RESEARCH CONCERNING DESIGN AND TESTING OF A LABORATORY RIG FOR THE STUDY OF THE AGRICULTURAL UNITS ACTIVE PARTS-SOIL INTERACTION

CERCETĂRI PRIVIND PROIECTAREA ŞI EXPERIMENTAREA UNUI STAND PENTRU STUDIUL INTERACȚIUNII ORGANELOR ACTIVE ALE UTILAJELOR AGRICOLE CU SOLUL

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Abstract. *The physical degradation of soil due to the interaction with the active parts of the agricultural units consists mainly in its compaction, but also in the deterioration of its structure. Experimental studies should be carried out in order to establish the values of the working parameters of the active parts leading to soil degradation and to establish the relationships between these parameters and the indices related to soil degradation. In order to solve the above-mentioned problems the Agricultural Machinery Department of the University of Agricultural Sciences and Veterinary Medicine has designed, built and tested a laboratory rig. The rig is composed of a soil channel, the carriage for mounting the studied active part and the carriage traction implement. Tests were carried out in order to validate the design of the rig and the conclusion was that all the imposed requirements were achieved.*
Key words: tillage active part, towing force, soil compaction

Rezumat. *Degradarea fizică a solului cauzată de interacțiunea organelor active ale utilajelor agricole cu acesta, se referă în special la deteriorarea structurii solului dar şi la compactarea lui. Este necesar să se facă studii pentru a se stabili la ce parametri de funcționare ai organelor active începe procesul de degradare a solului. Totodată, trebuie să se stabilească corelațiile care există între parametrii de funcționare ai organelor active ale utilajelor şi valorile indicilor de degradare ai solului. Pentru rezolvarea acestor probleme, la disciplinele de mecanizare a agriculturii din Universitatea de Ştiințe Agricole şi Medicină Veterinară din Iaşi a fost proiectat, realizat şi experimentat un stand de laborator destinat studiilor menționate mai sus. Standul este alcătuit din canalul de sol, căruciorul pe care se fixează organul activ şi dispozitivul pentru tractarea căruciorului. Acest stand a fost experimentat pentru a se vedea dacă s-au realizat parametrii constructiv-funcționali ai acestuia stabiliți inițial prin proiectare.*
Cuvinte cheie: organ activ, forță de tracțiune, tasarea solului

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INTRODUCTION

The physical degradation of the soil is caused by the interaction with the active parts of the agricultural equipments and its effects are the degradation of soil structure and soil compaction. Researches are needed in order to evaluate these effects and to establish when soil degradation begins. The connection between the working indices of the tillage tool and the indices related to soil degradation must also be investigated (Căproiu et al., 1982; Căproiu et al., 1973; Jităreanu et al., 2007; Țenu et al., 2010).

In order to solve these problems a laboratory test rig was designed, constructed and tested, aiming to investigate the interaction between the active parts of agricultural equipment and soil.

MATERIAL AND METHOD

The test rig (figure 1) consists of the frame of the soil channel (1), the soil channel (2) and the carriage (3), on which the tillage active part (6) and the compacting roller (7) are mounted. The electric cable drum (4) tows the carriage (3) by the means of a cable (5). The electric cable drum (4) consists of an electric motor (8), a cylindrical gear drive (9), a mechanical coupling and a drum (10).

An electrical control panel and electric cables (11), mounted on the support poles (12), are used in order to feed the test rig with electricity.

Due to its length (10240 mm), the soil channel is composed of five sections, which are jointed with screws.

The carriage (figure 2) is composed of a frame (1), on which all the other parts are mounted. The active part (2) can be any tillage tool (plow body, chisel type tools etc.); the compacting roller (3) is also mounted on the carriage frame. The active part is mounted on the bracket (5), that is clipped on the brackets (4), hinged to carriage frame. The vertical position of the bracket (5) and of the active part is adjusted by the means of the lifting-screw (8), in order to modify the working depth. The screw mechanism (7) is used in order to modify the tilt angle of the tillage tool ($\pm 25^0$ from the average position).

The compacting roller (3) is used in order to achieve a certain level of soil compaction before tillage. A screw mechanism (9) is used in order to adjust the vertical position of the compacting roller.

Four upper trundles (10) – two in the front and two in the back – and four lower trundles (9) - also two in the front and two in the back - are mounted on the carriage frame; the trundles are rolling on rails, mounted on each side of the soil channel frame.

The towing cable is connected to the carriage by the means of two strain gauge load cells, allowing the measurement of the traction force needed to displace the carriage.

The electrical control panel is used in order to feed the test rig. The electrical motors are controlled by the means of a frequency converter, allowing the adjustment of the rotation speed when the frequency is modified between 3 and 50 Hz. The dynamic braking principle is used in order to stop the carriage at the end of travel. Switches on the control panel allow the selection of the forward or reverse motion of the carriage.

Two strain gauges load cells (1000 daN maximum force) are used in order to measure the carriage towing force; the load cells are connected to an electronic controller, which displays the averaged value of the traction force.

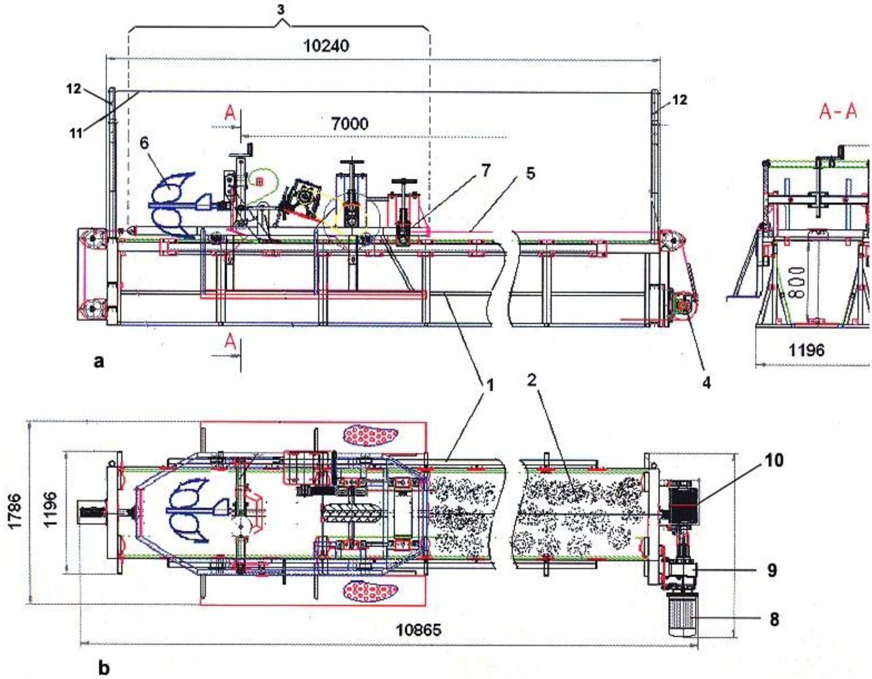

Fig. 1 - Laboratory test rig for the study of active parts-soil interaction:
a – side view; **b** – upper view. *1* – soil channel frame; *2* – soil channel; *3* – carriage; *4* – cable drum; *5* – carriage towing cable; *6* – tillage active part; *7* – compacting roller; *8* – electric motor; *9* – cylindrical gear drive; *10* –drum; *11* – electric cable; *12* – supporting poles.

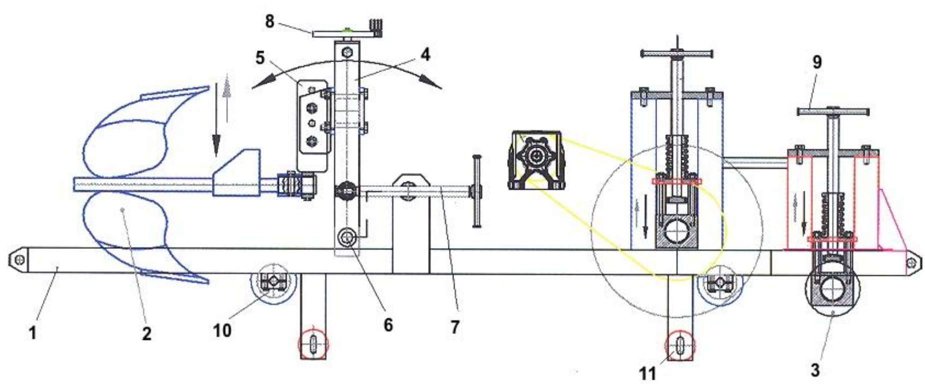

Fig. 2 - Carriage of the test rig:
1 – carriage frame; *2* – tillage active part; *3* – compacting roller; *4* – brackets for the active part tilt adjustment; *5* – tillage active part bracket; *6* – hinge; *7* –screw mechanism for the active part tilt adjustment; *8* – screw mechanism for the adjustment of the working depth; *9* – screw mechanism for the adjustment of the vertical position of the compaction roller; *10* – upper trundles; *11* – lower trundles.

The laboratory test rig has the following features:

- the carriage towing electric motor: 5.5 kW and 1000 rev/min;
- the carriage travel: 7 m;
- the carriage towing cable: D8 6x19 Seale IWR ISO 2408 (8 mm diameter, with 6 strands, each having 19 threads);
- overall dimensions of the soil channel: 0.8x0.8x10 m (width x height x length);
- overall dimensions of the test rig: 2035 x 10865 x 1764 mm;
- gear ration of the towing mechanism: 24.31;

RESULTS AND DISCUSSIONS

The tests were performed for two values of the soil penetration resistance: 0.2 MPa and 0.4 MPa (Neculăiasa, 1971; Şandru et al., 1983; Nedeff et al., 1997). An electronic penetrometer (Penetrologger, Eijelkamp Holland) was used in order to evaluate the soil penetration resistance.

In the first stage of the tests the working parameters of the test rig were evaluated. As a result, the following parameters were obtained:

- working depth: 0 – 300 mm;
- the setting angle of the tillage tool: $\pm 25^0$ from the average position;
- maximum vertical load on the compacting roller: 500 daN;
- carriage maximum towing force (at 0.55 m/s): 800 daN;
- carriage maximum towing force (at 1.55 m/s): 280 daN;
- cable breakdown point: 40.83 kN.

It was concluded that there were no significant differences between the design parameters and the achieved ones.

The second stage of the experiments aimed to evaluate the working parameters when a plough body was used as a tillage tool; the effects of the working depth, soil penetration resistance and working speed over the towing force and specific power consumption were evaluated. The results are presented in table 1.

It must be emphasized that the test rig reproduces, in laboratory conditions, the working process of a mould board plow body. The working width of the plow body was 200 mm; only the plow body was mounted on the rig carriage.

The experimental results showed that the towing force and the specific power consumption increased when the working speed increased.

In the meantime an increased soil penetration resistance led to a significant increase of both the towing force and the specific power consumption (Roş, 1978; Roş, 1984).

When considering the third working parameter (the working depth) it was concluded that its increase led to a significant increase of the towing force (Drăgan, 1969; Scripnic et Babiciu, 1979).

Regarding the specific power consumption it was concluded that increasing the working depth from 100 to 150 mm led to the decrease of the specific power consumption; the increase of the working depth from 150 to 200 mm led to the increase of the specific power consumption. These apparent inconsistancies may be thus explained: for low working depths (bellow 15 cm), the slice of soil cut by the plow body does not form a furrow (the slice does not undergo an action of torsion and inversion), leading to a lower specific power consumption. For working depths above 15 cm, the torsion and inversion of the furrow are achieved and these actions require additional power, leading to the increase of the specific power consumption.

Table 1

Working parameters of the laboratory test rig

Plow body working depth (mm)	**Soil penetration resistance** (MPa)	**Plow body working speed** (m/s)	**Towing force** (N)	**Specific power consumption** (W/cm^2)
100	0,2	0,75	705	2,65
		1,00	720	3,60
		1,25	735	4,59
	0,4	0,75	925	3,47
		1,00	940	4,70
		1,25	960	6,00
150	0,2	0,75	1055	2,64
		1,00	1070	3,57
		1,25	1080	4,50
	0,4	0,75	1380	3,45
		1,00	1400	4,67
		1,25	1420	5,92
200	0,2	0,75	1450	2,72
		1,00	1470	3,67
		1,25	1485	4,64
	0,4	0,75	1859	3,47
		1,00	1890	4,72
		1,25	1930	6,03

CONCLUSIONS

The experimental tests confirmed that the working parameters imposed by the design theme were achieved.

Based on the experimental results it was concluded that the effect of increasing the working speed is the increase of the towing force and of the specific power consumption.

It was also concluded that a higher penetration resistance led to a significant increase of the towing force and of the specific power consumption.

The increase of the working depth led to the increase of the towing force. In the meantime, increasing the working depth from 100 to 150 mm led to the decrease of the specific power consumption, while the increase of the working depth from 150 to 200 mm led to the increase of the specific power consumption.

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