Modern Serial Engines Operating with Natural Diesel Fuel 50 - 200 kW (60 - 270 b.h.p.)

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INTRODUCTION

Natural diesel is a fuel produced from crude plant oil. To use this high boiling and thick flowing fuel, a modern diesel engine has to be developed. The conventional pre-chamber engines in general are able to operate with natural diesel fuel. Biodiesel is the synonym for thin-bodied made plant oil methyl ester (PME). Both conceptions complement each other positively.

PME is suitable to be used for such engines already in production. Crude palm oil is more suitable for specially developed engines. Natural diesel is rather easily produced hence plant oil engine fleets are independent from central fuel distribution networks.

THE FUEL

The difference characteristics among plant oil, mixed fuel and diesel fuel are shown in *Figure 1*. The boiling characteristic of diesel fuel and plant oil differs by 80 K. The viscosity of plant oil is at one tenth power higher at the same temperatures within the fuel systems.

Polymerization tendency of various plant oils is different from one another, with palm oil it is rather low compared to other species of plant oil growing in Central Europe. This explains the fact that palm oil has a considerably low content of free fatty acids *(Figure 2)*.

THE ENGINE

On the advice of the Federal Ministry of Research & Technology (Ministry of Future), Thüringer Motorenwerke GmbH Nordhausen (TMW) had developed a modern direct injection plant oil engine. One of the characteristics of this engine is that its efficiency can reach 40 to 45%. Considering normal direct injection diesel engines at the maximum output, the temperature at the combustion chamber edge is about 350°C. By using special steel for the piston this temperature could be increased up to more than 600°C *(Figure 3)*. This compensates the higher boiling characteristic of plant oil.

A pre-heating device is installed in the fuel tank and fuel filter. The temperature of plant oil within the injection pump suction chamber is increased up to about 70°C. This resulted in the viscosity of plant oil being decreased to about 10 mm² per second *(Figure 4)*.

When plant oil, which has a considerable amount of free fatty acids comes into contact with water and air at high temperature, it undergoes polymerization. This is a common characteristic of linseed oil (basic material for paints). Therefore the fuel system of the engine in the stall position should be filled with diesel fuel. For colder climates this is useful for cold starting aid. Because of the lesser polymerization tendency of palm oil and coconut oil this fact should not be considered seriously.

As palm oil can only flow at temperatures above 31°C the mentioned pre-heating device is required. By mixing with diesel fuel, its ability to flow is given in *Figure 5*.

CONCLUSION

For plant oil operation an engine was developed which is able to operate over the whole family characteristics.

A long-term test, running under conditions analogous to truck operation, had proven the suitability of our plant oil engine. The test was made by Messrs. Porsche AG, an independent and neutral institution *(Figure 6)*. The stability in fuel consumption and fume emission are also given. Engines under practical use have proven that the long-term ability is possible; stationary engines with 15,000 operation hours, power unit for truck with more than 100,000 driven kilometres and in tractors

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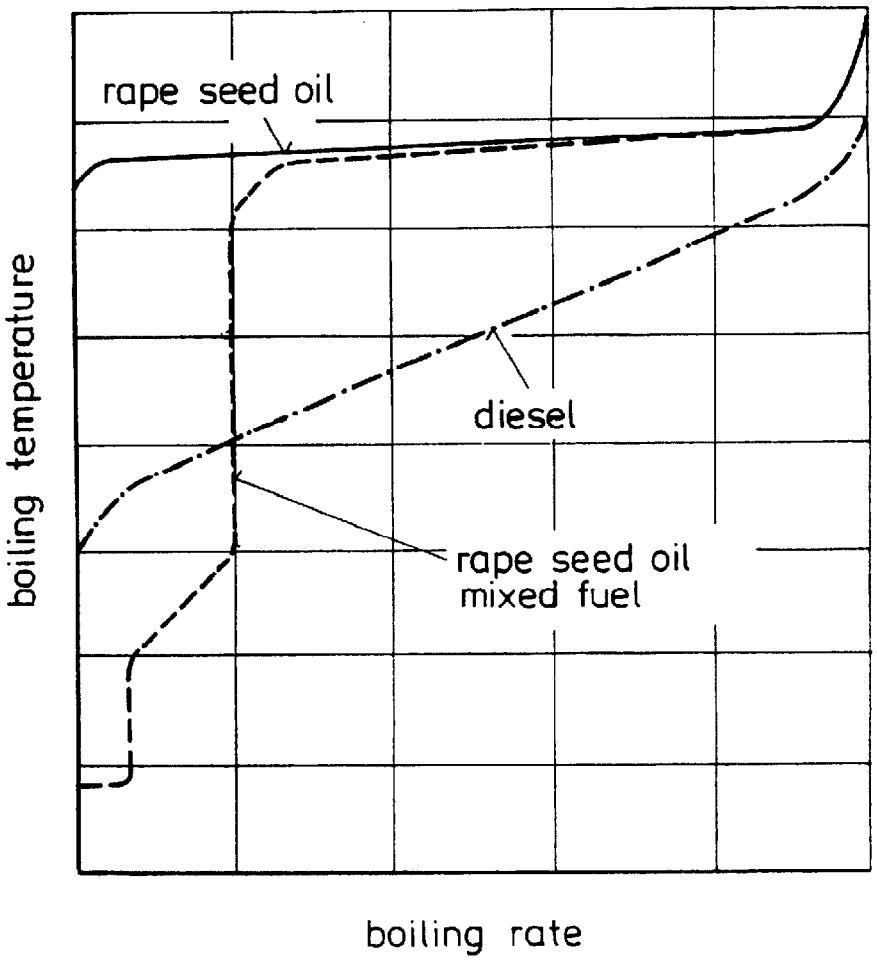

Figure 1. Boiling curve

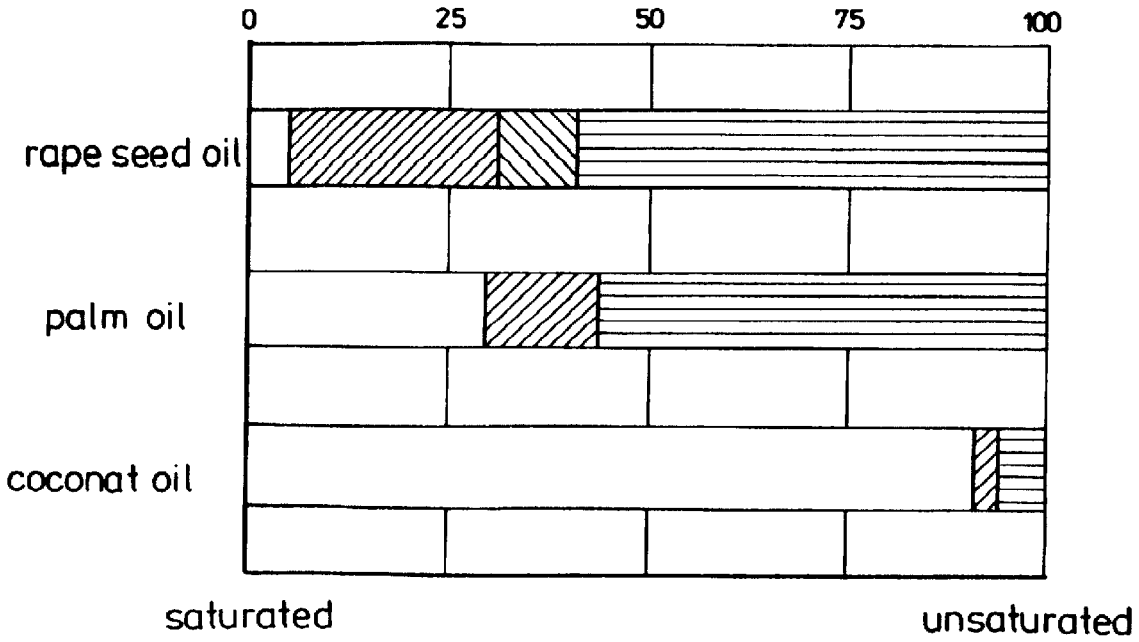

Figure 2. Fatty acid spectrum

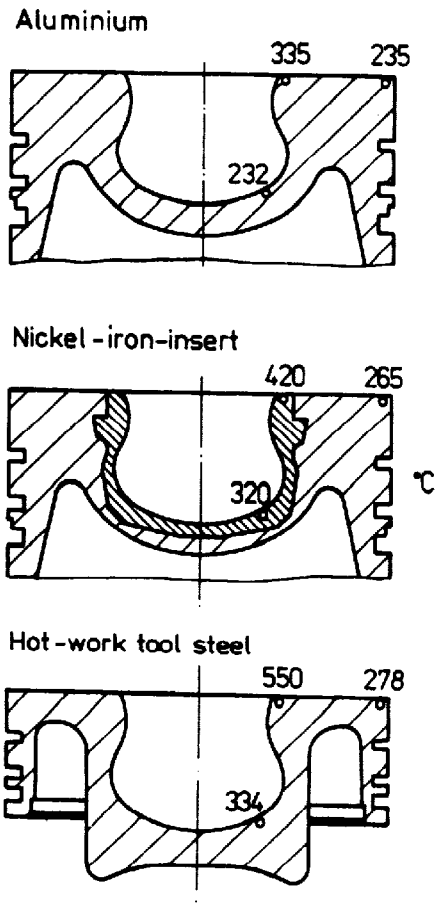

Figure 3. Temperatures in the piston head combustion chamber

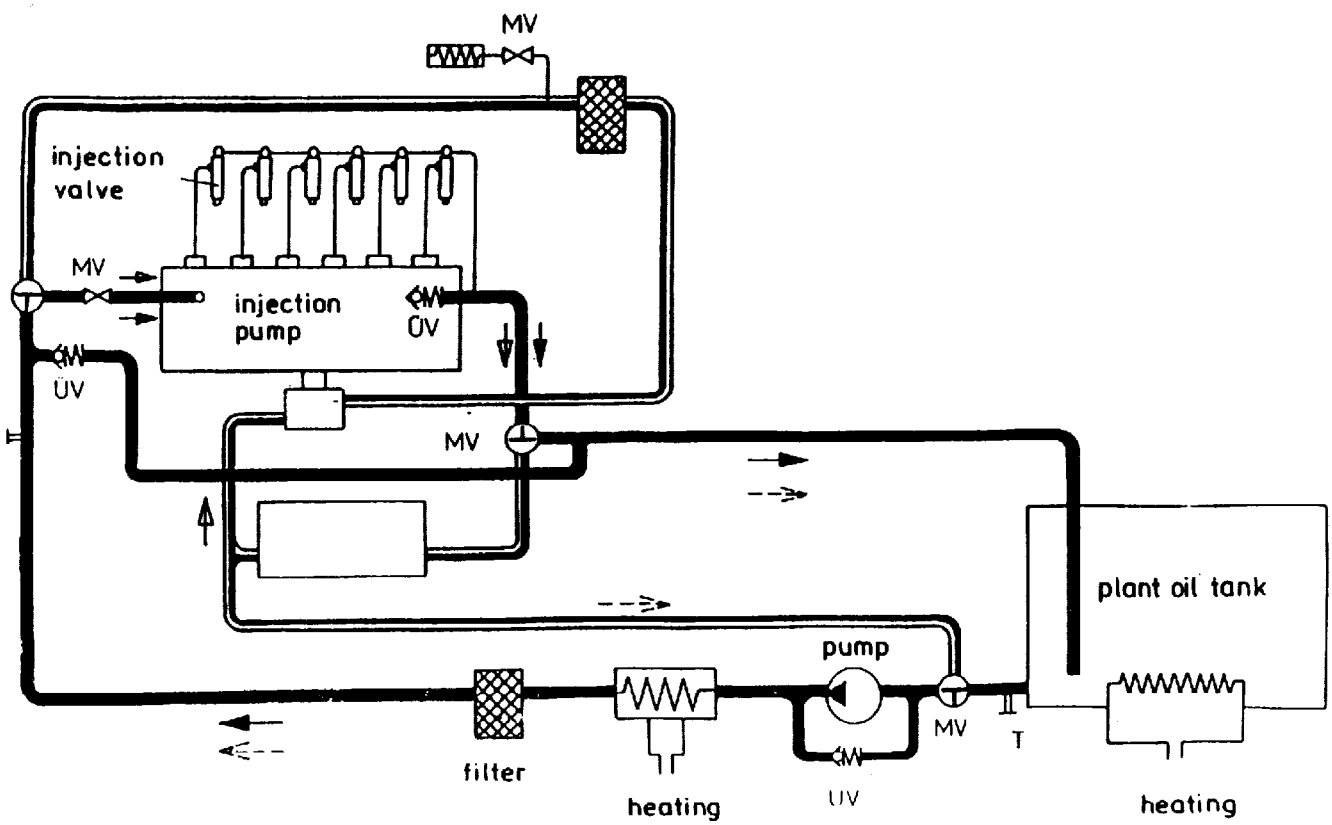

Figure 4. Fuel system

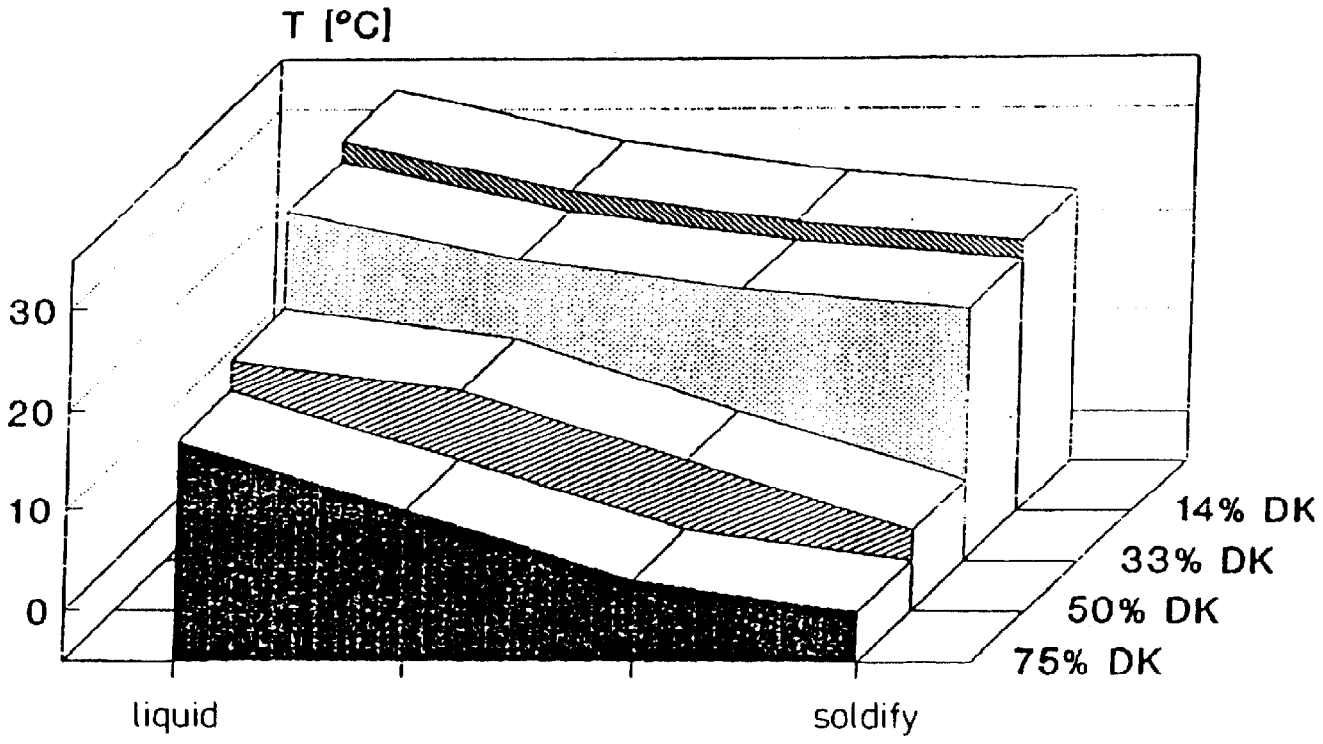

Figure 5. Flow behaviour of palm oil

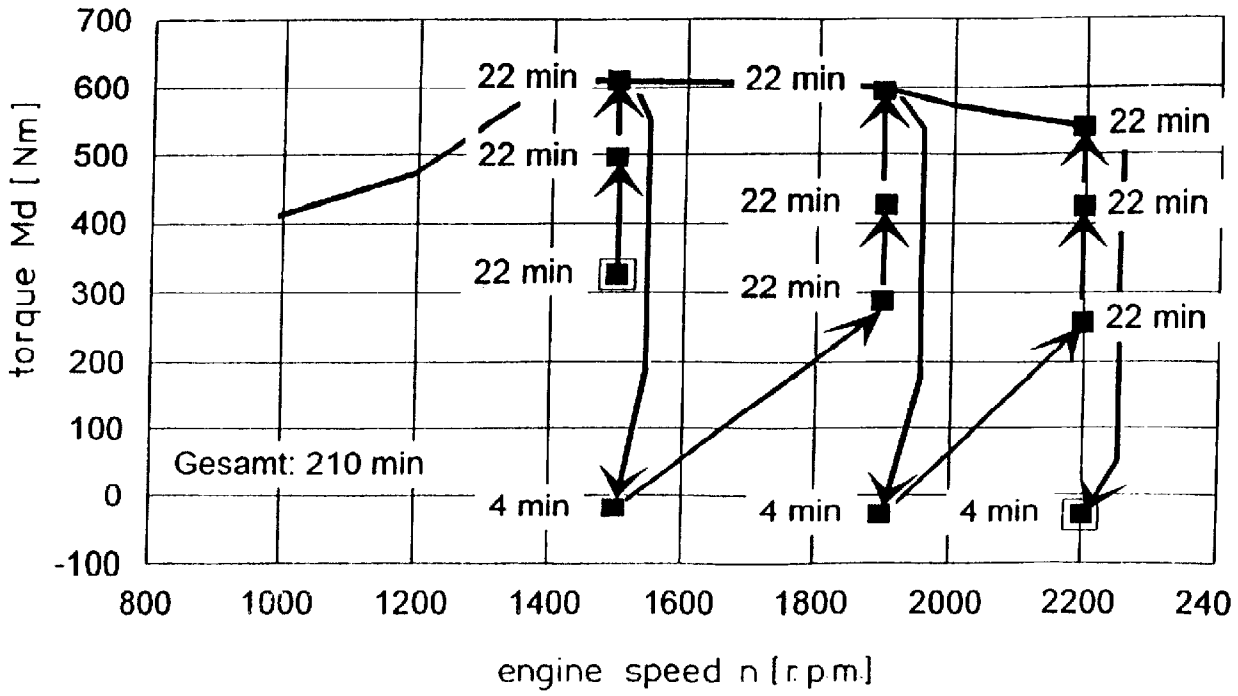

Figure 6.

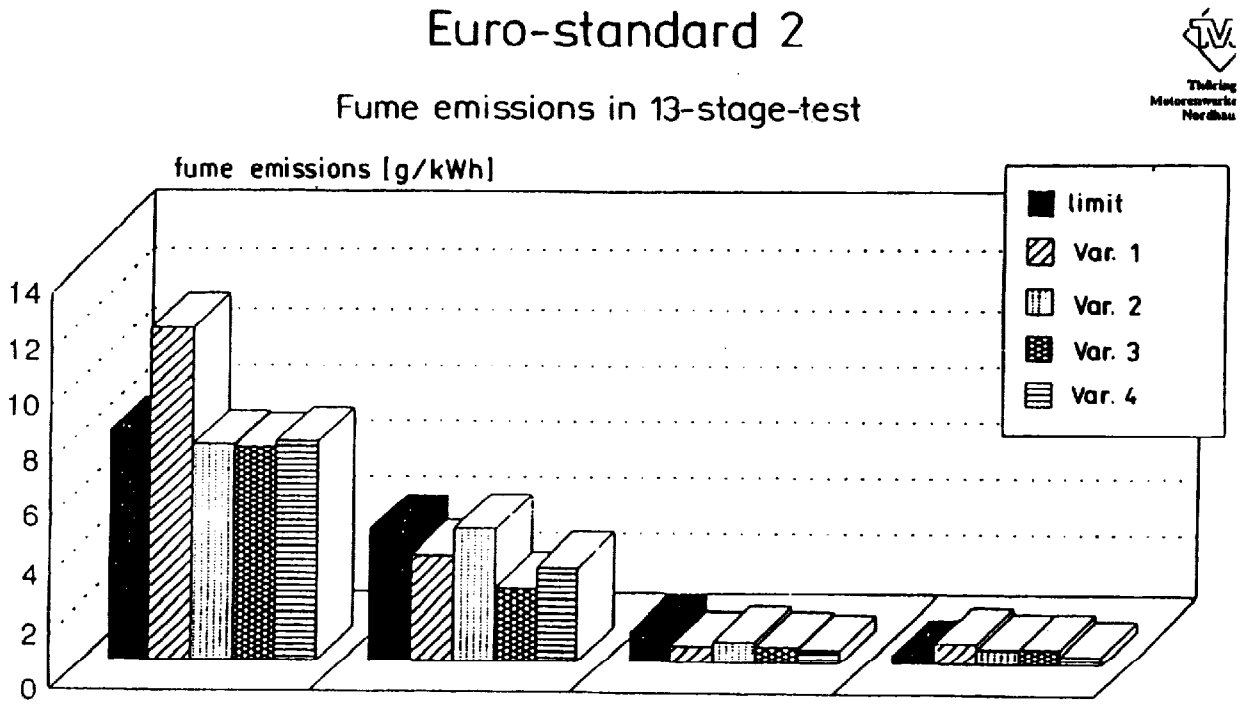

Figure 7. Fume emissions in 13-stage-test

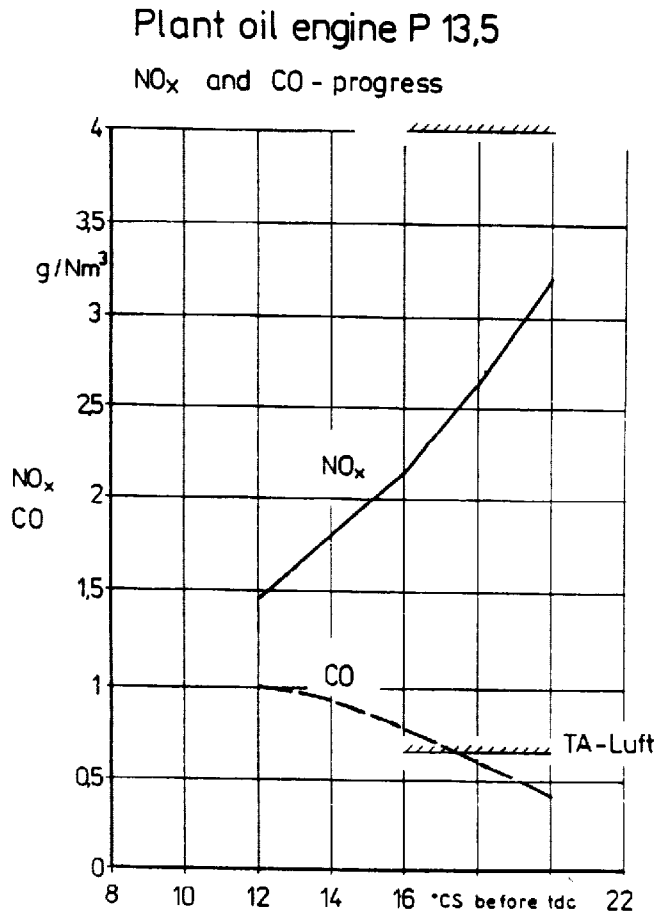

Figure 8. NOx and CO Progress

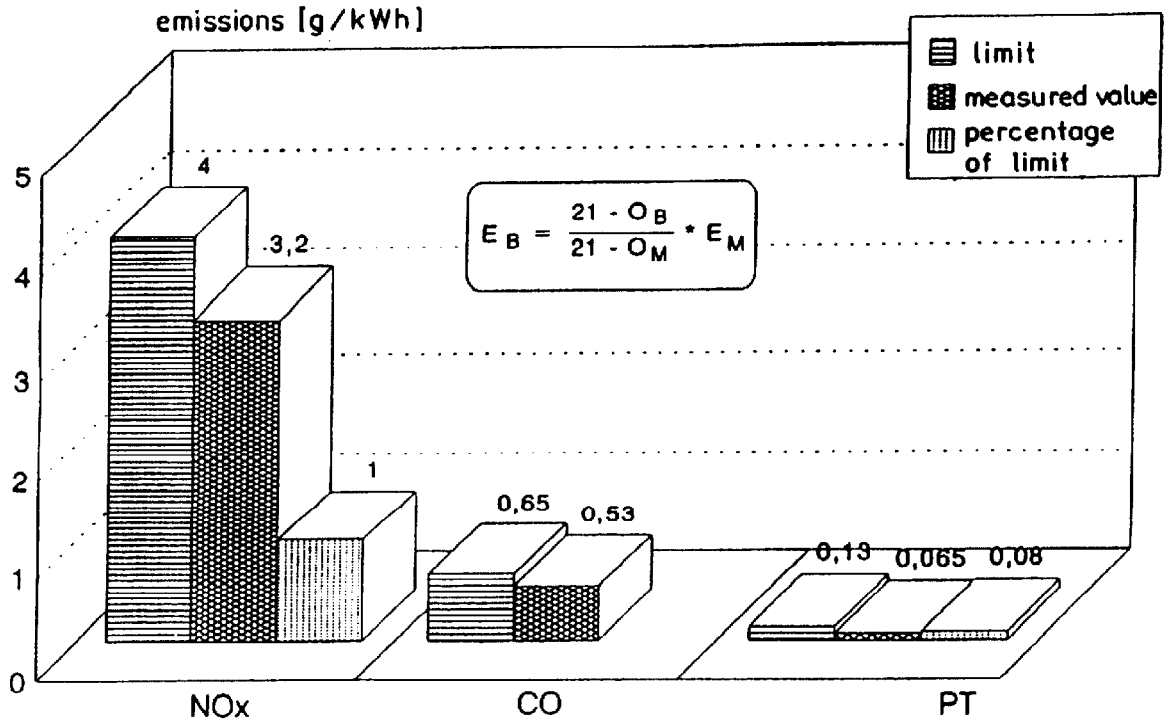

Figure 9. Fume emissions acc. to TA luft

(among these, there was a John Deere one) with about 3,000 running hours.

Further developments were done to achieve lowest fume emissions. For vehicle engines the "Euro standard 2" could be demonstrated *(Figure 7)*.

Engines running in housing areas have to meet the regulations of the so called "TA-Luft". The emissions of nitrogen oxides (NO_x) and carbon monoxide could be overcome by means of oxidation catalytic converter *(Figures 8* and *9)*.

OUTLOOK

In order to return into the natural substance cycle, an engine running with regenerative fuel is utmost desired. One of the solutions is by using plant oil engines.

In Europe, it can be expected that plant oil engines can generate 2 to 5% of energy demand. In the warmer countries and regions, most of the crops could have a multiple yield, thus plant oil engines can find a wider use there .