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Effect of Ballasting and Changing of Angles Disk Offset on Performance of Tractors

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Abstract: The important indicators in the energy consumption for tillage tractor's overall energy efficiency. For accurate measurement and same time these factors and other factors affecting it, Initially MF 399 is equipped to types sensors and the data collection units so that the parameters such as fuel consumption rate, Slip rear wheels and energy efficiency of the tractor during operation of discs. The using a factorial experiment that factors include: Field conditions (tilled T and not tilled NT), Ballasting (ballasting and UN ballasting) and the angles of disk offset (41 and 46) in the factorial experiment with three replications were conducted. After the data analysis was performed using Duncan's multiple range tests. According to the results obtained the highest overall energy efficiency 16.52% for non- plowing land with the ballasting and the lowest 12.92% the overall energy efficiency of a plowed field without the ballasting. The maximum and minimum slip rear wheel was 27.96% and 6.19%.

Keywords: Overall energy efficiency, Fuel consumption, Tractor MF399, Tillage, Ballasting, Offset disc.

1. Introduction

Nowadays manufacturing and Supply of food for a growing world population has increased use of power and energy, Therefore an important part of managing energy efficiency in agricultural production on how to use the power of the tractors. Use of fossil fuels in the production of crops high proportion of total energy input is allocated to and agricultural tractors as the main machine provides 35 to 50 percent of power the farm, so correct choice of machine management and motion in the direction of precision agriculture will be reduced inputs consumption, energy and costs. Of other hand, the continuous rise in fuel prices, energy consumption has become one of the most important matters in agricultural economy.

Using one differential and ballasting drive shafts of MF 399 tractor reduces drive shafts slip from 59% to 34.6% and fuel consumption from 31.5% to 27.4% [1]. Coordination of tractor and farming tools to optimize the operation is affected by the user's accuracy and decision making for using the equipment at his disposal. Including rev, gear, appropriate speed and the proper use of abilities such as lock, differential, 2 or 4 drive shafts, ballasts and speed handle. For example reducing one degree of gear with GUDT (gear up throttle down) can reduce up to 20% of fuel consumption [2].

Among the most important parameters that introduces the final status performance tractor- implements can be noted 3 parameters, the overall energy efficiency (OEE), traction efficiency (TE), and specific fuel consumption efficiency (SFC), So that kolator et al [3] have named parameters as Performance indicator, Among them OEE factors as the main indicator and of amount it as used to the very strong due to assess the performance of tractor.

Bower [4] the total energy efficiency in a variety of soils with some type of tillage machines and has done for several

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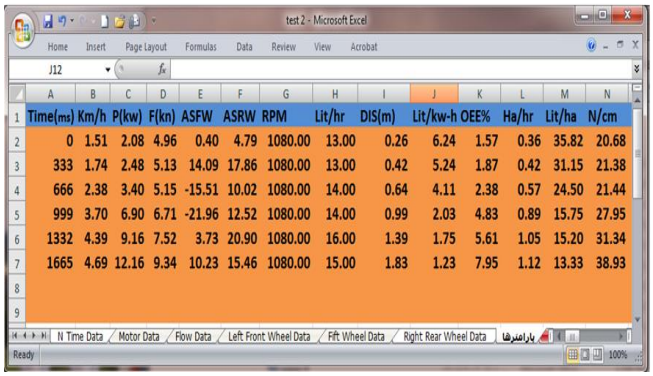
years, has stated, The normal range is of total energy efficiency10-20% and total energy efficiency is indicator that can quickly on the fuel consumption and the overall performance of the Tractor commented. Amounts of OEE for tillage with the disk offset between 15.4 to 18 percent fluctuate and Special traction resistance is variable of 4.5 to 5.3 KN per meter width stretching work. Kheirolla et al [5] showed in a study on the measurement indicators such as OEE and TE, The total energy efficiency and traction efficiency to offset disk intact at different depths in the order of 9 to 17% and 48 to 67 percent.

Serrano et al [6] investigated the effects of two factors ballasting and tire pressure announced, High traction efficiency occurred in the range of slip that for MFWD and 4WD tractors is about 10% and for 2WD tractors and chain wheel 13-15% and 6% respectively and these levels can be achieved with the appropriate ballasting. Also announced that the appropriate index for ballasting the tractors 120 to 145 pounds per horsepower tractor weight (54 to 65 kg) for 2WD tractors and for 4WD and MFWD tractors, 85-125 pounds per horsepower (28-51 kg). Sirelkatim et al [7] affect four levels of fluid ballasting, zero, 25, 50 and 75 percent on field performance was evaluated on a 2WD tractor. They showed that high levels of 50% of ballasting significant effect on improving the performance of agricultural tractors. So that ballasting acts, the slip amounted to decreased 26.7% and Qaisrani et al [8] reported, correct ballasting reduced the slip, fuel consumption, wheels abrasion and operating costs. So that the appropriate application of ballasting saves 33-26% of the fuel.

2. Materials and methods

The research in 2015 in the fields of agriculture and natural resources research, Ramin Khuzestan that has a loamy clay soil with bulk density of 1.43 grams per cubic centimeter, in fallow and was conducted at 26 to 33 ° C. This research using MF399 tractor equipped with RTPM system and according the algorithm (1) all necessary parameters to calculate OEE data recorded with a frequency of three. Finally, data's of each plot saved in Excel according to Figure (2) and data's analysis and graph drawing were performed with software SAS9.2 and Excel 2010.

This research is based on 2 major effective factors on fuel consumption management, including ballasting with liquids (ballasting and un ballasting) and the angles of disk offset (41° and 46°) in factorial experiment in form randomized complete block design with 3 replications was conducted in two environments, the effects of these factors be determined on fuel consumption



Time(ms)	Km/h	P(kw)	F(kn)	ASFW	ASRW	RPM	Lit/hr	DIS(m)	Lit/kw-h	OEE%	Ha/hr	Lit/ha	N/cm
0	1.51	2.08	4.96	0.40	4.79	1080.00	13.00	0.26	6.24	1.57	0.36	35.82	20.68
333	1.74	2.48	5.13	14.09	17.86	1080.00	13.00	0.42	5.24	1.87	0.42	31.15	21.38
666	2.38	3.40	5.15	-15.51	10.02	1080.00	14.00	0.64	4.11	2.38	0.57	24.50	21.44
999	3.70	6.90	6.71	-21.96	12.52	1080.00	14.00	0.99	2.03	4.83	0.89	15.75	27.95
1332	4.39	9.16	7.52	3.73	20.90	1080.00	16.00	1.39	1.75	5.61	1.05	15.20	31.34
1665	4.69	12.16	9.34	10.23	15.46	1080.00	15.00	1.83	1.23	7.95	1.12	13.33	38.93

Figure 2. An example of the data recorded and stored by the system RTPM

Accordance with review resources the main factors affecting the overall energy efficiency is acts ballasting's. So, in table 1, the weight of the ballasting of tractors operation is shown.

Table 1. The weight of the ballasting of tractor

	Rear axle weight (kg)	Front Axle Weight (kg)	total weight of tractor (kg)
Ballasting	3040	1300	4340
Un Ballasting	2470	980	3450
Added weight	570	320	890

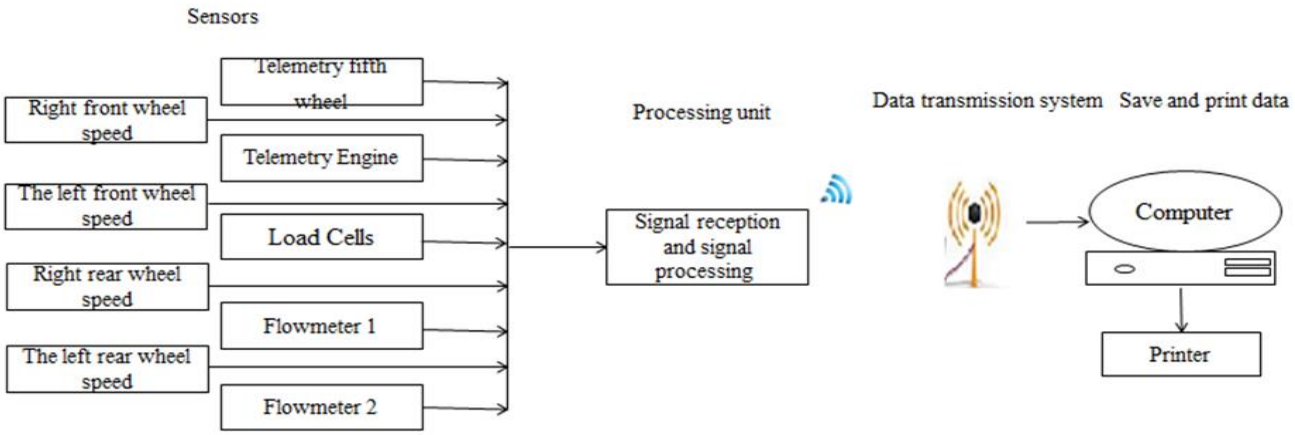


Figure 1: Figure 1. The block diagram of the system for collecting and presenting data to the remote

The main parameter in the study was overall energy efficiency (OEE) of tractors - tillage, which is calculated according to equation (1). Under the influence of three variables, the traction resistance force, the actual Forward velocity and real-time fuel consumption. Given that, system of data collection, these 3 factors instantaneously and the same time with operations measure and record and store. With the inclusion in relation (1), overall energy efficiency criterion at the same time measured, recorded and saved.

$$OEE = \frac{V_a D_r}{10.2 \times FC} \times 3.6 \qquad (1)$$

That, Va actual forward velocity in km/hr, Dr traction in KN, FC fuel consumption in Lit/hr, OEE overall energy efficiency in %.

Average tractor's wheels slip

Wheels slip (+% S or -% S) of each of the wheels relative to the actual forward speed Va (km/h) measured by the system RTPM and a pair of rear wheels slip average was calculated and recorded at the same time.

$$\%S = 100\left[1 - \frac{V_a}{V_t}\right] \qquad (2)$$

$$ASRW = \frac{SRRW\ \% + SLRW\ \%}{2} \qquad (3)$$

That, ASRW:

Specific fuel consumption (SFC)

Specific fuel efficiency index is based on Li/Kw.hr is calculated by the following equation.

$$SFC = \frac{FC}{P_{db}} \qquad (4)$$

Traction efficiency (TE)

One of the major indicators the tractive performance that determines what percentage of imported power to the wheels has become to a useful traction power. TE influenced by various factors such as weight or axle, wheel and tire characteristics, surface and... .

$$\begin{cases} TE = \frac{P_{db}}{P_{ax}} \\ P_{db} = V_a \times F_{db} \\ S = 1 - \frac{V_a}{V_t} \rightarrow TE = \frac{F_{db}}{F_{db}+F_R}(1-S) \\ P_{ax} = V_t \times F_R \\ F = F_{db} + F_R \end{cases} \qquad (5)$$

In the above equation, TE, tractive efficiency in %, P_{db} power drawbar traction, Fdb pure traction resistance or power drawbar force in KN and F the gross force resistance, F_R rolling resistance force in (KN) and s slip in (%).

3. Results and Discussion

According to the analysis of variance in functional parameters MF399 tractor tillage with a disc harrow can be seen, Factors that plowed field and plowing and disk angular offset on the total energy efficiency, front and rear wheels slip and tractive efficiency was significant in 1%. While operating ballast on all parameters except the tractive efficiency was significant in 1%. According to the analysis of variance, ballast and disk angles on the front wheels slip was significant in 1%.

Table 2: Analysis of variance in functional parameters MF399 tractor tillage with a disc harrow

	df	ASFW	ASRW	OEE	TE%
block	2	0.11	1.90	3.95	0.41
P	1	480.70**	514.2**	32.80**	561.94**
B	1	627.40**	19.89**	9.62**	0.07ns
A	1	789.91**	120.82**	28.52**	37.33**
P*B	1	19.60ns	0.67ns	0.52ns	0.22ns
P*A	1	1.23ns	0.1ns	0.008ns	0.13ns
B*A	1	98.37**	0.42ns	0.66ns	0.85ns
P*B*A	1	0.77ns	0.004ns	0.05ns	0.002ns
Error	23	2.91	0.72	0.52	0.44
CV		11.33	5.28	4.95	7.8

P: tilled and no- tilled field, A: angle and B: ballast

So that according to Figure (1) can be seen maximum 27.96% and minimum 6.19% of the front wheels slip, Respectively related to non- ballast and angle of 46 ° and ballast and angle of 41 °. The ballast is to show that the front wheels slip decreases the rate is 77% that corresponded to by results loghavi and Molasadghy [9].

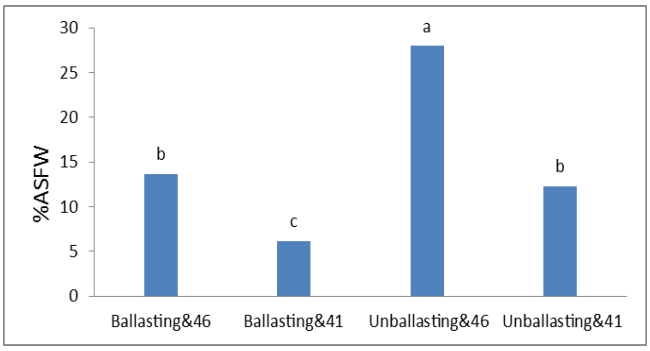


Figure 3: Interaction the ballasting and angle of disk harrow on average slip of the front wheels.

According to Figure (2) can be seen that the ballast acts is to increase overall energy efficiency in both the plowed field and not plowing, that the highest overall energy efficiency 16.52% for non- plowing land with the ballasting and the lowest 12.92% the overall energy efficiency of a plowed field without the ballasting. That with investigations Bower et al that a few years on tillage machines, the total energy efficiency of 6.9 to 13 percent reported and with investigations Kheirollah et al and Kazemi et al [10] which the total energy efficiency from 9 to 17% corresponded to expressed.

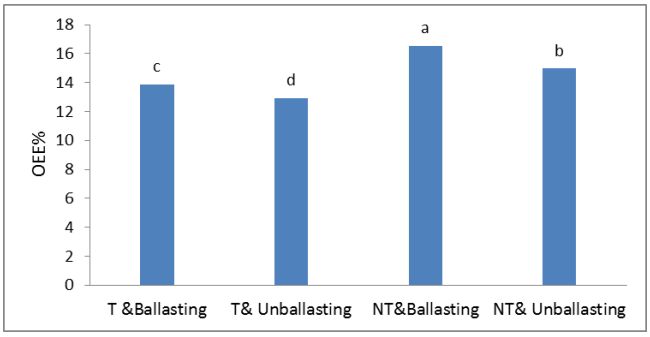


Figure 4: Interaction the tilled and no- tilled field and the ballasting on overall energy efficiency.

According to Figure (4), it is observed that the tractive efficiency non- plowing land at angle of 41° is maximum amount 79.09% and the plowed field at angle of 46° is the lowest amount 66.92%. That with respect in the plowed field without ballasting and increase the angle of disk is increases the specific fuel consumption. The acts managerial factors ballasting and angle adjustment to the disk will reduce fuel consumption by 10%, that in large reduced tillage soils are costly operations.

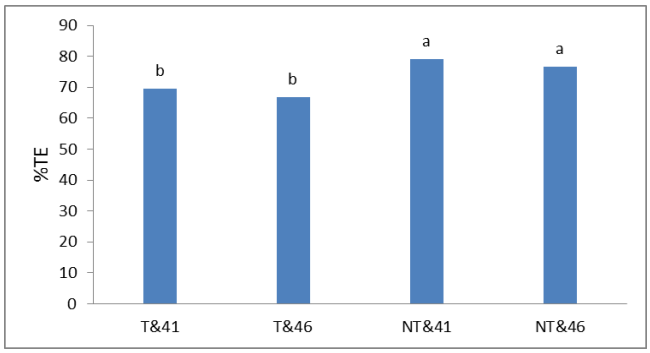


Figure 5: Interaction the tilled and no- tilled field and angle of disk harrow on tractive efficiency.

5. Conclusion

With respect to the treatments observed, it was seen that in treatment with ballast in comparison to without ballast, increase the angle of disk in both conditions of tilled and no-tilled lands causes increase of OEE. The maximum and minimum the front wheel slip was 33.39% and 3.03% respectively in Status without ballast, tilled field and angle of 46 ° and Status by ballast, no-tilled field and angle of 41 °. The rear wheels slip in Status plowed field without ballast and angle of 46 ° was 21.79%. While the highest overall energy efficiency was measured 17.82% in Status no-tilled field and angle of 41 °by ballasting. The tractive efficiency 79.33% on tilled field, by ballasting and angle of 41 ° was measured.

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