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ALTERNATIVE SOLUTIONS FOR SUPERCHARGING WITH AGGREGATES OF TURBOCHARGER TYPE

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Abstract: *In order to determine to what extent the supercharge with a pressure waves compressor of type Comprex represents an alternative to the supercharge with a turbocharger, this paper presents comparatively the values of ecological and economical parameters obtained from experimental research of a Diesel engine supercharged consecutively with turbocharger and with aggregate of type Comprex driven with a constant speed by an electric motor. Supercharging using a Comprex unit driven with a constant speed brings environmental and economical performances for the engine thus supercharged, a fast response in acceleration and a functional simplicity of the supercharged system.*

Key words: *turbocharger, Comprex, environmental and economical performances, functional simplicity.*

1. Introduction

Despite the research effort carried out in recent decades in development of supercharging systems of Diesel engines, there is still room for growth for the energy and environmental performance by improving the supercharge process.

Presently, the supercharge system used by manufacturers of engines for automotives is the one with turbocharger aggregate. Over the time, this aggregate has seen a continuous development, currently reaching a high degree of efficiency, especially when the turbine is processing a high flow of the exhaust. Diesel engine's operating modes (speed and load) which are not covered by the turbocharger's high performance zone, or - in other words - the modes in which the engine's energy and environmental performances are reduced by the poor quality of the turbocharger-based supercharging process are the ones characterised by a small value of the exhaust's energy, specific to small-medium speeds and loads.

In this context, the paper aims to identify other supercharging aggregates as alternatives to those of turbocharger type, thus realising a supercharging process characterised by a medium-high supercharging pressure.

2. Experimental Investigation of Turbosupercharge Process

2.1. Aspects of Experimental Research

Inside the "Engine Testing" Laboratory of University *Transilvania* of Braşov, experimental investigations on the test

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bench were conducted [8] with 392 L4 DT Diesel engine (Figure 1), in order to capture experimentally the performances and limits of the supercharging process performed with an aggregate of type turbocharger.

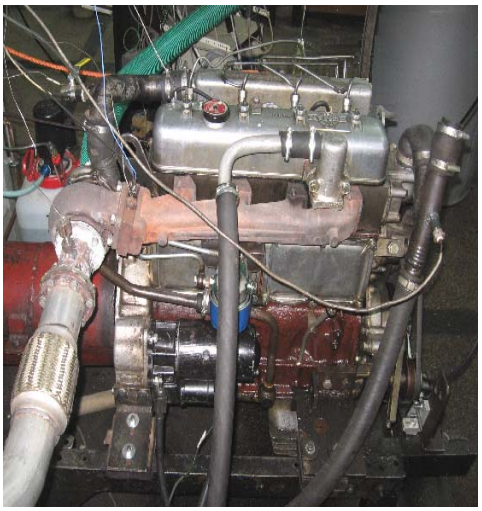


Fig. 1. *The 392 L4 DT engine supercharged with turbocharger*

The 392 L4 DT engine is a turbosupercharged engine, of Romanian production, it has four inline, vertical cylinders, a compression ratio equal to 17.6, a cylinder capacity of 3922 [cmc] and develops a maximum power of 80 [kW] at a speed of 2600 [rpm]. It was properly instrumented with sensors, transducers and equipments specific to testing stand, ensuring the required precision, of finesse, for experimental research.

2.2. Experimental Results

As a first result of the experimental research for the turbosupercharged 392 L4 DT engine, in Figures 2 and 3 we present the evaluation of pressure's value, at different loads (F), for intake air and exhaust, depending on engine speed (n).

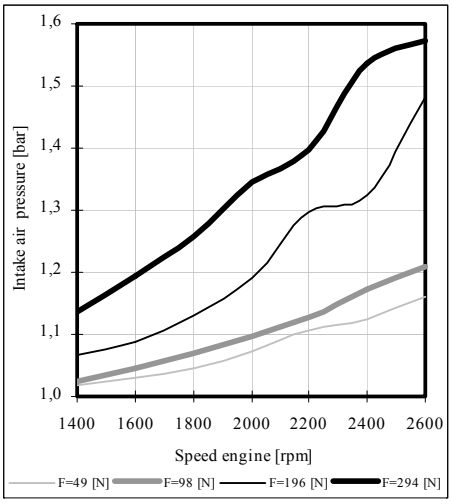


Fig. 2. *Variation of intake air pressure at different loads (F) for turbosupercharged 392 L4 DT engine*

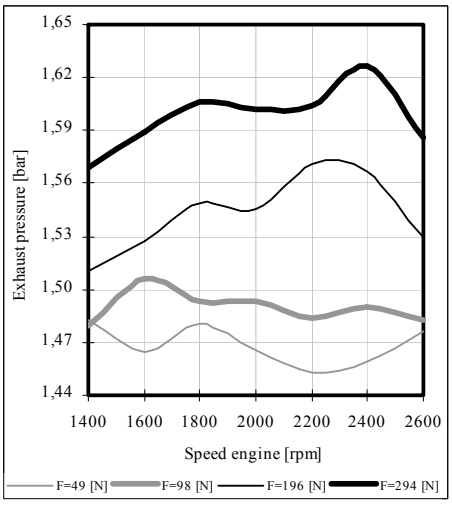


Fig. 3. *Variation of exhaust pressure at different loads (F) for turbosupercharged 392 L4 DT engine*

Figure 2 shows that at the small-medium speeds (n) and loads (F) (n < 2000 rpm, F < 196 N) of 392 L4 DT engine, corresponding to low energy levels of exhaust gases, the supercharge process performed by turbocharger achieves a

modest performance regarding the values of intake pressure. Also, Figure 3 shows that the exhaust gas pressure values are maintained at a high level in all operating modes - which were experimentally investigated - of the 392 L4 DT engine.

Following these observations drawn from the experimental tests on the above mentioned engine, we can assert that the use of a supercharging system which would compress the intake air using the exhaust pressure, and not its energy, is of interest. One such supercharge aggregate is the compressor with pressure waves of type Comprex.

3. Experimental Investigation of the Supercharge Process using Comprex

3.1. Comprex Function Description

The supercharge with aggregate of type Comprex (Figure 4) represents an efficient supercharging process that eliminates the shortcomings of turbosupercharging because the intake air pressure depends mainly on exhaust's pressure and not on its flow, and so high supercharging ratios can be obtained even at low loads and speeds.

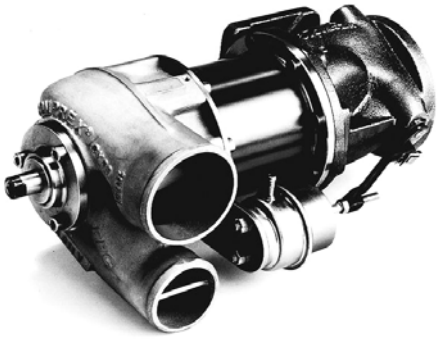


Fig. 4. *Supercharging aggregate of type Comprex* [6]

The functioning of Comprex unit (Figure 5) is based on processes that occur when two fluids (fresh air and exhaust gases) with different pressure values are connected directly, an equalization of the two pressures taking place initially, before their actual mixture. For this reason, the working speed of Comprex unit is of a particular importance, because its value depends on both the quantity of compressed air and the quantity of air contaminated with exhaust gas expelled into the engine's intake collector [1-5].

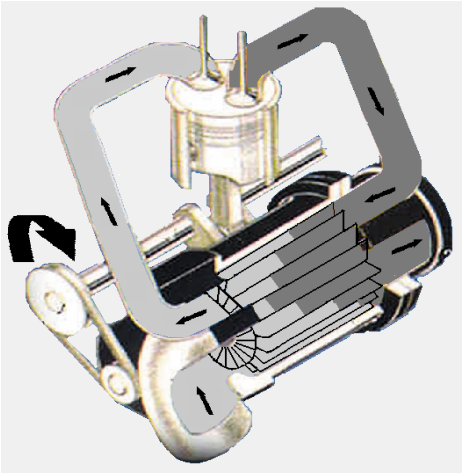


Fig. 5. *The functioning aggregate of type Comprex* [7]

Therefore, driving the Comprex unit with a speed proportional to the supercharged engine's one (an option frequently used nowadays) represents an obstacle in achieving an efficient supercharge process.

A solution to this is to drive the Comprex unit with a speed independent of Diesel engine, and, doing so, the supercharge unit, driven with an appropriate speed, will achieve an efficient process in all operating modes of the supercharged engine.

3.2. Aspects of Experimental Research

In this context, experimental investigations were performed on 392 L4 DT engine, supercharged (in the modified option) with an aggregate of type Comprex (Figure 6),

operating at the modes (speed and load) at which the performances of turbosupercharging have been modest. In order to supercharge the 392 L4 DT engine with Comprex under best conditions, a series of connectors and fixing parts were needed to be manufactured.

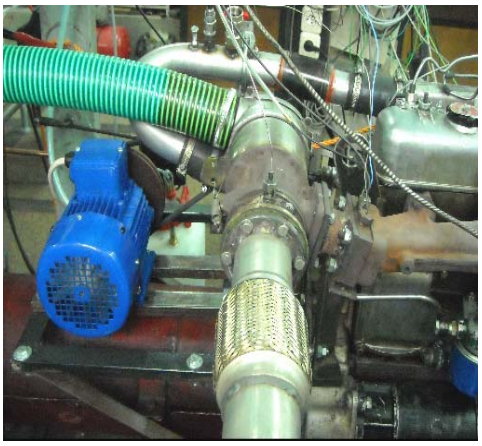


Fig. 6. *Engine 392 L4 DT equipped with aggregate of type Comprex*

During these experimental investigations of the supercharged 392 L4 DT engine, the aggregate of type Comprex was driven by an electric motor at several speeds, in order to identify, for each operating mode (speed and load), the driving speeds of Comprex unit for which the highest levels of the intake air pressure are obtained, compared with those from turbosupercharging.

3.3. Results of Experimental Research

After performing full series of experimental research, as mentioned above, we are able to claim that driving the Comprex unit at a constant speed of 12500 [rpm] provides to 392 L4 DT engine a supercharging process of a higher quality than that provided by turbosupercharge (Figure 7). In addition, due to the constant driving speed of Comprex, this supercharge solution presents both a functional simplicity with low manufacturing costs and a very fast response in acceleration.

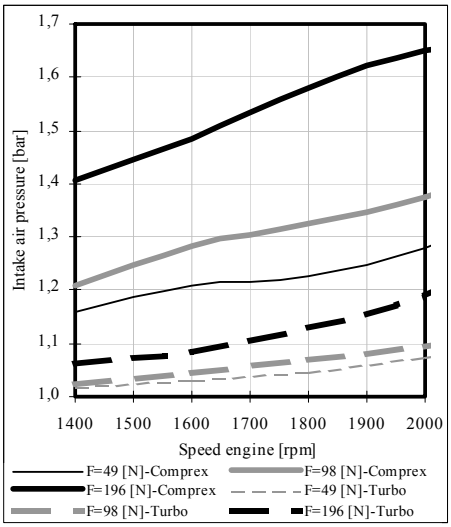
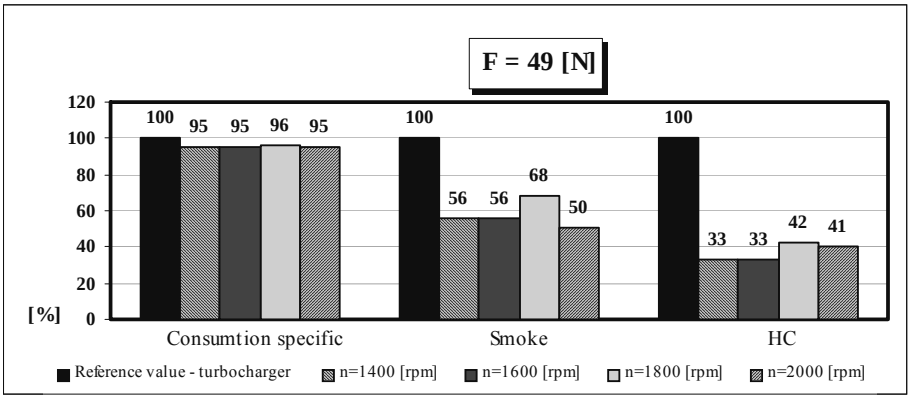


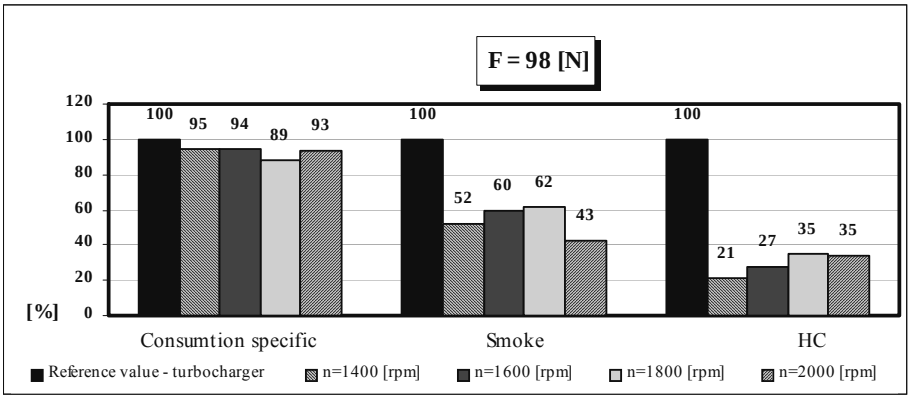
Fig. 7. *Variation of intake air pressure at different loads (F) for 392 L4 DT engine, supercharged with Comprex driven by a constant speed of 12500 [rpm]*

Analysing Figure 7, we see that all the values of intake pressure resulted from turbosupercharging process are lower than the pressure's variation curve obtained from the supercharging process with aggregate of type Comprex, for the load *F* of 49 [N], in the same operating mode (speed and load), the values obtained with the latter method being bigger with a percentage in 14-40 [%] range.

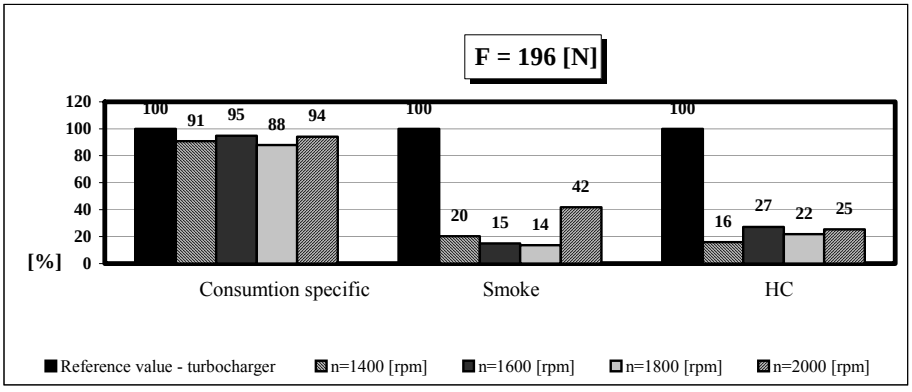
Because the quality of the supercharge process is reflected in the energy and environmental performance of the engine, the percentage deviation of the values for specific fuel consumption, smoke emissions and HC - acquired in the supercharge process with Comprex being driven by the speed of 12500 [rpm] - are presented below, in order to validate the superiority of the supercharge process made with Comprex, compared with the values obtained from turbosupercharge.



a)



b)



c)

Fig. 8. *Evolution of percentage deviation of the parameters of interest, at regimes* (*speed - n and load -* F) *characterised by small and medium speeds of the 392 L4 DT engine and by the loads: a*) *F = 49 [N]; b*) *F = 98 [N]; c*) *F = 196 [N]*

Analysing Figures 7 and 8, we conclude that the supercharge with an aggregate of type Comprex, driven with a constant speed of 12500 [rpm], for the investigated operating modes, gives the 392 L4 DT engine improved (significantly, sometimes) energy, economy and environmental performances, compared with those obtained from the same engine but equipped with a turbocharger.

It is necessary to mention that during the experimental investigations of 392 L4 DT engine supercharged with Comprex driven by a constant speed of 12500 [rpm], the power consumption for driving the Comprex unit was also measured, its average value being around 1.86 [%], which represents a reduced amount of the consumed power utilised to drive the supercharging unit.

4. Conclusions

Given the experimental results obtained from supercharging the 392 L4 DT engine with a Comprex unit driven by a constant speed of 12500 [rpm], we are able to state that all Diesel engines supercharged with this aggregate driven by a constant speed (which will be identified for each type of engine) will, also, experience an acceptable quality of the supercharge process in any operating mode.

Also, this supercharge solution requires reduced development costs and, compared with turbosupercharge, has the advantage of a fast response in acceleration.

In the same time, due to the small value of power consumed to drive the Comprex unit, the DC motor that will drive Comprex will have a reduced size, leading to an easy installation on the supercharged engines.

In the end, we can affirm that the pressure wave aggregates of type Comprex represent indeed a viable solution for supercharging process, being an alternative, worthy to consider, to the aggregates with turbocharger.

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