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Static test of iron-based additive catalyst on diesel engines; effect and results.

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Abstract: This paper will discuss the improvements of fuel combustion in internal combustion engines when a chemical fuel catalyst is added to the fuel itself. It results a substantial reduction of exhaust emissions and an increased fuel economy when the catalyst is used with respect to the same test without catalyst treatment.

The experience results from the continuous search on potential cost reduction of vehicles users, in particular diesel fleet operators. The idea was to improve engine performance and fuel economy using an iron-based catalyst.

Introduction: The increasing cost of diesel fuel and the demand of lower exhaust emissions became a major need for diesel engine users, both for economical and environmental reasons. The expenses for fuel are becoming an increasing voice in both domestic and industrial economy and environmental tendency requires fewer harmful emissions.

The fuel catalyst has been thus tested in order to verify the effects of the additive in an engine under steady-state conditions.

The aim of the test was mainly to verify the increase in fuel economy and the reduction of the amount of smoke and harmful emissions.

Typically, testing for fuel consumption determination in vehicles under actual operating conditions is quite difficule; for this reason, a stationary test was improved; that is to say, an AC generator was employed, and the electrical power supplied to the load was measured.

In the beginning, a criterion for screening was established and some considerations were formulated; the object of the test was focused on controlling the reduction of the comsumption of diesel fuel and of the harmful emissions.

The genset used for testing is a 4-cylinder diesel engine that moves a brushless type alternator rotating at 1500 rpm, and can supply a maximum load of 60 KVA.

The load was composed of an oleodynamic shaker that pushes at high pressure a piston in an oscillating movement. The load can be switched in two different positions: high pressure (140 Atm) and low pressure (40 Atm) that correspond to electric power loads of about 30 kW and 20 kW. The load is quite resistant, since the power factor (cos phl) measured was around power factor unity (0.99).

The measurement instrumentation of the electric load is an analyzer of electrical two and three phase quantities (*Multiver*); it can either plot the results, measured at programmable steps of time, on paper or store them. In the latter case, the data can be transfered afterwards on P.C., elaborated and visualized via dedicated software. A diesel fuel meter, previously calibrated, was used to measure the consumption of diesel fuel.

The complete system was conviently earth grounded in compliance with the National (Italian) law, in order to protect technicians from high voltage shock.

A combustion analyzer (*Enerac*) was employed to measure the emissions of the exhause system of the engine. The instrument, provided with an aluminum tube that goes into the stack, directly measures the outdoor temperature, the temperature of the gasses into the stack, the CO (carbon monoxide), the Oxygen, the Nox (primarily Nitric Oxide) and SO_2 (Sulfur Dioxide). It can also compute CO_2 (Carbon Dioxide), the effeciency and excess of air, as functions of the previous measurements.

Effeciency	+1.2%	+4%
Excess of Air	+3%	+5%
Average Opacity	-2%	-2%

An other instrument measured the percentage amount of smoke and black sooty exhaust (*smokemeter*), after at least three hours of continuous work; this instrument is normally used by authorized car shops that check the percentage of black sooty exhaust emmitted by on-road vehicles, according to the Italian Law (D.P.R. 22 February 1971, n. 323, art. 4. Law 13 July 1965, n. 615).

The test lasted almost 300 hours and it was shared in two main parts: during the first phase, the generator worked for about 60 hours with low load (40 Atm => 20 kW) and for 60 hours with high load (140 Atm => 30 kW) without treating the diesel fuel with the additive (baseline fuel).

In the second phase, the additive was added to the diesel fuel at 1/5000 ratio; again the engine worked for about 60 hours with low load (40 Atm => 20 kW) and for 60 hours with high load (140 Atm => 30 kW).

The analyzer of electrical quantities sampled, at a step of 300 seconds, the voltage (V), the current (A), the instantaneous, the average and the maximum active and reactive power (W) and the power produced (Wh).

The consumption of diesel fuel was tested at lease every 30 minutes; the data were reported in a table and stored. At the same time, the outside temperature was also reported and the environmental pressure was measured by the official weather information service of the nearby airport.

The amount of smoke was measured by using the *smokemeter* at every occurrence of condition for the load and for the fuel (in all, four measurements).

The measurements of exhaust gesses gave the following results:

Gas emissions	% change of exhaust gasses (Low pressure Test)	% change of exhaust gesses (High Pressure Test)
SO_2	-21 %	N.A.
CO	-19.5 %	-24 %
CO_2	-0.3 %	-0.1 %
O_2	+0.3 %	+0 %

The genset worked continuously more that six hours per day and the measurement started after 30 minutes of warming up of the generator without load and 10 minutes with load on, in order to avoid all transitory of the oleodynamic load and of the engine itself.

The results of the electrical measurement seem quite positive, since the consumption of the diesel fuel with the additive decreases from 3.7% to 5.7% compared to that without the additive catalyst.

Following, some plots are reported; every graph showes four different experimental curves, the four different tests. The curves follow an almost linear straight line, that demonstrates the optimal life condition of the engine and the stability of load.

Fig. 1 shows the electrical power required by at high pressure (140 Atm) or low pressure (20 Atm) load. It can be noticed that the electrical power produced at the same moment, in the same conditions of high and low pressure, is almost the same in both situations of persents or absence of the additive.

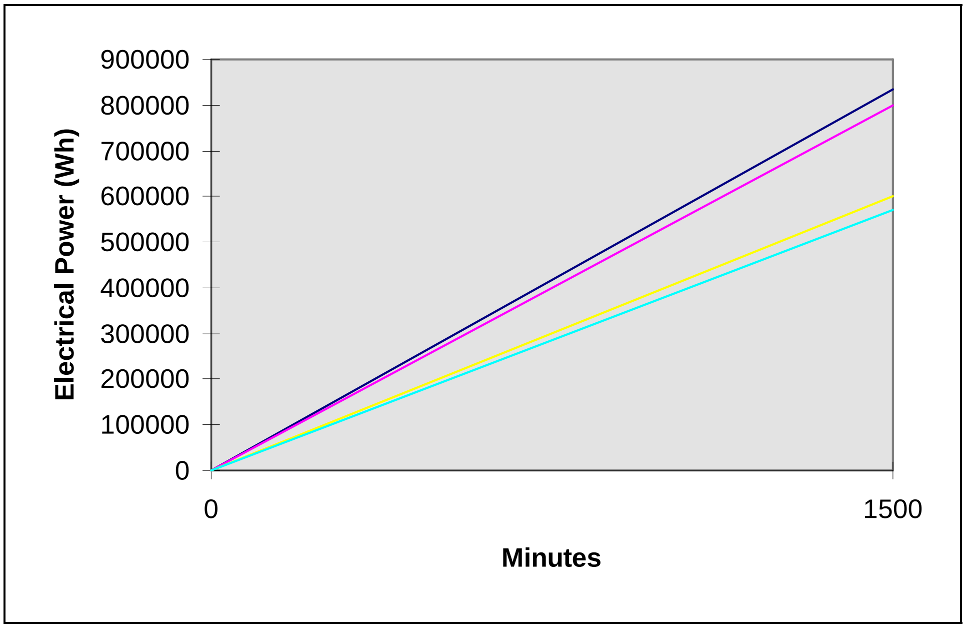

Fig.1 The four tests at high and low loads, with and without treatment; electrical power produced as function of the time of work.

On the other hand, figure 2 reveals the difference between the electrical power required by the load with the same amount of diesel fuel liters with and without the additive, at low and high pressure loads. It can be noticed the differences to produce the same amount of power in the different cases of diesel fuel with and without the catalyst, soon after a short quantity of combustible consumed.

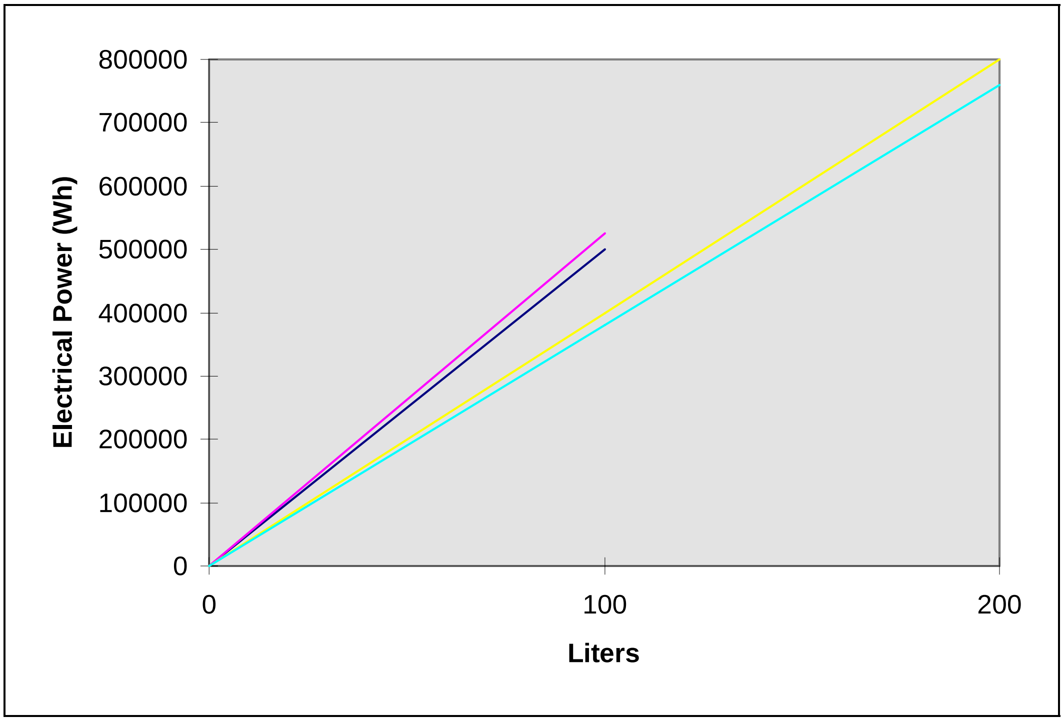

Fig.2 The four tests at high and low loads, with and without treatment; electrical power required by load as function of liters consumed.

The third graph shows the fewer quantity of diesel fuel used after the same time of work of the engine, with the two different loads, already after a very short period of almost equal consumption. This means that the engine consuming the additive fuel had a very short period of transient, (no advantage on using additive) then the curves tend to expand as the period of working tends to be greater.

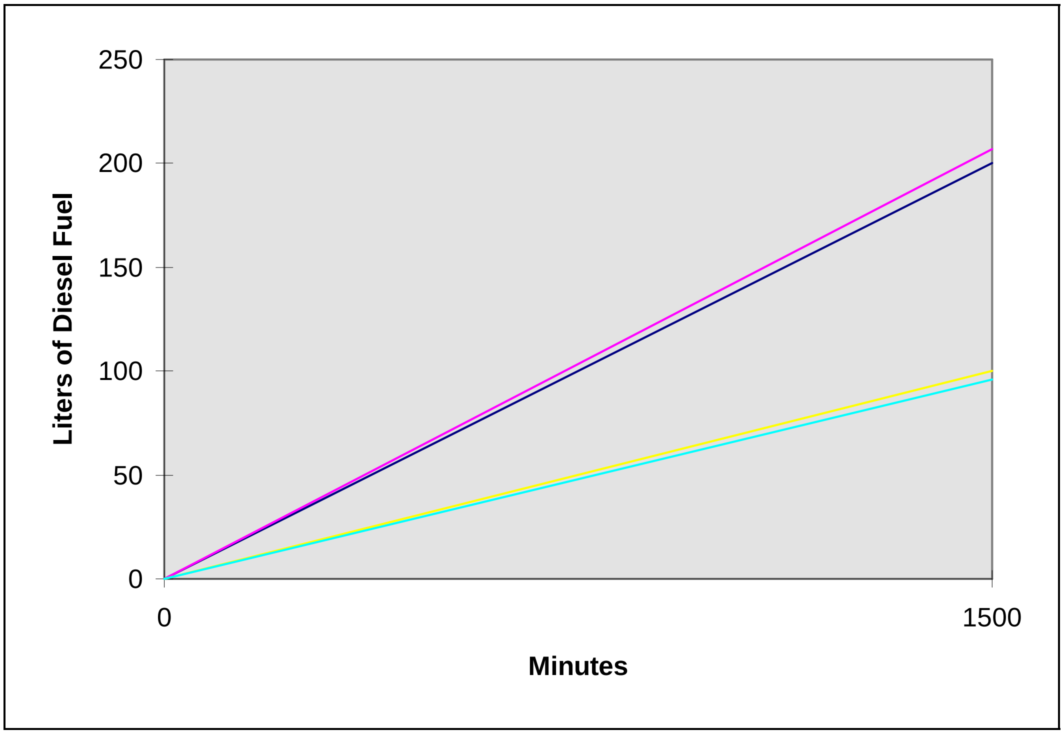

Fig.3 The four tests at high and low load, with and without treatment; liters consumed as function of time of work.

The following table shows the final data of the test:

	Consumption of liters	Power produced per liter
No Load	-5.7 %	*****
Low pressure	-3.7 %	+5.1 %
High pressure	-3.48 %	+4.2 %

A decrease of liters consumed by the system for the same time of work, and fewer liters consumed for the same electrical power produced are evidenced.
The results seem to be really encouraging to continue on developing the tests on diesel fuel engines, in particular on moving vehicles, such as urban buses fleet. In fact, they don't need particular increments on speed (not even tested in this situation), since Italian urban traffic speed is around 20 Km/h.

For these vehicles, fewer fuel consumption and fewer exhaust emission remedies are well considered both for economical and environmental reasons. After all, the conditions of the test, constant load and constant rpm, are such as that improvements created by the catalyst are smallest. Engines that operate under variable loads and engine speen should experience even greater improvements.