IRTENZ

Alternate liquid fuels for internal combustion engines – Russell Walsh

This document discusses some of the common options that can be used as replacement for or as a supplement to, diesel fuel in a Compression Ignition (CI) engine. It will not discuss the application of pure electric or hybrid engines or the use of an alternative to petrol, nor will it discuss alternative fuel use in stationary engines or heavy earth moving equipment.

Almost since Rudolf Diesel invented a practical CI engine in 1893 engineers and scientists have been working to find ways to make these engines more efficient. In recent times this research has evolved into not only making the engine more efficient but also to reduce, as much as possible, the impact of pollution combustion on the environment. In his early experiments with CI engines Rudolf used peanut oil, but this did not work as the vegetable-based oil available at the time had a high viscosity, (its ability to flow), and tended to gum up injectors, valves and piston rings, so he switched to 'diesel', a refined petroleum-based product specifically designed for use in a CI (diesel) engine, in 1897.

Objective

The objective of using any alternative fuel includes one or more of the following:

- Improving fuel consumption.
- Improving the thermal efficiency of the engine.
- Improving vehicle drivability.
- Improving vehicle efficiency
- Reducing exhaust emissions including Nitrogen Oxide (NOx), Carbon Dioxide (CO_2) and other harmful particulates into the atmosphere.
- Reducing overall operating costs.

Options that have received a lot of attention in recent years are to mix conventional diesel with another fuel, or use another fuel that has similar characteristics, as a fuel substitute.

Biodiesel

Biodiesel is derived from many sources including waste cooking oil and animal fats, the base product. It is a carbon neutral source of energy produced by chemically reacting the base product with an alcohol such as methanol or ethanol.

It is claimed that biodiesel can be used in many diesel engines but its use as full diesel replacement is not universally approved by the major engine manufacturers.

Hydrogenated Vegetable Oil

Hydrogenated Vegetable Oil (HVO) is an improved method to produce higher quality bio-based diesel fuels than straight biodiesel but with minimal impact on fuel supply, engines, exhaust aftertreatment devices, or exhaust emissions.

HVO is made from the similar base products that are used to produce biodiesel and is produced by hydrogenation, a chemical reaction using hydrogen and catalysts, and hydrocracking[1] of vegetable oils and animal fats at high temperatures and pressures.

Bioethanol

Due to the ready availability of raw material globally, such as sugar cane, wheat, and corn Bioethanol is used widely in transport. Sugar rich waste such as starch cellulose or bread can be also used.

A major advantage of Bioethanol is that it is comparatively easy to produce. Because of this it is often cited as the fuel that is most likely to be able to supply both large and sustainable volumes of the base product in the future.

Hydrogen Direct Injection

Hydrogen Direct Injection (HYDI) uses hydrogen on demand to improve the combustion of diesel fuel.

Distilled water from an onboard tank is subjected to an electrical charge from the vehicle's electrical system, which, through electrolysis splits the water into it constitute components, hydrogen, and oxygen. The oxygen is expelled into the atmosphere whilst the hydrogen is directly injected in the vehicle's intake system where it mixes with air before entering the combustion chamber. The amount of hydrogen required to meet engine demand is determined by a control box.

As no hydrogen is stored on the vehicle no storage tanks are required.

Renewable diesel

Renewable diesel sometimes known as green diesel, is made from fats and oils, such as refined soybean or canola oils, that are processed to be chemically the same as petroleum diesel. Renewable diesel meets the ASTM D975 specification for petroleum in the United States and EN 590 in Europe.

Renewable diesel can be used as a replacement fuel or blended with any amount of diesel and is in common use in some States of the United States.

Renewable diesel and biodiesel are not the same product.

Kerosine

Kerosine and diesel are both petroleum fuels from components of crude oil.
Kerosene is extracted first and then diesel. It is typically cheaper than diesel, and because it burns at a lower temperature than diesel, prevents gelling in freezing temperatures which would appear to make it an ideal substitute for diesel fuel but there are risks associated with this these include:

- Burns at a lower temperature than diesel therefore it is far less efficient and reduces engine power.
- Can cause damage to some engines.
- Is not universally approved for use in diesel engines.
- It is non lubricating.

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[1] Hydrocracking is a chemical process in which the components of oil are either partly or completely converted into lighter molecules under the influence of hydrogen and in the presence of a catalyst.

Jet fuel (JP-8)

In 1978 NATO approved the use of JP-8 as a universal fuel able to be used in both gas turbine engines, particularly helicopters, and diesel fuelled vehicles. The United States military adopted widespread use of this or its predecessor JP-4. In 1995 however some issues were discovered with this during operational service and resulting in experiments to find a more suitable universal fuel.

Claimed emission reduction.

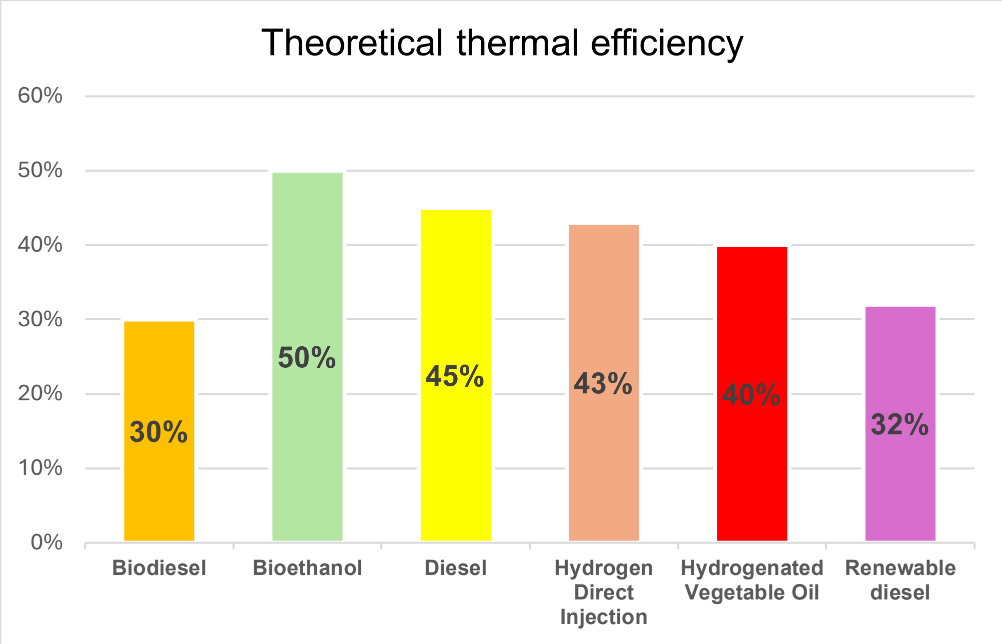
The following table shows the claimed emissions reduction possible compared to an engine using standard diesel only.

Fuel	Claimed emission reduction
Biodiesel	75-80%
Bioethanol	85-90%
Hydrogen Direct Injection	1-2%
Hydrogenated Vegetable Oil	90%
Renewable diesel	76%

A note on thermal efficiency.

Thermal efficiency, measured in percentage terms, is the ratio of energy contained in the fuel to the energy that is available to use, (to perform work).

Diesel engines of the 1960s were generally rated with a thermal efficiency of 30 to 36% whereas today similar engines are rated in the 45 to 50% range. This improvement has come about by improvements in engine design and fuel characteristics often as a result of regulatory intervention, engines that meet Euro standards are an example of this. Despite the advances that have been made the inherent characteristics of a diesel engine, they produce heat and friction, 100% thermal efficiency is unlikely ever to be obtained, theoretically the best that can be achieved is about 70%.



The percentages shown in the above chart are theoretical only.

The operating environment of any engine at a particular time can and does, have a large influence on the engine's performance.

References:

Information in the document was retrieved from a number of sources including:

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