Transactions on Ecology and the Environment vol 6, © 1995 WIT Press, www.witpress.com, ISSN 1743-3541

Emissions from two compression ignition engined vehicles running on mineral and rape seed oil based fuels

R. Howard-Hildige,[a] S. Condon,[a] J.J. Leahy,[b] K. McDonnell[c]
[a]*Department of Mechanical and Aeronautical Engineering, University of Limerick, Limerick, Ireland*
[b]*Department of Chemical and Environmental Science, University of Limerick, Limerick, Ireland*
[c]*Department of Agricultural and Food Engineering, University College Dublin, Dublin, Ireland*

Abstract

Emissions of carbon monoxide, carbon dioxide, oxygen, exhaust opacity, and engine performance were measured upon

(1) A 1.4 litre turbo charged Elsbett powered Volkswagen Transporter, running on cold pressed, filtered to 25 microns, unprocessed rape seed oil, compared with running on mineral fuel oil.

(2) A 2.4 litre naturally aspirated Toyota Dyna, running on rape methyl ester compared with running on mineral fuel oil.

Emissions of carbon monoxide were found to be generally higher with the mineral fuel oil (peak value 0.27%) than with the rape methyl ester (peak value 0.25%) used in the Toyota Dyna, however with the Elsbett engined vehicle running on unprocessed rape seed oil the carbon monoxide emissions were significantly higher than that of the mineral fuel oil (peak values of 0.29% and 0.19% respectively). The emissions of carbon dioxide were similar for both vehicles and for both fuels (typically 11% - 14%), whereas oxygen emission was found to be greater with the oil seed rape based fuels (typically 2.5% - 3.5%) than with the mineral fuel (typically 0.5% - 2.5%), for both vehicles.

Exhaust opacity was found to be significantly greater for the mineral fuel oil (typically 40 - 80 Hartridge smoke units) than the oil seed rape based fuels (typically 20 - 60 Hartridge smoke units), in the case of the Toyota Dyna running on rape methyl ester the exhaust smoke output was approximately half that of the mineral based fuel.

1 Introduction

Biologically sourced fuel (bio-fuel) had been the main source of man's energy requirement until the nineteenth century when mineral oil and coal became widely utilised. Since then man's energy requirements have been gained primarily from non renewable mineral fuels (MF). The use of mineral fuels introduces buried carbon into the present day atmosphere, resulting in increased levels of carbon dioxide which increases the greenhouse effect. By the year 2000 it is expected that 330 billion tonnes of carbon will have been emitted. The largest dependant on the world's mineral oil supply is the transportation industry IEA[1]. Elsbett et. al.[2] point out that the carbon dioxide produced from using bio-fuel is taken in the growth of further plants, simultaneously oxygen consumed in the use of bio-fuel is regenerated, thus maintaining a balance. The use of vegetable oil as a fuel also avoids the production of sulphur dioxide and heavy metal compounds. Elsbett et. al.[2,3] describes the construction of a compression ignition engine which is designed to run on a variety of fuels including vegetable oil. Special features of the engine are a duothermic combustion chamber which stratifies the charge within the cylinder into a hot core with a cooler layer near the cylinder wall, a piston with a cast iron crown and an aluminium skirt and a cooling system which employs engine lubricating oil.

2 Experimental Equipment

Two vehicles were used in the study

(i) A 2.4 litre naturally aspirated indirect injection compression ignition Toyota Dyna, which was run on either mineral fuel (Diesel road fuel oil), or rape methyl ester (RME).

(ii) A 1.4 litre turbo charged direct injection compression ignition Elsbett engined Volkswagen Transporter, which was run on either mineral fuel or cold pressed and filtered to less than 25 microns rape seed oil (RSO).

The power output from each vehicle was measured at the road wheels using a Sun "Road-a-matic" XI/1 chassis dynamometer. The exhaust composition from both vehicles was measured using a Sun MCA-3000 on line infra red exhaust analyser which was calibrated before each test. Exhaust opacity was measured using a Hartridge Mk 3 Smoke meter.

3 Results

The quantities brake power, smoke, carbon dioxide, carbon monoxide and oxygen emitted were all plotted against engine speed in revolutions per minute (RPM). Each quantity is plotted for each fuel and both vehicles on the same graph, and this data is given in figures 1 to 5. Figures 6 to 9 show how the quantities varied relative to each other with change in engine speed for individual tests. Due to relatively low emissions the carbon monoxide results have been multiplied by a factor of 100 to allow comparison with the other quantities on the same set of axes.

Exhaust opacity is measured in Hartridge smoke units (HSU). This data was also recorded in absolute smoke units, however HSU was presented as the numerical values allow more convenient comparison with the other quantities

Transactions on Ecology and the Environment vol 6, © 1995 WIT Press, www.witpress.com, ISSN 1743-3541

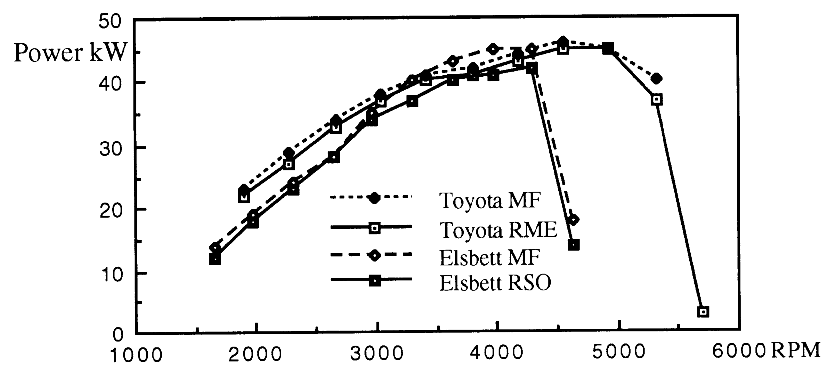

Figure 1: Brake power Vs. engine speed

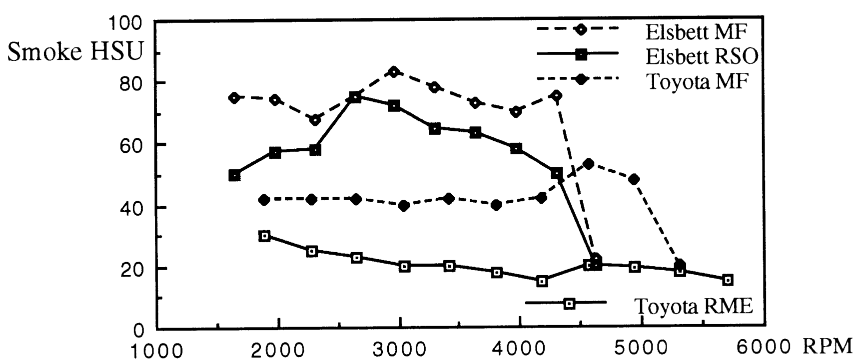

Figure 2: Smoke emitted Vs. engine speed

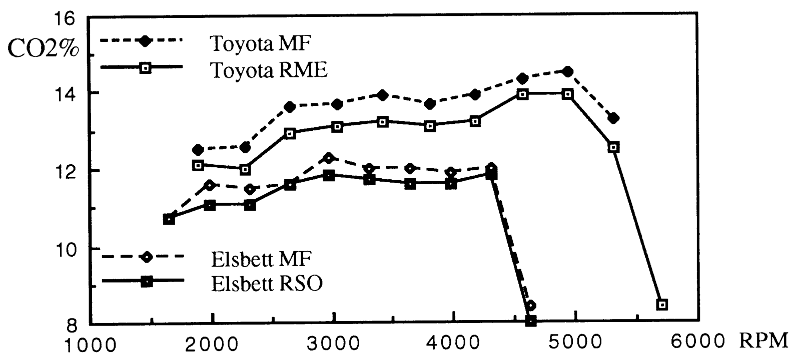

Figure 3: Carbon dioxide emitted Vs. engine speed

Transactions on Ecology and the Environment vol 6, © 1995 WIT Press, www.witpress.com, ISSN 1743-3541

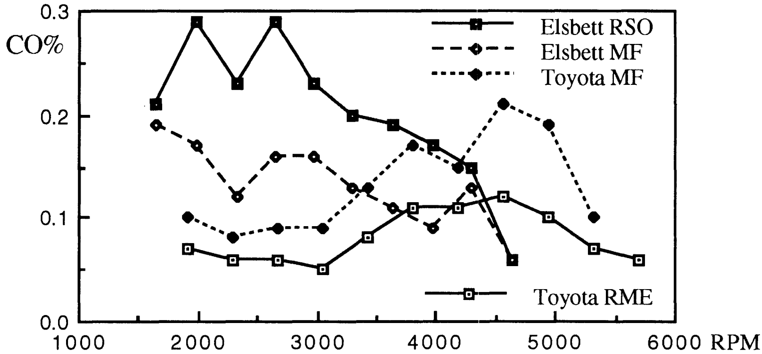

Figure 4: Carbon monoxide Vs. engine speed

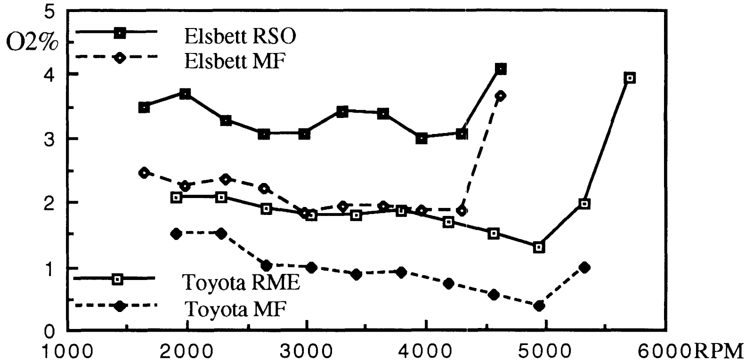

Figure 5: Oxygen emitted Vs. engine speed

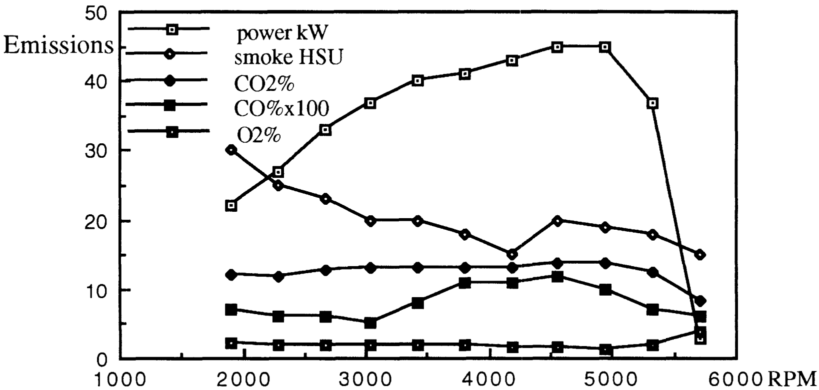

Figure 6: Toyota emissions when running on rape methyl ester

Transactions on Ecology and the Environment vol 6, © 1995 WIT Press, www.witpress.com, ISSN 1743-3541

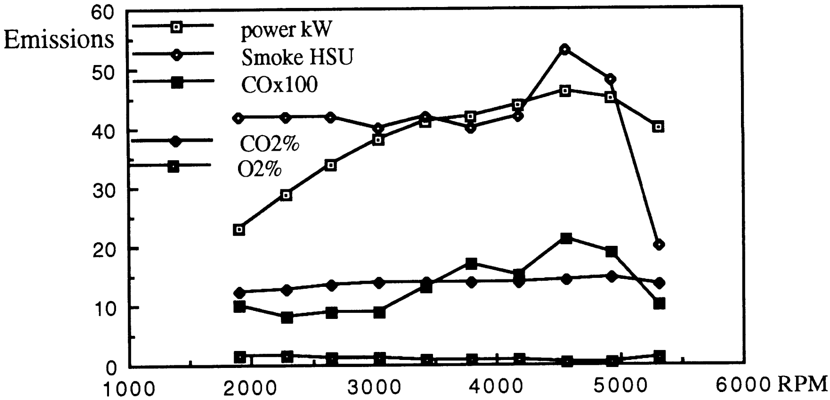

Figure 7: Toyota emissions when running on mineral fuel

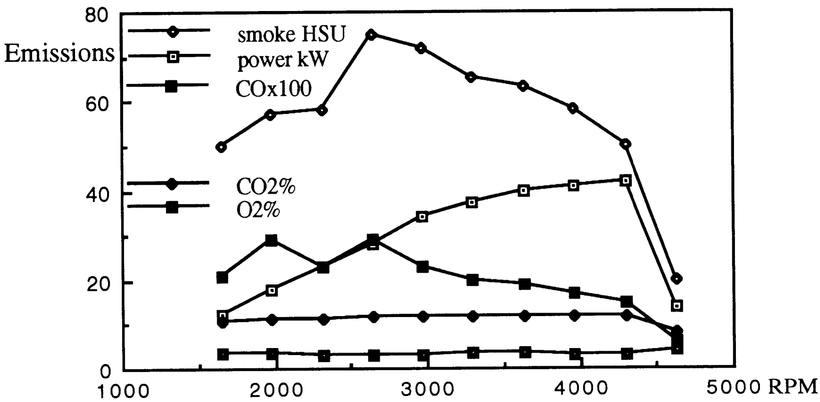

Figure 8: Elsbett emissions when running on rape seed oil

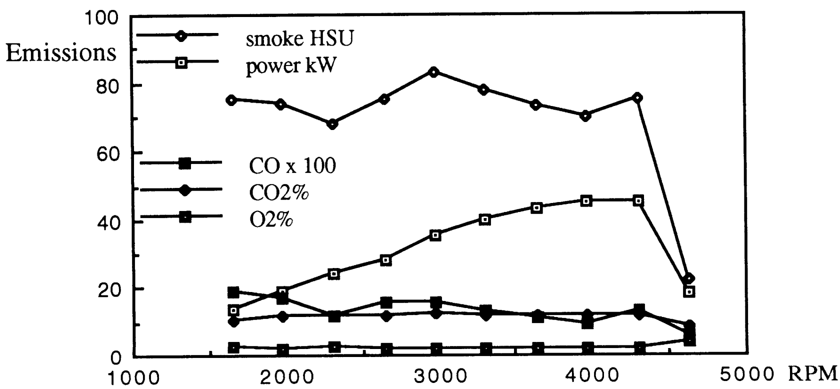

Figure 9: Elsbett emissions when running on mineral fuel

4 Discussion

Figure 1 shows that the brake power for the Toyota and the Elsbett to be similar up to approximately 4200 RPM, at higher engine speeds the power produced by the Elsbett falls off rapidly. The Toyota has a greater range and exhibits a slightly higher power output than the Elsbett at all engine speeds. It is this similarity of performance which perhaps provides some justification for presentation of data for the two vehicles on the same set of axes, but it must be remembered that the two vehicles achieve this similarity of performance by different means, and in the case of the vegetable oil by two different preparations of rape seed oil. These differences limit the comparison between the individual tests. It can be clearly seen that there exists little difference in performance of either vehicle whether running on mineral fuel or the oil seed rape fuels.

It can be clearly seen from figure 2 that in all cases the oil seed rape fuels give lower smoke emissions across the range of engine speeds, this agrees with the findings of Murayama et al[4]. The Toyota running on RME is clearly the best, typically producing half the smoke output of the mineral fuel. The higher smoke emissions of the Elsbett engined vehicle were expected as the Toyota had recently overhauled atomisers (injectors), although Whiteman[5] found that a 1.4 litre Elsbett gave much lower smoke emissions than a direct injection Steyr M1 engine, but the fuel used by Whiteman was not specified. The smoke emitted values for the mineral fuel and rape seed based fuel for the Elsbett were closer than the Toyota, but the rape seed oil used in the Elsbett was unprocessed apart from filtering to 25 microns.

Carbon dioxide emitted was also lower with the rape seed based fuels than with the mineral fuel for both vehicles, the Elsbett having a lower output than the Toyota.

The level of carbon monoxide output is much lower than the other emissions, and the oil seed rape based fuels in general produce more carbon monoxide than the mineral fuel. The carbon monoxide emitted by the Elsbett engine is generally greater than the Toyota for both fuels and tends to decrease with increasing engine speed, the same pattern is not repeated with the Toyota, and figure 4 shows that the carbon monoxide emitted tends to increase with engine speed up to approximately 4500 RPM before it starts to fall. The higher carbon monoxide readings from the Elsbett are most probably due to a breakdown in the duothermic system resulting in potential coking and unburned fuel passing through as smoke and carbon monoxide. Maintaining the duothermic system at all engine speeds and loads is virtually impossible according to Whiteman[5]. Figures 6 to 9 show that the Carbon monoxide emissions tend to follow the trend of smoke emitted this feature is particularly pronounced in figures 7 and 8 which are the Toyota running on mineral fuel and the Elsbett running on rape seed oil so the effect appears to be independent of fuel or engine type.

Figure 5 shows that the oxygen emitted is higher for the oil seed rape based fuels than the same engine running on mineral fuel. This is probably due to a high level of indigenous oxygen in the oil seed rape based fuels, table 1 drawn from Condon[4] shows the typical composition of rape methyl ester and mineral fuels used. It is this oxygen content of the rape seed oil fuels that provides the potential to increase the combustion efficiency, especially under high load situations and this increased combustion efficiency results in lower smoke and carbon dioxide emission levels.

Transactions on Ecology and the Environment vol 6, © 1995 WIT Press, www.witpress.com, ISSN 1743-3541

Element	Rape methyl ester	Diesel fuel (DIN 51 601)
C	77%	86.3%
H	12.1%	13.7%
O_2	10.9%	0%
S	0%	<0.3%
P	50.0 mg/kg	0 mg/kg

Table 1 Composition of Rape methyl ester and mineral fuel

5 Conclusions

1. Little difference in power output is evident between the use of mineral fuel or oil seed rape based fuel for both engines tested.

2. Significantly less smoke is emitted with the oil seed rape based fuels compared to the mineral fuel for both engines tested.

3. Lower carbon dioxide emissions result from the use of oil seed rape based fuels compared to the use of mineral fuels for both engines tested.

4. Carbon monoxide output is lower for the rape methyl ester than the mineral fuel for the Toyota, but the mineral fuel gave lower carbon monoxide emissions than the cold pressed and filtered rape seed oil for the Elsbett engine.

References

1. Anon. International Energy Agency, energy policies of IEA countries, 1991 Review, OECD/IEA, 1992.

2. Elsbett, K., Elsbett, L., Elsbett, G., Kaiser, T. Vegetable oil utilisation requirements for the engine and experimental results. Food and Agriculture Organisation of the United Nations, First Technical Consultation of the CNRE on Biomass Conversion (el/n.9) Freising, 14-17 October 1985.

3. Elsbett, K., Elsbett, L., Elsbett, G., Behrens, M. The Duothermic Combustion for D.I. Diesel Engines, SAE Technical Paper Series 860310, SAE 1986.

4. Murayama, T., Oh, Y., Miyamoto, N., Chikahisa, T., Takagi, N., Itow, K. Low carbon flower build up, low smoke, and efficient Diesel operation with vegetable oils by conversion to mono-esters and blending with diesel oil or alcohols. Paper 841161 Society of Automotive Engineers 1985.

5. Whiteman, P. The Elko engine,Technical evaluation of the Elsbett engine. The British Internal Combustion Engine Research Institute 1990

6. Condon, S. B.Eng Thesis, University of Limerick 1993.