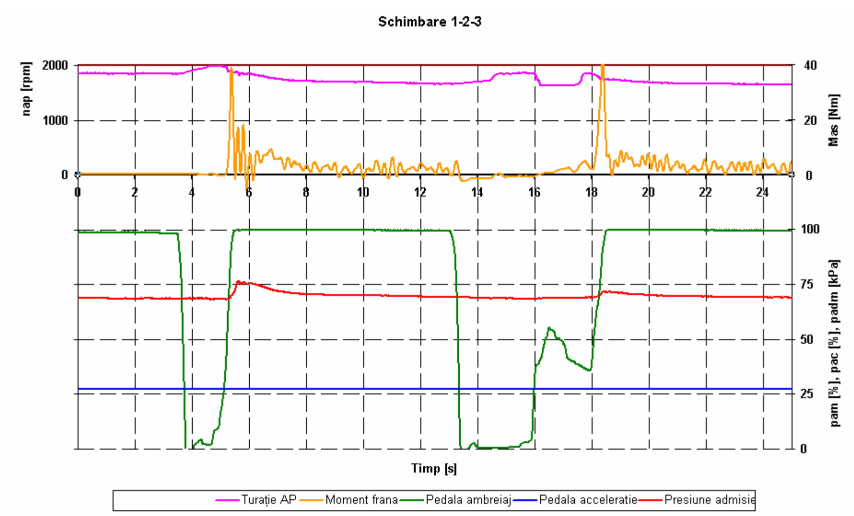

Figure 9 Recording of a start with shifting 1 – 2.

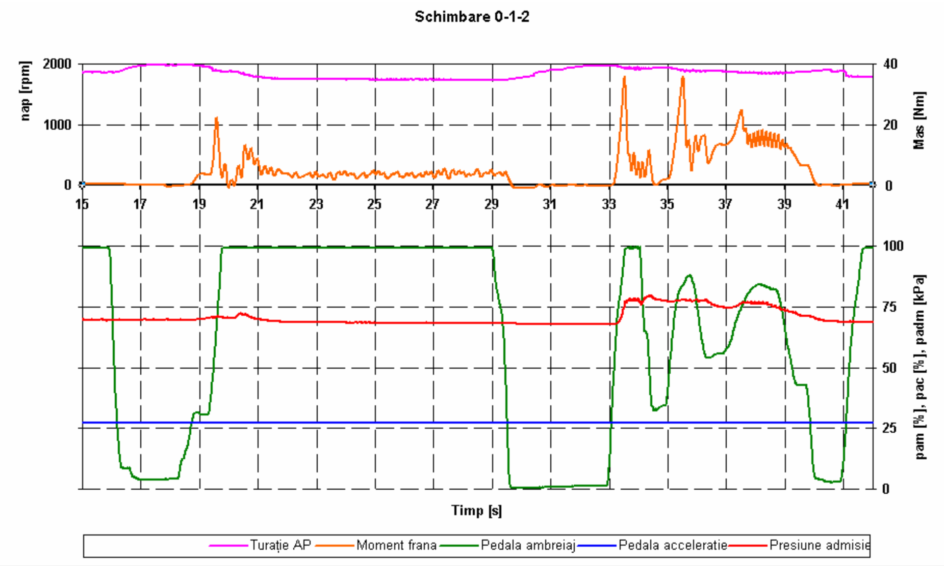

Figure 10 Recording of a shifting 2 – 3.

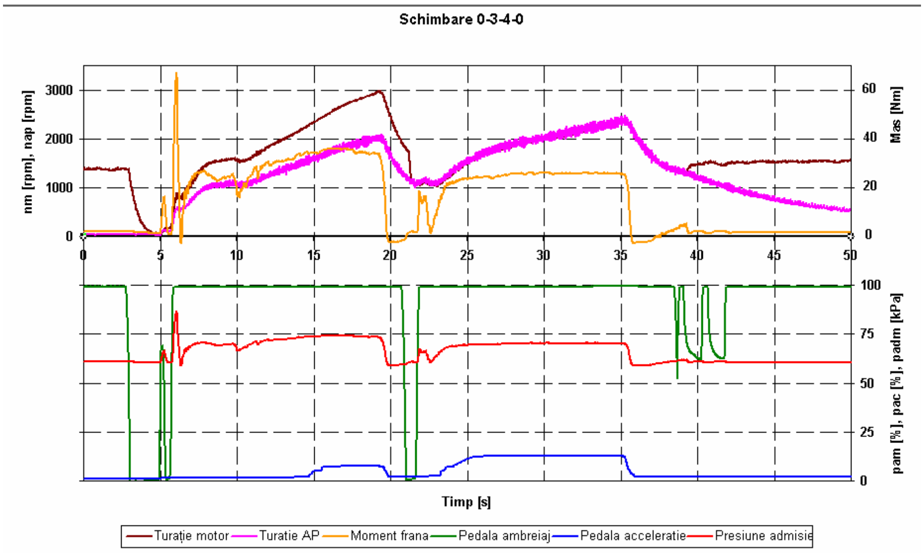

Figure 11 Recording of a shifting 1 – 2 – 3.

CONCLUSIONS

- The electronic circuit delivers the command signals for a properly gear shifting by acting the clutch and selecting and coupling levers;
- A reversible counter circuit is activated by B1 on the command input for 1-2-3-4 sequence (count-up), or activated by B2 for count-down sequence, for shift down;
- The optimum shift timming can be identified depending of the driving conditions and the driver desire;
- Experimental data has been achieved following the submodels for clutch, synchronizers and wheel-road interface;
- The synchronization interval was 0.15 sec. and the clutch coupling linear in 0.5 sec.

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