Determination of The Effects of Loads on Some Engine Parameters for Agricultural Tractors

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Abstract : The objective of this study is to determine the load based engine exhaust temperature, cooling water temperature, fuel consumption and specific fuel consumption parameters and to examine the relationship between them. To this end, partial loads have been applied to three different tractor brands that are widely used in our country (Massey Ferguson 3085, New Holland TD85 and John Deere 5625) under workshop conditions at different PTO speeds (540, 540E, 750) by using an Eddy Current dynamometer. The trials have been carried out separately for each tractor and the engine parameters have been measured concurrently with the applied loads. In all trials the exhaust gas temperature has been found to be between 181.10-603.40 °C, the engine cooling water temperature between 63.20-83.40 °C, the fuel consumption between 3.15-15.68 L/h and the specific fuel consumption to be between 230.37-1112.79 g/kWh. According to the results of the research there is a distinct increase in the exhaust gas temperature and fuel consumption parameters due to the increase of PTO and there is a decrease with similar ratios in specific fuel consumption. Whereas cooling water temperature values tend to decrease very slightly due to power change. According to variance analysis results it has been determined that the PTO speed and PTO power factors and their interactions have statistically significant ($P<0.01$) effects on all the measured parameters. As a result of the study it has been concluded that even though the three PTO speeds have different engine operation parameters, they can be used as alternatives for each other for many PTO driven agricultural machines.

Keywords: Tractor, PTO, engine performance parameters

Introduction

Nowadays in the world against the energy shortages, quality and quantity of production, as well conscious of the mechanization of agricultural production to achieve the most ideal conditions is obligatory.

Mechanization of agricultural practices to ensure efficiency, knowledge of the ability of the tractor in agricultural enterprises, and accordingly the use of tractors conveniently, the use of tractors and business machines by increasing efficiency can help reduce operating costs

Aging of engine and the reduction in work efficiency depending on the annual working hours and working conditions of tractor usually are not being noticed or not ignored by the users. This situation is realized by the consume of more fuel for the same work of the tractor or unable to fulfill the work. These conditions causing significant losses in business is need to be foreseen and taken precautions.

To detect and evaluate negative changes mentioned by the tractor engine periodically parameters such as temperature and fuel consumption are required to determine. Because he loss of efficiency in engines are directly effective on tail shaft torque and power transferred from the agricultural machine, periodcally and practically the efficiency of PTO should be meassured. For this process, in static conditions usually workshop-type hydraulic dynamometer is used. With dynamometer, maximum tractor PTO power can be determined. The measurements will be made periodically, it informs users about the efficiency of the tractor engine.

In this study partial loads have been applied to three different tractor brands that are widely used in our country (Massey Ferguson 3085, New Holland TD85 and John Deere 5625) under workshop conditions at different PTO speeds (540, 540E, 750) by using an Eddy Current dynamometer. The objective of this study is to determine the load based engine exhaust temperature, cooling water temperature, fuel consumption and specific fuel consumption parameters and to examine the relationship between them.

Specific Fuel Consumption and Fuel Consumption

Motor is a machine that converts heat energy resulting in the burning of fuel in cylinders to mechanical energy. Power produced per unit time to the amount of fuel consumed is called the specific fuel consumption. Specific fuel consumption varies depending on engine load conditions. For example, the fuel consumption at full is less than the half that of gas.

Engine Exhaust Gas and Water Temperature

In ınternal combustion engines, the ratio of beneficial work from the motor shaft to the energy supplied with fuel to machine is defined as brake thermal efficiency. The fuel to the engine that convert heat energy into mechanical energy, some losses have occurred. These losses occur by exhaust, cooling, friction and radiation. To increase the brake thermal efficiency, it is necessary to reduce these losses and to know the share of total losses.

Kayıp enerjilerin ve efektif gücün belirlenerek değerlendirilmesine ısı balansı denilmektedir.

Evaluation of energy loss and effective power is called as heat balance. Heat balance that define the economy in engine also give idea about the various losses.

In ınternal combustion engines, the maximum cycle temperature is limited due to the structural features of the engine. Therefore, in reciprocating internal combustion engines, it is necessary cooling systems to check the temperature of engine parts. For four-stroke diesel engines, the heat loss through the cooling is ranged from 20-28%. This heat loss comprises the heat passing to cooling water and lubricating oils. An average of only 8% loss of lubricating oil is in question.

Material and Method

In workshops, experiments conducted at static conditions, full and partial load is applied to three test trials of the tractor tail spindle and the necessary parameters have been determined. Measurement systems used for this purpose is given schematically in Figure 1.1

In experiments carried out in workshop conditions, loads connected to the tractor PTO engine exhaust gas temperature, cooling temperature, fuel consumption and specific fuel consumption parameters are examined, evaluated the relationship between them.

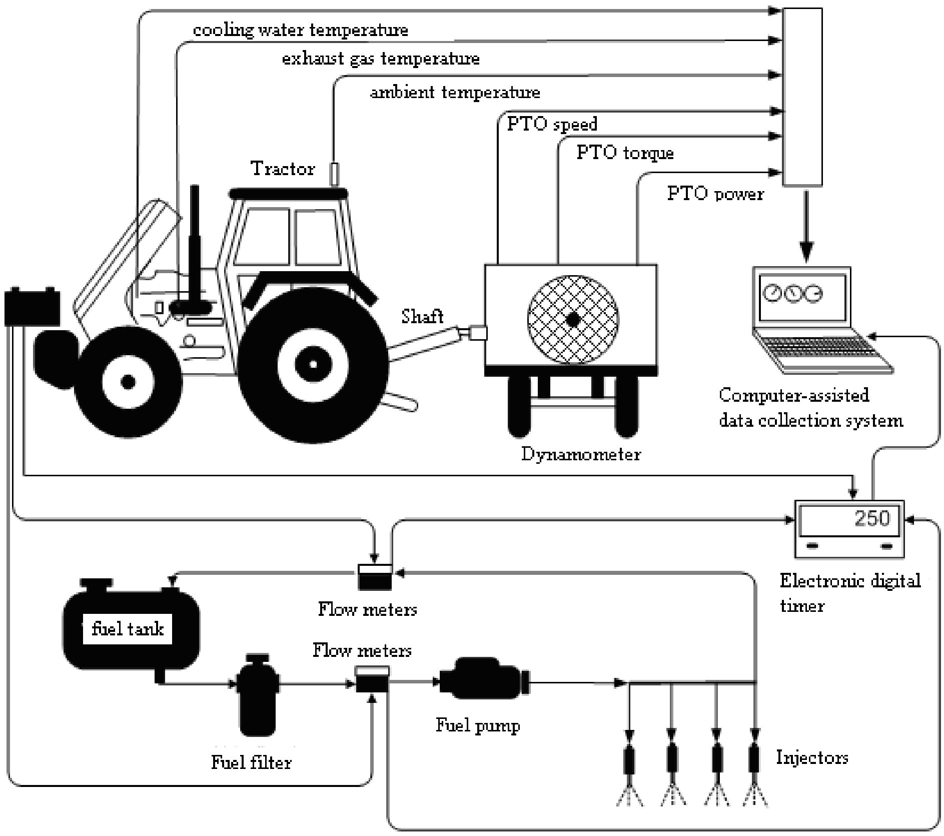

Figure 1.1. Schematic illustration of measurement systems used in research

Relations Between PTO Power and the Exhaust Gas Temperature

Engine exhaust gas temperatures measured for each load level applied to the tractor PTO are given in Table 2.1.

PTO power (kW)	exhaust gas temperatures (°C)								
	540			540E			750		
	JD 5625	NH TD85	MF 3085	JD 5625	NH TD85	MF 3085	JD 5625	NH TD85	MF 3085
5	238.00	248.30	267.80	181.10	203.70	219.30	232.00	267.20	276.80
10	253.10	277.60	302.20	209.80	244.00	270.50	256.60	293.90	308.30
15	278.20	311.80	337.30	248.80	286.90	320.00	281.30	324.80	342.90
20	299.30	345.60	373.90	281.60	330.40	372.40	302.00	354.80	376.00
25	323.30	378.90	404.60	310.50	368.80	420.00	331.40	387.90	414.80
30	348.50	412.00	437.00	339.50	411.20	474.80	356.70	419.10	443.00
35	373.80	446.10	471.20	368.50	452.80	518.00	374.20	448.90	477.00
40	405.30	481.00	501.00	407.20	494.40	570.90	406.90	480.20	504.20
45	422.50	514.70	531.90	439.90	540.30	603.40	428.60	511.50	532.70

Table 2.1. Engine exhaust gas temperatures

When the charts examined, exhaust gas temperatures obtained for John Deere 5625, New Holland TD85 ve Massey Ferguson 3085 tractors was found to increase in application of three PTO depending on the load levels.

Relations Between PTO Power and Cooling Water Temperature

Engine cooling water temperatures measured each load level applied to the tractor PTO are given in Table 2.2

PTO power (kW)	cooling water temperatures(°C)								
	540			540E			750		
	JD 5625	NH TD85	MF 3085	JD 5625	NH TD85	MF 3085	JD 5625	NH TD85	MF 3085
5	81.90	67.00	64.10	79.40	65.00	63.20	82.80	66.00	63.20
10	82.20	67.50	67.30	80.10	65.10	66.60	81.90	66.00	64.80
15	82.30	68.00	70.70	80.10	66.00	69.40	82.20	66.80	71.60
20	82.10	69.00	74.10	80.00	66.00	72.20	81.90	67.00	74.10
25	81.80	69.40	74.60	80.00	67.00	75.00	82.90	67.30	74.60
30	82.60	70.00	74.70	80.30	67.50	76.00	82.60	68.00	74.70
35	82.90	70.00	76.00	80.80	68.00	76.40	82.80	68.00	76.00
40	83.40	71.00	75.10	81.40	69.00	77.00	82.10	69.00	75.10
45	83.40	71.20	76.00	81.50	70.00	76.80	83.00	69.00	76.00

Table 2.2. Engine cooling water temperature values

Cooling water temperatures obtained for he John Deere 5625 ve Massey Ferguson 3085 tractors was not found significant difference in the application of three PTO depending on the load levels.

Relations Between PTO Power and Fuel Consumption

Engine fuel consumption measured each load level applied to the tractor PTO is given in Table 2.3

PTO power (kW)	Fuel consumption (L/h)								
	540			540E			750		
	JD 5625	NH TD85	MF 3085	JD 5625	NH TD85	MF 3085	JD 5625	NH TD85	MF 3085
5	6.62	5.09	4.76	3.93	3.55	3.15	6.73	5.83	5.36
10	7.45	5.95	5.72	4.81	4.58	4.14	7.52	6.75	6.27
15	8.44	6.90	6.73	5.79	5.60	5.22	8.52	7.82	7.45
20	9.52	8.02	7.79	6.85	6.75	6.38	9.63	9.00	8.73
25	10.55	9.08	9.00	7.89	7.81	7.50	10.74	10.08	9.96
30	11.66	10.21	10.17	8.98	8.95	8.73	11.96	11.38	11.15
35	12.92	11.30	11.34	10.08	10.06	9.88	13.28	12.54	12.43
40	14.33	12.53	12.70	11.36	11.33	11.17	14.50	13.63	13.80
45	15.38	13.78	13.93	12.59	12.67	12.54	15.68	14.92	15.02

Table 2.3. Motor fuel consumption values

Fuel consumption values for John Deere 5625, New Holland TD85 ve Massey Ferguson 3085 tractors was found to increase in application of three PTO depending on the load levels.

Relations Between PTO Power and the Specific Fuel Consumption

Engine specific fuel consumption values measured each load level applied to the tractor PTO is given in Table 2.4

PTO power (kW)	Specific fuel consumption (L/h)								
	540			540E			750		
	JD 5625	NH TD85	MF 3085	JD 5625	NH TD85	MF 3085	JD 5625	NH TD85	MF 3085
5	1095.64	841.17	786.86	649.90	586.84	520.82	1112.79	964.33	886.27
10	616.01	492.45	472.74	398.19	378.53	342.31	622.29	558.24	518.90
15	465.19	380.50	370.78	319.01	308.48	287.62	469.78	431.18	410.83
20	393.68	331.59	322.21	283.19	279.06	263.81	398.09	372.12	361.02
25	349.10	300.27	297.65	261.03	258.42	248.10	355.14	333.52	329.64
30	321.35	281.43	280.33	247.52	246.80	240.78	329.63	313.64	307.31
35	305.29	266.99	267.92	238.15	237.65	233.48	313.85	296.19	293.63
40	296.23	259.02	262.51	234.80	234.26	231.01	299.85	281.86	285.36
45	282.58	253.26	256.04	231.36	232.90	230.37	288.20	274.11	276.05

Table 2.4. Engine specific fuel consumption values

Specific fuel consumption values obtained for the John Deere 5625, New Holland TD85 ve Massey Ferguson 3085 tractors was found to decrease in application of three PTO depending on the load levels.

Conclusions and Recommendations

Study, for 540 rpm , the tail of a tractor PTO shaft speed to the load applied in the experiment in the with the tail.In this study, for loads applied to the trial tractors which are in 540 rpm PTO speed , tractor fuel consumption, specific fuel consumption and PTO torque variables were determined.

Torqu values depending on the loadings for 540 rpm PTO speed are varied among the 88 888 Nm. That implies the change in PTO speed with the same power levels will also change the torque values. In other words, because of the different torgque needs of agriculturel machinery moving from PTO, operating characteristics of an agricultural machine working with 540 rpm speed may vary with 750 rpm speed. 750 rpm PTO option is used for agricultural machines that not require more torque as an alternative speed option for 540 rpm and 1000 rpm PTO speed.

During the dynamometer test, torque power and speed measurements in parallel with the fuel consumption values were also measured. The data obtained by processing the results of calculations , specific fuel consumption was also determined. Values for fuel consumption increased proportionally with the power values despite specific fuel consumption decreased with increasing levels of power. For Massey Ferguson 3085, New Holland TD85 ve John Deere 5625 tractors with the same speed level, avarage special fuel consumption value increased 9.92%, 11.16% ve 1.70% respectively when it is passed from 540 rpm PTO to 750 rpm PTO.

Fuel consumption values of 750 rpm instead of 540 rpm PTO speed with the case has shown a certain tendency to increase. When all the applied load is taken into account (5 50kW), the fuel consumption increase rate between two PTO speed varied between the values 7.56-12.63% for Massey Ferguson 3085, 7.59 14.64% for New Holland TD85 and 1.00-2.80% or John Deere 5625 tractor.

Cooling water temperatures are 63–77 ºC, 66–72 ºC and 79–87 ºC respectively for Massey Ferguson 3085, New Holland TD85 ve John Deere 5625 tractors respectively. These difference between cooling water temperatures are thought to be arised from the different thermostat features.

In this study, 540 rpm and 750 rpm PTO speed were compared statically only workshop conditions. From the evaluations, especially fuel consumption and specific fuel consumption parameters are emphasized. However, this study should be support with the field work. For example when disk fertilizer distribution machine is run with 750 rpm instead of 540 rpm PTO speed, it would be possible that work wildth will increase and work completion time will be influenced. For these reasons, the differences between the two PTO speed (work size, operating time, fuel consumption, torque, etc) should be compared for various agricultural machinery moving from PTO in actual working conditions.

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