- a total amount of water and methanol of at least 60% by weight of the fuel composition, and
- one or more additives, in a total amount of at least 0.1% by weight of the fuel, wherein the level of sodium chloride, if present as an additive, is between 0 to 0.5% by weight of the fuel, and the level of flavourant, if present as an additive, is between 0 to 1.5% of the composition, wherein the fuel composition comprises not more than 20% by weight dimethyl ether.

The present invention also provides a diesel engine fuel composition comprising methanol and at least 3% by weight water, and one or more additives selected from the group consisting of: ignition improvers, fuel extenders, combustion enhancers, oxygen absorbing oil, lubricity additives, product colouration additives, flame colour additives, anti corrosion additives, biocides, freeze point depressants, deposit reductants, denaturants, pH controlling agents, and mixtures thereof, wherein the fuel composition comprises not more than 20% by weight dimethyl ether.

In accordance with the present invention there is also provided a process for powering a compression ignition engine using a fuel comprising methanol and water, including:

pre-heating an intake air stream, introducing the pre-heated air into a combustion chamber of the engine and compressing the pre-heated air; and

introducing ~~the~~ a fuel comprising methanol and at least 3% by weight water, and not more than 20% dimethyl ether, into the combustion chamber and igniting the fuel/air mixture to drive the engine.

The invention can result in simplification and a lower cost of fuel manufacture and reduced environmental impact by elimination of the need for production of high purity components and by-product components, by acceptance of a blend of such components into a fuel according to the methods described herein. Cost and environmental benefit may also arise from the use of fuel in cold climates, since the freezing point of the fuel can readily meet any low temperature environments likely to be encountered.

The exhaust resulting from fuel combustion may contain low impurities, making it ideal for subsequent processing. As one example, the CO2 may be converted back to methanol to directly reduce the greenhouse gas CO2 or high purity CO2 can be used for organic growth such as algae for multiple end uses including methanol manufacture, utilizing energy sources which can include renewable sources, including solar.

According to one embodiment, the additive comprises ether, at a level of up to 20% by weight of the fuel. The ether may be dimethyl ether.

It will be noted that references to a fuel composition that "comprises not more than 20% by weight dimethyl ether" encompass fuels containing no dimethyl ether. However in some embodiments, dimethyl ether is present in the final composition. Dimethyl ether in such cases may constitute more than 0% and not more than 20% of the fuel composition.

In some embodiments, water generated during fuel combustion can be recovered, which is a major advantage for remote areas where water is scarce. In other instances, heat generated in operation of the diesel engine can be utilised for local area heating requirements. Some embodiments as described below accordingly provide systems for power generation through the operation of a diesel engine which utilise the water and/or heat output of the engine in a suitable way.

In accordance with the present invention there is further provided a power generation system comprising:

powering a compression ignition engine using a methanol-water fuel to generate power, wherein the methanol-water fuel comprises methanol and at least 3% by weight water, and not more than 20% by weight dimethyl ether;

preheating an inlet air stream of the compression ignition engine, and/or fumigating the inlet air stream with an ignition enhancer;

treating engine exhaust gas to recover exhaust heat and/or water from the engine, and redirecting the heat and/or water for further use.

In some embodiments the heat and/or water can be recycled back into the engine for re-use. Alternatively or additionally, the heat and/or water can be re-directed locally for use elsewhere. In one example, heat may be supplied through a hot water loop to a nearby community to provide the community with energy in the form of heat, for example to heat domestic or commercial premises. The engine in this example could be used to generate electricity for the community, which may especially be beneficial to remote communities.

In other embodiments the system may be adapted to power vehicles, including rail and marine vehicles. In these applications exhaust is treated to remove particulates, and recover heat and water for re-use in the engine and for other use as required on the rail or marine vehicle.

In accordance with the present invention there is still further provided a method of transporting a two-part pre-fuel composition comprising methanol and ether, including transporting the pre-fuel from a first location to a second location remote from the first location, and separating the ether from the methanol to yield a first fuel part comprising methanol, and a second fuel part comprising ether.

In accordance with the present invention there is still further provided a pre-fuel composition comprising methanol and up to 10% by weight of an ether.

In accordance with the present invention there is still further provided use of the diesel fuel composition described above in the process or power generation system described above.

air with a fumigant.

All amounts referred to in this document are by reference to weight, unless specified otherwise. Where a percentage amount of a component in the main fuel composition is described, this is a reference to the percentage of that component by weight of the fuel composition. When a fumigant is used, this is not considered as part of the fuel composition itself, so the fuel composition in this context is read as excluding fumigant.

Whilst this specific new diesel fuel composition forms one aspect of the present invention, and can be used in the operation of the process of the present invention, methanol-water fuels containing lower water levels may also be used in the process. In the following, features of the more general methanol-water fuels are described. It is noted that features of these fuels may be present in the new diesel fuels claimed in this application.

In general, the relative amount of water to methanol in the fuel composition may be in the range of from ~~0.2:99.8~~3:97 to 80:20 by weight. According to some embodiments, the minimum water level (relative to methanol) is ~~1:99~~3:97, such as a minimum ratio of ~~2:98, 3:97,~~ 5:95, 7:93, 10:90, 15:95, 19:81; 21:79. The upper limit of water (relative to methanol) in the composition according to some embodiments is 80:20, such as 75:25, 70:30, 60:40, 50:50 or 40:60. The relative amount of water in the composition may be considered to be in the "low to medium water" level range, or a "medium to high water" level range. The "low to medium water" level range covers the range from any of the minimum levels indicated above to a maximum of either 18:82, 20:80, 25:75, 30:70, 40:60, 50:50 or 60:40. The "medium to high water" level range covers the range from either 20:80, 21:79, 25:75, 30:70, 40:60, 50:50, 56:44 or 60:40 to a maximum of one of the upper limits indicated above. A typical low/medium water level range is ~~2:98~~3:97 to 50:50, and a typical medium/high water level range is from 50:50 to 80:20. A typical low water level range is from 5:95 to 35:65. A typical medium level water range is 35:65 to 55:45. A typical high water level range is 55:45 to 80:20. The new higher-water content diesel fuel of the present invention may contain the above relative amounts of water and methanol, provided that the fuel contains the features of the fuel described previously (such as the minimum 20% water content).

Considered in terms of the percentage of water in the entire (main) fuel composition by weight, the relative amount of water in the main fuel composition may be a minimum of at least ~~0.2%, at least 0.5%, at least 1%, at least 2%, at least~~ 3%, at least 4%, at least 5%, at least 6%, at least 7%, at least 8%, at least 9%, at least 10%, at least 11%, at least 12%, at

The technology described herein with water production, HWL heat integration and emissions outcomes will come at a cost in terms of engine efficiency, however this aspect is in many cases expected be offset by supply chain benefits and the benefits mentioned above.

Examples

Example 1: Experimental Program to investigate methanol water fuel compositions for compression ignition engines

1.1 Summary

This report summarises the results obtained during an experimental programme undertaken by the University of Melbourne on the performance and engine-out emissions of different methanol based fuels in a compression ignition engine. Some fuel compositions tested contained less than 3% water, but the test data on such fuels contributes to the overall understanding of the new fuel compositions and processes of the claimed invention.

The fuels tested were mixtures of methanol, water, dimethyl ether (DME) and diethyl ether (DEE). As methanol is not normally a compression ignition fuel, two ignition promoter systems were used. The first consisted of an inlet air pre-heater. By heating the engine inlet air to up to 150degC (an imposed safety limit), higher temperatures are reached near the end of the compression stroke, at which point the main fuel charge is injected. In some cases, these temperatures were high enough such that compression ignition of the injected fuel occurred.

The second system for promoting ignition involved the continuous injection (i.e. fumigation) of gaseous di-methyl ether (DME) into the engine's inlet port. Because DME has a relatively low ignition temperature and a high cetane number, the DME auto-ignites as the air/fumigant mixture is compressed during the compression stroke, thus releasing thermal energy that in turn can ignite the main fuel charge.

The tests were conducted on a modified 1D81 Hatz, single cylinder diesel engine, mounted on an in-house built motoring/absorbing dynamometer facility. In its unmodified state, this naturally aspirated engine produces up to 10kW of shaft power from a single cylinder of approximately 670cc volume. It is very likely that the absolute performance of all fuels tested

will be better in larger engines, as it is commonly known in the engine community that peak engine efficiency increases with engine size due to fundamental physical laws.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A diesel engine fuel composition comprising:
- methanol at a level of at least 20% by weight of the fuel;
- water at a level at least 20% by weight of the fuel;
- a ratio of water to methanol of between 20:80 to 80:20;
- a total amount of water and methanol of at least 60% by weight of the fuel composition, and
- one or more additives, in a total amount of at least 0.1% by weight of the fuel, wherein the level of sodium chloride, if present as an additive, is between 0 to 0.5% by weight of the fuel, and the level of flavourant, if present as an additive, is between 0 to 1.5% of the composition,

wherein the fuel composition comprises not more than 20% by weight dimethyl ether.

2. The diesel engine fuel composition of claim 1, wherein the additives are selected from the group consisting of: ignition improvers, fuel extenders, combustion enhancers, oxygen absorbing oil, lubricity additives, product colouration additives, flame colour additives, anti corrosion additives, biocides, freeze point depressants, deposit reductants, denaturants, pH controlling agents, and mixtures thereof.

3. A diesel engine fuel composition comprising methanol and <u>at least 3% by weight</u> water, and one or more additives selected from the group consisting of: ignition improvers, fuel extenders, combustion enhancers, oxygen absorbing oil, lubricity additives, product colouration additives, flame colour additives, anti corrosion additives, biocides, freeze point depressants, deposit reductants, denaturants, pH controlling agents, and mixtures thereof, wherein the fuel composition comprises not more than 20% by weight dimethyl ether.

4. The diesel engine fuel composition of claim 3, wherein the fuel comprises from 3% to 40% <u>by weight</u> water, and not more than 20% <u>by weight</u> dimethyl ether.

<u>5. The diesel engine fuel composition of claim 3, wherein the fuel comprises from 5% to 40% by weight water.</u>

~~5.~~<u>6.</u> A diesel engine fuel composition of claim 3, comprising between 12% and 23% <u>by weight</u> water, methanol, and not more than 20% by weight of additives.

~~6. The diesel engine fuel composition according to claim 3, comprising between 20% and 68% by weight water, methanol, and not more than 20% by weight of additives.~~

7. The diesel engine fuel composition according to claim 3, comprising between 20% and 22% by weight water, methanol, and not more than 20% by weight of additives.

8. The diesel engine fuel composition according to claim 3, comprising between 20% and 22% by weight water, 4-6% by weight dimethyl ether and methanol.

9. The diesel engine fuel composition of any one of claims 3 to 8, comprising at least 20% by weight methanol.

10. The diesel engine fuel composition of any one of the preceding claims, wherein the diesel fuel composition is a single phase fuel composition.

11. The diesel engine fuel composition of any one of the preceding claims, wherein the total amount of water and methanol is at least 80% by weight of the fuel composition.

12. The diesel engine fuel composition of any one of the preceding claims, wherein the methanol in the diesel fuel composition is a crude methanol.

13. The diesel engine fuel composition of any one of the preceding claims, wherein the additives comprise:
- a product colouration additive at up to 1% by weight, and
- a flame colour additive, at up to 1% by weight of the fuel.

14. A process for powering a compression ignition engine using a fuel comprising methanol and water, including:

pre-heating an intake air stream, introducing the pre-heated air into a combustion chamber of the engine and compressing the pre-heated air; and

introducing the fuel comprising methanol and <u>at least 3% by weight</u> water, and not more than 20% by weight dimethyl ether, into the combustion chamber and igniting the fuel/air mixture to drive the engine.

<u>15. The process for powering a compression ignition engine as claimed in claim 14, including preheating the intake air to at least 50°C.</u>

16~~5~~. The process for powering a compression ignition engine as claimed in claim 14, including pre-heating the intake air to 150°C-300°C.

17~~6~~. The process for powering a compression ignition engine as claimed in claim 14, 15 or 16~~5~~, including passing exhaust material from the engine through a heat exchanger to pre-

heat the intake air stream entering the engine.

18~~7~~. The process for powering a compression ignition engine as claimed in claim ~~16~~17, including cooling exhaust material through the heat exchanger, collecting water from the cooled exhaust material and recycling at least a portion back to the fuel.

~~18. The process for powering a compression ignition engine as claimed in claim 16, including cooling exhaust material through the heat exchanger, collecting water and fuel and other combustible components from the cooled exhaust material and recycling at least a portion back to the fuel.~~

19. The process for powering a compression ignition engine as claimed in any one of claims 14 to 18, including condensing exhaust material, collecting water from the condensed exhaust material and recycling at least a portion back to the fuel.

~~20. The process for powering a compression ignition engine as claimed in any one of claims 14 to 19, including purifying exhaust material to capture unburnt exhaust pollutants and recycling these to the engine.~~

20~~1~~. The process for powering a compression ignition engine as claimed in any one of claims 14 to 19~~20~~, including fumigating the ~~inlet~~ intake air with a fumigant containing an ignition enhancer.

21. The process for powering a compression ignition engine as claimed in any one of claims 14 to 20, wherein the fuel has the composition of the diesel engine fuel as claimed in any one of claims 1 to 13.

22. A power generation system comprising:

powering a compression ignition engine using a methanol-water fuel to generate power, wherein the methanol-water fuel comprises methanol and at least 3% by weight water, and not more than 20% by weight dimethyl ether;

preheating an inlet air stream of the compression ignition engine, and/or fumigating the inlet air stream with an ignition enhancer;

treating engine exhaust gas to recover exhaust heat and/or water from the engine, and

redirecting the heat and/or water for further use.

23. The power generation system claimed in claim 22, comprising recycling the exhaust heat and/or water back into the engine.

24. The power generation system claimed in claim 22, comprising exchanging heat from the exhaust gas through a heat exchanger to water in a hot water loop, and transferring heat in the water through the hot water loop to a local community.

25. The power generation system claimed in claim 22, wherein the system is adapted to power a rail vehicle, comprising treating exhaust gas to remove particulates from the exhaust gas and recover heat and water to recycle back into the engine and/or to use on the rail vehicle.

26. The power generation system claimed in claim 22, wherein the power generating system is adapted to power a marine vehicle, comprising treating exhaust gas in a desalinator to recover heat and water to recycle back into the engine and/or to redirect for use on the marine vehicle.

27. The power generation system claimed in claim 22, comprising mixing engine exhaust gas with water in a mixer to cool the exhaust gas and recover water from exhaust gas condensate.

28. The power generation system claimed in claim 27, comprising pumping water from the mixer to a liquid/gas heat exchanger to further cool the water.

29. The power generation system claimed in <u>any one of</u> claim<u>s</u> 22 <u>to 28</u>,~~ comprising recovering water from exhaust gas in a final stage exhaust gas condenser~~ <u>wherein the fuel has the composition of the diesel engine fuel as claimed in any one of claims 1 to 13</u>.

30. The power generation system claimed in any one of claims 22 to 29, comprising processing in a pre-processor a pre-fuel composition comprising methanol and ether, and optionally water, wherein the pre-processor separates the ether from the methanol, and the using the ether as the ignition enhancer in fumigating the inlet stream.

31. The power generation system claimed in claim 30, wherein the pre-fuel composition comprises 7-10% of ether.

<u>32. The power generation system as claimed in any one of claims 22 to 31, including pre-</u>

heating the intake air to at least 50°C.

332. The power generation system as claimed in any one of claims 22 to 31, including pre-heating the intake air to 150°C-300°C.

~~33. A method of transporting a pre-fuel composition comprising methanol and ether, including transporting the pre-fuel from a first location to a second location remote~~

~~from the first location, and separating the ether from the methanol to yield a first fuel part comprising methanol, and a second fuel part comprising methanol and not more than 20% by weight ether.~~

~~34. The method of claim 33, wherein the ether is dimethyl ether.~~

~~35. A pre-fuel composition comprising methanol and up to 10% by weight of an ether.~~

~~36. The pre-fuel composition of claim 34, wherein the ether is dimethyl ether.~~

~~37. The pre-fuel of claim 34, further comprising water.~~

3<u>4</u>~~8~~. Use of the diesel fuel composition of any one of claims 1 to 13 in the process of any one of claims 14 to 21, or power generation system of any one of claims 22 to 3<u>3</u>~~2~~.