



EVALUATING WORKING QUALITY OF TRACTORS BY THEIR HARMFUL IMPACT ON THE ENVIRONMENT

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Abstract. The paper presents tractor working data and their engine conditions from economical and ecological point of view. Overlooked results presented in literature have a straight relation with reduction of tractor fuel consumption and unfriendly impact on the environment. The results of measurements show that for investigation of tractor performance quality during its working life, information collected in its microprocessors can be used. Investigation results of engine speed and torque aspects of different Deutz Fahr Agrotron tractor models with different working output are presented in the paper.

Investigation results show that a tractor on average worked from 37% to 52% of the total working hours at a high torque (>50% M_{max}) and at medium (1000–2000 rpm) and high (>2000 rpm) engine speed. The investigation results show that almost half of tractor working time is unreasonable. The paper presents big improvement possibilities for tractor operating technologies by using a wider range of engine power, decreasing fuel consumption and unfriendly impact on the environment.

Keywords: tractor, fuel consumption, environmentally-unfriendly impact, engine speed, engine load, working life, torque.

1. Introduction

Increase of agricultural equipment and high performance of tractor stock influence pollution of the environment by exhaust gases. Poisonous exhaust substances, oil products and their vapour are disposed to the environment through engine breather and various wane products. The bigger concentration of equipment used, the bigger noise level. Environmentally-unfriendly impact factors break ecological balance, decrease soil productivity and have a negative influence on human health (Šimatonis and Tiškevičius 1994).

If fuel in the engine would combust totally, exhaust gases would consist of nitrogen oxides NO_x , carbon dioxide CO_2 , vapour H_2O and nitrogen N_2 . But in reality fuel doesn't combust completely, therefore, exhaust gases can contain carbon monoxide CO , pure carbons (soot) C , hydrocarbons HnC_m , aldehydes $R\cdot CHO$, nitrogen oxides NO_x . Combustion of sulphurous fuel creates sulphur dioxide SO_2 and SO_3 , sulphur hydrogen H_2S in exhaust gases (Šimatonis and Tiškevičius 1994; Labeckas and Slavinskas 2003).

Quality combustion of a diesel fuel product and carbon dioxide (CO_2) emission amount has a close relation to each other. Investigation results show, that CO_2 emission has a direct dependence on fuel consumption. Increase of fuel consumption equally increases CO_2 emission. From ecological point of view CO_2 is a dangerous gas because it creates a kind of a film which inhibits the warming of the Earth surface. Because of thermal effect the Earth temperature, during the last century, has

increased on average by 0,3–0,7 °C (Šimatonis and Tiškevičius 1994; Baltrėnas *et al.* 2004).

Equipment in agricultural technological processes makes a less negative impact on the environment when it is used under reasonable and optimal conditions. Impact on the soil compaction is less when tractors are aggregated with correct agricultural equipment, it means when optimal torque is achieved. Low tractor load requires more passes on the same field. This leads to a bigger fuel consumption for the same plot of a cultivated area. High fuel consumption leads to a higher pollution of the environment. Too big tractor load could lead to wheel slippage which damages the soil structure and increases fuel consumption for the same plot area. Besides, fuel consumption and noxiousness depends on engine working conditions (Kraujalis 2002; Air ... 2005; Janulevičius and Juostas 2007; Jun *et al.* 1998).

The task of the work is to investigate tractor performance quality by their economical factors and unfriendly impact on the environment (engine speed and torque aspects) during its working life.

2. Study area and data

One of the most important factors of a tractor is its working efficiency. It means efficient usage of its power for work to be done. Nominal working range of tractor engines is not an efficient operation (Šimatonis and Tiškevičius 1994; TTV ... 2002; Automotive ... 2000). Such features are observed in most tractor characteristics.

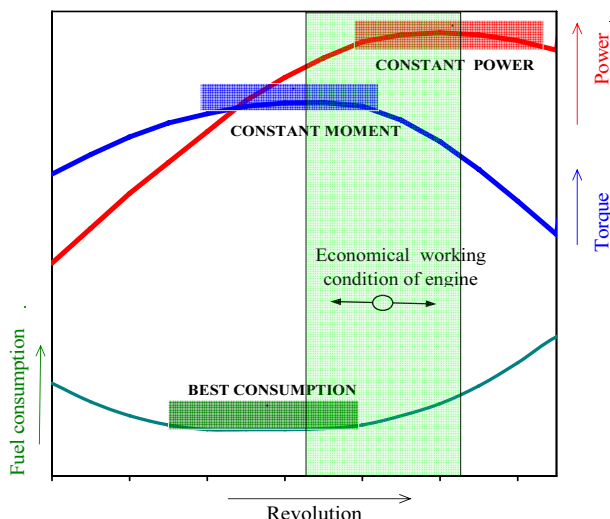


Fig. 1. Curve sheet of tractor diesel engine characteristics (from idle to nominal engine speed range)

The tractor Deutz Fahr Agrottron TTV 1160 engine characteristics show that the maximum engine power is reached at 1800 rpm, whenever nominal engine speed is 2350 rpm (Fig. 1) (TTV ... 2002). Low fuel consumption of 209 g/kWh is in a high torque range at a speed range of 1450–1750 rpm. Deutz Fahr Agrottron TTV 1160 engine has 30% of torque rise. Gear shifting can be delayed until the speed drops as low as 1200 rpm. Constant engine performance in a wide speed range suggests relaxed work, power reserve, less gear shifting without traction interruption, high flexibility values with lower fuel consumption at lower speeds, but at the same engine performance. Deutz engine characteristic curves sheet (Fig. 1) shows that economical engine working conditions (maximum torque and power and the lowest fuel consumption) are achievable at a lower than nominal engine speed. During tractor maintaining in the following conditions we could get fuel consumption reduction by 5% (Kraujalis 2002; Air ... 2005; Janulevičius and Juostas 2007).

Test measurements were carried out using John Deere 6910 (103 kW/140 hp) and semi-mounted 5.70 m. wide Horsch stubble cultivator (Air ... 2005). The tractor scaled 6410 kg without extra weights, with 41% (2630 kg) resting on the front axle. Down below, the tractor was shod with 540/65R28 and 650/65R38 sized Continental Contract AC 65 front and rear tires.

The first cultivation pass and test measurements were conducted on unprepared and dry field stubbles, and the working depth varied between 7 and 9 cm. The second trial was carried out at the end of the following month on a cultivated ground. Conditions were wet underfoot, and the working depth increased to between 10 and 12 cm. Measurements included engine speed, fuel consumption, forward speed, wheel slip and draft required. Draft was calculated by relating pulling power and travel speed. Fuel consumption also varies according to engine speed. With most tractors, optimum fuel consumption is lower down the revolution range when maximum power is not needed. To find out how

much cost can be saved, the test John Deere 6910 tractor was operated at 2250 rpm and then, in a higher gear, at 1850 rpm. The same working speed was achieved, and there was a 5% reduction in fuel use (Air ... 2005).

Experimental investigation of fuel consumption at transport work for a different engine speed was performed with a tractor Deutz Fahr Agrottron TTV1160 (111 kW/150 kW) and a trailer OZTP9554 loaded by gravel of 12 tons. Investigation was performed on a wheat stubble and gravelled road. Driving speed on a stubble was 8 km/h, on a gravelled road – 18 km/h. Chosen driving speeds were kept at 2300 rpm engine speed. Later, driving speed lowered to 1800 rpm engine speed. At a lower engine speed 4.5–5% fuel economy was reached. Significant fuel economy was reached without engine load at an idle engine speed.

A literature source shows that one of the significant fuel consumption criteria is engine speed (Kraujalis 2002; Air ... 2005; Janulevičius and Juostas 2007). The same tractor driving speed is reached at a higher gear and at a lower engine speed, and reached fuel consumption economy is of 5%. A lower fuel consumption may lead to less environmental pollution.

Exhaust gas composition of internal combustion engines is presented in Table 1.

Table 1. Composition of exhaust gases in internal combustion engines (Šimatonis and Tiškevičius 1994; Automotive ... 2000)

Exhaust gas components	Idle speed	Full load
Nitrogen oxides (NO _x), ppm (vol)	50...250	600...2500
Hydro carbons (HC), ppm (vol)	50...500	150
Carbon monoxide (CO), ppm (vol)	100...450	350...2000
Carbon dioxide (CO ₂), volume %	...3,5	12...16
Vapour, volume %	2...4	Up to 11
Oxygen, volume %	18	2...20
Soot, mg/m ³	≈20	≈ 200
Aldehydes	0,001	...0,009

Noxiousness of exhaust gases depends on engine working conditions (Šimatonis and Tiškevičius 1994; Labeckas and Slavinskas 2002, 2003; Baltrėnas *et al.* 2004; Automotive... 2000; Altin *et al.* 2001; Tat and Gerpen 2004; Vaitiekūnas and Banaitytė 2007; Mockus *et al.* 2006; Lebedevas *et al.* 2006).

Otto engine gives its maximum power when shortage of oxygen reaches $\alpha = 0.85...0.95$. Therefore, it is normal that exhaust gases of a loaded engine have CO. If blend of fuel is too thin ($\alpha > 1$), the combustion speed is decreased, and this generates CO in exhaust gases.

Diesel engines always have excess of oxygen. However, practically there is lack of time to prepare a good-quality mixture. The duration for this process is only few thousands of seconds. Besides, there is lack of oxygen in fuel spray patterns which leads to incomplete combustion, and this generates CO.

Soot (pure carbon C) exhausted from the engine in the form of black smoke: when the concentration of soot in exhaust gases is 120...130 mg/m³, exhausted gases are

visible; when the concentration is bigger than 600 mg/m^3 , the gases become black. The biggest smoking appears from a loaded engine and during the engine acceleration (Šimatonis and Tiškevičius 1994; Labeckas and Slavinskaskas 2006; Nwafor ... 2004).

Hydrocarbons (H_nC_m) in exhaust gases are increasing when a fuel mixture is too lean or too rich. The biggest influence on hydrocarbon formation results from a relative area of the combustion chamber, residual of exhaust gas, turbulence of gases during the combustion process, final phase of combustion, etc.

Aldehydes forming on engine cylinder walls were residuals of oil and fuel bands with oxygen. It is greater in exhaust gases when engine works under a low load.

NO_x make about 90% of nitrogen oxides in exhaust gases. It is generated at a high temperature of gases and enough oxygen. When the combustion process is perfect, the temperature of a cycle is higher, there is more of NO in exhaust gases. When this process is imperfect, there is more CO and H_nC_m in exhaust gases (Šimatonis and Tiškevičius 1994). It is determined that the chemical content of mineral fuel doesn't have an influence on the quantity of NO in exhaust gases.

Direct-injection diesel engines pollute the environment more than engines with a complex chamber (Šimatonis and Tiškevičius 1994; Automotive ... 2000). Increased compression rate ε , improves mixture preparation conditions. This leads to decrease of CO and H_nC_m in exhaust gases, especially when engine load and speed are not high. Increase of compression rate ε , increases combustion temperature and quantity of NO_x in exhaust gases too. The quantity of NO_x can be reduced by making fuel injection later. In this case fuel consumption is increasing. However, the quantity of CO , H_nC_m and aldehydes in exhaust gases does not vary at an advance fuel injection.

Fuel supply has an influence on NO_x quantity in exhaust gases. Concentration of NO_x increases when fuel in the combustion chamber is injected at a high pressure. Diesel engines have a large load and speed range. The coefficient of air excess is uneven, α is approximately in the range of 1.3...5. Air should be enough to burn the fuel. However, composition of the mixture doesn't influence the quantity of CO and H_nC_m in exhaust gases; this is because lack of air is at the edge of flame and near the walls of the combustion chamber. Figs. 2, 3 present the quantity of toxic gases and its smoke dependence on engine load and speed.

The biggest amount of H_nC_m is at a low load and idle engine speed exhaust gases. An overloaded engine forms the biggest concentration of CO and more smoke. A diesel engine gives more smoke in the case of a high engine speed because of unburned fuel. Also, smoke increases during engine run up. This is significant for turbocharged engines. An important thing is that the quantity of CO , H_nC_m and NO_x in exhaust gases increases slightly.

Increase of emission rate between combustion of diesel fuel and carbon dioxide (CO_2) is related to each other. Investigation results show (Labeckas and Slavinskaskas 2002, 2006; Vaitiekūnas and Banaitytė 2007; Mockus

et al. 2006; Lebedevas et al. 2006; Nwafor ... 2004; Saving ... 2001) that CO_2 emission has a direct dependence on fuel consumption. Increase of fuel consumption evenly increases CO_2 emission.

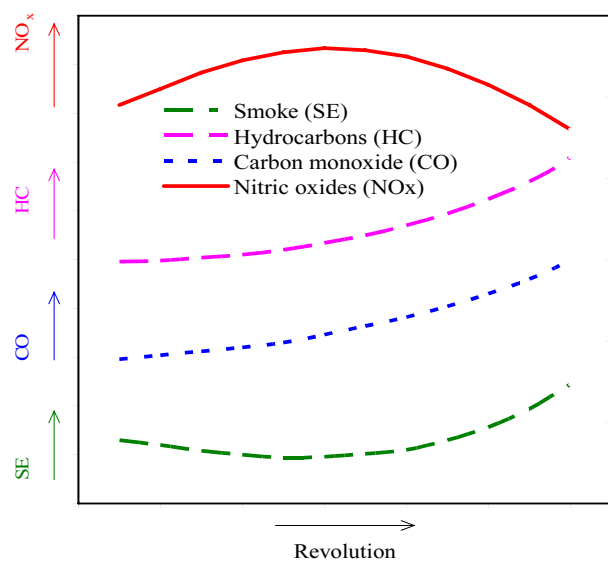


Fig. 2. Principal characteristics of diesel engine toxic gas dependence on engine speed (from idle to nominal engine speed range)

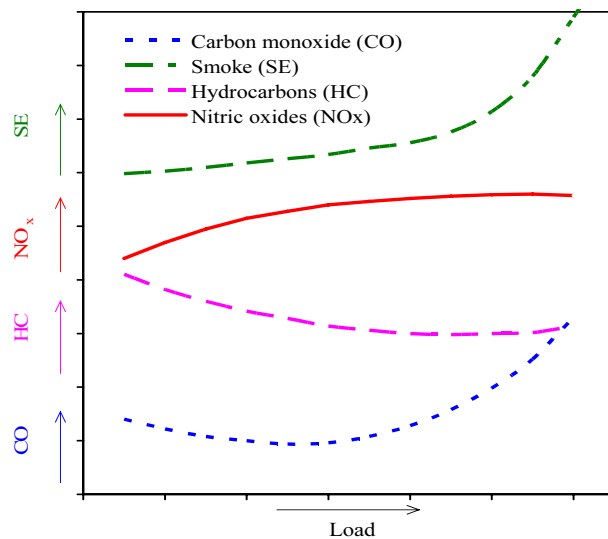


Fig. 3. Principal characteristics of diesel engine toxic gas dependence on engine load (from idle to nominal engine speed range)

Vegetable oil-based fuels applied as Diesel fuel extender could alleviate environmental pollution contributing to closed-cycle CO_2 circulation. The emission characteristics of Diesel engines operating on neat rapeseed oil methyl ester (RME) and its blends with Diesel fuel have been reported in various research papers (Labeckas and Slavinskaskas 2006; Nwafor ... 2004). In many investigations, reductions in CO , HC and PM emissions and smoke, along with higher NO_x , in the exhausts have been determined. For a fully loaded John Deere 4276T engine, nitrogen oxide increase by 11.6% for yel-

low grease methyl ester and by 13.1% for soybean oil methyl ester, while the CO₂ emissions increase by 1.2% and 1.8%, respectively, along with significantly lower CO (17.8% and 18.2%), unburned HC (46.3% and 42.5%) and smoke (SN 0.38 and 0.41). However, RME mixing with Diesel fuel reduces the calorific value of the fuel blend that may result in engine power losses and increased brake specific fuel consumption (bsfc) (Altin *et al.* 2001; Nwaor ... 2004). Investigations conducted on a Petter model ACI indirect injection, four-stroke, single-cylinder Diesel engine showed by about 11% increased fuel consumption and higher CO₂ concentrations for neat RME along with reduced CO emissions at higher loads (Nwafor ... 2004).

The total NO_x emissions, as a sum of both harmful pollutants, NO and NO₂, depend actually on the biofuel feedstock, its chemical structure, oxidation rate, thermal stability and iodine number, i. e. the presence of double bonds, cetane number, its volatility, flammability and other properties. Biodiesel emission levels depend also on engine design and test conditions, i. e. whether studies were conducted on a bench stand or chassis dynamometer, the “route” and rate of acceleration of vehicles, fuel physical and chemical properties (Nwafor ... 2004; Manual ... 1999), its oxidation rate, fuel injection timing advance and actual start of combustion (Tat and Gerpen 2004; Labeckas and Slavinskas 2006). It has been disclosed that all performance modes, RME leads to lower CO and to higher NO_x emissions than the fossil fuels, however, no general tendency was found regarding HC emissions. The emission of unburned hydro carbons HC for all fuels is low, 5–21 ppm, showing slightly milder values for RME and its blends with Diesel fuel (Labeckas and Slavinskas 2006).

From ecological and economical point of view, it is important that tractors and their engines would get proper operation: improving starting conditions, shortening of

time of idling on a high and low load and at a high speed ensured regular thermal conditions.

The second task of the work is to investigate the quality of tractor operation (for engine speed and load factors) during working life.

3. Method and object of investigation

For tractor load investigation during its working life, information collected in (EMR) Electronic Engine Control was used. Microprocessors collect information, such like engine speed, torque, working hours, etc., and enables to make tractor analysis during its working life.

Digital Electronic Engine Control Units (ECU) have become a normal part of modern engine technology. These ECUs are designed, at the very least, to fulfill the functions of comparable mechanical modules (e. g. governors) as well as to provide additional functionality. SERDIA 2.5 is required in order to make communication with these digital electronic DEUTZ ECUs and diagnostic program possible (Manual ... 1999). SERDIA is a software program. With the help of the notebook and interface, it constitutes a tool, which serves as an aid to communication with the engine ECUs. The SERDIA 2.5 menu points have a large possibility for extracting different information. The variety of database depends on Engine Control modules ECU. For investigation, the following groups of data were chosen: torque, engine speed, tractor load spectrum.

With the help of software SERDIA 2.5 and 12 pin DEUTZ diagnostic cable we have recorded tractor load spectrum according to its load condition (Fig. 4).

For investigation of tractor working quality (engine speed and load conditions) during its working life, 12 Deutz Fahr Agrotron tractors were chosen. They were for different farming profiles, making a plough, soil tillage, seeding, transport and other jobs. They were also of different models and power, and different working output (Table 2).

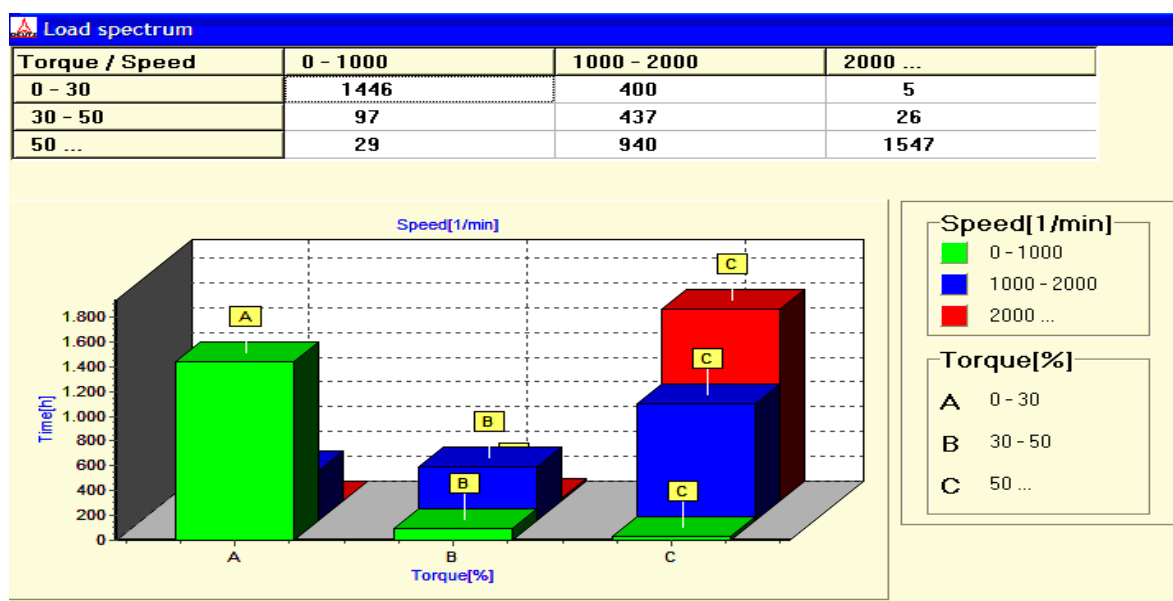


Fig. 4. Load spectrum of Deutz Fahr Agrotron 230 MK3 tractor (No. 9)

Table 2. Engine load factors of 12 investigated Deutz Fahr Agrotron tractors during their working life

No.	Tractor model	Nominal power kW / speed, rpm	Engine hours h.
1	AGROTRON 135	135 / 2300	2758
2	AGROTRON	150 / 2300	2270
3	AGROTRON	150 / 2300	2021
4	AGROTRON 165	160 / 2300	2315
5	AGROTRON	160 / 2300	2363
6	AGROTRON 200	200 / 2300	3997
7	AGROTRON 215	198 / 2300	451
8	AGROTRON 230	230 / 2300	4913
9	AGROTRON 230	230 / 2300	4927
10	AGROTRON 235	231 / 2300	3237
11	AGROTRON 265	250 / 2300	1653
12	AGROTRON 265	250 / 2300	1495

4. Investigation results

Fig. 4 shows the load spectrum of Deutz Fahr Agrotron 230 MK3 (No. 9) tractor. From this load spectrum, we could see working conditions during the tractor working life of 4927 motohours.

This load spectrum shows how many hours a tractor worked at a low (up to 30% of the maximum torque (M_{max}), medium (30–50% M_{max}) and high (>50% M_{max}) working load. On the load spectrum and its table we could see how many hours a tractor worked at a low (up to 1000 rpm), medium (1000–2000 rpm) and high (>2000 rpm) engine speed. A summary table of the load spectrum is shown in Table 3.

Table 3. Distribution of Deutz Fahr Agrotron 230 tractor working hours (h/%)

Speed, rpm \ Torque, %	0–1000	1000–2000	>2000	Total, h / %
	0–30	1446/ 29.3	400/ 8.1	5/ 0.1
30–50	97/ 1.97	437/ 8.9	26/ 0.53	560/ 11.4
>50	29/ 0.6	940/ 19.1	1547/ 31.4	2516/ 51.0
Total	1572/ 31.9	1777/ 36.1	1578/ 32.0	4927/ 100

The first row of Table 3 (0–30%) shows that for 1851 hours from the total 4927 hours a tractor worked at a very low load and idle speed. It makes up to 37.6% of the total tractor working hours.

With a low engine load (up to 30%) and at a high engine speed (>2000 rpm) a tractor worked for 5 hours. At a low engine load and medium (1000–2000 rpm) engine speed a tractor worked for 400 hours, or 8.1% of the total working hours.

At a high (suitable) engine load (>50% M_{max}) and high engine speed (≥ 2000 rpm) a tractor worked for 1547 hours, or 32% of the total working hours. Under economical conditions at a medium (30–50% M_{max}) and high (>50% M_{max}) engine load at a medium (1000–2000 rpm) engine speed a tractor worked, accordingly for 437 and 940 hours, or accordingly, 8.9% and 19.1% of the total working hours.

A conclusion can be drawn that Deutz Fahr Agrotron 230 MK3 tractor from its 4927 working hours worked:

- for 2487 hours (50.5%) at a high (suitable) engine load and high engine speed (≥ 2000 rpm), that is under good engine power utilization conditions, thereof for 940 hours (19.1%) at economical conditions;

- for 1851 hours (37.6%) at a very low engine speed (up to 1000 rpm) and very low engine load or at idle speed.

It will be observed, that a Deutz Fahr Agrotron 230 MK3 (No. 9) tractor a big part of the total working hours (31.9%) worked at a very low engine speed (up to 1000 rpm), and a similar part (32%) of hours worked at a big engine speed (≥ 2000 rpm). These tractor engine working conditions are not good from both economical and ecological point of view. The results of parallel investigation with 12 chosen Deutz Fahr Agrotron tractors are represented in Figs. 5, 6 and 7. As we can see from Fig. 5, all the investigated tractors during their working life the biggest part of working hours (up to 30%) worked at a very low engine speed (up to 1000 rpm) and very low torque (0–30% M_{max}). A similar part of hours the tractors worked at a high torque (>50% M_{max}) and medium (1000–2000 rpm) and high (>2000 rpm) engine speed. 5–10% of their working hours tractors worked at a medium engine speed and low and medium torque. Under the rest working conditions (unsuitable for tractors and the environment) tractors worked a small amount of the total working hours.

The investigated tractors at a high engine torque range (>50% M_{max}) (Fig. 7) worked about 50% of the total working hours. However, different tractors worked at different engine speeds. Tractors No. 4, 7, 8 worked about an equal period of time at an engine speed range of 1000–2000 rpm and ≥ 2000 rpm. It is not a bad time utilization result during their working life under high-load conditions. However, at a torque range of >50% M_{max} the tractors should work for a longer period of time. Tractors No. 2, 6 a bigger part of time worked at a torque range of >50% M_{max} , at a lower engine speed (1000–2000 rpm), and tractor No. 5 – at a higher (>2000 rpm) engine speed. With reference to investigation results (Air... 2005; Janulevičius and Juostas 2007; Labeckas and Slavinskas 2006) it could be said that tractors No. 2 and 6, during their working life worked at an economical and less environment-polluting range.

Much worse results were obtained for tractors No. 1, 3. Tractor No. 3 more than half of its total hours worked at a very low torque (0–30% M_{max}) or at an idle speed. At a torque of >50% M_{max} the tractor worked a bit more than 30% of its total working hours. The results of the above mentioned tractor are poor in all the aspects.

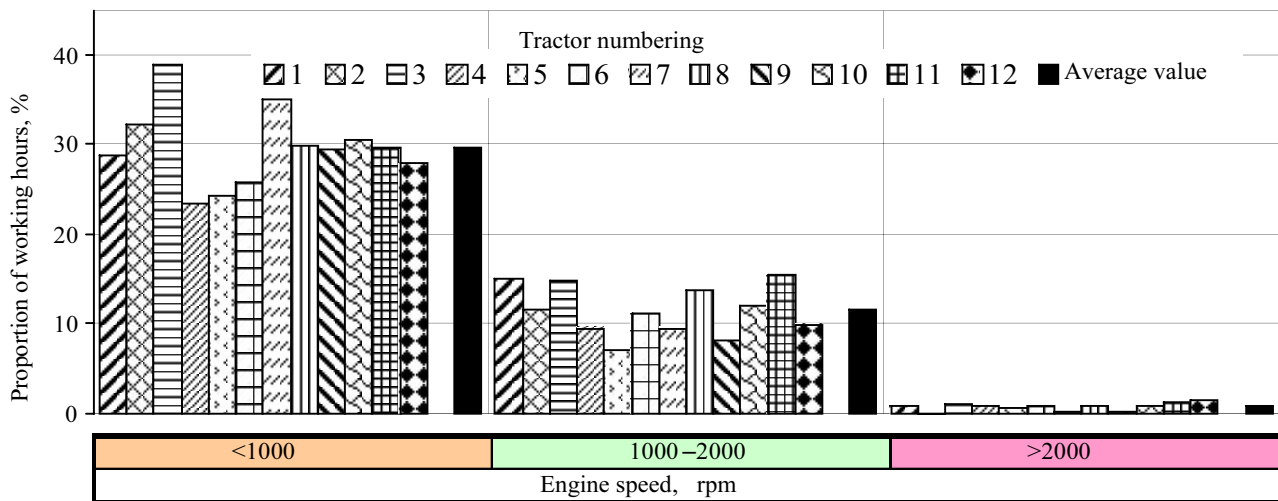


Fig. 5. Percentage of 12 Deutz Fahr Agrottron tractor working hours at a low torque (0–30% M_{max}) during their working life at a low (<1000 rpm), medium (1000–2000 rpm) and high (>2000 rpm) engine speed range

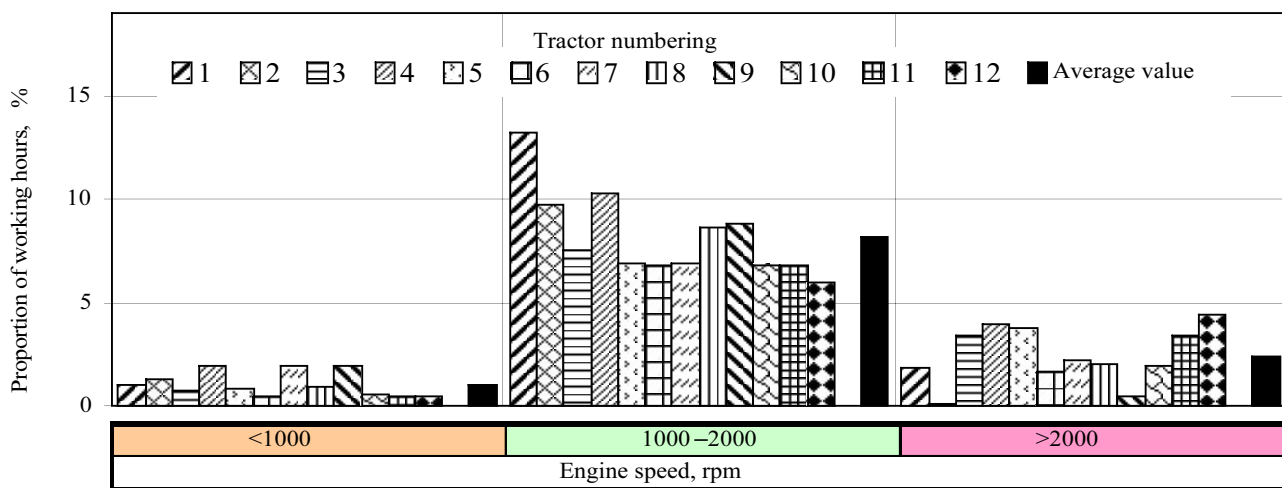


Fig. 6. Percentage of 12 Deutz Fahr Agrottron tractor working hours at a medium torque (30–50% M_{max}) during their working life at a low (<1000 rpm), medium (1000–2000 rpm) and high (>2000 rpm) engine speed range

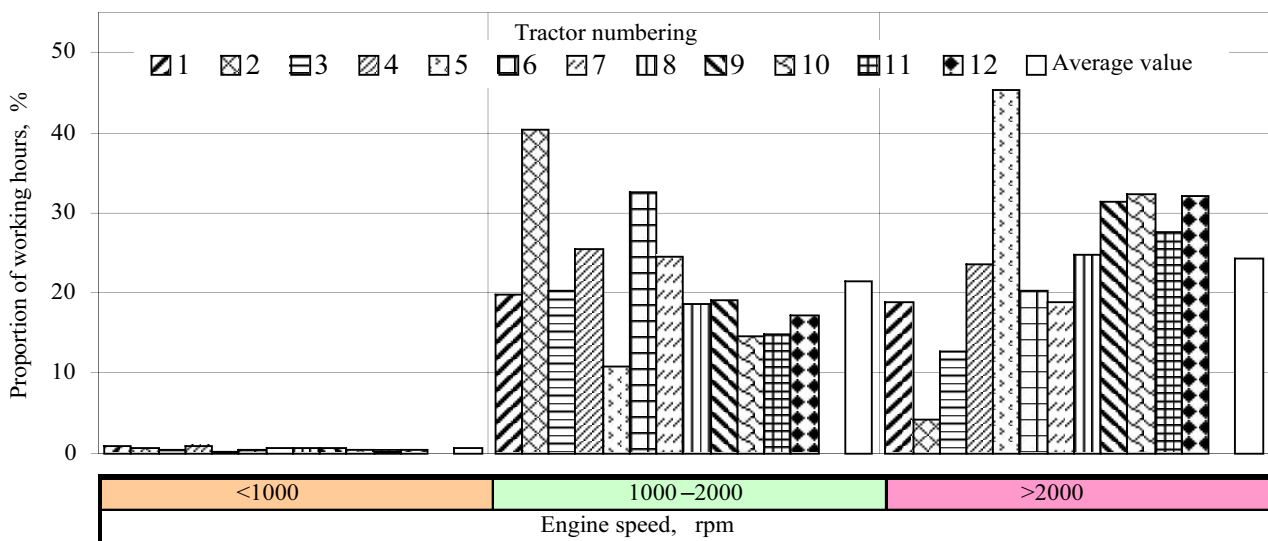


Fig. 7. Percentage of 12 Deutz Fahr Agrottron tractor working hours at a high torque (> 50% M_x) during their working life at a low (<1000 rpm), medium (1000–2000 rpm) and high (>2000 rpm) engine speed range

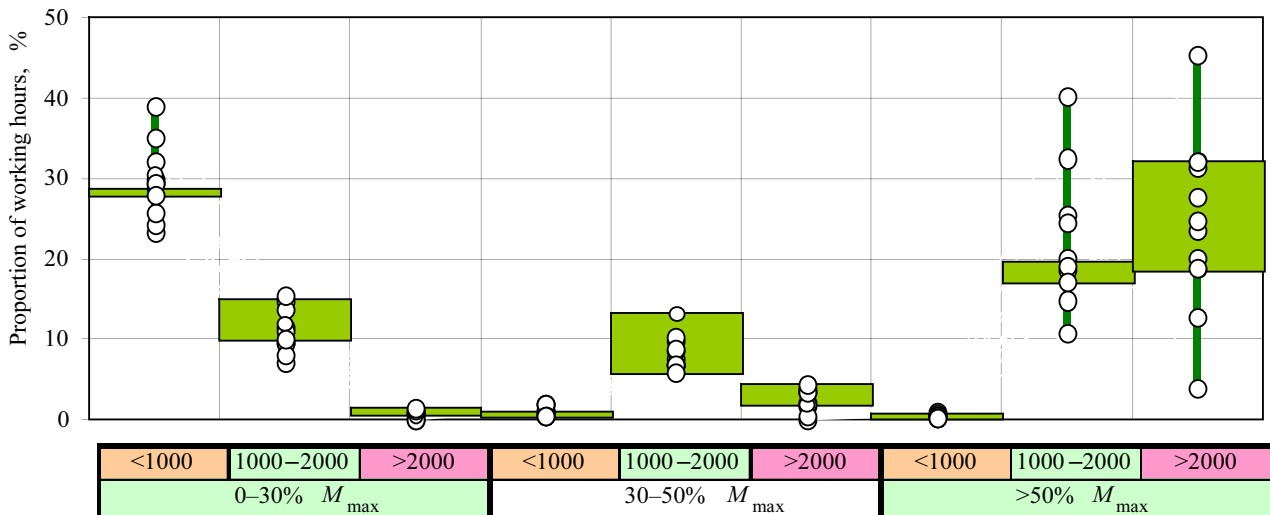


Fig. 8. Distribution of working hours (in %) of investigated Deutz Fahr Agrotion tractors in torque and speed ranges

According to the investigation results, the biggest dispersion is at a high torque ($>50\% M_{max}$) range and at a higher than 2000 rpm engine speed (Fig. 8). At a high range the tractors worked 19–32% of the total working hours. Big dispersion in torque range shows unsuitable handling of engine power by creating the tractor aggregates and choosing optimal working processes. At an economical range, high torque ($>50\% M_{max}$) and medium (1000–2000 rpm) engine speed the tractors worked 18–20% of the total hours. Better results occurred only for single tractors. Totally at a high torque ($>50\% M_{max}$), medium (1000–2000 rpm) and high (>2000 rpm) engine speeds the tractors on average worked 37–52% of the total working hours. It means that about half of the tractor working time is unreasonable. There we could explain the working range at a medium (1000–2000 rpm) engine speed and at a low (0–30% M_{max}) torque what is unavoidable because of travel from field to field. Accomplished investigation shows, that at this range the tractors worked on average 10–15% of the total working time. However, without additional investigation it would be difficult to explain the range of a low torque (0–30% M_{max}), where engine speed is less than 1000 rpm (idle speed). This range makes 30% of the total working time.

By a customer survey we tried to determine the reason of unsuitable handling of tractor power during its working period. We did not succeed in getting concrete answers. So, to get a rising character of this working range additional investigation would be needed.

5. Conclusions

1. From environmentally-unfriendly impact and economical point of view, handling of tractors and their engines is very important as well as reduced engine working time at a low engine speed and unsuitable high torque, high engine speed, and keeping of normal engine heat condition.

2. Investigation results have shown less fuel consumption at a lower engine speed than at rate speed. By taking this feature into account fuel saving could reach

5%. Reduction of fuel consumption in industrial processes would reduce unfriendly impact on the environment.

3. For investigation of tractor load during its working life, information collected in its microprocessors can be used.

4. During the biggest part of their working hours (up to 30%) all the investigated tractors worked at a very low engine speed (>1000 rpm) and very low torque (0–30% M_{max}). These working conditions are not suitable from both economical and environmentally-unfriendly impact point of view.

5. At a high torque ($>50\% M_{max}$) and medium (1000–2000 rpm) and high (>2000 rpm) engine speed, the tractors on average worked 37–52% of the total working hours. Of the total hours, 18–20% of hours the tractors worked at an economical range, at a high torque ($>50\% M_{max}$) and medium (1000–2000 rpm) engine speed.

6. Accomplished investigations showed big possibilities for improving tractors handling technologies, by using wider range of engine power, by decreasing fuel consumption and environmentally-unfriendly impact. This is proven by results of properly used single tractors.

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TRAKTORIŲ DARBO KOKYBĖS VERTINIMAS PAGAL JŲ ŽALINGĄ POVEIKĮ APLINKAI

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Santrauka

Tirta traktorių degalų sąnaudų ir žalingo poveikio aplinkai mažinimo galimybės. Matavimų rezultatais pagrindžiama, kad traktorių darbo kokybei per eksploatavimo laikotarpį tirti galima naudoti jų mikroprocesoriuose sukauptą informaciją. Pateikiami įvairių modelių ir įvairaus išdirbio *Deutz Fahr Agrottron* traktorių darbo kokybės (variklio sūkių dažnio ir apkrovos aspektais) per eksploatavimo laikotarpį tyrimų rezultatai. Nustatyta, kad didelė apkrova (>50 % M_{max}) vidutiniais (1000–2000 min⁻¹) ir dideliais (>2000 min⁻¹) variklio sūkiiais traktoriai vidutiniškai dirba 37–52 % eksploatacijos laikotarpio, ir apie pusę eksploatacijos trukmės traktorių darbas neracionalus. Daroma išvada, kad visą traktorių eksploatavimo laiką galima tobulinti technologijas, parenkant tinkamesnius variklių darbo režimus, mažinti degalų sąnaudas ir žalingą poveikį aplinkai.

Reikšminiai žodžiai: traktorius, degalų sąnaudos, žalingas poveikis aplinkai, variklio sūkių dažnis, variklio apkrova, eksploatacijos laikotarpis, sukimo momentas.

ОЦЕНКА РАБОЧЕГО КАЧЕСТВА ТРАКТОРОВ ПО ИХ ВРЕДНОМУ ВЛИЯНИЮ НА ОКРУЖАЮЩУЮ СРЕДУ

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Резюме

Целью исследований было уменьшение потребления горючего в тракторных двигателях и их вредного влияния на окружающую среду. Проанализированы качественные характеристики (обороты и нагрузка двигателя) разных моделей тракторов фирмы *Deutz Fahr Agrottron*, с разной наработкой моточасов за весь период эксплуатации. Исследованиями выявлено, что время работы тракторов с большой нагрузкой (>50% M_{max}) при средних (1000–2000 мин⁻¹) и больших (>2000 мин⁻¹) оборотах двигателя составляет 37–52% всего периода эксплуатации. Около половины всего времени в период эксплуатации тракторы работают нерационально. Делается вывод, что в период эксплуатации тракторов существует возможность совершенствовать технологии, шире применять лучшие режимы работы двигателей, снижать потребление горючего и вредное влияние на окружающую среду.

Ключевые слова: трактор, расход горючего, вредное влияние на окружающую среду, обороты двигателя, нагрузка двигателя, эксплуатационный период, крутящий момент.

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