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Calibration of Wheeled Tractor for Energetical Parameters

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ABSTRACT

Experiments were carried out in the laboratory condition to prepare the tractor in order to obtain the accurate energetical paremeters such as axle torque and revolution of the drive wheels. The tractor was equipped with a tenjometrical system and calibration was done to eliminate the possible errors of the system. Experimental results showed that the system was properly set up and adjusted to measure the desired parameters.

INTRODUCTION

Accurate calibration of tillage machinery and equipments is essential because only slight change in the regime of work causes loss of energy and produces improper soil tilth resulting in poor yield of crops. therefore, it is required to adjust the regime of work such as tillage depth, speed of work at which the fuel consumption, energy requirement and work rate will be optimum but quality soil tilth will be produced. Work below the optimum regime may be ineffective and produce an undesirable or insignificant soil tilth but only wastes valuable time and the cost of tillage operation. Works above the optimum may produce an undesirable response and result in economic penalties through excessive fuel consumption, energy requirement, shear waste of the material being engaged (1). Therefore, tractor and tillage machinery should be calibrated and procedures be established such that, when followed, will result in better performance at desired pre-determined regiime of work and adjustments.

The above discussions helped to determine the aims and objectives of the present research work (2), some of which may be stated as follows :

1. To find out the procedures of setting and readjusting the strain gauge transducer to each semi-axle of the four drive wheels;
2. To find out the effective ways of eliminating the errors in recording the input signals of torque and revolution of the four drive wheels by applying known static loads.

MATERIALS AND METHODS

To obtain the above mentioned aims and objectives a small farm tractor TZ-4K-14 of 10 kW nominal

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rating, made in USSR, was equipped with a 12 channel oscilloscope K-12-22, amplifier TOPAZ-3, strain gauge transducer PKB-T-20-200 and battery 6STM-50 (12V each). The oscilloscooe consisted of 8 galvanometers NU-84: I,II.IIIa, IV, V,VI and VIII with sensitivity 0.21, 0.57,2.37,9.5,33.2, 285, 575 and 1045 mm/mA. The oscilloscope was assigned to record signals of wheel-axle torque and revolution as obtained from the strain gauge transducers through amplifier with a speed of 16mm/s. The oscilloscope was capable to work at a temperature of -60°C to 50°C. To each semi-axle of the drive wheels strain gauge transducer was set up (Fig. 1).

The entire system was calibrated for the input signals of torque and revolution of the drive wheels with the help of a metallic arm1m long, dynamometer DOSM 3-1 and a hydraulic jack by applying known static loads.

The procedure of calibration was accomplished by fitting one end of the arm to the semi-axle and the other end rested on the dynamometer supported by the jack (Fig.2). At the time of calibration the wheels were locked and brakes were applied. Alternately loads were applied to and removed from the supported end of the arm for each wheel separately and the movement of the rays/signals were observed on the osciloscope. On the placement of loads to each semi-axle of the drive wheels the rays were displaced either to the right or to the left and returned back to the original position after removal of the loads. This procedure was follo-wed for the four drive wheels. If the entire system be properly equipped and adjusted the rays must return back to the original postition and supposed that the oscilloscope gives correct result. But if the rays failed to follow the rules this means that there remains fault or error in setting and adjusting the entire system or part of it. Therefore, the entire system was again checked and readjusted until the oscilloscope given the correct result. This is what was said to be the calibration of the tractor and tenjometrical system to obtain accurate result. There were 8 rays/signals for 8 parameters : 4 for torque and another 4 for revolution of the four drive wheels. The deflection of the 8 signals were measured on both the sides of their original position. For accurate results the repitations of loading and unloading were made twice.

During calibration of the tenjometrical system as the signals for wheel revolution returned back to their criginal position during the prjocess of loading and unloading, therfore, only the deflection of signals for wheel torque on either side (3) were determined by the following formula :

$$S_{av} = \frac{(S + S')}{n} \qquad (1)$$

where S_{av} = average deflection of signal, mm
S = deflection of signal after loading, mm
S' = deflection of signal after unloading, mm
n = times of loading and unloading.

Difference between the maximum and average deflection were estimated by the expression (3) as follows :

$$d = S_{max} - S_{av} \qquad (2)$$

where d = difference between the deflections, mm
S_{max} = maximum deflection, mm

In the process of loading and unloading the relative errors (4.5) were determined by the following expression :

$$e_r = \frac{d}{S_{av}} \qquad (3)$$

where e_r = relative error, %

The average value of errors during the process of calibration of the tenjometrical system (4,5) were determined by the relation as follows:

$$e_{av} = \frac{e_r}{n} \qquad (4)$$

Where e_{av} = average value of errors, %
The sequence of testing of the drive wheels of tractor TZ-4K-14 is shown in Fig. 3.

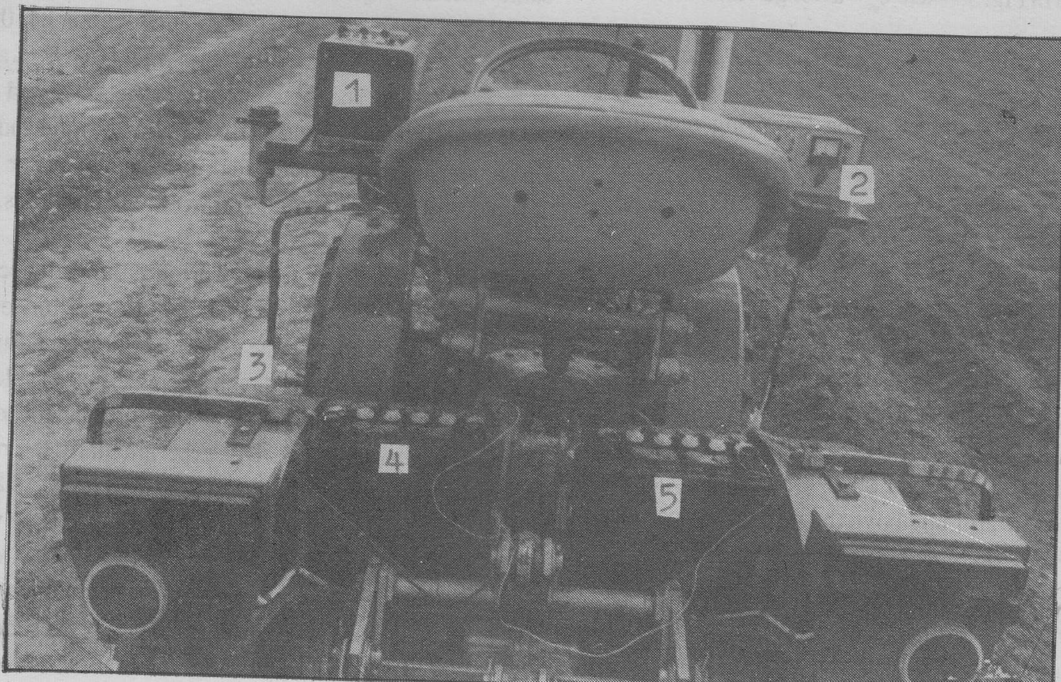

Fig. 1. Rear view of the instrumented tractor TZ-4K-14: oscilloscope (1), amplifier (2), strain guage transducer (3), battery (4,5).

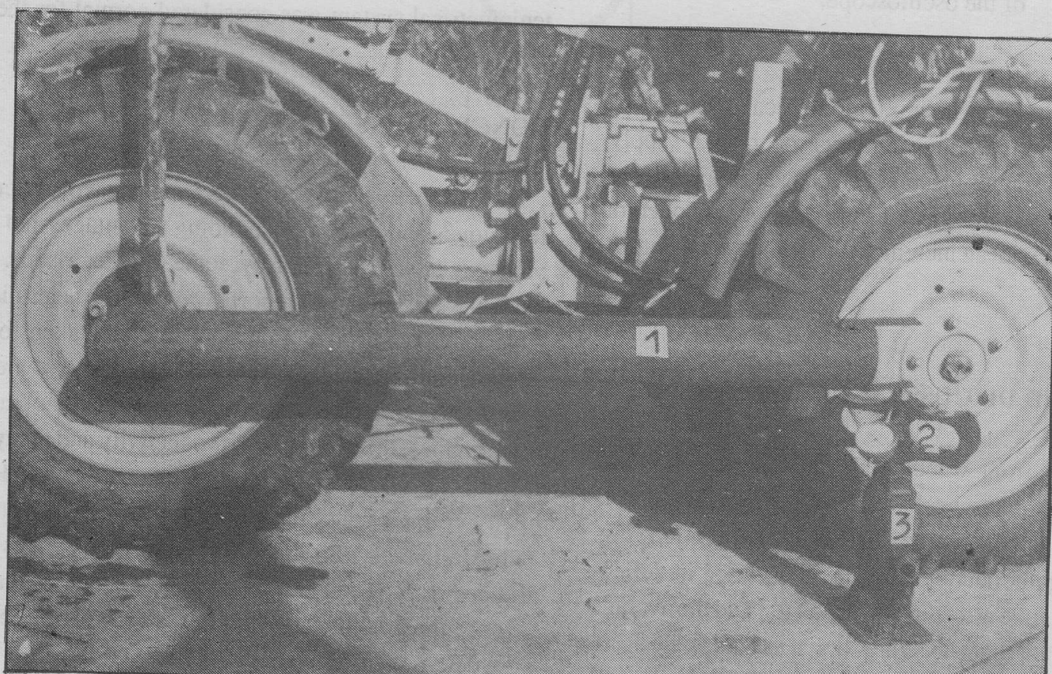

Fig. 2. Calibration process for the semi-axle of tractor TZ-4K-14: metallic arm (1), dynamometer (2), hydraulic jack (3).

Where e_{av} = average value of errors, %

The sequence of testing of the drive wheels of tractor TZ-4K-14 is shown in Fig. 3.Where e_{av} = average value of errors, %

The sequence of testing of the drive wheels of tractor TZ-4K-14 is shown in Fig. 3. For eliminating errors in the recording system of parameters the following measures were taken :

1. Government proved electronic apparatus whre used;
2. During experiment the effect of environment such as change in temperature were considered;
3. All the measuring apparatus and instruments were calibrated and readjusted before the tenjometrical system were set up;
4. The tractor engine and other measuring apparatus were allowed to warm up above the normal temperature after which balancing of amplifier and oscilloscope were conducted ;
5. Voltage of the power supply unit (battery)was kept stable during therecording of the desired parameters;
6. Adopted powerful transducer and cables;
7. Measures were taken against distortion which amy cause vibration of the oscilloscope.

When the whole tenjometrical system was found properly adjusted the circuit was operated by applying switch and 8 signals instantaneously were appearedc on the miror of the oscilloscope. Then loads were applied on the metallic arm with an increment of 10 kN, a total upto 70 kN.

RESULTS AND DISCUSSIONS

The left front wheel, right front wheel, left rear wheel and right rear wheel wre marked by A,B,C and D respectively to avoid complexities during calibration (Fig. 3). The average deflection (S_{av}), the difference in deflection (d), the relative errors in deflection (e_r) and the average value of errors for the wheels are shown in Tables 1,2,3 and 4. It was found from the calibration chart (Tables 1,2,3 and 4) of the wheels that for the same amount of load the deflection of signals were not the same i.e. for wheels A and C deflections were 6.5 mm and 6.25 mm for loading and unloading respectively. but for the wheels B and D the deflections were 5 mm and 5.5 mm respectively for the same amount of load. Similarly, defferences were also found in the average errors of the deflections i.e. 0.91%, 1.9%, 0.77% and 1.90% for the wheels A,B,C and D respectively (2). The differences in deflections and errors were appeared perhaps due to the nature of fitting and setup of the measuring apparatus and instruments or due to the influence of environmental and working conditions.

Specified average error of the oscilloscope in the registration of wheel torque was within the limit of + 1% to 1.5%. But the values of the experimentally found average error were little bit higher than the specified (Table 1,2,3 and 4). Similarly, the limit of relative error for the tenjometrical system was 2.5 %. But experimentally the relative errors were found in the range of 0.56% to 1.96%, 0.80% to 4.76%, 0.28% to 1.96% and 0.78% to 4.76% for the wheels A,B,C and D respectively (2). It was obsedrved from the experimental investigation that the maximum limit of relative errors for the wheels B and D exceeded the specification during the process of calibration. Three times repitation were made to keep these values of the error within the specification but failed. So, with this condition the tenjometrical system was considered normal for the field experiment.

CONCLUSIONS

Evaluation of the effectiveness of agricultural techniques and their corresponding advantages and disadvantages are represented by some characteristics. Exact characteristics are very important and can be determiend by experiments after which decision may be taken for their adoptation in field conditions. Accurate result of measurements affect the accuracy of estimation, quality of machine performance, their reliability, productivity and many other factors. Therefore, accuracy of characteristics depends upon two inter-connecting indices; error in measurement and its reliability. By the law of occurances errors can be grouped in two categories such as systematic and random. Error of the present study fall in the second category and were determined statistically.

There were possibilities to occur errors in each step of calibration of tractor. but the author has been

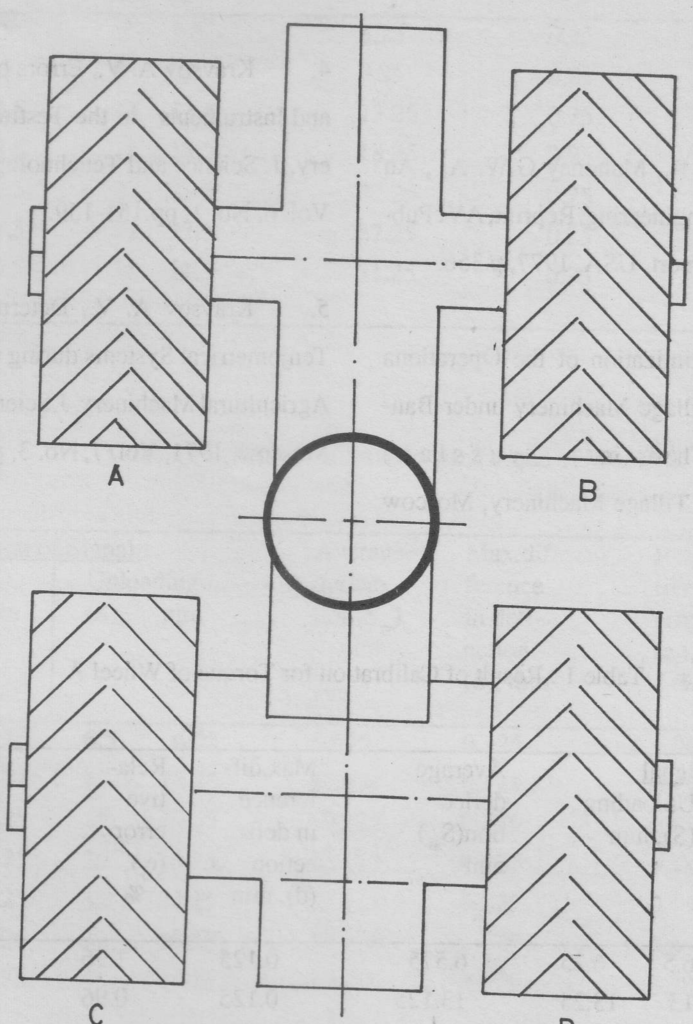

Fig. 3: Schematic of calibration for four drive wheels of tractor TZ-4K-14: left front wheel (A), right front wheel (B), left rear wheel (C) and right rear wheel (D).

tried his best to eliminate these during the calibration of the entire system. it was found from the study that the magnitude of errors in the calibration process did not exceed seriously the specified values. Hence it can be said that the calibration procedure was correct and the tenjometrical setup could be used for the determination of the energetical parameters of the tractor TZ-4K-14 during field operation.

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Table 1 : Result of Calibration for Torque of Wheel A

Loads kN	Deflection of Signal				Average deflection(S_{av}) mm	Max.difference in deflection (d), mm	Relative error (e_r), %	Average error (e_{av}), %
	Loading (S),mm		Unloading (S), mm					
0.10	6.5	6.25	6.5	6.25	6.575	0.125	1.96	
0.20	13	13.25	13	13.25	13.125	0.125	0.96	
0.30	18	18.50	18	18.50	18.25	0.25	1.36	0.91
0.40	26	26.25	26	26.25	26.125	0.125	0.48	
0.50	31.5	31.25	31.5	31.25	31.125	0.125	0.40	
0.60	38.5	38	38.5	38	38.25	0.25	0.65	
0.70	44.5	45	44.5	45	44.75	0.75	0.56	

Table 2 : Result of Calibration forTorque of Wheel B

Loads kN	Deflection of Signal Loading (S), mm		Unloading (S), mm		Average deflection(S_{av}) mm	Max.difference in deflection (d), mm	Relative error (e_r), %	Average error (e_{av}), %
0.10	5	5.5	5	5.5	5.25	0.25	4.76	
0.20	9	9.5	9	9.5	9.25	0.25	2.70	
0.30	13	13.5	13	13.5	13.25	0.25	1.87	
0.40	18	18.5	18	18.5	18.25	0.25	1.37	1.93
0.50	22	22.5	22	22.5	22.25	0.25	1.12	
0.60	27	27.5	27	27.5	27.25	0.25	0.92	
0.70	31	31.5	31	31.5	31.25	0.25	0.80	

Table 3 : Result of Calibration for Torque of Wheel C

Loads kN	Deflection of Signal Loading (S), mm		Unloading (S), mm		Average deflection(S_{av}) mm	Max.difference in deflection (d), mm	Relative error (e_r), %	Average error (e_{av}), %
0.10	6.5	6.25	6.5	6.25	6.575	0.125	1.96	
0.20	12.5	12.75	12.5	12.75	12.624	0.125	0.99	
0.30	19	19.25	19	19.25	19.125	0.125	0.65	0.77
0.40	26	26.25	26	26.25	26.125	0.125	0.48	
0.50	32	32.25	32	32.25	32.125	0.125	0.59	
0.60	39	39.25	39	39.25	39.125	0.125	0.64	
0.70	45	45.75	45	44.75	44.875	0.125	0.28	

Table 4 : Result of Calibration for Torque of Wheel D

Loads kN	Deflection of Signal Loading (S), mm		Unloading (S), mm		Average deflection (S_{av}) mm	Max. difference in deflection (d), mm	Relative error (e_r), %	Average error (e_{av}), %
0.10	5	5.5	5	5.5	5.25	0.25	4.76	
0.20	9	9.5	9	9.5	9.25	0.25	2.70	
0.30	13	13.5	13	13.5	13.125	0.125	0.95	
0.40	17	17.75	17	17.75	17.375	0.375	0.16	1.90
0.50	22	22.25	22	22.25	22.125	0.125	0.56	
0.60	27	27.75	27	27.75	27.325	0.325	1.37	
0.70	32	32.5	32	32.5	32.25	0.25	0.78	