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ANALYSIS OF DYNAMIC SUPERCHARGE INFLUENCE ON ECONOMICAL ENGINE WORK INDEXES

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Summary: The article presents the study outcomes of an influence of the dynamic supercharge on size and location of the isoline of unit fuel consumption of the engine SW-680 type. It has pointed out the possibility of fitting the engine profile to the conditions of vehicle drive through the transmission change in drive system. Some of the research outcomes regarding dynamic supercharge of the SW-680 engine have been presented. A methodology of simulation tests is proposed and explained by the author regarding an adjustment of the engine work point to driving conditions.

Key words: fuel consumption, dynamic supercharging, torque curve, power.

INTRODUCTION

In contemporary cars' engines, besides more commonly used compressor supercharge, a lot of attention is also devoted to dynamic phenomena occurring in approaching systems.

The approaching systems of piston combustion engines are simply combination of wires and containers connection, their task is to provide a stream of air from the surroundings to the engine's cylinders. In approaching systems, as a result of serial supply of air to the cylinders, some of the waves phenomena are created which can improve or make it worse to fill the cylinder with the load (air or flammable mixture). In case of improving the filling, we are saying that the supercharge effect took place. We are dealing with the supercharge effect only when during opening of the approaching valve, the overpressure wave is occurring before it and it is created as a result of adequate harmony of camshaft phases, geometric parameters of approaching system and rotary speed of an engine's crankshaft. Cylinder filling is better when the pressure difference is bigger in the cylinder and before approaching valve in its middle opening phase. It should be emphasised, that the above-mentioned difference cannot be negative because the supercharge withdrawal has taken place then [3,10,11,12,14].

Structural solutions of approaching systems which carry out the non-compressor supercharge effect can be divided into two groups [11]:

- a single approaching line supercharge (inertial),
- a common collector supercharge (resonance),

A single approaching line supercharge is using the dynamic phenomena in approaching lines separately for each cylinder. Comparative tests of both dynamic systems' supercharge have shown, that using the system with single approaching line increases the filling in a wide range of rotary speed, while in resonance supercharge the essential increase in filling takes place only in the vicinity of resonance speed [11,14]. We are also dealing with the supercharge systems which are the combinations of dynamic and compressor supercharge. It ensures more profitable compressor work conditions and allows to obtain desirable course of rotary moment. [7,8,9,11].

TESTS

The engine house tests concerned the engine with the spontaneous ignition of SW-680 type. This kind of engine has been used in lorries (truck) of Jelcz type, buses and agricultural and building machines.

The examined engine was equipped with dynamic supercharge system with single approaching line. The used supercharge system made it possible to change the length of approaching lines. During the tests a lot of external profiles were carried out for the following lengths of approaching lines Ld: 643, 693, 743, 793, 843, 893, 943, 993, 1043, 1093, 1143, 1193, 1243 and 1293 mm. Based on the obtained results, for further tests and analysis, the following lengths were chosen: 743, 843 and 1143 mm. For those lengths partial and loading profiles were calculated. External profiles and the partial profiles of rotary moment (Mo), usable power (Ne) for 50 and 75% of maximum loading are presented in Fig. 1, 2, 3, 4. Loadings of 50 and 75 % of the maximum loading are the most often met ones in normal exploitation of the lorry (truck) [2,4,5]

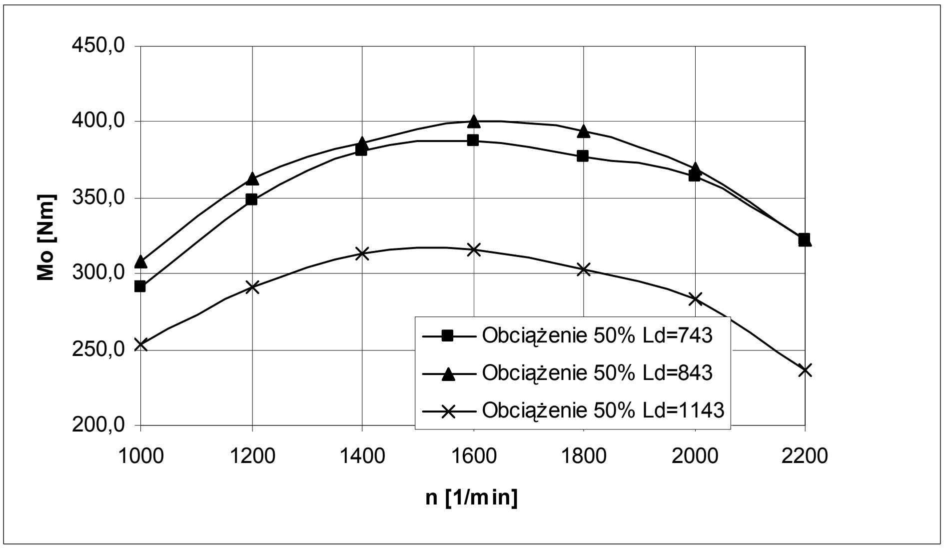

Fig.1. Relationship between Mo and n for 50% of loading (LD = 743, 843, 1143 mm)

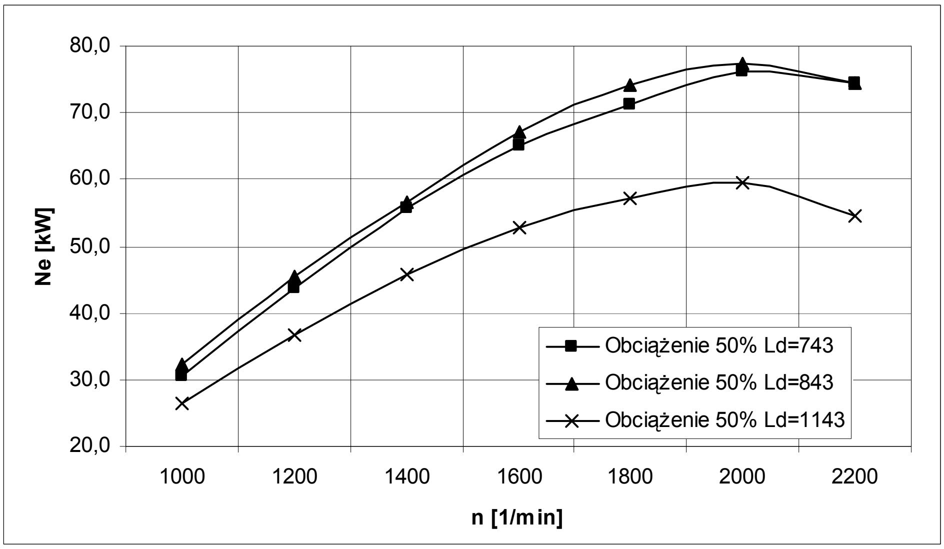

Fig. 2. Relationship between Ne and n for 50% of loading (LD = 743, 843, 1143 mm)

Based on Figures 1 and 2 we can notice, that for 50% of loading, the engine with approaching lines of 843 mm in length reaches the highest power (77 kW) and rotary moment (400 Nm). It turns out that slightly worse, about 3%, is the engine with 743 mm length of approaching lines. A significantly worse result, about 20%, is presented by the engine with 1143 mm length of approaching lines.

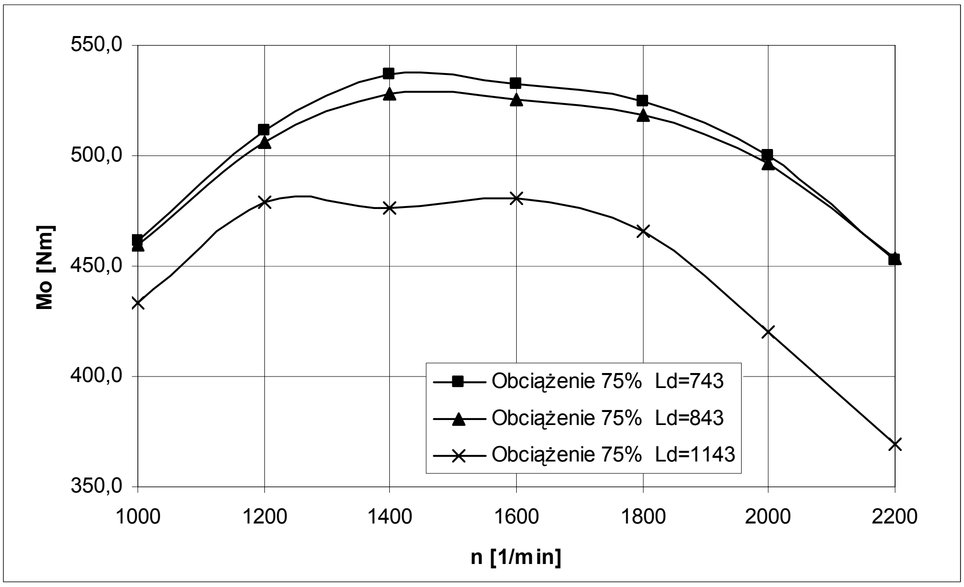

Fig. 3. Relationship between Mo and n for 75% of loading (LD = 743, 843, 1143 mm)

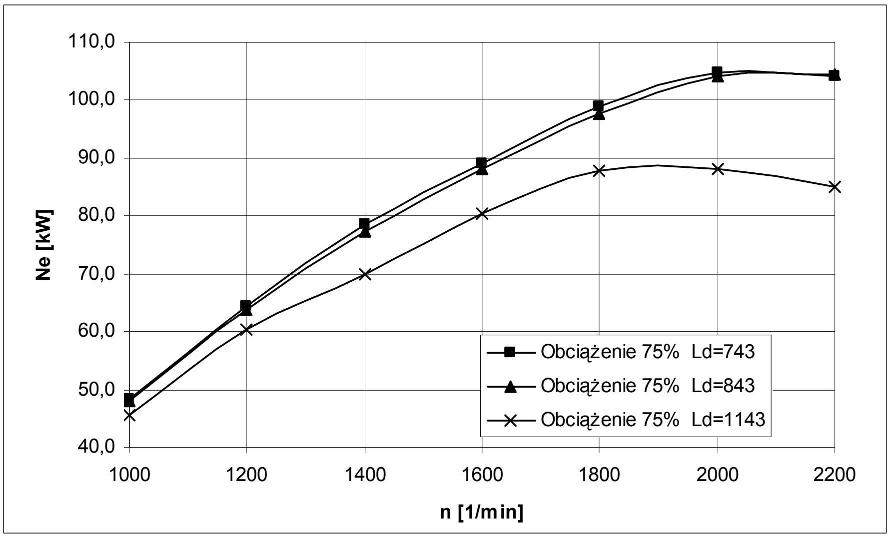

Fig. 4. Relationship between Ne and n for 75% of loading (LD = 743, 843, 1143)

For the loading of 75% (Fig. 3 and 4) the best, if you consider rotary moment and usable power, appears to be the engine with 743 mm length of approaching lines. A slightly worse result, about 3%, is presented by the engine with 843 mm length of the lines. Again, the worst result can be observed in the engine with 1143 mm length of approaching lines, reaching lower power and rotary moment in almost the whole range of the profile, in about 10%.

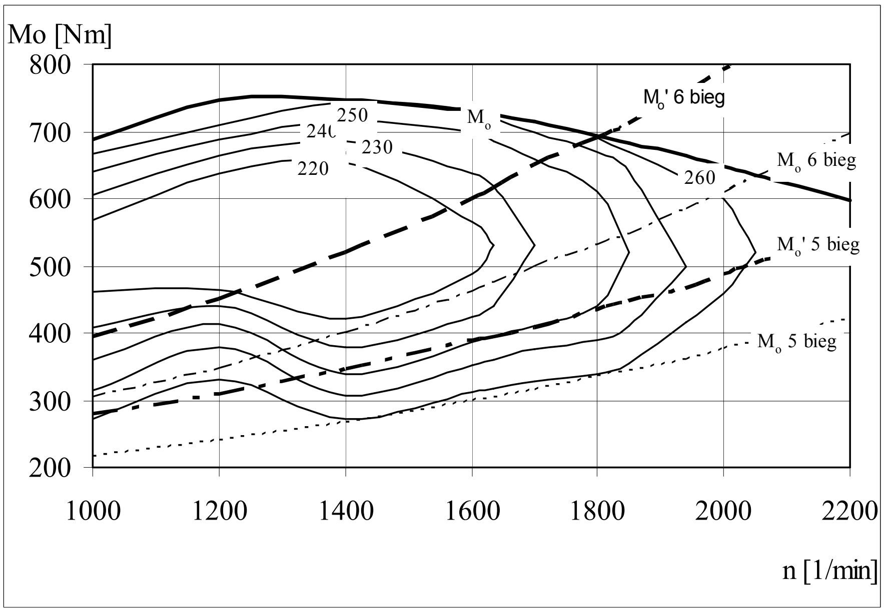

Fig. 5. Universal profile for 843 mm in length of approaching line

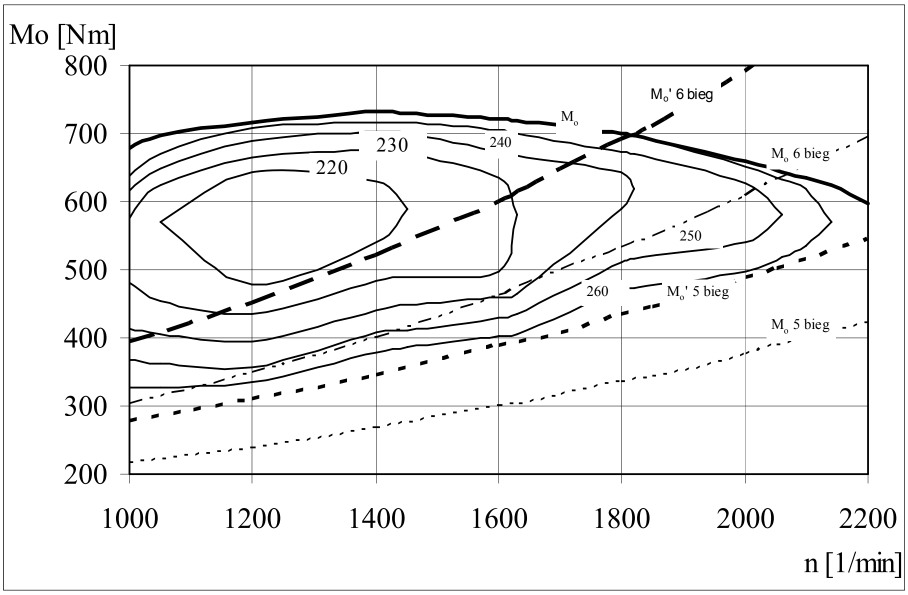

Fig. 6. Universal profile for LD = 743 mm in length of the approaching line

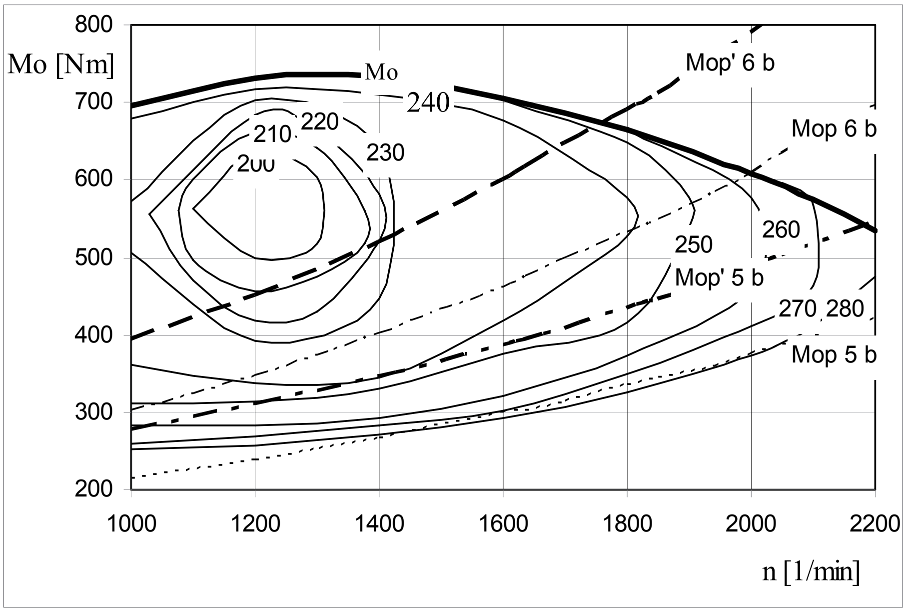

Fig. 7. Universal profile for LD = 1143 mm in length of the approaching line

Analysing universal profiles of the engine (Fig. 5, 6, 7) we can say that, considering the effectiveness of work, the best appeared to be the engine with the approaching lines with 843 mm in length (Fig. 5). The area of relatively low, limited by isoline 220 g/kWh, unit fuel consumption embraces a significant part of the whole area of the profile. Special attention should be devoted to the fact, that the mentioned area is located in the range of low and medium rotary speeds, it means, from about 1000 rotation per minute to about 1600 rotation per minute and medium loading, from about 400 to 650 Nm. Lorry engines most often work in this range [2,3,4].

The engine with 743 and 1143 mm in length of the approaching lines is characterised with slightly worse layout of the unit fuel consumption with the worth of 220 g/kWh. In both cases, those areas are covering much less of the universal profile's area than for the length of 843 mm. So, the probability that work point of the engine during normal exploitation will be situated inside that area is extremely low.

In order to check how the work points of the engine will be distributed on the universal profiles during normal exploitation of a lorry (truck), the engine lines of loading moments corresponding to basic resistance of the movement were marked.

Those lines were calculated for the fifth and sixth gears, based on the link [1,6]:

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

where: W_t – resistance of the turning (rolling) [N],
W_p – resistance of the turning (rolling) [N],
r_d – a dynamic radius of the circle [m],
i_c = ibigizw – a total transmission ratio as a product of a gearbox transmission, a main transmission and a reduction gear,
f_t – resistance factor of base turning,
v – speed of the vehicle [m/s],
c_x – dimensionless factor of air resistance (shape factor),
G_c – total weight of the vehicle [N],
F – a head (front) area [m2].

As we can see, for transmission ratios in factory (edition) work (lines Mo 5 b and Mo 6 b), points of engine work will never enter the area limited by isoline 220 g/kWh. In order to get work points into the area of low unit fuel consumption, the author decreased the value of transmission ratio of the main transmission from 1,96 to 1,5 (lines Mop' 5 b and Mop' 6 b).

As you can see, for the lines with 843 mm in length, the resistance movement moment line for the sixth gear (Mop' 6 b) is located in the significant range of the area limited by isoline 220 g/kWh. For the length of 743 mm this line is placed out of the interesting area and for the length of 1143 mm only an insignificant part of that line is located in the area.

CONCLUSION

The engine test house examination allowed us to show an influence of the approaching line on the fuel consumption by a dynamically supercharged engine of SW-680 type. The best results in fuel consumption with simultaneous preservation of high values of rotary moments and usable power in the range of partial loading were achieved by the engine in which approaching line with the length of LD = 843 mm was used. Similar results if you consider rotary moment and usable power to that with the approaching line of LD=843 mm in length can be obtained by the use of the line with the length of 743 mm but the size and location of the isoline of unit fuel consumption by the engine with those lines is less profitable.

The most profitable for work effectiveness is such a profile in which the areas limited by the isoline with the lowest unit fuel consumption have the biggest area and are located in that part of the profile where the engine work's point is most often located. It is obvious, that the location of work's points in which the most frequently and for the longest time the engine runs depends on its use. Based on the presented universal profiles we can notice that for different lengths of approaching lines the layout of isoline of the unit fuel consumption is different. So, dynamic supercharge is one of the means of shaping an engine's profile.

In normal exploitation of a lorry (truck), the time of work of the loading engine in 50 – 75 % is the longest [3,4,5]. Considering the fact that the engine profile can be controlled in a very limited range, there is a necessity of adjusting engine work points to the existing universal profile. It can be done by using proper transmission in the drive system.

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