INFLUENCE ON QUALITY AND ENERGY INDICES FOR A REVERSIBLE PLOW EQUIPPED WITH ELECTRIC VIBRATORS

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Keywords: plow, energetic indices, qualitative indices, electric vibrator motors.

ABSTRACT

The qualitative indices of the tillage as well as the exploitation energy indices represent two relevant factors in the exploitation of the agricultural equipments, these being the main barometer of the quality of the used equipment. The paper presents a comparative study of qualitative work indices, respectively energy indices, performed on two reversible plows with three troops, one used in the classical system and one optimized by implementing electrical systems for generating vibrations, located on each of the three active troops during operation

INTRODUCTION

Ploughs are machines designed to conduct the soil's essential work, called ploughing, in which the top layer of soil is cut into strips called furrows of a certain width and thickness, which are lifted, shredded, laterally shifted, twisted and flipped. (Dobre, 2010).

The ploughing units consisting of plough, carried or semi-carried, consisting of tractor and plough coupled behind the tractor (to the suspension mechanism), play the most important role in mechanizing the tillage works, being at the same time the largest consumer of energy (Ormenişan, 2014; Poenaru et al., 2015).

Currently, the heat engine agricultural tractor is the most commonly used machinery in agriculture. Electric motors, typically powered by batteries, provide one alternative (Matache et al., 2020).

Experimental research has been developed to develop mathematical models that take into account the type of soil (in order to analyse the influence of different parameters on the traction force of the plough) and to find the most important parameters of influence on tensile strength of the plough (Bandy et al., 1985; Biriş et al., 2008).

To increase the applicability of no-till farming by alleviating biophysical, technical, social and cultural constraints, soil-specific research is required (Lal et al., 2007).

In addition to trying to do proper tillage operations that consume a large portion of the energy in crop production, optimizing the operations and implements used for cultivating agricultural products is very necessary (Dexter et al., 2007; Kheiralla et al., 2003).

In order to explore the use of an effective para-plough instead of the mouldboard plough, experimental testing was also carried out to test the draft, vertical and lateral forces acting on the mouldboard plough, para-plough without a wing, para-plough with a forward-bent wing, and para-plough with a backward-bent wing at three working depths and three forward speeds in clay loam soil (Andersen et al., 2016).

It is of great importance to determine the force acting on soil agricultural implements (soil resistance), to estimate the energy needed to carry out tillage operations and to select a favourable traction force to carry out the desired operations, as well as to manage the decisions required for large-scale mechanization to save fuel and energy consumption (Al-Janobi and Al-Suhaibani, 1998; Gilandeh et al., 2020).

MATERIAL AND METHOD

In order to conduct the experiments, a reversible plough with three plough bodies was used in aggregate with an agricultural tractor with a power of 75 kW. The electric vibrators were mounted on each active body of the reversible plough as can be seen in Figure 1.

Fig.1. – Mounting the electro-vibrators on each body of the reversible plough

The determination of the skidding of the drive wheels of the tractor *δ* was made together with the determination of the average working speed, depending on the number of rotations of the drive wheels when operating the tractor in load (*ns*) and without load - *ng*. For this purpose, the start-stop command of the device for recording the number of revolutions of the *ns* and *ng* drive wheels during the test was performed (after traversing the space established by pegging, *s*)

The skidding of the tractor wheels, in the process of transmitting the traction power of the tractor for the realization of the working process of the MSP machine, was calculated with the following formula:

$$\delta=(n_s-ng)/ns \times 100, \% \qquad (1)$$

The tensile strength was achieved using a QuantumX 1615 data acquisition system, with 2 modules, 32 measuring channels for each module and KYOWA tensometric marks model KFSC-6-120-C1-11N15C2, 120 Ω, type, total size 10.00 mm x 3.40mm, mounted on the plough attachment rods.

CATMAN software, which is specialized for data acquisition and processing was used to record data acquired directly on a laptop.

The power supply of the QuantumX system was made by means of an inverter attached to the tractor's power supply system. The specialized CATMAN software for data acquisition and processing allowed the filtering of the signals received from the transducers and the determination of their minimum, maximum and average values. The signals recorded and saved in the computer's memory, in ASCII type files, were processed and played back by the data acquisition system in the form of graphs showing the oscillation of the force as a function of time. The data obtained was processed and the average values of the traction forces for the stabilized working regimes were determined (by eliminating the transitional regimes from the beginning and the end of the tests).

RESULTS AND DISCUSSIONS

The results of the determinations of the qualitative work indices are presented in table 1.

Table 1. Experimental results obtained

Quality indices	Working width, (cm)	Working depth, (cm)	Degree of grinding, (%)	Degree of incorporation of plant residues, (%)
Measured values without the vibration system activated	105; 93; 97; 101; 105; 96; 100; 102; 98; 100 **Average: 99.9**	24; 25; 26; 25; 26; 24; 25; 24; 26; 25 **Average: 25**	Mass of selected fractions: ->100 mm: 21.6 kg (7.55%) - 100...80 mm: 38.8 kg (13.53%) - 80...50 mm; 36 kg (11.51%) - 50...20 mm; 78 kg (27.2%) - < 20 mm: 115.3 kg (40.21%)	- Mass of plant residues before the plough passing: 455.8 g/m^2 - Mass of plant residues after the plough passing: 65,4 g/m^2 Degree of incorporation of plant residues: 85,6 %.
Measured values with the vibration system activated	103; 105; 100; 97; 98; 101; 102; 103; 102; 104 **Average: 101.5**	24; 25; 26; 25; 26; 24; 25; 24; 26; 25 **Average: 25**	Mass of selected fractions: - > 100 mm: 19.7 kg (6.76 %) - 100...80 mm: 42.5 kg (14.6%) - 80...50 mm; 38.7 kg (13.29%) - 50...20 mm; 79.4 kg (27.28%) - < 20 mm: 110.8 kg (38,07%)	- Mass of plant residues before the plough passing: 455,8 g/m^2 - Mass of plant residues after the plough passing: 62,5 g/m^2 - Degree of incorporation of plant residues: 86,28%.

The determination of the loads acting on the plough body and the tensile strength of the plough was performed by the tensometric method using tensometric marks and an acquisition system coupled to a computer with a package of specialized programs.

The results obtained from experiments under operating conditions are presented in Figures 2 and 3.

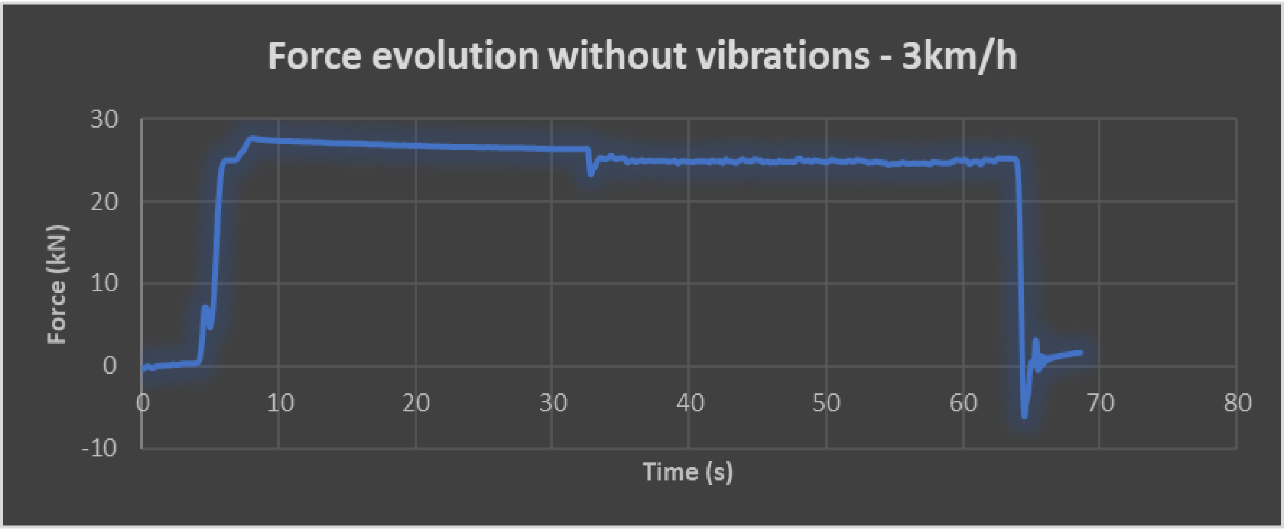

Fig.2. – Graphical representation of the evolution of Traction Force - without activating the vibration systems

The average value of the traction force in the plateau area was 25.5 kN

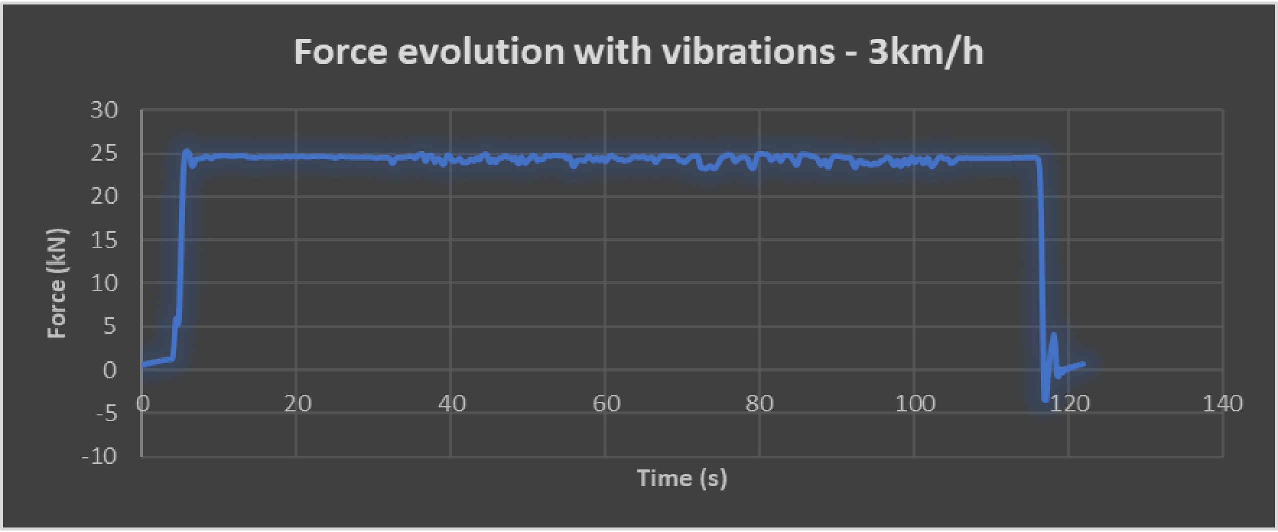

Fig.3. – Graphical representation of the evolution of Traction Force - with the vibration systems activated

The average value of the traction force in the plateau area was 24.3kN.

CONCLUSIONS

From the analysis of the graphs, a significant difference of the average traction forces can be observed. Thus, for the classic operating mode of the plough it can be seen that the value of the average traction force recorded in the plateau area is 25.5 kN, and for the operating mode with electro-vibrators mounted on each body of the plough, the value of the average traction force in the plateau area was 24.3 kN.

Following the analysis of the qualitative indices presented in Table 1, it was concluded that they were influenced by the state of high compactness of the experimental plot.

ACKNOWLEDGEMENT

This work was supported by the Romanian Research and Innovation Ministry, through the Project entitled “Researches on achieving integrated systems for the bioeconomy field according to the concept of intelligent agriculture” – PN 19 10 01 01 – Ctr. 5N/07.02.2019.

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