TENSILE RESISTANCE OF THE COMBINE HARVESTER WITH TRACKED CONCEPT OF CHASSIS

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For measuring was used the combine harvester John Deere S685i with track units. For reading of tension force there was used specially developed measurement tool - a pull dynamometer. It is constructed as a towing drawbar which was connected between rear hitch of combine harvester and three-point hitch of pulling tractor. It means that measuring set moved in reverse mode. Measuring was running on the same path as in case of wheeled combine harvester: asphalt surface, maximum slope 0.2°, length of path 120 meters. Speed of towing simulated usual working speed during harvest. There were measured three variants of speed it were 4, 6 and 8 km.h-1 and each variant was repeated three times. After collecting of data for each speed variant consequently there were calculated different tensile resistance which we can observe. Tensile resistance correspond with load of drivetrain, load of engine and it directly affects fuel consumption.

KEYWORDS

combine harvester, tensile resistance, tracks, travel gear

1 INTRODUCTION

For agricultural machinery are put more and more demands on performance [McPhee 2015]. Raper [Raper 2005] reported that efficient mechanization in agriculture is a major factor underlying high productivity. Larger machinery is often related with timeliness, higher work rates, and lower labour requirements. The drawback of it is that larger machinery usually means increased machinery weight which increases the danger of soil compaction. Soil compaction affects the physical, chemical, and biological properties of soils and is one of the main causes of agricultural soil degradation [Hakansson 1988].

Manufacturers of agricultural machines are trying to solve this problem by using wide low-pressure tires with low pressure on the ground. Or second way is installing the track units with belts on the machines.

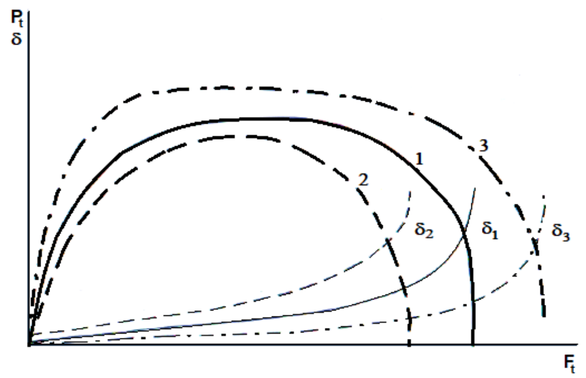

Figure 1. Influence of ground to potential characteristic: 1 – stubble; 2 – soil; 3 – asphalt surface; δ – wheelspin; Pp – potential pulling power; Pt – pulling power; Ft – tensile force [Bauer 2006 – remade Benes].

The rubber tracks has an effects on tractive force, rolling resistance, torque, tractive coefficient, and tractive efficiency under different soft terrains [Fan 1997]. Changes in these parameters can be easily observed in the change of tensile force. When characteristic of tensile force is influenced by ground. Bauer [Bauer 2006] discloses the characteristics of tensile for the various ground surface in Fig. 1. The tracks are also reflected in the change of tensile force at different speeds. Tracks assembly and weight balance shows Fig. 2.

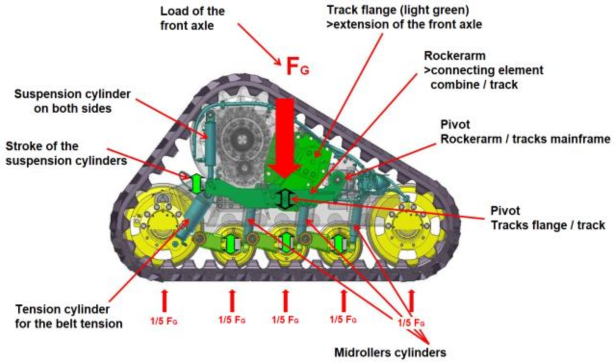

Figure 2. Track assembly and weight balance [Deere 2017]

Current knowledge of draught force could be a useful tool in many ways. The results can be used in routine practice to compare the energy performance of travel gear of self-propelled machines, verification of technical changes on machines and verification of agronomical measures [Kroulik 2013].

For comparison is impotant to know that hydraulic components in hydrostatic system of travel gear at both machines are the same. Measuring of performance parameters at hydraulic systems (pressure, flow, etc.) is very benefitable for their compare and it shows energic consumption of both type of chassis. Theoretical losses of hydraulic system was published in the past. Total power which is lost in hydrostatic system of combine harvester travel gear is 16.95 kW [Benes 2015]. It means that at constant flow (constant speed) pressure changes depending on the load. Load is given many paramenters and one of them is tensile resistence which will be discussed below.

2 MATERIALS AND METHODS

Field measurements took place in Nové Strašecí in Central Bohemia. In affiliated workshop of agricultural company Skolni statek Lany, CZU. The measurements were taken in 5th of March 2016. Combine harvester was dragged on the asphalt surface. During the measurement surface was wet and the ambient temperature around 4 °C. The measured path was 120 meters long with an average incline of 0.1 degrees.

To measure of the tensile draught force was used the combine harvester John Deere S685i without header. The weight of the machine was 16400kg and type of tires and their pressures are in Tab. 1. Combine harvester ravel gear was decommissioned by using disconnecting axle shafts due to mechanical resistance of gearbox and differential.

	Front tracks	Rear tires
Maker	Camso	Goodyear
Dimensions	700 mm width	620/75 R26
Pressure	-	0.3 MPa

Table 1. Pameters of tracks and tires

Figure 3. Measuring set. From left: pulling tractor John Deere 7930, measuring instrument, pulled combine harvester John Deere S685i without header

For actual measurement was used measuring instrument of draught force developed in collaboration of Czech University of Life Sciences and BEDNAR FMT ltd. As a pulling tractor means served John Deere 7930. Combine harvester was dragged back in order to facilitate connect the measuring equipment (Fig. 3).

Basic part of measurement apparatus was strain gauge load cell S-38 with measuring range up to 200 kN. The load cell was necessary to place into a steel cage so that the forces were applied only in tension or compression. Bending of the load cell may cause its destruction. The load cell was calibrated on a stationary workplace. Calibration was carried out on tensile testing machine ZDM 50t. The data from load cell were sensed every 2 s into the laptop which was situated in the cabin of the tractor. Measuring equipment was complemented by hinges for mounting between a pair of machines (Fig. 4).

Figure 4. Measuring equipment between combine harvester and tractor

The measurements were made for alternative speeds 4, 6 and 8 km.h^{-1}. These speeds simulates normal range of operating speeds, which combine harvester moves on the land at work. For each speed were always carried two repeats.

3 RESULTS AND DISCUSSION

Calibration results and calibration curve can be seen in Fig. 5. Linear dependence of measuring apparatus output frequency on tensile force was proved. Resulting linear dependence was used as calibration equation for draught force calculation [Novak 2014].

The graph in Fig. 6 shows that the tensile force values for the individual travel speed have similar values. When measuring at higher speeds (6 and 8 km.h-1) is a problem of high variance of values. This is due to impacts due to the inertia during the measurement. Sensor these values recorded and these are after processing, appear as outliers and extremes.

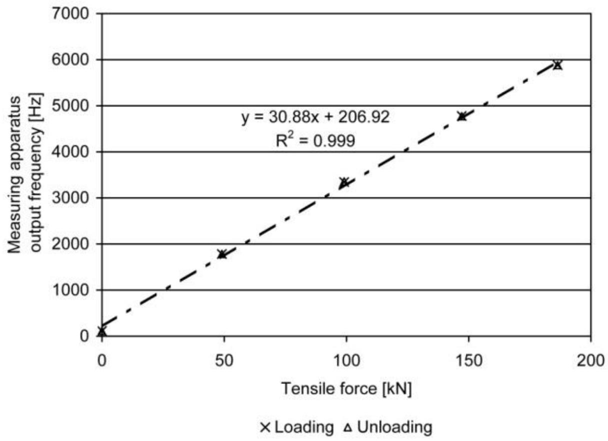

Figure 5. Dependence of measuring apparatus output frequency on tensile force. Load cell calibration curve.

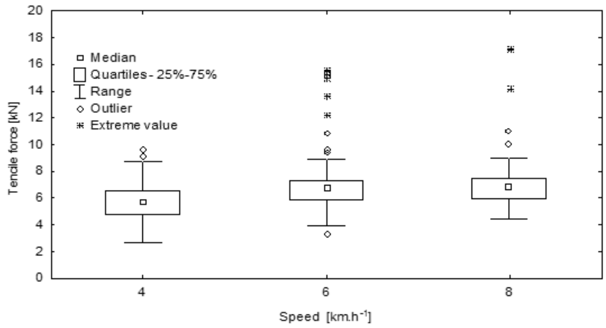

Figure 6. Dependence of tensile force on pulling speed

This fact affects subsequent statistical evaluation with using of Fisher LSD test. Results of Fisher LSD test are given in Tab. 2. Fisher's test confirms the assumption that among the values of the tensile resistance are not statistically significant differences. Nevertheless in the average values of tensile resistance is visible trend of gradual increase in tensile resistance.

LSD test: Tensile force [kN] alfa=0.05000		
Speed [km.h^{-1}]	Tensile force [kN] Average	1
4	5.82	****
6	6.57	****
8	6.56	****

Table 2. Results of Fisher LSD test

4 CONCLUSIONS

Performing of tensile test of the combine harvester has been found that at operating speeds 4, 6 and 8 km.h^{-1} was not found significant difference in tensile resistance. The average value of tensile resistance at operating speed 4 km.h^{-1} was 5.82 kN. At speeds 6 and 8 km.h^{-1} were the average values of tensile resistance higher and almost the same (6.57 and 6.56 kN).

Higher tensile resistance needs higher torque of hydromotor. It means that increase pressure in high-pressure circuit of hydrostatic system of combine harvester travel gear. It is reason for higher energetic consumption of hydrostatic system and consequently higher fuel consumption.

In comparison with measuring of combine harvester with wheeled chassis these values are higher. But comparison of two different concept of combine harvester will be published in next article where will be stated exact values and reason of difference.

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