STUDIES UPON THE POSSIBILITIES OF THE BIOFUEL USE IN THE CASE OF DIESEL ENGINES USING THE WALL FILM INJECTION SYSTEM

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Abstract. The paper presents the possibilities of the “M” system diesel engines to work with biofuels (the green energy), with regard to the specific fuel consumption and level of pollution. The experiments showed that the engines working on the base of wall film injection have a very large adaptability to biofuels. It must be done only few changes at the engines, regarding the form of the cylinder head, the material of the piston and the preheating of the fuel. So, their power and torque are slightly similar to the case of diesel oil use, the specific fuel consumption is in acceptable limits and the pollution has a major reduction.

NOTATION

- DI - direct injection
- DIM - “M” direct injection system
- DO - standard diesel oil
- WRO - winter rapeseed oil
- RME - rapeseed oil methyl ester
- TES - tessol (see cap.2)
- Pe - effective engine power
- Me - effective engine torque
- n - speed
- CC - combustion chamber
- UM - unit of measure
- cₙ - specific fuel consumption
- Eₙ - specific emissions

Introduction

Under the pressure of the Kyoto Protocol and EU Directives regarding the environmental demands the use of biofuels in the case of diesel engines has been reconsidered, especially for the engines working in the most protected areas as agriculture, sylviculture and communal activities.

According to the natural conditions for agriculture existing in Romania, the winter rapeseed oil (WRO) and its methyl ester (RME) represents the best choice of the alternative fuels, together with the corresponding products obtained from sunflower and soybean.
In these new conditions, the diesel engines based on the wall film fuel injection (“M” system) could play an important role, as they have been already produced in our country, for trucks and for self-propelled agricultural machines.

The present study is focus on the possibilities of the DIM engines (that are very spread in Romania) to work with the rapeseed oil and/or its derivates.

MATERIALS AND METHOD

The test stand-bench studies were performed with a 4 cylinders (105/120, 4156 cm$^3$) DIM engine, optimized for combustion of WRO (fig.1). In the case of normal DI engines, at the maximum output, the temperature at the combustion chamber edge is about 350 $^\circ$C, so for DIM engines it was necessary to adopt a “ferrotherm” piston that can work up to 700 $^\circ$C without any destruction. In the same time CC had a special form [3], corresponding to the optimum fuel-air mixture formation.

![Fig.1 Construction of the experimental engine](image)

1. “ferrotherm piston; 2-single jet nozzle)

The rigorous studies upon the engines working with biofuels request a special prepared experimental-stand, fig.2 (it is presented in [4]). For data acquisition and analysis a microprocessor-controlled data acquisition system was used (DATAC-1). Date recording and evaluation were controlled by a MS-DOS compatible computer with Windows user interface (PCMS01).
Fig. 2 Engine test bench

Pollutants were measured by a chemiluminescence analyzer type Tecan CLD 700 (NOx), a flame ionization detector type Bernath Atomic 3005 (HC) and a no dispersive infrared analyzer type Rosemount BINOS (CO, CO2, O2). The Bosch number was measured by a filter smoke number detector type EFAW 65 A.

During the experiments there were used several sorts of fuels as: diesel oil, rapeseed oil, rapeseed oil methyl ester and tessol (80 % WRO + 14 % petrol + 6 % isopropanol) in comparison with standard diesel fuel. Their principal characteristics are presented in table 1. WRO was produced in the uncentralized system.

Table 1

The characteristics of the fuels used during the experiments

<table>
<thead>
<tr>
<th>Indices</th>
<th>UM</th>
<th>DO</th>
<th>WRO</th>
<th>RME</th>
<th>TESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (20°C)</td>
<td>0,834</td>
<td>0,916</td>
<td>0,852</td>
<td>0,895</td>
<td></td>
</tr>
<tr>
<td>Flame point</td>
<td>74</td>
<td>246</td>
<td>116</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Cinematic viscosity (20°C)</td>
<td>4,30</td>
<td>76,9</td>
<td>6,0</td>
<td>26,3</td>
<td></td>
</tr>
<tr>
<td>Volume calorific power</td>
<td>35676</td>
<td>34074</td>
<td>32918</td>
<td>33283</td>
<td></td>
</tr>
<tr>
<td>Mass calorific power (20°C)</td>
<td>42778</td>
<td>37199</td>
<td>38637</td>
<td>37188</td>
<td></td>
</tr>
<tr>
<td>Cetane number</td>
<td>52,1</td>
<td>39,5</td>
<td>53,8</td>
<td>39,1</td>
<td></td>
</tr>
<tr>
<td>Cloudpoint (CP)</td>
<td>3,9</td>
<td>-1,0</td>
<td>-6,0</td>
<td>-5,0</td>
<td></td>
</tr>
<tr>
<td>CFPP</td>
<td>-10</td>
<td>+14</td>
<td>-8,0</td>
<td>-5,5</td>
<td></td>
</tr>
<tr>
<td>Jod number</td>
<td>-</td>
<td>114</td>
<td>122</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td>Free saturated fatties</td>
<td>0,64</td>
<td>0,08</td>
<td>0,08</td>
<td>0,53</td>
<td></td>
</tr>
<tr>
<td>Total phosphate</td>
<td>3,0</td>
<td>&lt;1,0</td>
<td>&lt;1,0</td>
<td>&lt;1,0</td>
<td></td>
</tr>
<tr>
<td>Conradson number</td>
<td>0,56</td>
<td>0,43</td>
<td>0,33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water content</td>
<td>0,044</td>
<td>0,031</td>
<td>0,047</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

EXPERIMENTAL RESULTS
The results of the test stand studies pointed out that the DIM engine has a facil adaptability to the alternative fuels.

So, the power and the torque of the DIM engine are only slightly lower in the case of WRO, RME and TES than in the case of standard DO (fig. 3 and 4). It demonstrates clearly the high potential of the biofuels.

![Fig. 3 Effective engine power for different fuels](image1)

![Fig. 4 Effective engine torque in the case of different fuels use](image2)

The specific fuel consumption (fig. 5) of the alternative biofuels is higher (13 % in the case of WRO, 10.6 % in the case of RME, 11 % in the case of TES) than of DO, but still into the acceptable (economical) limits.
The specific emissions of the pollutants for the above mentioned fuels, is presented in figure 6. It shows that the carbon monoxide, hydrocarbon and particulates have an important decrease in the case of RME (in comparison with standard DO) being below the current standards according to EURO II.

With respect to nitrogen oxides WRO has an unequivocal decreasing emission trend, but still above the limits of EURO II.
CONCLUSIONS

According to the research results a number of conclusions can be settle up:

- DIM engines have a facile adaptability to work with biofuels, heaving a large potential in this direction;
- rapeseed oil can be an important renewable source of energy for Romania;
- it is absolutely necessary the biofuel preheating in order to rich the diesel oil physical state;
- burning WRO contributes to the emissions reduction;
- vegetable oil has a high level of biological decomposability;
- production of WRO and RME opens new opportunities for the agriculture;
- WRO has a high level of safety regarding the storage and transportation;
- engines working on the base of wall film injection are very suitable for the biofuels;
- the development of multi-fuel engines is now a very important task for the engineers in the field.

REFERENCES

2. NAGHIU, AL., NAGHIU, LIVIA, Poluarea produsă de motoarele cu ardere internă și posibilități de reducere a acesteia (The pollution made by the internal burning engines and possibilities to decrease it), rew. Mecanizarea Agriculturii, no. 11/2005, pg. 10-15
4. BURNETE, N., NAGHIU AL., BARABAS, I., TEBEREAN, I., VARGA, B., COSTEA, A.-R., Researches regarding injection pressure influence on compressed ignited engines running on vegetal oil based fuel performance, CAR20051078, Pitești, 2005