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Functional performance testing of the universal super absorbing air filters FSU 70 „Air by Corneliu"

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Abstract. This paper presents the experimental methodology to carry out functional performance tests for an air filter with a particular design of its housing, generically named *Universal super absorbing FSU 70 „Air by Corneliu"*. The tests were carried out in the Internal Combustion Engines Laboratory, within the specialization "Road automotives" belonging to the Faculty of Engineering Hunedoara, component of "Politehnica" University of Timişoara. We present some comparative values of various operating parameters of the engine fitted, in the first measuring session, with the original filter, and then with the studied filter.

1. Introduction

The proper filtration of the air entering the cylinders of an internal combustion engine is essential for extending its service life [1], [2], [3]. Preventing various impurities from entering the engine along with the atmospheric air reduces significantly the wear over time of the engine moving parts.

Unfortunately, in addition to the purpose of filtering the air drawn from the atmosphere, the air filter – as a distinct part of the engine – represents a significant gas–dynamic resistance, interposed on the suction route. If it is not regularly cleaned, and the vehicle travels frequently within a dusty environment, the suction pressure (p_a) is consistently decreasing and the air–filling coefficient (η_V) suffers penalties.

Therefore, we can say that the innovative design of the air filtration system is essential for a high performance filtration and air flow improvement, with effects on increasing of the engine performance and service life [1], [6], [7].

The design proposed by the authors aims at reducing the shortcomings described above by designing filter housing with particular geometry, enabling the improvement of the gas–dynamic performance at the engine air inlet [1], [8] . We note that this study does not deal with the nature of the filtering element of the filter, which is a standard one [4], [5].

2. Presentation of the experimental equipment

For performing the experimental measurements, we had an engine test stand, produced by Christiani, consisting of a multi–point fuel injection engine, brand VW, 1.4 MPI, used by the *Golf VI 5K1* models, cylinder capacity: 1390 cm^3, power: 59 KW/80 CP, 4 cylinders in line, manufacturing years: 2009–2012.

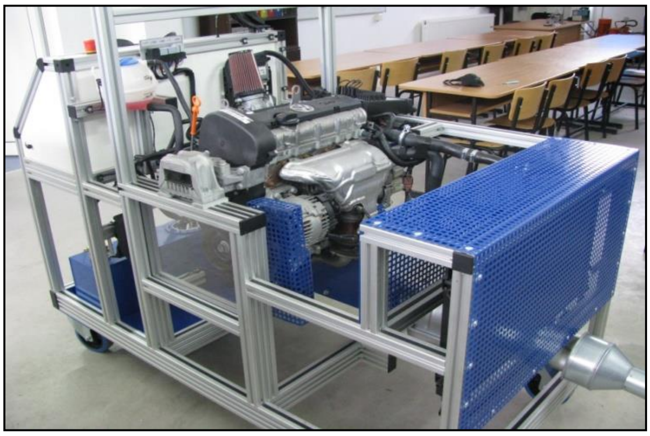

Figure 1. Overview of the test stand.

The stand offers the possibility to monitor the engine during its operation. It enables the connection to the OBD port of all the testers usually found in garages, and the measurement of signals and electrical quantities, with the possibility of assessing the obtained parameters.

The related software contains a professional interface that allows the PC to be transformed, via an USB port, into a device to be used for diagnostics and visualization of the functional parameters. Also, it enables the visualization and simultaneous storing of three measuring blocks, and can graphically display the essential features of the engine.

The tested super absorbing filter is cylindrical and contains an internal universal spreader. This has the additional function of accelerating the air speed at the output of the filter. Due to the constructive geometry, it provides a significant increase in the air–filling coefficient of the engine cylinders.

The filter (Figure 2 and Figure 3) is provided with a perforated housing (1) that has an internal spreader (2) fitted by removable mounting, at one end of the housing. The spreader has a cylindrical connector (3) attached in the opposite side of the perforated housing (1), that provides the connection with the intake manifold of the internal combustion engine, which is not illustrated in the drawing. In the opposite side of the internal spreader (2), the perforated housing (1) has a cover (4) attached through removable mounting, fitted with an internal cone (5). This one is provided on the outside with four or more targeting and swirling wings "C". Inside the perforated housing (1), it is placed the filtering element (6), cylindrically shaped.

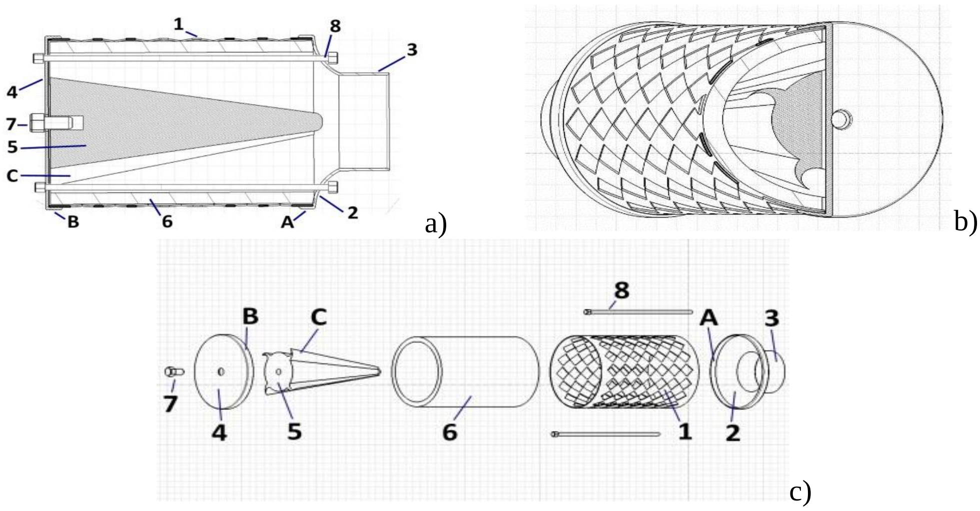

Figure 2. Super absorbing filter FSU 70 „Air by Corneliu", the exploded model [1]
a, b – drawings of the installed filter; c – drawing of the exploded model;

The perforated housing (1) is cylindrical, being concentrically framed by the centring edge “A” of the internal spreader (2), and on the opposite side by the centring edge “B” of the cover (4).

The internal cone (5) is attached to the cover (4) by means of a screw (7).

To maintain in contact the internal spreader (2), the perforated housing (1) and the cover (4), two threaded connecting rods (8) have been provided.

The targeting and swirling wings “C” have a concave or convex curvilinear profile, and a straight or spiral orientation over the lateral area of the internal cone (5).

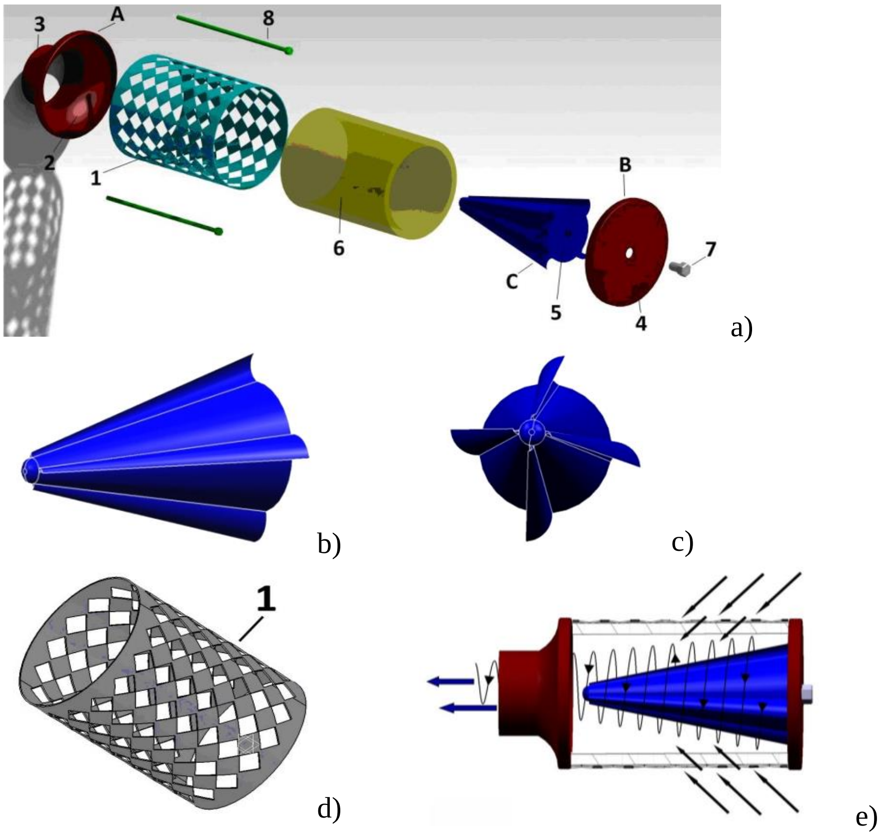

Figure 3. Super absorbing filter FSU 70 „Air by Corneliu”, virtual model [1]
a – exploded virtual model, realised in AutoDesk Inventor; b, c – virtual model of the internal cone; d – perforated housing; e – illustration of the operating principle.

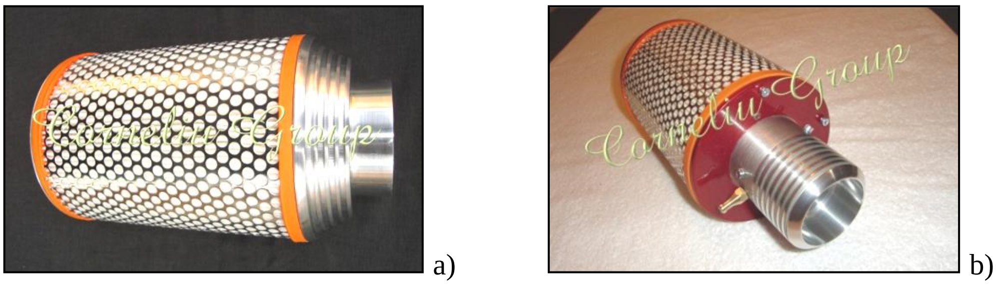

Figure 4. Super absorbing filter FSU 70 „Air by Corneliu” [1]
a, b – physical models

The components of this type of filter are removable, being able to be installed and removed as needed. The internal spreader has variable size, depending on the engine cylinder capacity. A higher cylinder capacity requires a larger spreader capacity, and vice versa.

3. Testing session and the experimental methodology

The tests consisted in determining the key operational parameters of the engine, at various speeds at idle, the engine being equipped, at a time, with the original filter or with FSU 70. The measuring sessions were repeated to confirm the results, and the test conditions for the two variants (engine equipped with original filter and with FSU 70) were maintained strictly constant. The filtering element is the same for both filters.

For the first measuring session, the experimental engine was equipped with the original filter (Figure 5). The data acquisition was made at various engine speeds at idle, beginning with the idling speed and continuing with 1500, 2000, 2500, 3000, 3500 and 4000 rpm. We measured:

- engine speed;
- throttle position;
- manifold air pressure;
- coolant temperature;
- manifold air temperature;
- hourly fuel consumption;
- ambient temperature;
- atmospheric pressure.

Figure 5. The experimental engine equipped with original filter.

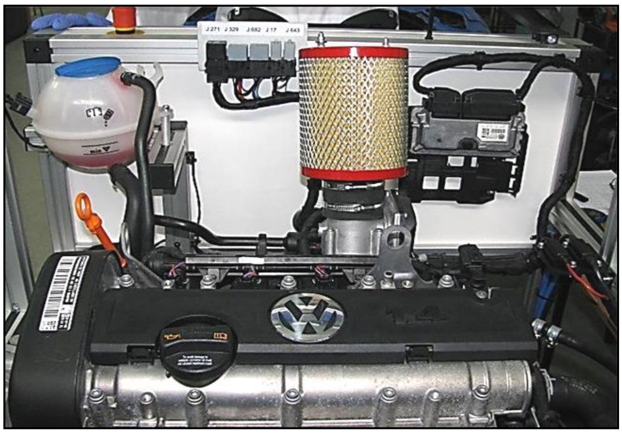

Figure 6. The experimental engine equipped with FSU 70.

The next session of measurements was carried out with the engine equipped with FSU 70 (Figure 6). The same above–specified parameters have been determined, under the same conditions.

We mention that the measuring sessions were conducted inside the laboratory, where the temperature and pressure remained strictly constant.

4. Results and conclusions

We present below the comparative values of the above–specified parameters on the performance of the engine equipped with original filter and FSU 70, respectively.

The chart presented in Figure 7 shows that, at engine speeds below 2000 rpm, when using the FSU 70, the throttle valve opens less, which means less gas–dynamic resistance due to this filter installation, situation beneficial for the process of filling the engine cylinder with fresh load. At higher speed values, it can be seen that the throttle valve position is identical in both cases.

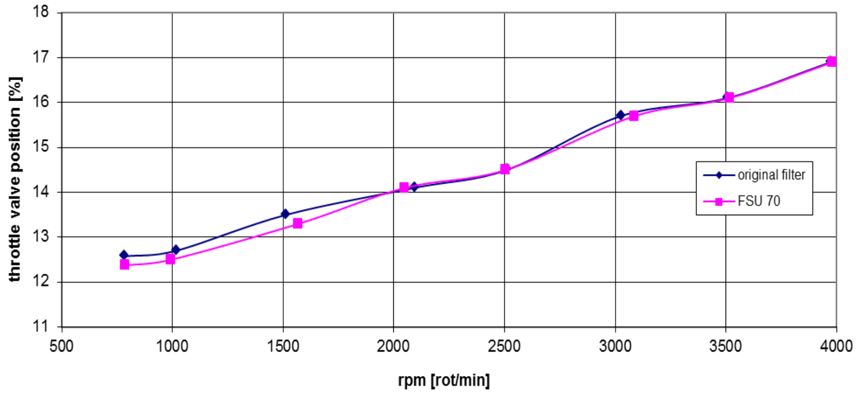

Figure 7. Position of the throttle valve versus engine speed at idle.

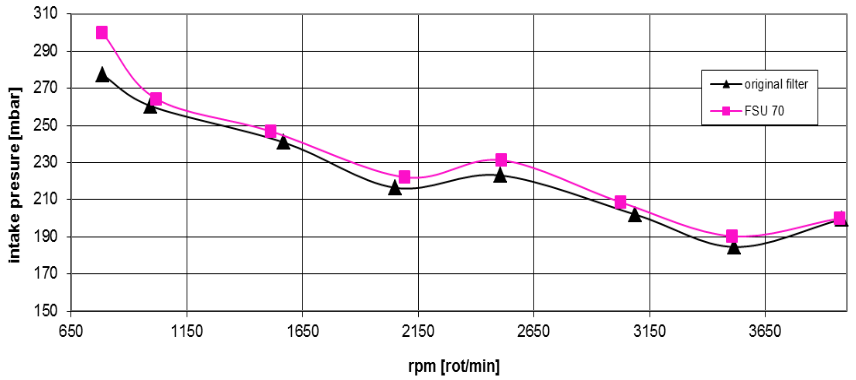

Figure 8. Pressure in the intake manifold versus engine idle speed.

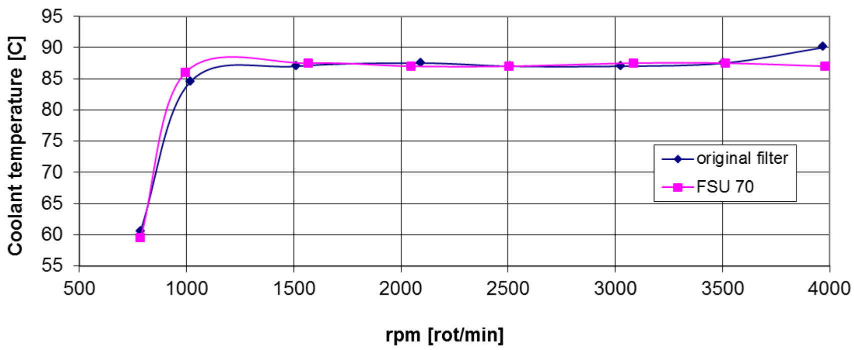

Figure 9. Coolant temperature versus engine idle speed.

From Figure 8, we can deduct that, throughout the range of speeds at which the tests have been performed, the pressure in the intake manifold is higher when using FSU 70 than when using the original filter, situation beneficial for the process of filling the engine cylinder with fresh load.

From Figure 9, we can deduct that there are no major differences in the coolant temperatures when using the two filters.

From Figure 10, it can be concluded that, up to a speed of 3300 rpm, the air temperature in the intake manifold, when using the FSU 70, is lower than that obtained when using the original filter, situation beneficial for the cylinder filling process, because a lower air temperature when entering the engine means a higher density, and therefore a larger amount introduced into the cylinders, with beneficial consequences for the engine power.

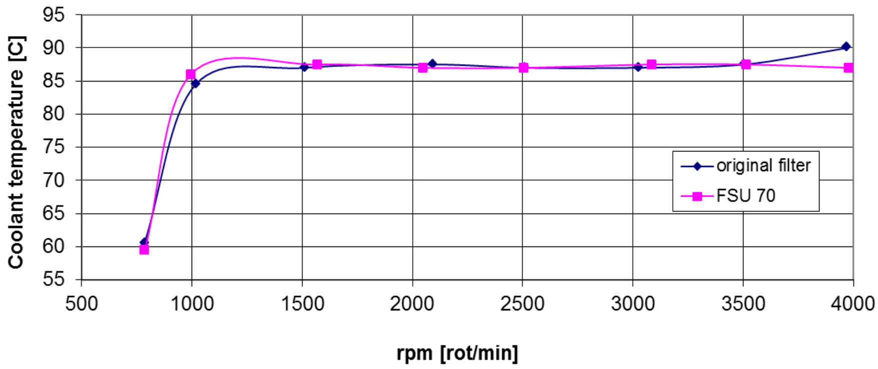

Figure 10. Air temperature in the intake manifold versus engine idle speed.

The most important parameter monitored during the tests was the hourly fuel consumption, in litres/hour. In Figure 11, we can see the variation of the hourly fuel consumption with the engine speed, for the cases when the engine is running equipped with the original filter and with FSU 70, respectively. It appears that, from speed values around 1000 rpm, the fuel consumption begins to decrease considerably when using the FSU 70.

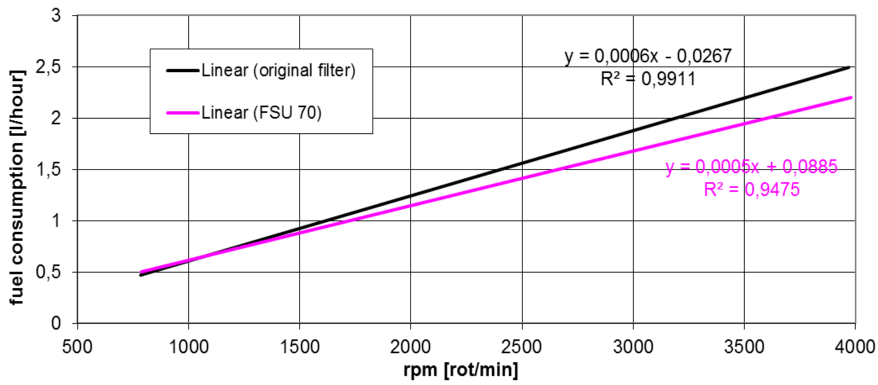

Figure 11. Hourly fuel consumption versus engine idle speed.

The percentage difference between the hourly consumption with original filter and the hourly consumption with FSU 70 is calculated using the relation:

$$d = 100 - \frac{Ch_{FSU70}}{Ch_{original\,filter}} \cdot 100 \ \ [\%] \tag{1}$$

In Figure 12, we can see that the percentage difference is positive at all the engine speeds, with the exception of 2000 rpm (more precisely: 2049 rpm). The positive values show lower fuel consumption than in case of the original filter.

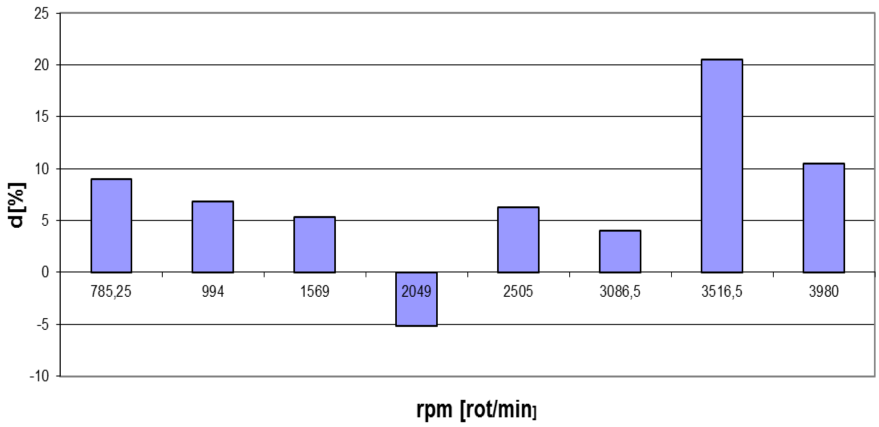

Figure 12. The percentage consumption difference.

Throughout the speed range used for conducting the tests, the reduction of fuel consumption by using the universal super absorbing FSU 70 is 7.15%.

Following the conducted researches and monitoring of the behaviour when installing the filter on various types of engines, we concluded that this one has a number of advantages, such as:

- being in contact with the air, the filter element ensures a minimum gas–dynamic resistance to the absorbed air, increasing thereby the absorption and capture rates;
- the self–cleaning possibility of the filter element;
- visualisation of the filter element, without the prior removal of the filter, for checking its pollutant loading level;
- the capacity of air filter housing to significantly increase the speed of absorbed air, both at the input and output of the filter;
- the ability to "pre–cool" the air drawn inside it;
- the ability to create a slightly boost, which increases proportionally to the vehicle movement speed.

The tests were carried out in the Internal Combustion Engines Laboratory, within the specialization "Road automotives" belonging to the Faculty of Engineering Hunedoara, component of University Politehnica Timişoara.

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