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PTNSS–2011–SC–200

Exhaust Emissions from agricultural vehicles used in transport

Abstract: The paper discusses the issues of exhaust emissions from vehicles most frequently used on farms. Transport is an integral part of food manufacturing almost on every stage of the product life cycle. Ready-to-eat food very often needs processing; it often incorporates transport of half products to appropriate facilities. The transport between the processing facilities and the distribution of food products are carried out by typical road vehicles i.e. heavy and light trucks. In the case of agricultural produce it is very often the farm tractors with appropriate trailer sets that are used for transport. The paper presents the comparison of the exhaust emissions and fuel consumption from a farm tractor and a car. The tests were performed under real operating conditions in real traffic. For the tests the authors used a portable exhaust emission analyzer Semtech by Sensors. Both vehicles covered the same route with the same load of 4000 kg.

Keywords: exhaust emissions, agricultural vehicles, transport

Emisja związków toksycznych spalin z pojazdów rolniczych wykorzytywanych do transportu

Streszczenie: Artykuł dotyczy problemu emisji związków toksycznych ze środków transportu najczęściej wykorzystywanych w rolnictwie. Z produkcją żywności związany jest transport niemal na każdym etapie istnienia produktu. Żywność gotowa do spożycia niejednokrotnie wymaga przetwarzania, bardzo często związane jest z transportem półproduktów do odpowiednich zakładów. Transport między zakładami przetwórstwa oraz dystrybucja produktów żywnościowych odbywa się przy wykorzystaniu typowo drogowych pojazdów, tzn. ciężarówek i samochodów dostawczych. Natomiast w przypadku płodów rolnych bardzo często do transportu wykorzystywane są ciągniki rolnicze z odpowiednim zestawem przyczep. W artykule przedstawiono porównanie emisji związków toksycznych oraz zużycia paliwa z ciągnika rolniczego i samochodu. Badania wykonano w rzeczywistych warunkach eksploatacji, w ruchu drogowym, przy użyciu mobilnego analizatora spalin Semtech firmy Sensors. Oba pojazdy pokonywały tą samą trasę z takim samym obciążeniem 4000 kg.

Słowa kluczowe: emisja związków toksycznych, pomiary w warunkach drogowych

1. Introduction

Transport is still one of the major sources of exhaust emissions and consumers of crude oil-based fuels. An important branch in the whole transport system is the transport of food. In this case this type of transport is very often carried out with the use of farm tractors (particularly in the case of transport of agricultural products to processing facilities). Also, in the case of transport within the farm area the farm tractors are used most frequently. The aim of the performed investigations was a comparative analysis of the exhaust emissions and fuel consumption under real operating conditions of a utility vehicle and a farm tractor. Such investigations represent the latest methodology in exhaust emissions testing and they become more and more important as their results show the real exhaust emission [2–6]. During the tests the vehicles covered an extra-urban road portion (a rural area) towing a trailer of the GVW of 4000 kg. The utility vehicle was coupled with the trailer through a novel towing solution in agriculture also known as hitch and pin. The actual semi-trailer is an effect of works on a transport system – it can be coupled with both a vehicle and a farm tractor. The developed solutions provide vehicle sets for transport purposes within a farm, orchard and field areas as well as in regular traffic. Replacing the tractor with a vehicle we ensure a road transport with speeds higher than regular tractor speeds. The proposed solution does not require reloading of the transported goods and reduces the time of transport to the destination and reduces the inconvenience in the road related to the vehicle speed, which is advantageous also for other road users. The hitch and pin compliant trailer is designed for coupling with the pickup vehicles fitted with a ball coupling. These trailers can also be coupled with farm tractors fitted with a ball-coupling adapter fitted in the rear three-point hitch. The use of this semi trailer enables an increase in the load of the drawbar on the rear axles of the towing vehicle. The consequence is the increase in the trailer payload.

2. Subject of the investigations and methodology

The tests were performed on a farm tractor and a utility pickup vehicle (fig. 1). The basic technical specifications have been presented in tables 1 and 2. Both vehicles were fitted with a diesel engine. The engine of the tractor (John Deere) is a modern VGT turbocharged, 1600 bar common rail multiple injection unit.

Fig. 1. View of the vehicles and the measuring devices

Table 1

Basic engine specifications John Deere 7530

Number of cylinders/displacement	6 cylinder, straight /6.8dm^3
Maximum power output	132 kW/ at 2100 rpm
Charging system	Turbo VGT
Cooling system	Forced flow - coolant
Injection system	Common rail
Number of valves	24

Table 2

Basic engine specifications Mitsubishi L200

Engine	4 cylinder, straight/2.477 dm^3
Maximum power output	100 kW/ at 4000 rpm
Maximum torque	314 Nm/ at 2000 rpm
Cooling system	Forced flow – coolant
Charging system	Turbocharged

The tests under real operating conditions were carried out on a road portion of 29.445 km. The route went through an extra-urban rural area. During the tests the vehicles hauled trailers with a load of approximately 4000 kg. During the tests the concentration of the exhaust components were measured (CO, HC, NO_x, CO_2) and the exhaust emission and fuel consumption were determined. The map with the marked route has been shown in figure 2.

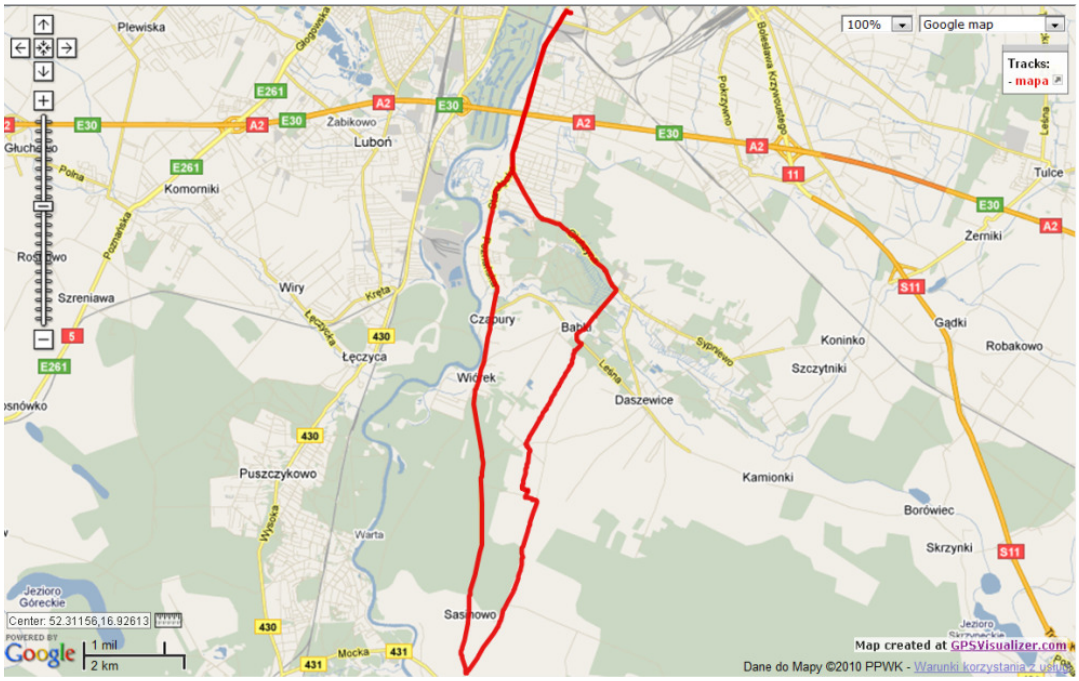

Fig. 2. The test route marked on the map

In order to measure the concentration of the exhaust emissions a portable exhaust emissions analyzer (SEMTECH DS by SENSORS) was used (fig. 3, tab. 3) [7]. The analyzer measures the concentration of the exhaust components and simultaneously measures the flow rate of the exhaust gases. The exhaust gases are introduced into the analyzer through a probe maintaining the temperature of 191°C. Then the particulate matter is filtered out (compression ignition engine) and the exhaust is directed to the flame-ionizing detector (FID) where HC concentration is measured. The exhaust gases are then cooled down to the temperature of 4°C and the measurement of concentration of NO_x (NDUV analyzer), CO, CO_2 (NDIR analyzer) and O2 follows in the listed order. It is possible to add data sent directly from the vehicle diagnostic system to the central unit of the analyzer and make use of the GPS signal. In the tests measurements of emissions were used and also, for the purpose of comparison, signals from an on-board diagnostic system were recorded, e.g. engine speed, load, vehicle speed and the temperature of the intake air. Some of these signals served to specify time density maps presenting the share of the operating time of the vehicles in real operation conditions.

Table 3

Characteristics of a portable exhaust analyzer SEMTECH DS

Parameter name	Measurement method	Accuracy
1. Emissions		
CO	NDIR, range 0–8%	±3%
HC	FID, range 0–10.000 ppm	±2%
$NO_x = (NO + NO_2)$	NDUV, range 0–2500 ppm	±3%
CO_2	NDIR, range 0–20%	±3%
O_2	Electrochemical, range 0–25%	±1%
2. Data storage capacity	Over 10 hours at 1 Hz data acquisition rate	
3. Vehicle interface capacity	SAE J1850 (PWM), SAE J1979 (VPW) ISO 14230 (KWP-2000) ISO 15765 (CAN), ISO 11898 (CAN) SAE J1587, SAE J1939 (CAN)	

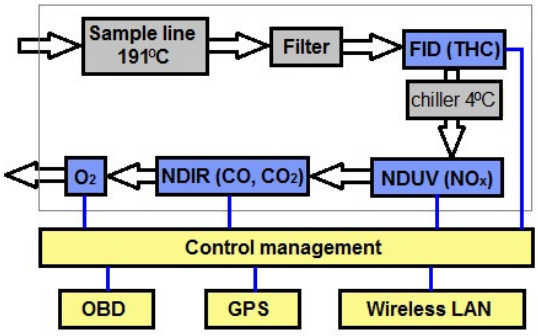

Fig. 3. A diagram of a portable analyzer SEMTECH DS; exhaust gas flow channels (arrow) and electrical connections circled (blue line)

3. Tests results and analysis

Based on the performed tests under real operating conditions it has been observed that the utility vehicle is characterized by better ecological parameters than the farm tractor (fig. 4). When analyzing the road emission from the whole driving test (the utility vehicle) it has been observed that the emissions of all the exhaust components were the lowest of the two tested vehicles and the emissions of the farm tractor were many times higher. The greatest difference was observed for the emission of CO that, for the tractor, was over 25 times higher. The emission of HC was 11 times higher and NO_x almost 6 times higher. The obtained results were compared with the Euro 4 standard. Except the emission of CO of the utility vehicle the emission of all the exhaust components for both the vehicle and the tractor exceeds the limits of the Euro 4 standard. Also, the fuel consumption/CO_2 emission was higher for the farm tractor (fig. 5) – over three times as compared to the utility vehicle.

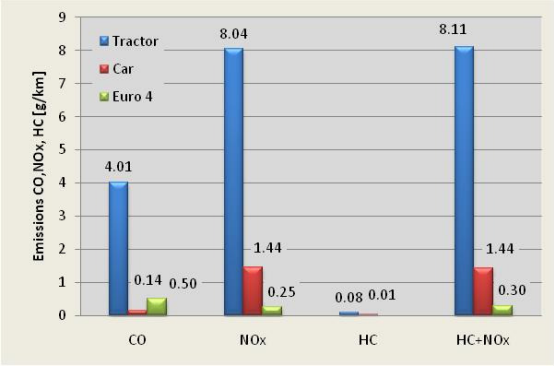

Fig. 4. Comparison of the road emission of the utility vehicle and the farm tractor during the tests under real operating conditions

In the aspect of load transport and use in regular traffic we also need to consider other parameters such as time and speed. Also in this respect the use of the farm tractor is disadvantageous. The time elapsed to cover the road portion during the tests was 72.6 min while the utility vehicle needed only 47.7 min. The average speed of the tractor was 24.58 km/h while in the case of the utility vehicle it was 37.33 km/h (fig. 6). These are significant parameters from the point of view of the traffic – farm tractors on public roads usually slow down the whole traffic.

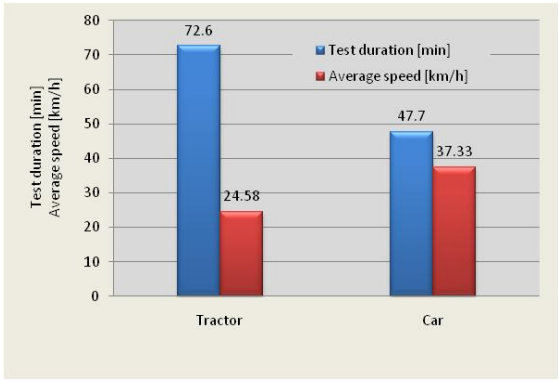

Fig. 5. Time and average drive cruise speeds during the tests under real operating conditions

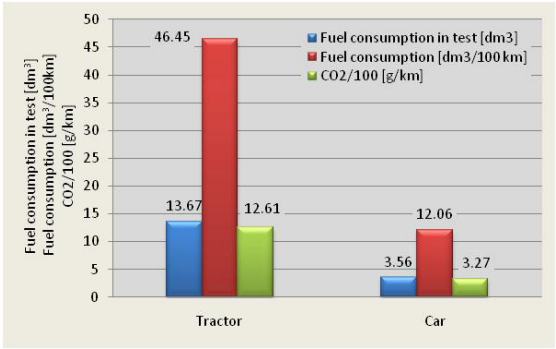

Fig. 6. Time and average cruise speeds during the tests under real operating conditions

4. Conclusions

The here presented exhaust emission testing methodology provides an opportunity of evaluating the emission level from farm tractors, utility vehicles and trucks used in agricultural transport. From the presented investigations it results that the transport of load of the mass of 4000 kg and probably also of lower mass is more advantageous when the utility vehicles are used. The transport with the use of a utility vehicle is characterized by a much lower emission of all the exhaust components as well as lower fuel consumption/CO_2 emission. Also other significant parameters put the utility vehicles before the farm tractors when transiting agricultural loads. The transport of load with the use of a utility vehicle reduces the time to the destination while the vehicle uses much less fuel and, thus is more economical. Another advantage that comes from the use of an agricultural utility vehicle instead of a farm tractor is the elimination of the traffic incon-

venience resulting from the fact that farm tractors are slow-moving vehicles.

The proposed trends in the here-discussed research should focus on the comparison of transport of higher loads, typical of agricultural characteristics reaching several tons. As a trend in further research in agricultural transport the authors are planning an evaluation of the ecological properties and other parameters related to the farm tractors and other agricultural machines carrying much higher loads then those presented in this paper.

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