Load Characteristics of Three-Point Tractor Linkage

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Abstract: *The paper deals with the issue of load characteristics of the three-point tractor linkage for subsequent design of tractor hydraulic test method according to OECD code. The results of experimental measurements of forces and pressures in the three-point hydraulic linkage of tractor plow set allows design and implement simulation method of dynamic operating loads of three-point linkage system under laboratory conditions. In this area ware the theoretical and experimental works focused in ZTS tractors.*

Key words: *tractor, three-point linkage, plow*

INTRODUCTION

The requirement of current development trend of agricultural tractors are high versatility tractor and a wide range of additional devices. These devices allow wider use of tractor and facilitate its tenter due to technical progress and high level products. Meanwhile it was developed several types of regulatory systems of three-point tractor linkage based on mechanical-hydraulic, electro-hydraulic principle [7].

At the present time, hydrostatic systems are widely dispersed in the industry. It provides the various types of motions. The power transmission is realized by hydraulic fluid. Hydraulic fluid needs service and observation of operating parameters [3, 4]. In working conditions of agricultural tractors plays a crucial role operating temperature of common transmission-hydraulic oil fill [1, 4]. From utilization of hydraulic fluid in a machine point of view there is the most important to know the running properties of fluid i.e. to know the influence of fluid on technical state of parts in the hydraulic system [2, 5, 6].

MATERIALS AND METHODS

In the context of rising demand for new mobile energy resources, especially in terms of performance and operation productivity, together increasing the demands to life, operational reliability of functional and constructional groups. Other than the introduction of new construction components requires the possibility of testing the parameters during operation, which has its justification mainly in terms of operational reliability. It is understood that in this situation increase the requirement of measurement of technical parameters and properties of construction components and systems. Compliance with these requirements can not to ensure without the necessary measuring devices and measurement methodologies.

In the Slovak Republic in tests using the practices specified by STN standard, ISO, EHK code, ES directives and procedures stated in the OECD standards, for the official testing of agricultural tractors.

These tests can be divided into two groups:

- homologation tests aimed at verifying compliance with requirements of manufacture for safety work, hygiene, traffic safety and fire safety,
- declaration tests, which determine the technical parameters of tractor without any evaluation.

OECD codes are currently widely used in Europe, for reason to facilitate the import and export of tractors OECD countries, so we focus on test field which are determining by the OECD directives, especially Code II, part 2, aimed at testing of tractors hydraulic circuit. This test of agricultural tractor is based on Code II (restriction code). In this Code are these mandatory tests:

- the performance test of the main tractor shaft,
- the performance test of lifting hydraulic device of tractor, it's the same as the test in Code I,
- the test of thrust horsepower and fuel consumption on unloaded tractor and tractor in basis weight.

For analyzing of dynamic load of tractor pump in hydraulic circuit of three-point linkage during the random variable working condition, to obtain data from operational tests to simulate dynamic load of hydraulic pump. Measurements were performed with a tractor plow consisting of a tractor ZTS 164 45 a supported plow KHUN. For operational measurements was chosen following:

- carry out experiments with a plow set consisting of a tractor ZTS 164 45 with digital electro-hydraulic control (fy. Bosh) + supported plow by power, position and combination regulation.

The measurements are carried out in order to obtain the following experimental data:

- output pressure of hydraulic pump of three-point linkage p_G,
- operating revolutions of hydraulic pump of three-point linkage n_G,
- revolutions of combustion engine n_m,
- operational speed of device v_p,
- plowing depth h.

The measured length of distance for all measurements was 100 m and especially were marked a stretches with a length of 25 m, as well as to measure forces in three-point linkage in aggregation with plow.

Mechanical and physical condition of the soil was determined by penetrometer. The whole complex of measurements was made in one day. On selected stretches was loamy soil with maize stubble. For measurements were also collected soil samples. The soil samples for the determination of particle size were taken before the actual measurements, samples for determination of bulk density and soil during and after the test.

Physical and mechanical properties of samples were specified as follows: weight moisture 14.2 %, bulk density of dry soil 1.15 $g.cm^2$, bulk density of moisture soil 1.4 $g.cm^{-3}$, specific weight of soil particles 2.6 $g.cm^{-3}$ and porosity 38%. For measurements were used the following sensors:

- strain gauge TT 320, manufacturer ZPA Jinonice,
- pressure gauge with a flexible tube with a range of 0-40 MPa, manufacturer Chirana Stara Tura,
- photoelectric revolutions sensor FS-01, TF manufacturer KDM SPU Nitra.

Pressure p_G was measured at the output of hydraulic pump, revolutions of hydraulic pump n_G and revolutions of motor n_m were measured indirectly via the tractor output shaft. Operating speed of device v_p, we calculated from the length of the measuring section (100 m) and the measured time stopwatch.

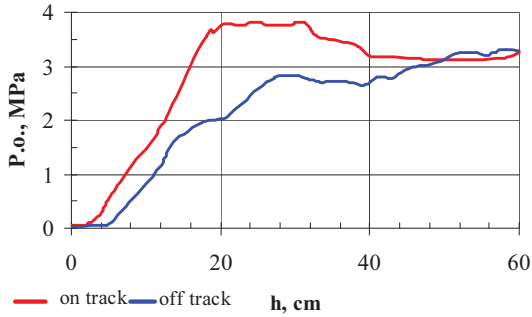
RESULTS

In terms of a fair comparison within the results obtained in the experimental measurements, we determined the characteristics of the test conditions, focusing on the physical-mechanical properties of the treated soil area – bulk density, moisture, penetrometric resistance and shear strength of the soil. The average values of these parameters during test are in Table 1.

Tab.1. Physical and mechanical soil properties of processed land

Device with tractor	Bulk density of soil $g.cm^{-3}$		Soil moisture %		Shear strength in depth kPa		
	wet	dry	bulk	weight	10 cm	20 cm	30 cm
ZTS 164 45	1.81	1.46	34.37	24.14	25.42	84.09	89.25

The selected record of penetrometric trace and outside of trace during the test with above device is in Figure 1. Table 2 shows the selected measured and calculated operating parameters of monitored plow device.



Obr.1. Penetrometric record during the measurements with the tractor ZTS 164 45 test with additional device

Tab.2. Operating parameters of sets with tractor ZTS 165 45

Indicator		Mark	Unit	KUHN and regulation position
Average depth of the plowing		h	cm	19.50
Average speed of set		v_p	$m.s^{-1}$ $km.h^{-1}$	2.06 7.423
Performance	flat	W_p	$m^2.s^{-1}$ $ha.h^{-1}$	1.487 0.535
	volumetric	W_o	$m^3.s^{-1}$ $m^3.h^{-1}$	0.2899 1043.6
	mas	W_G	$t.s^{-1}$ $t.h^{-1}$	0.5238 1885.7

Based on the measurement results of physic-mechanical properties of the soil can be said that it was a land with severe soil with a high content of clay and stone parts. Measured and calculated operating properties for the plow set ZTS 164 45 with plow KUHN are listed in Table 2. Aggregation with supported semitrailer plow KUHN, pressures in the hydraulic cylinder during plowing reaches values from 3 to 8 MPa and carrying plow at the hedland from 1.5 to 18 MPa. Very unfavorable shows a values of the pressure on output of hydraulic pump, which during plowing oscillate form 1.5 to 9 MPa and with carrying plow at the headland from 1.5 to 18 MPa.

From the measurements and the evaluation shows that the set showed relatively high fuel consumption. High fuel consumption per hectare is justifiable with high soil moisture processed land (average specific humidity 'soil was 34.37 %) and the high density of the soil (average bulk density of wet soil was 1.807 g.cm-3). At high soil moisture values of operating space and operating depth of plowing there was a drive slip δ = 19.7 %.

In Figure 5 are measured time courses of pressure on output of hydraulic pump and in hydraulic cylinder of three-point linkage during plowing with tractor ZTS 164 45, turning plow kit headland and subsequent plowing with Kuhn plow with position regulation, Figure 2 with combined regulation, and Figure 3 with the force regulation.

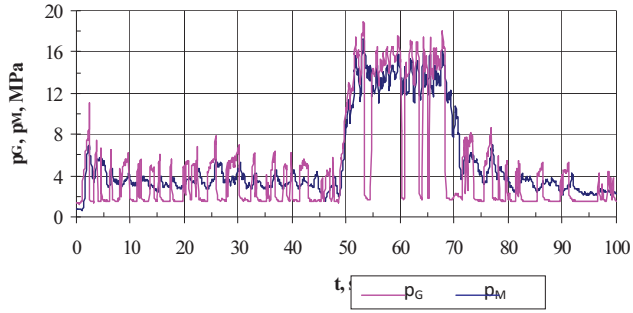


Figure 2 Time courses of pressure on output of hydraulic pump and hydraulic cylinder during plowing, turning at the headland and subsequent plowing with KUHN plow – position regulation.

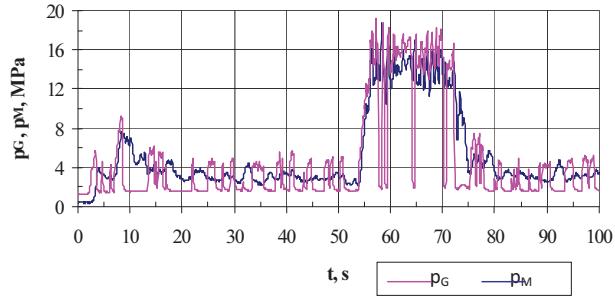
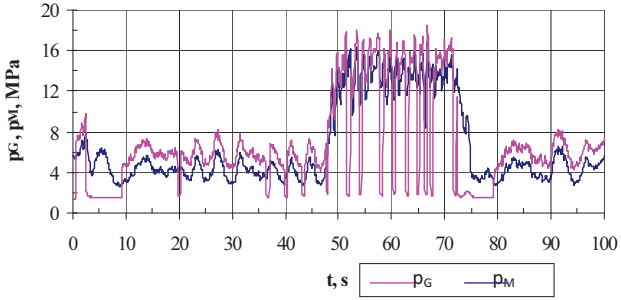


Figure 3 Time courses of pressure on output of hydraulic pump and hydraulic cylinder during plowing, turning at the headland and subsequent plowing with KUHN plow – combined regulation.



Obr. 4 Time courses of pressure on output of hydraulic pump and hydraulic cylinder during plowing, turning at the headland and subsequent plowing with KUHN plow – force regulation.

During the pressure measurements on hydraulic pump output and hydraulic cylinder of three-point linkage of tractor ZTS 164 45 results that, the hydraulic system of three-point linkage with electro-hydraulic regulation showed relatively low leakage resistance. That confirms the pressures on output of hydraulic pump during position

regulation. About 50th seconds during plowing with supported KUHN plow, the hydraulic pump fill up the hydraulic circuit 22 times.

CONCLUSION

In connection with the increasing demands for new mobile energy resources in terms of work productivity, performance and improving their functions by introduction of new design solution using electronics further increasing demand for their operating life, reliability and dynamic properties.

The measured pressure cycles show good functionality and quality of hydraulic system and regulatory system. From the results of time course of pressures its stands to reason, that for some measurements the regulatory system was vibrant. For this unstable state most affected by, among other things the revolutions of hydraulic pump wherefore, we recommend measure the regulatory system in the whole range of operating revolutions to determine the regulatory system stability.

ACKNOWLEDGEMENT

Supported by the Ministry of Education of the Slovak Republic, Project VEGA 1/0857/12 “Reduction of unfavorable impacts of agricultural and transport machinery on environment”.

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