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Characteristic load states of a tractor engine under farm operating conditions

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Summary. The paper presents the results of the in-use investigations of a U912 tractor operating in the conditions of an average farm in the Province of Lubuskie. In-use investigations of tractor engines under actual operating conditions allow an obtainment of a great deal of important information from the point of view of the end-user and the manufacturer. They determine the scale of mechanical loads on the engine and characterize the engine speed ranges at which they occur. An exact exploration of the load conditions and the characteristics of operation lead to an improvement of the engine design and optimize its durability and reliability of its individual elements.

Key words: farm tractor, combustion engine, in-use investigations.

INTRODUCTION

Empirical tests on farm tractors under actual farm operating conditions allows for an obtainment of valuable information on the engine loads that they must withstand while in operation. The loads that come from the coupled machinery and tools are realized by a combustion engine supplying mechanical energy. The value of the loads depends on many factors that are characteristic of the individual operating conditions. Field plowing, one of the hardest tasks for the same kind of plow may generate different power demand, which may result from different terrain conditions, type of soil, humidity, wheel slip, type of plowing etc. Different loads are generated during transport and other light tasks in agriculture [1, 2, 11]. A combustion engine of a farm tractor must thus have sufficient power output and dynamics in order to be able to fulfill such different conditions of operation – as opposed to combustion engines fitted in road vehicles [10]. An example analysis of the obtained in-use test results of the farm tractor engine loads is significant when evaluating the reliability and durability of the individual engine elements and fuel economy of the engine operation [3, 7].

The obtained results of the in-use tests of the farm tractors may be helpful improving the existing designs of both the engines and farm tractors as a whole as well as they may turn out invaluable in designing new machinery (engines). The changes may reduce the loads on the individual engine elements and reduce the fuel consumption, noise level, exhaust emissions and result in a more effective use of the farm tractors [4, 5, 6]. Despite the fact that in-use investigations are time consuming and costly we can still observe a growing interest of the manufacturers in this type of research.

RESEARCH METHODS

The in-use tests were conducted on a U912 farm tractor used in the farm located in the northeastern part of the province of Lubuskie in the strzelecko-drezdenecki powiat, municipality of Dobiegniew. This farm mostly grows winter cereals - rapeseed, wheat, rye and spring cereals - barley and oat and has an area of 87,6 ha. The tests were carried out in the period – July, August, and September when the tractor was most intensely used in fieldwork and for transporting of the crops. In the monitored period the tractor effectively operated for 100,3 hours. The URSUS 912 tractor is fitted with a Z8401.1 engine. In Table 1 its technical parameters have been specified.

Table 1. Technical specifications of the Z8401.1 engine

Basic technical data of the Z8401.1 engine		
Parameter	Unit	Value
Number of cylinders, c	-	4
Engine displacement, V_{ss}	dm^3	4,562
Rated power output, N_e	KW	57,1
Engine speed at rated power output, n_N	rpm	2200
Maximum torque, M_o	Nm	277,6
Engine speed at maximum torque, n_M	rpm	1450
Unit fuel consumption, g_e	$g \times kW^{-1} \times h^{-1}$	240

For the recording of the selected operating parameters of the tested engine the authors used a tractor recording system TRS-1 developed in the Chair of Agrotechnical Systems Engineering at West Pomeranian University of Technology in Szczecin [9]. The device generates time density TD characteristics of a piston combustion engine under actual operating conditions.

After a proper installation the device allows a fully automatic unassisted measurement. The activation of the measuring systems begins with the engine start-up and the end of the measurement takes place as the engine is switched off. TRS-1 measures and records in real time the engine speed, the amount of consumed fuel and the time of operation. The system is also fitted with a GPRS that enables the recording of the instantaneous location, covered distance and speed of the vehicle. The recorded quantities are stored on a removable data carrier from which the data is subsequently transferred to a PC computer for statistical processing.

Due to a small size of the measurement equipment and a full automation of the recording the tractor user operated the tractor similarly to previous years (which is of significance in terms of the representativeness of the collected data). The tractor user only indicated the kind of work performed in the subsequent days. The results obtained under such conditions can be deemed as typical use of a farm tractor on a farm coupled with similar machinery. The aim of the performed tests was to explore the distribution of engine speeds and torque of the tested engine under farm operating conditions while performing different tasks.

RESEARCH RESULTS

In the monitored period the engine was used for crop transport works (transport from the field to the farm premises and from the premises to the buying stations), and other works such as soil braking, disking, fertilizing etc. That is why in the figures the engine speed and torque were listed for these two tractor applications and the collective value for the whole period. Figure 1 presents the distribution of engine speeds for the transport task Fig. 1a and during 'other' works Fig. 1b.

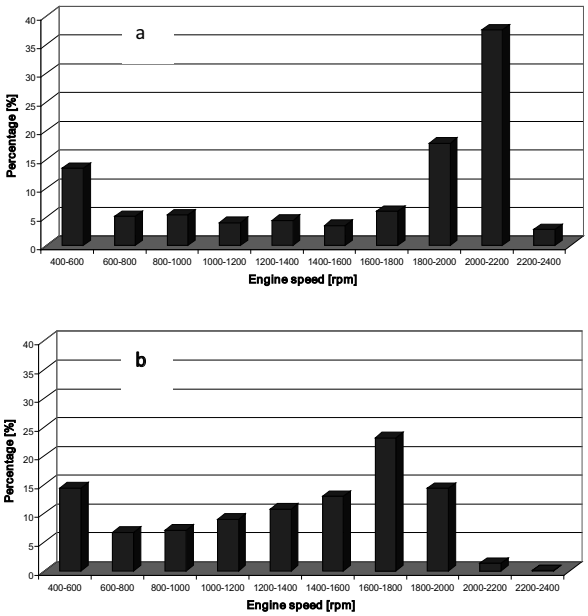
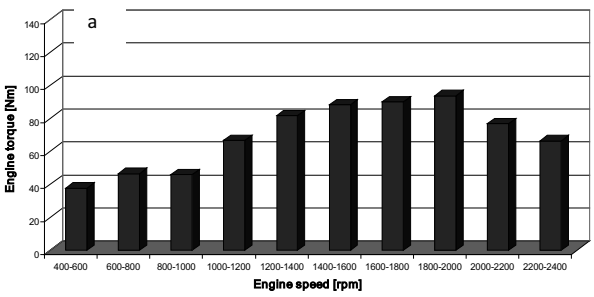


Fig. 1. Distribution of the Z8401.1 engine speed during: a) transport, b) 'other' works

From the analysis of the collected information on the use of the tested tractor and the time of performance of the individual tasks it results that these works were performed for 46,1 hours and other works for 54,2 hours. Such a high share of the works related to transport could be explained by high agrotechnical season during the tests when the tractors are coupled with trailers and collect grain from the harvester to transport it to the storage buildings.

As we can see in the results shown in Fig. 1 the distribution of engine speeds is different for transport tasks and 'other' tasks. The dominating speed for the transport task is the range from 2000 to 2200 rpm, which constitutes 37,5% of the total time of tractor operation with this task. For other works the dominating range is 1600-1800 rpm, which constitutes 23,2% of the total operating time. In both cases of the engine operation we can observe a great share of the engine operation at idle i.e. engine speed of 400-600 rpm (13,4% for transport tasks and 14,3% for 'other' tasks). Such a high share of this range is caused by the fact that he machines need to be coupled with the tractor and maintenance for 'other' works needs to be carried out (the driver does not switch off the engine). In the case of the transport tasks this is caused by waiting in a line for the buying station.



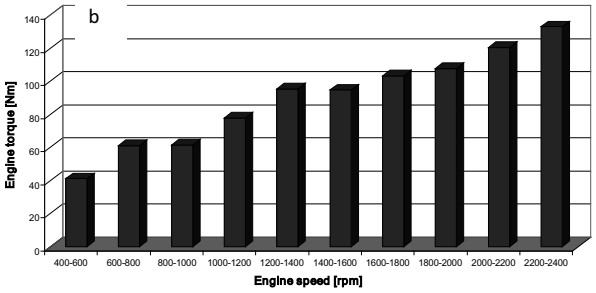


Fig. 2. Distribution of the Z8401.1 engine torque during: a) transport task, b) 'other' works

Fig. 2. in the form of graphs shows the distribution of the average torque as a function of speed and Fig. 3 the share of the individual ranges of torque in time. Approximately 75 % of the time in the transport task the engine worked with the torque in the range from 20 to 100 Nm (Fig. 2a). When performing transport tasks the torque was most frequently within the range of 60-80 Nm and constituted 25,8% of the total operating time. This torque is approximately 25% of the rate torque, which suggests a very small employment of the engine potential. When performing 'other' works we can distinguish two ranges of torque that were most frequently used. These were 20-80 Nm (38,5 % of the item) and 140-200 Nm (25,1 %). The first range corresponds to works at light field tasks (fertilizing, spurting) and the other to groundbreaking or disking [8].

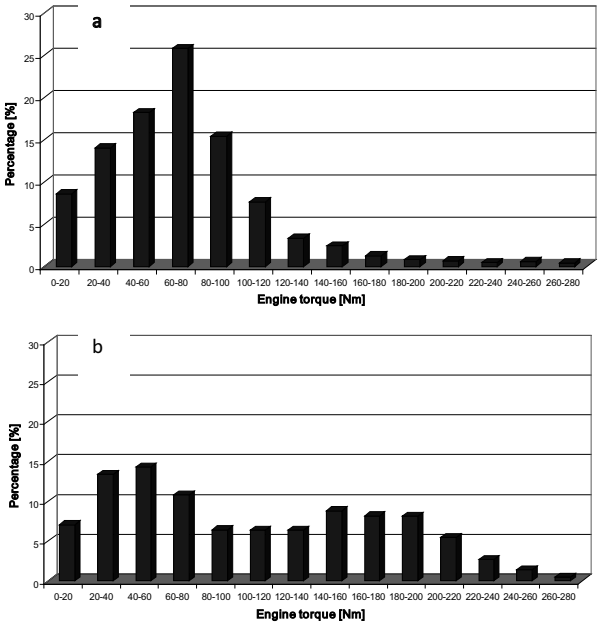


Fig. 3. Distribution of torque in the total work time a) transport, b) 'other' works

Figures 4, 5 and 6 show the average of the tested values in the whole period of the conducted investigations. The analysis of the obtained results from the in-use investigations of the Z8401.1 engine has shown that irrespective of the performed tasks (fieldworks, transport) there is a great share of the engine operation at idle (400-600 rpm) in the whole period of its operation (13,95 %).

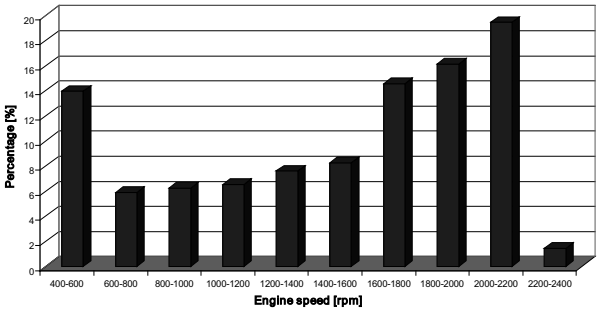


Fig. 4. Distribution of the average Z8401.1 engine speeds

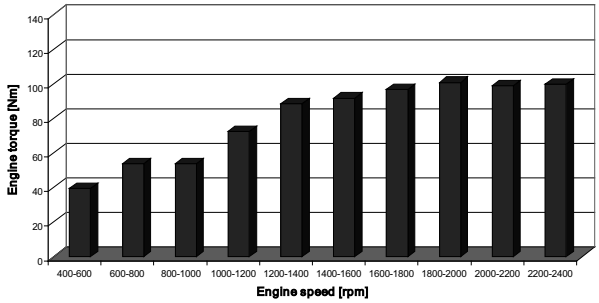


Fig. 5. Distribution of the average torque of the Z8401.1 engine for the individual engine speeds

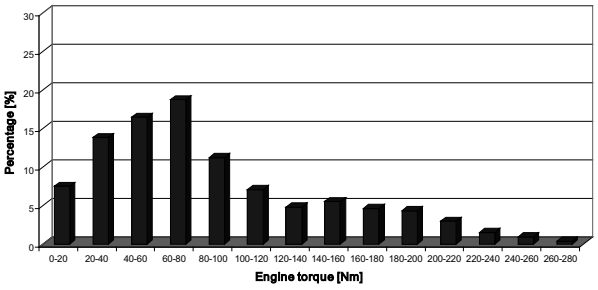


Fig. 6. Distribution of the average torque in the total operating time

Another range of the engine speeds i.e. 1600-2200 is over 50 % of the total operating time (including the engine speed of 2000-2200 - 19 %). Such a great share of the engine speed of 2000-2200 is caused by the fact that the tractor was used for road transport of the crops and was driven at its maximum road speed. At the same time the engine operated with the torque of 60-80 Nm. As results from Fig. 6 the tested farm tractor operated mostly at the torque within the range of 20 to 80 Nm (49 % of the total operating time – which constitutes approximately 49 hours). The operation at the torque from 140 to 200 Nm is 14,5 % of the time (approximately 14,5 hours).

CONCLUSIONS

1. The conducted in-use investigations of the Z8401.1 engine have shown that the farm tractor operated at idle for approximately 13,95% of the total operating time.

2. The dominant range of the engine speed was 2000-2200 rpm.
3. In the tested period the engine most frequently ran at the torque from 60 to 80 Nm (18,7 %) of the total operating time.
4. The employment of the engine power in the farm under analysis is very low and indicates an improper selection of the type of tractor to the agricultural tasks.
5. The results of the performed investigations confirm the purposefulness of this type of investigations as regards optimizing the selection of machines for tasks and designing machines for specific tasks in terms of maximum employment of their potential.

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CHARAKTERYSTYCZNE STANY OBCIĄŻEŃ SILNIKA CIĄGNIKOWEGO EKSPLOATOWANEGO W WARUNKACH GOSPODARSTWA ROLNEGO

S t r e s z c z e n i e . W artykule przedstawiono wyniki badań eksploatacyjnych ciągnika U912 eksploatowanego w warunkach przeciętnego gospodarstwa rolnego województwa lubuskiego. Badania eksploatacyjne silnika ciągnikowego w warunkach rzeczywistych umożliwiają uzyskanie bardzo wielu informacji istotnych z punktu widzenia zarówno użytkownika jak i producenta. Pozwalają one określić skalę obciążeń mechanicznych jakim jest poddawany obiekt oraz scharakteryzować zakresy prędkości obrotowych przy jakich one występują. Dokładne poznanie wymuszeń oraz charakterystyki eksploatacji pozwala poprawiać konstrukcję silnika jak i optymalizować trwałość i niezawodność poszczególnych węzłów.

S ł o w a k l u c z o w e : ciągnik rolniczy, silnik spalinowy, badania eksploatacyjne.