EXPERIMENTAL INVESTIGATIONS OF ALCOHOL BLENDS ON COMBUSTION AND EMISSIONS IN A TWO STROKE SI ENGINE

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Abstract. Internal combustion engines play a major role in transportation, due to the future emissions reduction legislation; researches are done in order to improve the combustion process behaviour and lowering the exhaust emissions. Two-stroke engines have a very good power-weight ratio, reliable, and they have a simple mechanical structure. The aim of this paper was to investigate the combustion process and the resulting exhaust emissions by using the air – assisted direct injection (DI) fuelling system and alcohol blends as fuels. For this experimental investigation the air – assisted DI was combined with a flame ionization detector (FID) and a CO, CO_2 and NO_x analyzer in order to measure the resulting exhaust emissions of the combustion process.

Keywords: engine, combustion, gasoline, alcohols, exhaust emissions

1. Introduction

The concept of direct alcohol injection for improved combustion and emissions reduction is presented through the results of this experimental research and compared between the original CR (compression ratio) and the increased CR, between different fuels used for the engine's fuelling system and different ignition points.

In order to obtain an improved engine's efficiency the compression ratio (CR) was increased, the combustion process and the resulting emissions are also presented and compared in this paper.

It was found that at similar engine conditions with the conventional system, using the air – assisted direct injection (DI) and adding alcohol content to gasoline, results in increased engine efficiency and improved engine power output. It was also found that with a higher CR the engine's efficiency can increase by using alcohol mixtures, and as a result, the fuel economy penalty associated with the lower energy content of alcohols can be reduced.

The fuel consumption and the emissions were lower when the conventional fuelling system was replaced by the air – assisted DI system; the DI system was manually controlled in order to achieve the optimal combustion process and emissions results.

Working with alcohol blends requires that the beginning of ignition (the ignition point) to be delayed or set earlier in order to achieve the best combustion process behavior. The air – assisted direct injection system and gasoline – alcohol blends result in achieving an improved engine power output, a good behavior of the combustion process and lower exhaust emissions.

2. Experiments and results

The experimental investigations described in this paper refer to the usage of alcohol and alcohol blended with super gasoline in a two-stroke spark ignition engine. The engine type is used for handheld power tools like chainsaws, blowers and trimmers.

The two-stroke SI engine is described in the table 1.

Table 1. Two-stroke spark ignition engine

Engine type	Two-stroke SI engine for handheld power tool
No. of cylinders	1
Cylinder displacement	70 cc
Cylinder bore	50 mm
Stroke	36 mm
Power output	4 kW (5.4 HP) at 9500 rpm
	Crankcase scavenging
	Schnürle full loop

As fuelling systems two types were used:

- The 1st fuelling system is the carburetor; used without the two-stroke mixture fuel (oil-gasoline blend) and due to the fact that the engine needs lubrication and the used fuels do not ensure this, the two-stroke engine was equipped with a two-stroke oil pump;
- The 2nd fuelling system is the air-assisted direct injection.

The cylinder was modified so that the air-assisted direct injection system could be fixed on it; also the cylinder was modified to allow the air-fuel mixture to be injected into the combustion chamber.

During the experiments the cylinder's compression ratio was increased in order to obtain improved combustion and lower emissions. The types of used fuels are:

- Super gasoline;
- Super gasoline mixed with alcohol (E85);
- Pure alcohol (E 100).

Two cylinder types were prepared for this research:

- Engine 1: Compression ratio (8:1);
- Engine 2: Cylinder with increased compression ratio (10:1).

The combustion process in the two-stroke SI engine is described in the next charts and diagrams.

The combustion process as it occurs in Engine 1 and in Engine 2 using the carburettor as fuelling system and super gasoline as fuel is presented in figure 1 and it can be observed that the pressure rises in the case of Engine 2 up to 4.41 MPa at 5.8° crank angle degrees ATDC. The ignition point is at – 43° crank angle degrees BTDC. The combustion process is similar to Engine 1, due to the fact that the ignition timing was left constant.

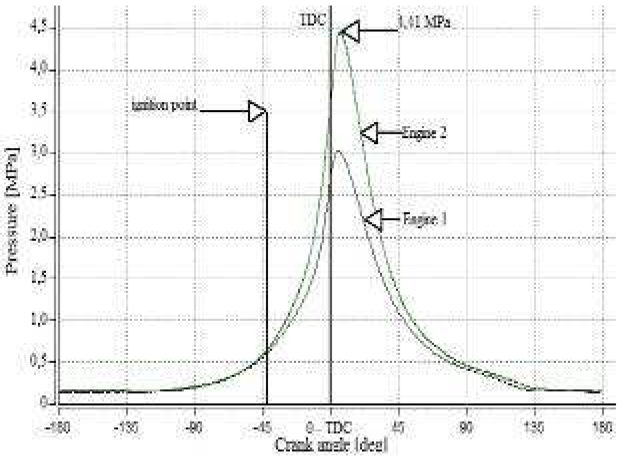

Figure 1. Pressure curves development using the carburettor

Figure 2 shows pressure traces of Engine 1 and Engine 2 using the air-assisted direct injection as fuelling system and Super Gasoline as fuel. It can be noticed that the combustion process is similar to Engine 1 and the pressure rises in case of Engine 2 up to 4.17 MPa at 8.4° crank angle degrees ATDC. Milling the cylinder changes the compression ratio and determines also a small outlet and overflow timing change.

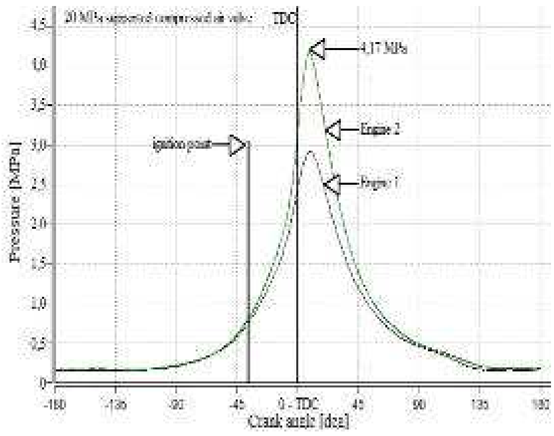

Figure 2. Pressure traces development by using the air-assisted DI

As shown in figure 3 it can be observed the pressure traces as they occur in Engine 1 and in Engine 2 using the air-assisted DI as fuelling system and Ethanol 85 as fuel and it can be noticed that increasing the compression ratio and using E85 the pressure increases up to 4.58 MPa at 6° crank angle degrees ATDC, this means also that the power output increases. In this case we can observe that from – 44° crank angle degrees BTDC, during the compression phase, there is a difference between the pressure curves due to the fact that the injection timing was modified and additional compressed air entered the combustion chamber.

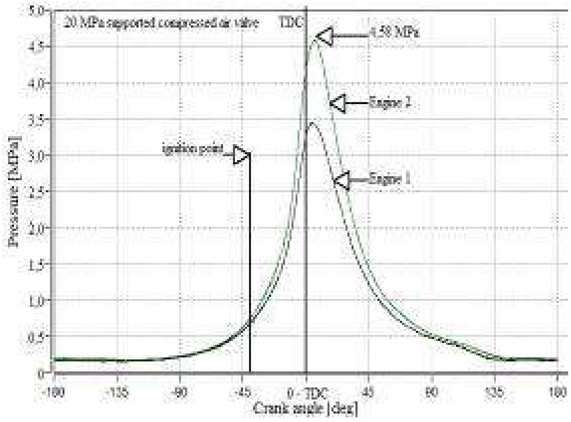

Figure 3. Pressure curves development by using the air-assisted DI and E85

Figure 4 shows the pressure traces of Engine 1 and in Engine 2 using the air-assisted direct injection as fuelling system and Ethanol 100 as fuel and in this case it can be observed that from – 42° crank angle degrees BTDC, during the compression phase, there is a difference between the pressure curves due to the fact that the injection timing was modified and additional compressed air entered the combustion chamber. The pressure increases up to 4.74 MPa at 4.1° crank angle degrees ATDC.

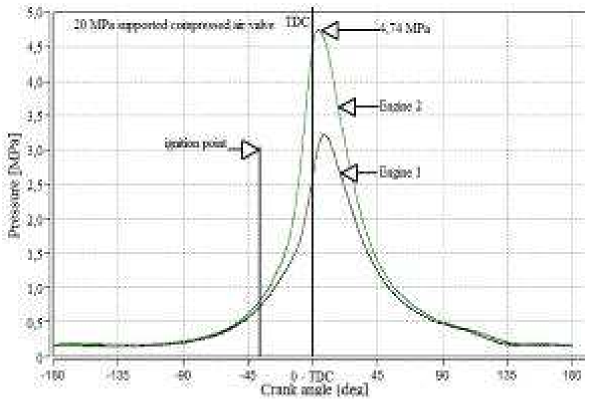

Figure 4. Pressure curves development by using the air-assisted DI and E100

3. Emissions Analysis

The two-stroke SI engine reaches maximum power output at 7000 rpm's using the carburetor as fuelling system, as presented in figure 5. The air-assisted direct injection's maximum power output point is also at 7000 rpm and as it can be seen the maximum power output, 3.74 kW, is achieved by using pure ethanol.

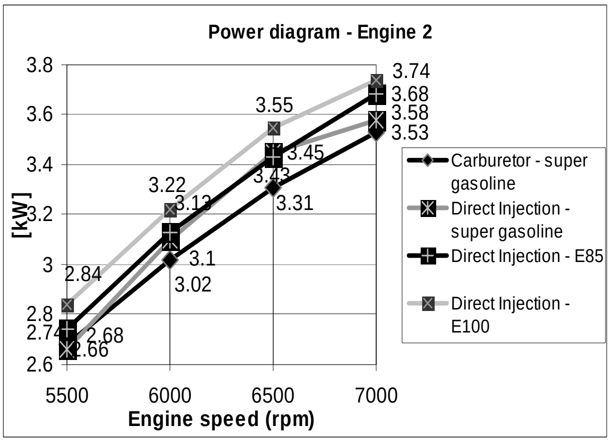

Figure 5. Power diagram

By using the air-assisted DI system, as shown in figure 6, instead of the conventional fuelling system the HC emissions are decreasing. In case of Engine 1 it can be observed that the HC emissions are decreasing furthermore by using Ethanol blends extended to using pure Ethanol fuel.

In figure 7 it can be seen that the CO and CO_2 emissions drop significantly when changing the fuelling system from conventional to the air-assisted DI system. The effect when changing to E85 is that the amount of CO and CO_2 increase. Using as fuel E100 in Engine 2 shows that CO emissions and CO_2 emissions are at about the same values.

In figure 8 it can be observed that the NO_x emissions increase by using the air-assisted direct injection and super gasoline, but this increase is a result of burning a slightly lean mixture. It can be seen that by using E85 in Engine 1 and in Engine 2 with the air-assisted DI the NO_x emissions decrease. Furthermore NO_x emissions drop also when using pure Ethanol in Engine 1, but they increase when injecting in Engine 2.

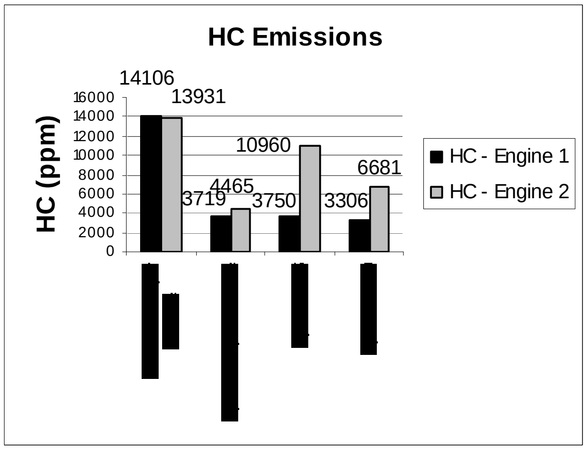

Figure 6. HC Emissions

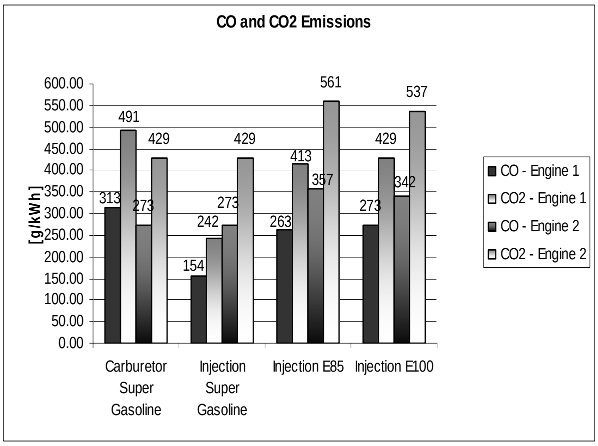

Figure 7. CO and CO2 Emissions

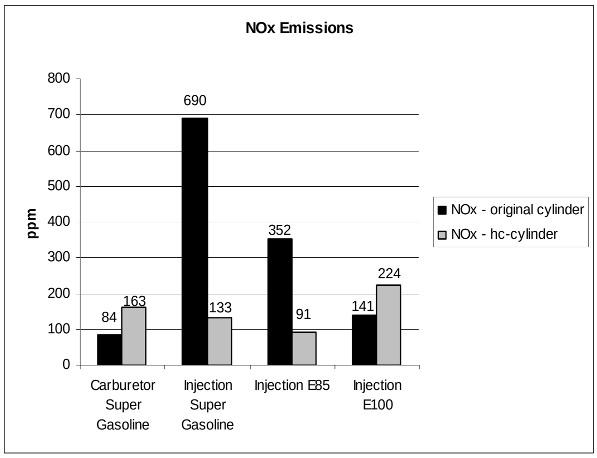

Figure 8. NO_x Emissions

4. Conclusions

Using advanced fuelling systems like the air-assisted DI shows that not only the efficiency of the engine is increased but also the exhaust emissions and fuel consumption are lower. The air pressure was induced into the air-fuel mixture formation chamber of the air-assisted direct injection system with a pressure of 0.45 ÷ 0.55 MPa.

The combustion process has a very good behavior in all cases due to the fact that the air-assisted DI was manually regulated in order to achieve this. The pressure rises due to higher compression ratio and the power output reaches its peak when using E100 in Engine 2. In order to gain power output from a spark ignition engine without bringing important changes to it, increasing the compression ratio is one technical solution and the second solution is by using alcohols blended with Super Gasoline (E85) or in pure state as fuel.

Working with alcohols requires the replacement of the machines conventional ignition system with a HT – coil so that the start of ignition could be delayed or set earlier in order to achieve the best combustion process behavior.

HC Emissions dropped by 27% in comparison with the carburetor fuelling system and they decreased furthermore by using alcohols in pure state (E100) or blended with Super Gasoline (E85).

CO emissions dropped by 49% using the air-assisted DI fuelling system in Engine 1, nevertheless in Engine 2 the CO Emissions dropped also. When using the air-assisted DI in Engine 1 CO_2 emissions dropped also by 49% compared to the carburetor fuelling system.

NO_x emissions increase when using the air-assisted DI with super gasoline due to the fact that the engine worked with a leaner air-fuel mixture. It can be observed that by using alcohols and the air-assisted direct injection in the original and hc – cylinder NO_x emissions are lower.

Overall, using the air-assisted DI fuelling system in the combustion chamber of Engine 2 leads to higher power output, lower emissions and lower fuel consumption. Replacing conventional fuel with alternative fuel shows an improvement in power output and exhaust emissions decrease.

Using ethanol and the air-assisted DI is one answer to have an improved engine combustion process behavior, a cleaner environment and therefore protecting human health.

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