

ANALYSIS OF FUEL CONSUMPTION BY MACHINE-TRACTOR UNITS

Gafurov V.D., Zinatullin V.V., Abdrazakov F.G., Kabirov A.

Keywords: diesel engine, fuel consumption, monitoring, working hours.

Abstract. The article analyzes the experimental results of rationing fuel consumption over the treated area, and using satellite-based monitoring of operating time. The most optimal modes have been identified for controlling fuel use at agricultural enterprises.

АНАЛИЗ РАСХОДА ТОПЛИВА МАШИННО-ТРАКТОРНЫМИ АГРЕГАТАМИ

Гафуров И.Д., Зиннатуллин В.В. Абдразаков Ф.Г., Кабиров А.

Ключевые слова: дизельный двигатель, расход топлива, мониторинг, время работы.

Аннотация. В статье проанализированы результаты экспериментов нормированию расхода топлива по обработанной площади, а по средствам спутникового мониторинга времени работы. Выявлены наиболее оптимальные режимы, для контроля использования топлива на предприятиях АПК.

Fuel costs during the operation of machine-tractor units (MTA) are 30 ... 40% of all operating costs. Therefore, in recent years, agricultural enterprises have been paying increasing attention to the issues of controlling MTA fuel consumption. In particular, satellite monitoring systems are widely introduced that allow monitoring in various ways: connecting to a standard analog fuel level sensor, connecting to a CAN bus, installing a fuel level sensor in a tank, installing a flow meter for fuel on an engine.

Each of these methods has drawbacks [2], which do not allow to completely exclude cases of wasteful use of fuel, including theft. Therefore, often along with the means of operational technical control, enterprises are guided by the fuel consumption rate (NRT). Moreover, in some cases, NRT is the only way to control.

It should be noted, however, that the use of collections of typical fuel consumption rates for these purposes is not entirely acceptable: firstly, the norms of per hectare fuel consumption have a significant error (up to 60%) [3], and secondly, for a huge number of modern MTAs NRT are absent.

In this regard, we proposed to normalize fuel consumption not according to the treated area, but according to the unit operating time determined by means of satellite monitoring in various modes [1]. It was shown that this technique gives good results in relation to harvesting equipment [1].

For a preliminary assessment of the appropriateness of using this technique for rationing fuel consumption by tractor units, experimental studies were carried out, the results of which are given below.

A satellite monitoring controller and a digital fuel level sensor were installed on the T-150K tractor. This made it possible to determine the driving time, mileage and fuel consumption in two operating modes of the units: 1) main work and turns; 2) moving.

Table 1 shows the MTA in the first of these modes.

Tab. 1. Indicators of machine-tractor units at the main work and turns

№ Measure- ment	Conditional field number	Duration of work, h	Average speed, km / h	The treated area, ha	Fuel consumption		
					total, l	per hectare, l / ha	hourly , l / h
T-150K+ BDM-3×4 (operation - stubble disking, working width 3.2 m)							
1	1	2,07	10,60	5,38	55,91	10,72	27,06
2		8,07	11,60	23,02	234,23	10,35	29,04
3		2,87	11,30	7,70	82,96	10,86	28,94
4	2	4,97	11,90	13,74	142,12	10,52	28,61
5		4,33	11,30	12,64	120,71	9,69	27,86
6		1,88	12,00	5,34	49,60	9,29	26,34
7		1,93	11,80	6,24	57,15	9,18	29,56
8		0,73	11,90	2,08	19,45	9,38	26,52
9	3	0,93	12,00	3,55	25,60	7,32	27,43
10		1,83	12,00	6,09	57,85	9,54	31,56
11		2,80	12,10	7,86	83,43	11,11	29,80
12		1,83	12,10	5,82	54,50	9,36	29,73
13		1,05	12,20	3,87	28,35	7,34	27,00
14		2,02	12,00	6,89	61,61	9,06	30,55
15		3,10	11,90	9,25	90,32	10,03	29,14
The average value of the operation			12,04	-	-	9,11	29,31
The coefficient of variation, %						12,34	5,24
T-150K+ 4SKP-2,1 (operation - sowing, working width 8.2 m)							
16	3	1,33	9,50	6,86	32,85	4,80	24,64
17		1,21	9,70	6,89	35,80	5,20	29,59
18		1,13	9,90	7,57	32,10	4,24	28,41
19		1,27	9,90	8,34	34,60	4,21	27,32
20		1,27	10,50	7,53	34,90	4,63	27,48
21	4	0,98	11,00	7,46	30,60	4,16	31,12
22		0,90	10,20	6,24	28,30	4,54	31,44
23		1,92	10,40	14,54	53,80	3,70	28,07
24		3,63	10,60	27,66	107,61	3,94	29,62
25		0,98	10,40	7,87	27,81	3,65	28,28
The average value of the operation			10,21	-	-	4,31	28,60
The coefficient of variation, %						11,39	6,94
T-150K+ PLN-5-35 (operation - plowing, working width 1.75 m)							
26	5	1,63	12,00	2,86	44,80	15,70	27,43
27		2,82	11,80	4,92	80,70	16,42	28,65
28		3,57	11,90	8,03	96,26	12,17	26,99
29		1,88	11,90	3,31	55,40	16,74	29,42
30		3,07	11,60	5,06	86,45	17,11	28,19
The average value of the operation			11,84	-	-	13,36	28,14
The coefficient of variation, %						15,00	3,43
The average value for all operations						-	28,53
Coefficient of variation for all operations, %						-	5,57

As can be seen from table 1, the hourly fuel consumption on the move with turns in different conditions (in different fields, with different composition of the unit and the type of work performed) varies in a relatively narrow range - from 24.64 to 31.56 l / h, therefore when using its average value of 28.53 l / h as a standard, the average error will not exceed 1.6 l / h. If we assume that during the 7-hour shift the unit's main operation time is 5 hours, then the error in predicting fuel consumption when working in the field will be $1.6 * 5 = 8$ liters, which is quite acceptable.

Per hectare fuel consumption, even with the same settings of the agricultural machine, varies over a wide range:

- on disking - 7.32 to 10.86 l / ha;
- at sowing - from 3.65 to 5.20 l / ha;
- on plowing (on one field) - from 12.17 to 17, 11 l / ha.

This once again testifies to the fact that significant errors are possible in setting consumption rates per hectare.

In addition to the standard for hourly fuel consumption at the main job, when implementing our methodology, a consumption standard for MTA crossings is necessary. Table 2 shows the relevant indicators for the object of study.

Tab. 2. MTA indicators based on the T-150K at level crossings

Speed range, km / h	№ Measurement	Duration of work, h	Mileage, km	Average speed, km / h	Fuel consumption		
					total, l	per 100 km, l	hourly, l / h
19-21	1	0,48	8,20	16,97	8,60	104,88	17,79
	5	0,30	5,40	18,00	5,20	96,30	17,33
	3	0,15	2,80	18,67	2,70	96,43	18,00
	4	0,13	2,50	18,75	2,40	96,00	18,00
	5	0,15	3,00	20,00	3,10	103,33	20,67
	6	0,20	4,30	21,50	3,30	76,74	16,50
Average				18,98		95,61	18,05
The coefficient of variation, %						10,49	7,77
22-24	7	7	10,80	22,34	9,70	89,81	20,07
	8	8	6,80	31,38	4,80	70,59	22,15
	9	9	5,60	24,00	4,90	87,50	21,00
	10	10	4,60	19,71	5,30	115,22	22,71
Average				25,03		91,10	21,96
The coefficient of variation, %						20,21	5,39
25-27	11	0,15	3,70	24,67	3,70	100,00	24,67
	13	0,23	4,90	21,00	6,10	124,49	26,14
	12	0,18	4,70	25,64	4,50	95,74	24,55
	14	0,33	10,90	32,70	8,10	74,31	24,30
Average				26,00		98,64	24,91
The coefficient of variation, %						20,86	3,35

28-30	15	0,15	3,70	24,67	4,70	127,03	31,33
	16	0,27	7,50	28,13	7,90	105,33	29,63
	17	0,12	3,30	28,29	3,50	106,06	30,00
	18	0,17	5,80	34,80	4,90	84,48	29,40
	19	0,50	14,40	28,80	14,10	97,92	28,20
	20	0,12	3,40	29,14	3,40	100,00	29,14
	21	0,10	3,10	31,00	2,90	93,55	29,00
Average				29,26		102,05	29,53
The coefficient of variation, %						12,98	3,30

As can be seen from table 2, the hourly flow rate varies slightly, and the coefficient of variation does not exceed 7.8%, while pokilometer consumption has a variation of up to 20.9%.

Fuel consumption at level crossings significantly depends on the speed of movement (Figure 1). When normalizing the flow rate on the basis of satellite monitoring data and hourly standards, this fact can be used to reduce the error, whereas in the traditional standardization based on hectare and kilometer-wide standards, the unit speed is unknown and cannot be used to refine the calculations.

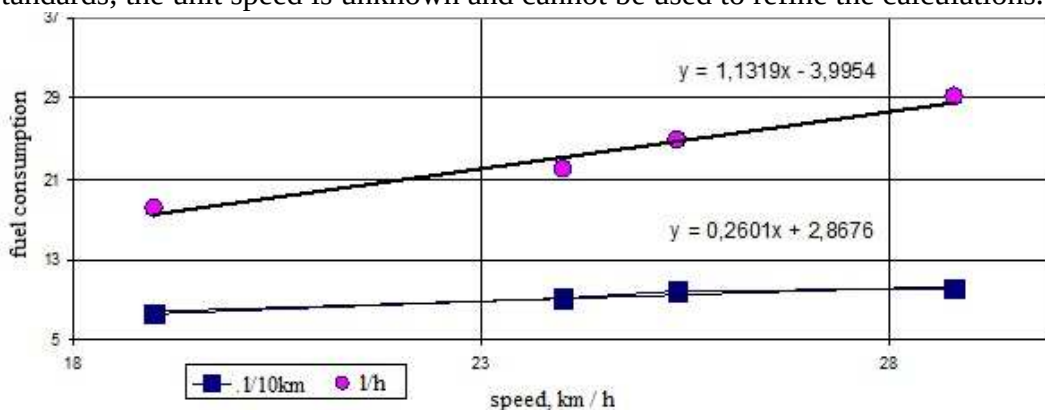


Fig. 1 Dependence of fuel consumption at level crossings on speed

Findings.

1. It is confirmed that control of fuel consumption by tractor units based on hectare norms at the main work and kilometer-high norms at level crossings leads to significant errors.

2. Rationing on the basis of hourly fuel consumption standards for the main work, moving, as well as satellite monitoring data on the operating time of tractors (units) in these modes is one of the reliable tools for monitoring fuel use in agricultural enterprises.

References

1. Patent №2510958 RU. The method of rationing fuel consumption by machine-tractor unit: patent application of the Russian Federation. / Gafurov I.D., Ryabov A.V., Akhmadullin I.M. publ. 10.04.2014, Bull. №10.

2. Gafurov I.D., Akhmadullin I.M. Accuracy assessment of fuel consumption by satellite monitoring system according to CAN-bus data // Improving the design, operation and technical service of automotive and agricultural machinery: Materials of the International scientific-practical conference. 2013. P. 91-94.
3. Gafurov I.D. Operational rationing of field mechanized works // Technics in agriculture. – 2009. – No. 3. – P.26-29.

Список литературы

1. Патент №2510958 РФ. Способ нормирования расхода топлива машинно-тракторным агрегатом / Гафуров И.Д., Рябов А.В., Ахмадуллин И.М. – опубл. 10.04.2014, Бюл. №10.
2. Гафуров И.Д., Ахмадуллин И.М. Оценка точности определения расхода топлива системой спутникового мониторинга по данным CAN-шины // Совершенствование конструкции, эксплуатации и технического сервиса автотракторной и сельскохозяйственной техники: Материалы Международной научно-практической конференции. 2013. С. 91-94.
3. Гафуров И.Д. Оперативное нормирование полевых механизированных работ // Техника в сельском хозяйстве. – 2009. – № 3. – С.26-29.

Гафуров Ильдар Данилович – кандидат технических наук, доцент кафедры автомобилей и машинно-тракторных комплексов, gafurov62@mail.ru	Gafurov Ildar Danilovich – candidate of technical sciences, associate professor of department of cars and machine-tractor complexes, gafurov62@mail.ru
Зиннатуллин Вячеслав Валерьевич – старший преподаватель кафедры автомобилей и машинно-тракторных комплексов, Slawa915@yandex.ru	Zinnatullin Vyacheslav Valerievich – senior lecturer of department of cars and machine-tractor complexes, Slawa915@yandex.ru
Абдразаков Фарид Гафиятович – аспирант,	Abdrzakov Farid Gafiyatovich – post-graduate student, dimarik-suvorov@mail.ru
Кабилов Альберт Айратович – магистрант, maratovna1985@yandex.ru	Kabirov Albert – master's degree student, maratovna1985@yandex.ru
Башкирский государственный аграрный университет, Уфа, Россия	Bashkir State Agrarian University, Ufa, Russia

Received 26.09.2019