AN ANALYSIS OF FUEL CONSUMPTION BY A LORRY WITH THE COMPRESSION IGNITION DYNAMIC CHARGED ENGINE

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Summary. The article presents tests results over the influence of dynamic charge on the volume of fuel consumption by a lorry /car/. Besides, some of the tests results are discussed regarding dynamic charge of the engine SW-680. The traction profiles have been made of mileage fuel consumption. The usefulness of such type of tests for making analyses of influence of construction changes on car properties has been proved.

Key words: fuel consumption, dynamic charge, rotary moment, movement resistance.

INTRODUCTION

In the last period of time a fast increase of oil prices has been observed resulting in the growing price of fuel. The increasing tendency of fuel prices cannot be avoided because of continuously diminishing reserves of the oil and using it as an instrument of political pressure. Because of these reasons, the constructors' efforts are acting in two directions:

- the first is to use alternative fuels such as fuels of vegetable origin, hydrogen, electrical energy etc.,

- the second direction is to lower the fuel consumption.

The use of alternative fuels is pretty inconvenient, because of significant differences in physical and chemical properties /characteristics/ in relation to oil-derivative fuels, however in the country as well as abroad some successes are noticed in that field.

Lowering the fuel consumption can be reached by the organisation improvement of combustion process and increasing the general efficiency of the engine.

One of the methods of effectiveness improvement of engine work is charging.

Presently, the most popular charging is with the use of turbo-compressor complex, making use of fumes /exhaust gas/ energy for powering turbine, which subsequently powers compressor. The use of turbo-charging allows reaching this same power from the engine with lower cubic capacity. An engine with lower cubic capacity will use less fuel [1,7,8,15,20].

Another way of charging is dynamic charge, which is using vibration of the pillar /stud/ charge in approaching line. The system of dynamic charge doesn't ensure such spectacular results as turbo-charge, however it is used as a way of influence on the profile of engine moment. Well, the proper selection of the engine's approaching system ensures occuring /the presence of/ the charge effect in specific range of crankshaft's rotary speed of the engine, which allows to fit the engine to the character of car work. Proper adjustment of the engine to the character of car work will result , among other things, in lower fuel consumption in the area of general profile in which the engine works the most often [3,7,8].

Considerations regarding the fuel consumption are not giving in any case the ultimate results. This is caused by car work in different, most often impossible for repetition, conditions. Because of that the necessity of elaboration of different, applicable tests arose, simulating different conditions. The applicable tests are carried out in chassis of engine test house in conditions more or less different from the real ones. However, the results obtained in road measurements link to specific conditions of work and they cannot be compared with the results received in other conditions.

A lot of factors influence the fuel consumption by the car. They have been presented in Fig. 1 as a system of driver - car - environment [18]. As you can see those factors are closely tied with each other, it means, that any change of any factor will influence the amount of fuel consumption.



Fig 1. Connection diagram of the factors which have an influence on fuel consumption by the car [18]

It is obvious, that fuel consumption by the car will be influenced, to a large degree, by the level of fuel consumption by the engine. It is determined with the help of hourly and unitary fuel consumption. At the moment we are dealing with certain discrepancy of expectations of cars' and engines' constructors. For the constructor of combustion engine the most important is the level of unitary fuel consumption, which is the measure of engine efficiency, however for the constructor of a car and for its user the most crucial will be how much of fuel the engine uses per a definite distance [2,9,12,18,19]. During those types of considerations we should keep in mind, that the

lowest mileage fuel consumption does not appear during the engine work with the lowest unitary fuel consumption [2].

SIMULATION TESTS ON FUEL CONSUMPTION

For initial assessment of fuel consumption by a car, perfectly fit are different kinds of simulation tests based on a theoretical analysis of fuel consumption by the car in such conditions in which the car will most often work [3,7,8]. According to the opinion of the author, a good tool for simulation of fuel consumption in any motion /movement/ conditions is the traction profile of fuel consumption. The traction profile presents the relationship of driving power on wheels Pk as a function of linear speed V of the vehicle. From the traction profile the balance conditions of driving powers on individual transmission ratios and movement resistance can be read [2,9,18,19]. Classical traction profile is determined for driving powers on wheels with regard to rotary moment of the engine working with maximum dose of fuel. With the use of classical traction profile it will not be possible to make a readout of fuel consumption by the car. To be able to do that, an isoline of mileage fuel consumption should be plotted on traction profile. For making the profile of mileage fuel consumption by the car the loading profiles of the engine will be used, from which proper values of rotary moment should be read out as well as adequate to that moment values of hourly fuel consumption. The values of the moment will be converted to driving power on wheels according to the relationship [2,9,18,19]:

$$P_k = \frac{M_s \cdot \sigma \cdot \eta_m \cdot i_c}{r_d} \text{ [N],}$$

where: Ms - rotary moment of the engine [Nm],

 δ – coefficient of power loss under the mask

ηm - mechanical efficiency of driving system,

ic - total shift,

rd - dynamical wheel radius.

The values of hourly fuel consumption will be converted to the mileage fuel consumption with definite linear speed of the vehicle according to the following relationship [2,9,18,19]:

$$Q = \frac{100 \cdot G_h}{\gamma_n \cdot V} \, [\mathrm{dm}^3/100 \, \mathrm{km}],$$

where: Gh - hourly fuel consumption [kg/h],

 γp – density of the fuel [kg/dm3]

V - linear speed of the car [km/h].

The author used such units on purpose, because they are commonly used, and consequently, the interpretation of research results will be easier and and better comparable.

In order to link the fuel consumption to driving conditions, the lines of the sum of rolling resistance will be plotted on the profile, air and raising calculated based on the following relationship [2,18,19]:

$$M_{op} = \frac{\left(W_t + W_p\right) \cdot r_d}{i_c} = \frac{\left[f_t^{\ 0} \left(1 + 0,0005 \cdot v^2\right) \cdot G_c + 0,613 \cdot c_x \cdot F \cdot v^2\right] \cdot r_d}{i_c},$$

where: Wt - rolling resistance [N],

Wp – rolling resistance [N],

 r_d – dynamical radius of the wheel [m],

 i_{c} = ibigizw – total transmission ratio as a product of transmission ratios of gearbox, main transmission and reduction gear,

 f_t^0 – resistance coefficient of base rolling,

v - speed of the vehicle [m/s],

c_v – undimensional /dimensionless/ coefficient of air resistance (shape's coefficient)

 G_{c} – total weight of the vehicle [N],

F - front area [m2].

TESTS RESULTS

The object of the engine test house was an engine with spontaneous ignition of SW-680 type. That kind of engine was used in Jelcz lorries, buses and agricultural and building machines.

The tested engine was equipped with dynamic charge system with single approaching line [6,10,11,12,13,15,16,17,20]. The tested charging system made it possible to change the length of the approaching lines . During tests a lot of external profiles have been made for the following lengths of approaching line Ld: 643, 693, 743, 793, 843, 893, 943, 993, 1043, 1093, 1143, 1193, 1243 and1293 mm. Based on an analysis of the received results the following lengths have been chosen for future tests and analysis: 743, 843 and 1143 mm. For those lengths the partial and loading profiles have been made.



Fig 2. Traction profile of mileage fuel consumption for the engine with the length of approaching line of 743 mm

Based on loading profiles the traction profiles of mileage fuel consumption have been made. The simulation tests assumed that the total weight of the car was Gc = 200000 [N], the rest of the parameters describing vehicles (dynamical wheel radius, total transmission ratio, mechanical efficiency of driving system, width and height of the vehicle) were taken from technical profile of Jelcz 317 lorry[10,11,12,13]. The outcomes of the simulation are presented in Fig. 2, 3, 4.

As it can be seen in Fig. 2 the maximum driving power on wheels comes to 44000 Nm. That kind of power makes it possible to overcome the hills with the slopes slightly above 20% with the use of the fuel approximately 450 dm3/100 km. The lowest fuel consumption at which it is still possible, to cause the movement /motion/ of the lorry with the speed of 70 km/h comes to 35 dm3/100 km, using sixth gear. The maximum speed of a lorry, reached on fifth gear comes to 90 km/h with the fuel consumption of 50 dm3/100 km. On sixth gear, a slightly lower speed can be reached of 87 km/h with the fuel consumption on the level of 45 dm3/100 km.



Fig. 3. Traction profile for mileage fuel consumption for the engine with the length of approaching line of 843 mm

For the length of approaching line of 843 mm drawing 3 maximum driving power on wheels comes to 45000 N. Maximum hill which can be overcome also exceed slightly 20% with the fuel consumption of 430 dm3/100 km, a little bit less then than in previous case. Maximum speed of the lorry /car/ comes to a bit more than 90 km/h on fifth gear with the fuel consumption on the level of 50 dm3/100 km. On the sixth gear the car is reaching the speed of 88 km/h with the fuel consumption of 41 dm3/100 km. The lowest fuel consumption coming to 30 dm3/100 km makes it possible to drive a car with the speed of 70 km/h on sixth gear.



Fig. 4. Traction profile for mileage fuel consumption for the engine with the length of approaching line of 1143 mm

For the length of approaching line of 1143 mm the maximum driving power on wheels comes to approximately 44000 N and makes it possible to drive on hills with the slope slightly exceeding 20%, using first gear. The car will be consuming then over 420 dm3/100 km of fuel. Maximum speed of the vehicle is reached on the fifth gear and comes to 87 km/h with the fuel consumption of 48 dm3/100 km. On the sixth gear the speed will slightly drop (85 km/h) with fuel consumption of 40 dm3/100 km. Movement of the vehicle with the speed of 70 km/h is possible on sixth gear with the fuel consumption of 29 dm3/100 km.

CONCLUSIONS

Based on the presented results of the analysis, the following conclusions can be formulated: - the lowest fuel consumption characterised the car equipped with the engine with the length of approaching line equal to 1143mm,

- the lowest ability to overcome hills had a car with the engine with the length of approaching line equal to 843 mm,

- a dynamic charge has a slight influence on the level of fuel consumption by a car.

It should be mentioned here, that an influence of dynamic charge imperceptibly influences the fuel consumption, however in a sufficient way influences the course of rotary moment lines, which enables its adjustment to the character of executed work. Besides, in the engine tests house has not been performed any adjustment of the injected fuel.

The conducted analysis showed usefulness of such type of simulation tests in order to determine the work parameters of a car in different conditions. An additional advantage of those tests is the possibility of a relatively easy analysis of an influence of the introduced construction changes on the properties of the vehicle.

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ANALIZA ZUŻYCIA PALIWA PRZEZ SAMOCHÓD CIĘŻAROWY Z SILNIKIEM O ZS DOŁADOWANYM DYNAMICZNIE

Streszczenie. W artykule przedstawiono wyniki badań nad wpływem doładowania dynamicznego na wielkość zużycia paliwa przez samochód. Podano niektóre wyniki badań dotyczących doładowania dynamicznego silnika SW-680. Wykonano charakterystyki trakcyjne przebiegowego zużycia paliwa. Wykazano przydatność tego typu badań do dokonywania analiz wpływu zmian konstrukcyjnych na właściwości samochodu.

Słowa kluczowe: zużycie paliwa, doładowanie dynamiczne, moment obrotowy, opory ruchu.