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APPLICATIONS OF NRTC CYCLE TO DETERMINE A DIFFERENT FUEL CONSUMPTION AND HARMFUL EMISSIONS CAUSED BY CHANGES OF ENGINE'S TECHNICAL CONDITIONS

The main topic of the paper is to determine different fuel consumption and harmful emissions caused by engine's changes of technical conditions. The change of technical condition of combustion engine at any working point of engine proves different change of fuel consumption and production of harmful emissions. Therefore it is necessary to compare two technical conditions to determine the same engine load. For this purpose the special simulation programme of engine load in Non-Road Transient Cycle (NRTC) was created.

Keywords: *internal combustion engine, fuel consumption, harmful emissions.*

1. Introduction

The flawless, reliable, ecological and economical operation is required from vehicles's engines and their equipment. These requirements are not possible to guarantee by quality of design and production only but it is necessary to maintain the engine by regular controls.

During technical life the growth of specific fuel consumption (as increase of carbon dioxide emissions) accompanied with other harmful emissions is caused by engine's impacts of progressive detritions. Application modern diagnostic methods are possible to reach rectification and decrease the production of harmful emissions on to standard level app. by 90 % of cases. From the point of economy and ecology of operation the specific fuel consumption is one of the most important parameters of combustion engines. The lesser is engine's specific fuel consumption the better is environment protection. But the specific fuel consumption is too complex diagnostic signal because almost any engine failures are shown in its increase.

2. Methods

For experiment of different engine consumption and harmful emissions in dependence on change the engine's technical condition was used in Non-Road Transient Cycle (NRTC) [1,2]. This cycle is accepted by European Union directives to represent the typical tractor's engine load during work under outdoor conditions (terrain).

The tested engine was Zetor 7701. Parameters of this engine are below in the Tab. I. The fuel consumption and the production of harmful emissions depend on different adjusted engine's speed and torque. Measurement was carried out under good technical conditions of engine and subsequently under the worse technical conditions of engine. The worse technical condition has been simulated by a modification of the pre-injection angle (changed onto 18 %). Discreet measuring values were processed onto continuous surface of fuel consumption and harmful emissions depending on engine speed and torque. The fuel consumption and harmful emissions at every working points of NRTC cycle was obtained from the continuous surface by the help of PC program.

Tab. 1. Parameters of the engine Zetor 7701

engine type	*Z 7701*
fuel	*diesel*
maximum power output	*55 kW*
maximum torque	*280 Nm*
cylinder number	*4*
piston bore	*102 mm*
piston stroke	*120 mm*
compression ratio	*17*
nominal rpm	*2200 ot/min*
pre-injection	*25° in front HÚ*
injection pressure	*18,7 ± 0,1 MPa*
injection pump	*PP 4 M 3137 S 0164*
efficiency regulator	*RV M 900 1100 3300*
injector-nuzzle	*DOP 160 S 430 – 1436*

2.1. The characteristic of fuel consumption in good technical condition

The continuous surfaces are created from values engine consumption and harmful emissions in dependence on engine speed and engine torque measured in two technical engine conditions. These created surfaces subsequently limited by maximal moment and losing engine moment. Thereby we delimit the working engine area.

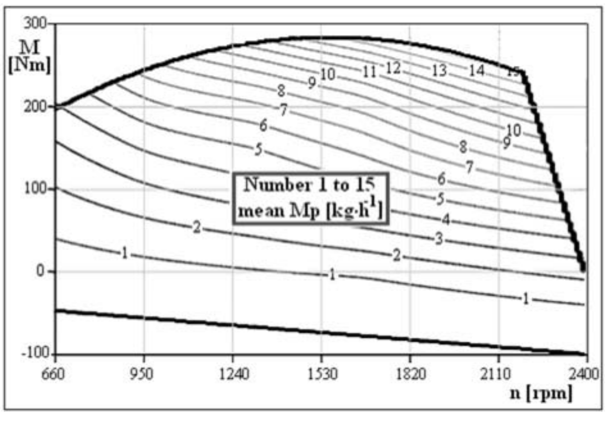

Fig. 2.1. The hourly fuel consumption in dependence of engine speed and engine torque

Tab. 2.1. The example of fuel consumption in selected working engine points

fit(660,28)=0.819	fit(1500,100) = 4.139	fit(2000,280) = 16.834
fit(1000,0) = 0.709	fit(1500, 180) = 6.692	fit(2200.100) = 6.397

2.2. The characteristic of fuel consumption in worse technical condition

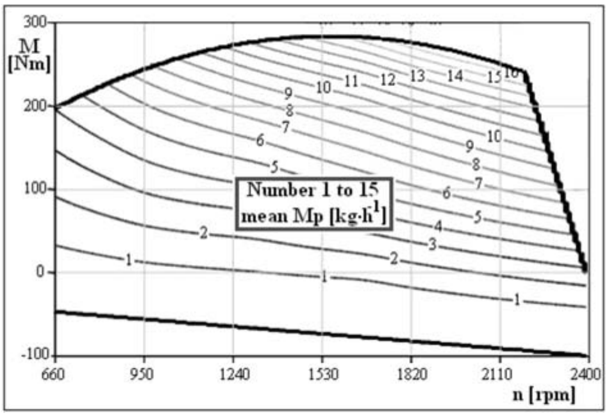

Fig. 2.2. Hourly fuel consumption in dependence of engine speed and engine torque

Tab. 2.2. The example of fuel consumption in selected working engine points

fit(660,28) = 0.913	fit(1500,100) = 4.485	fit(2000,280) = 18.77
fit(1000,0) = 0.782	fit(1500,180) = 7.642	fit(2200,100) = 7.294

2.3. The course of engine speed and torque

The engine speed and torque is given percentage in cycle. The first necessary step which is needed for other processing is lead over this percentage setting on engine speed [rpm] and engine torque [Nm].

Specified percentage rpm are transfered into the rpm depending on the time, this way:

There will determine referential rpm, which forms a base (100 %) for calculation of actual motor rpm. This is close to the nominal rpm:

$$n_{ref} := n_{lo} + 0.95(n_{hi} - n_{lo}) \quad (2.1)$$

Where: n_{ref} is referential engine speed [rpm]; n_{lo} is low engine speed [rpm], determined by calculating 50% of the declared maximum net power; and nhi is engine speed [rpm] determined by calculating 70% of the declared maximum net power (so rpm higher then nominal).

The actual engine speed:

$$n(s) := \frac{(n_{ref} - n_{idle}) \cdot n_{\%_s}}{100} + n_{idle} \quad (2.2)$$

where: *n(s)* are actual engine speed in NRTC cycle [rpm], nidle idle engine speed 660 [rpm], nref are reference engine speed 2294 [rpm] and $n_{\%_s}$ are set percentage engine speed.

Specified percentage engine torque will transform on the torque [Nm] depending on the cycle time, this way:

The actual engine torque:

$$M_c(s) := M_{max}(s) \cdot 0.01 \cdot M_{\%_s} \quad (2.3)$$

Where: $M_c(s)$ is course of engine torque [Nm], $M_{max}(s)$ is maximal moment by given engine speed cycle and $M_{\%_s}$ is set engine torque in cycle.

3. Result

If we know the mode of engine speed and engine load in given cycle (fig. 2.4), we would have to assign to single points (engine speed x engine load) from surface of hourly engine consumption given by immediate fuel consumption. The model of NRTC cycle is founded on presumption that every measured point continuance in its course for a period 1 second. By this period is every points assigned fuel consumptions which is corresponding by given engine speed and engine load.

Influence of engine failure the fuel consumption increased in cycle from 1,779 kg to 2,002 kg and average specific fuel consumption increased from 275,755 [g·kWh-1] to 306,784 [g·kWh-1].

In the same way as the fuel consumption, the different production of pollutant emission can be expressed.

The engine produced in good technical condition during cycle 5,411 kg emission carbon dioxide, 165,373 g emission carbon monoxide, 1,025 g emission hydrocarbon and 42,71 g emission nitrogen oxides.

The engine produced in worse technical condition 5,77 kg emission carbon dioxide, 254,058 g emission carbon monoxide, 1,157 g emission hydrocarbon and 30,6 g emission nitrogen oxides.

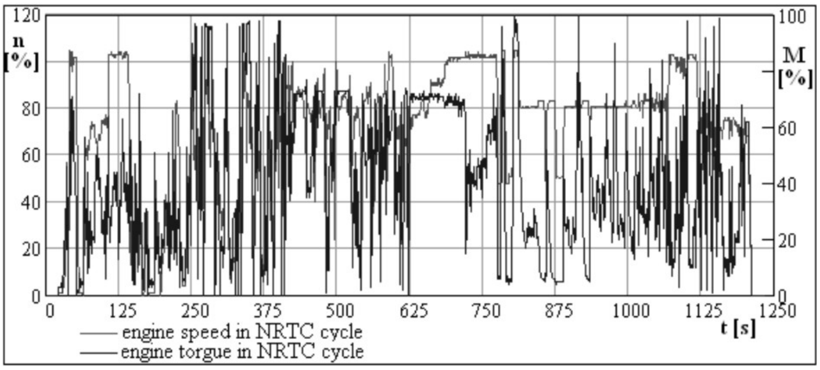

Fig. 2.3. The course of percentage engine speed and engine torque in NRTC cycle

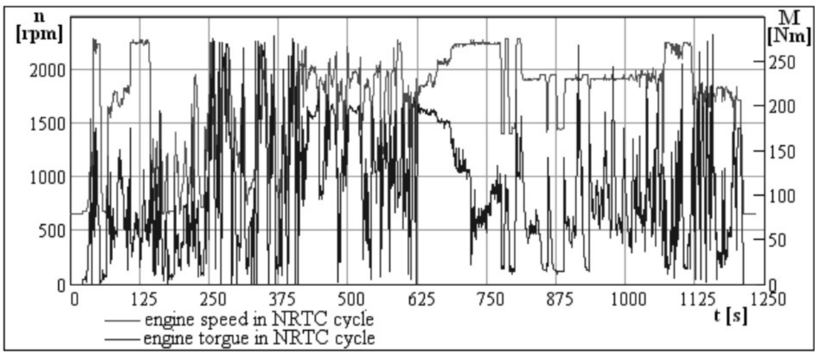

Fig. 2.4. The course of engine speed and engine torque in NRTC cycle

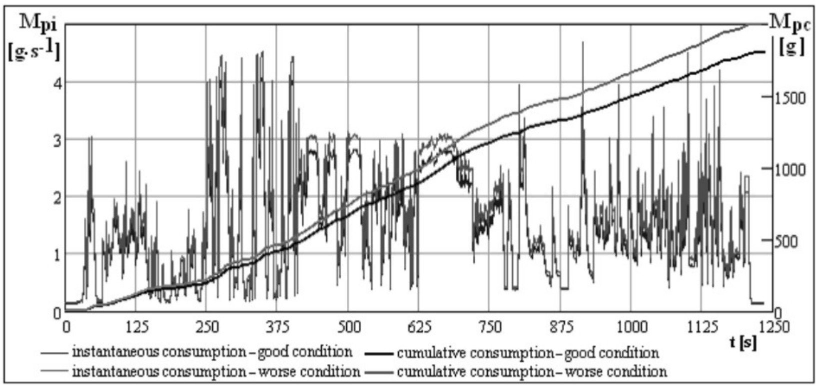

Fig. 2.5. The course of immediate and cumulative fuel consumption in NRTC cycle

4. Discussion

The technical condition has undoubtedly impact on fuel consumption and production of harmful emissions. The evaluation impacts on change of engine's technical condition by mere comparison with fuel consumptions and harmful emissions production in a few points of working characteristic has only minimal testify ability about harmfulness vehicles.

Because during of operation happen to ingravescence of technical engine condition and thereby too increase emissions production, is controlled the emissions production from motor vehicles in regular interval. At present is provided this measure in Vehicle Technical Station and is technical and economical compromise by which is evaluated only combustion's quality in two working points the motor's characteristic. Like this provided control has only little predicative ability about its harmfulness.

Into the future will be suitable to lead new inspection maintenance, which will be objective in adjudication given vehicle.

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