HOW TO RUN AN AIR-COOLED LISTER ENGINE ON JATROPHA OIL

ZERO
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Zero Emission
Resource Organisation

About ZERO

Zero Emission Resource Organization is an environmental organization dedicated to reducing climate change by demonstrating and gaining acceptance for zero emission energy solutions. We believe a zero emission solution exists for all energy use. Our mission is to work consistently for these solutions. Visit us at www.zero.no:

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Introduction

This report describes the process and experiences of converting a two cylinder air- cooled Lister diesel engine (see below for further details) to run on pure plant oil (PPO).

The engine conversion was performed as part of a renewable energy initiative on the coast of Kenya initiated by Norwegian Church Aid (NCA) in cooperation with Energy for Sustainable Development (ESD) Africa and Zero Emissions Resource Organization (ZERO). The project is organized locally under the auspices of the Jatropha Integrated Energy Project. It is implemented through the joint activities of nine community based organizations focusing on bio energy and agro processing in the two coastal districts of Lamu and Tana Delta.

Background

Running a diesel engine on pure plant oil (PPO)

Most diesel engines are well suited to run on pure plant oils, so-called PPO. In fact, Rudolf Diesel's first engine prototype from 1893 did not run on diesel fuel, but ground nut oil. In his patent application for the engine, Diesel wrote: "The use of vegetable oils for engine fuels may seem insignificant today. But such oils may become in course of time as important as petroleum and the coal tar products of the present time."

Today, pure plant oil is used in many different diesel applications. Especially in Western Europe PPO has been widely used, due to favorable tax rules and periodically low prices on plant oil. In Germany in 2005, almost 200 000 metric tons of PPO were used in modified diesel engines, mostly in the agriculture sector. In 2003 it was estimated that some 5000 vehicles were using PPO as fuel in Germany (Jensen, 2003, p. 1). Some engine manufacturers even offer engines which need no additional modification in order to run on PPO. The german company Elsbett offers small scale generators ready for PPO, and Deutz-Fahr deliver tractors for PPO.

Due to its high viscosity and significantly higher flash point compared to diesel fuel, PPO must be preheated before injected into the cylinder or the combustion chamber. The most common method for preheating is to exchange heat with the engine's cooling agent, in most cases water. This results in a relatively constant temperature

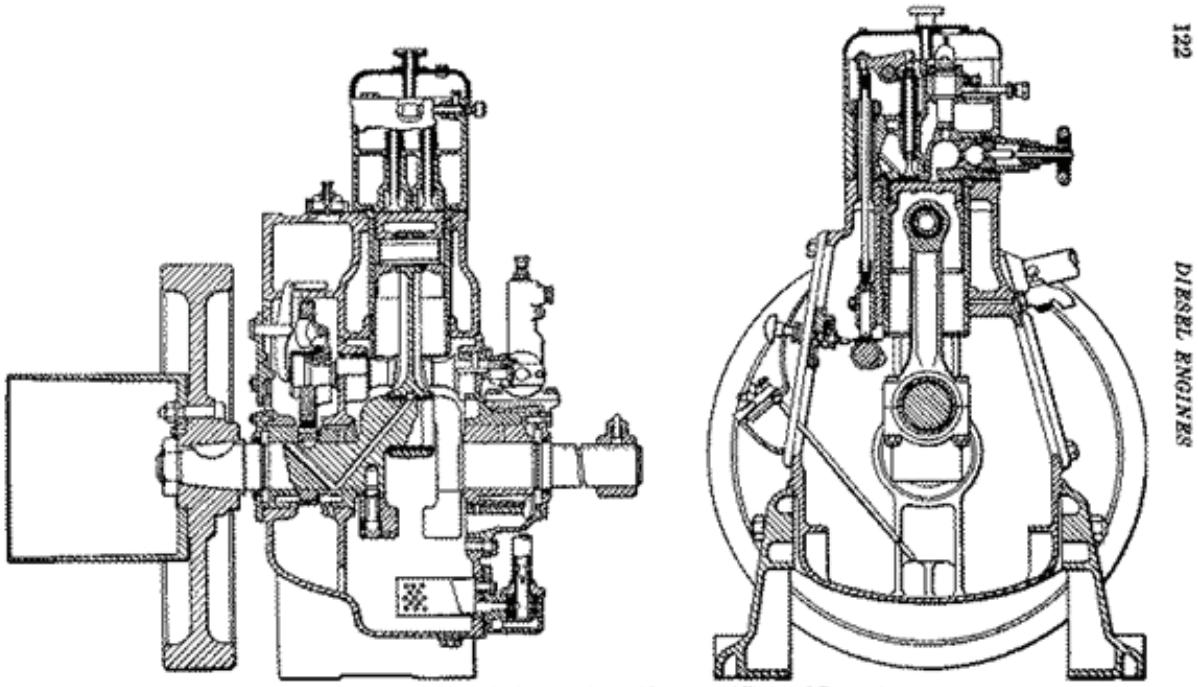


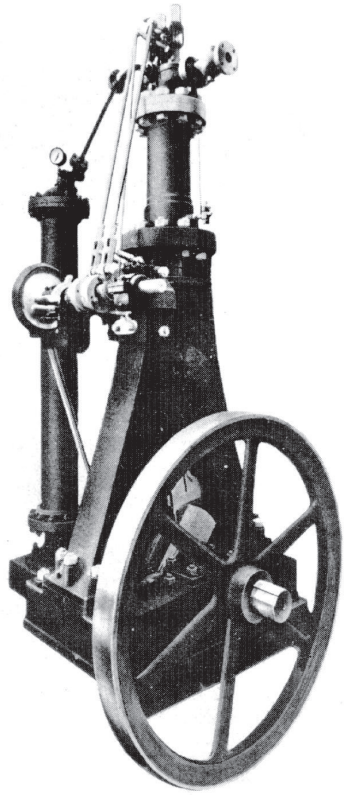
FIG. 76.—Sectional views of Lister engine. (*Courtesy of Peat and Powers.*)

of about 90°C. In some systems, the oil is heated even more using an extra electrical heating unit.

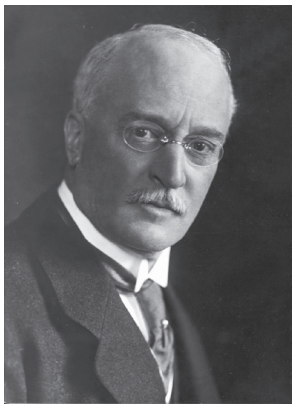
There is a variety of kits available on the market today for PPO modification. All available designs provide some sort of preheating of the oil. There are two main types of kits: The two tank systems, where the engine is started on diesel fuel and then switched to PPO when a certain temperature is reached; and the one tank design where PPO is preheated, using electricity . The latter design is often more complex than the two tank design but easier in use. It is found mostly in cars. Depending on the size and complexity of the engine, the price of these ready-made conversion kits ranges from 700 to 5 000 USD.

Aim of this project

The main purpose of this specific project was to make a Lister engine owned by Kipini Community Power Project (KCPP) ready to run on pure Jatropha oil. An additional goal was to try out a cheaper and easier way of converting diesel engines than by using the kits currently available on the market. In this project, we were particularly interested in seeing whether PPO could get overheated in any way when exposed to exhaust heat. Such s situation would lead to carbonization, which again would lead to clogging of filters and tubes and probably also melting of the rubber fuel hoses.



Rudolf's first design of his engine.



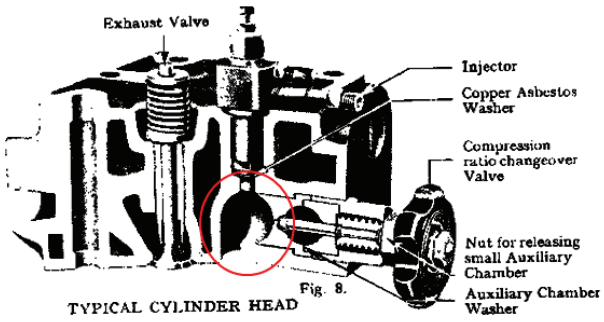
The father of the diesel engine, Rudolf Diesel.

Lister engines

The Lister Cold Start (CS) series of Diesels were converted from an existing petrol (gasoline) engine design. The Lister L, built since 1909, was a side-valve, low-compression, spark-ignition engine. Lister chose to base their new Diesel engine series on the proven "L" design. Introduced in 1930, these engines were produced by Lister up until 1987. Several companies in India still produce copies of the Lister CS diesel engines, often referred to as Listeroids.

There is much to be said about the design of the Lister Diesel engine, but the feature most relevant to running the engine on PPO is the design of its injection system and cylinder head. This type of injection system is often referred to as a "turbulence chamber", a type of pre-combustion chamber where the fuel gets partly gasified before entering into the cylinder. Such a design is advantageous when running the engine on PPO, as this type of indirect injection (IDI) engine is known to work better with PPO than direct injection systems, where the fuel is injected directly into the cylinder (Jongh, 2006, p. 33).

The parts included in a one tank modification kit from the German company ATG



Cross section of a typical Lister cylinder head displaying the special "turbulence" chamber (red circle).

Converting the Lister

Measuring temperature

Before any modification was done to the engine owned by KCPP, the temperature when running it on diesel fuel on a typical working load was measured. This was done in order to identify the most suitable location for the preheater. As expected, the surface temperature of the exhaust manifold quickly reached more than 100°C and was measured at around 250°C after one hour. The manifold was hence an ideal location for the heat exchanger.

Mounting the kit

The original diesel tank was then cleaned and filled with PPO. An additional tank for diesel was constructed out of an old yellow cooking oil container made of plastic. Both tanks where then connected to a three-way valve. The fuel line from the PPO tank was also run through a stainless steel pipe fitted to the exhaust manifold. This steel pipe was intended to work as a heating device.

When converting an engine in this manner, it is not important whether the original tank is used for PPO or diesel. But if the engine has a return hose for overflow fuel, as was the case here, it is an advantage if this fuel is returned to the PPO tank, hence the initial one. Otherwise, the diesel tank could get filled up with PPO through the return hose, something which is not desirable. It is better to have smaller amounts of diesel mixed

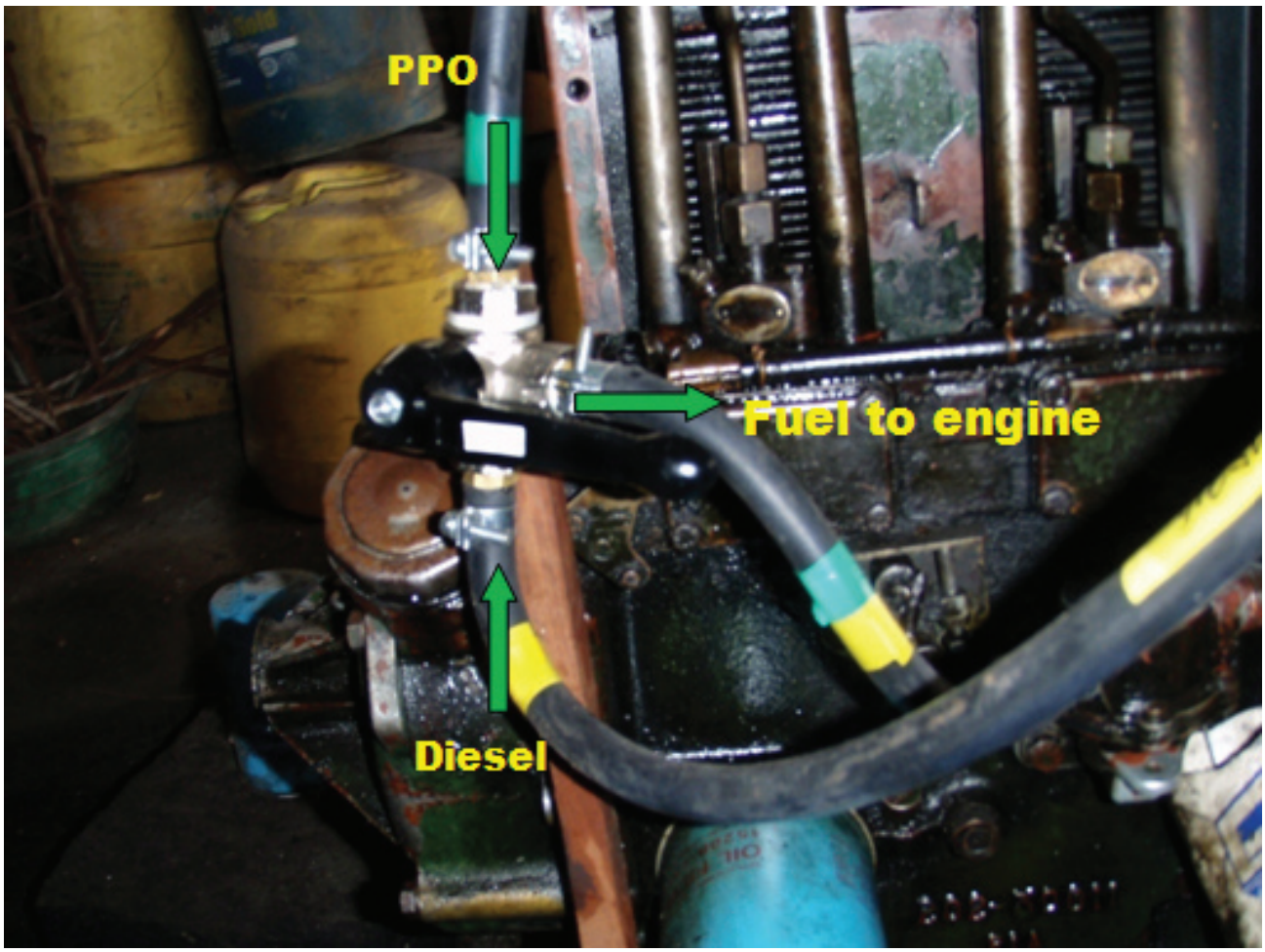
The image shows the fitting of the preheating devise for PPO, circled in red.

into the PPO than the other way around. A three-way valve system could of course be fitted on the return hose as well, but this would raise costs unnecessarily and also complicate the operation of the engine; one more valve to turn.

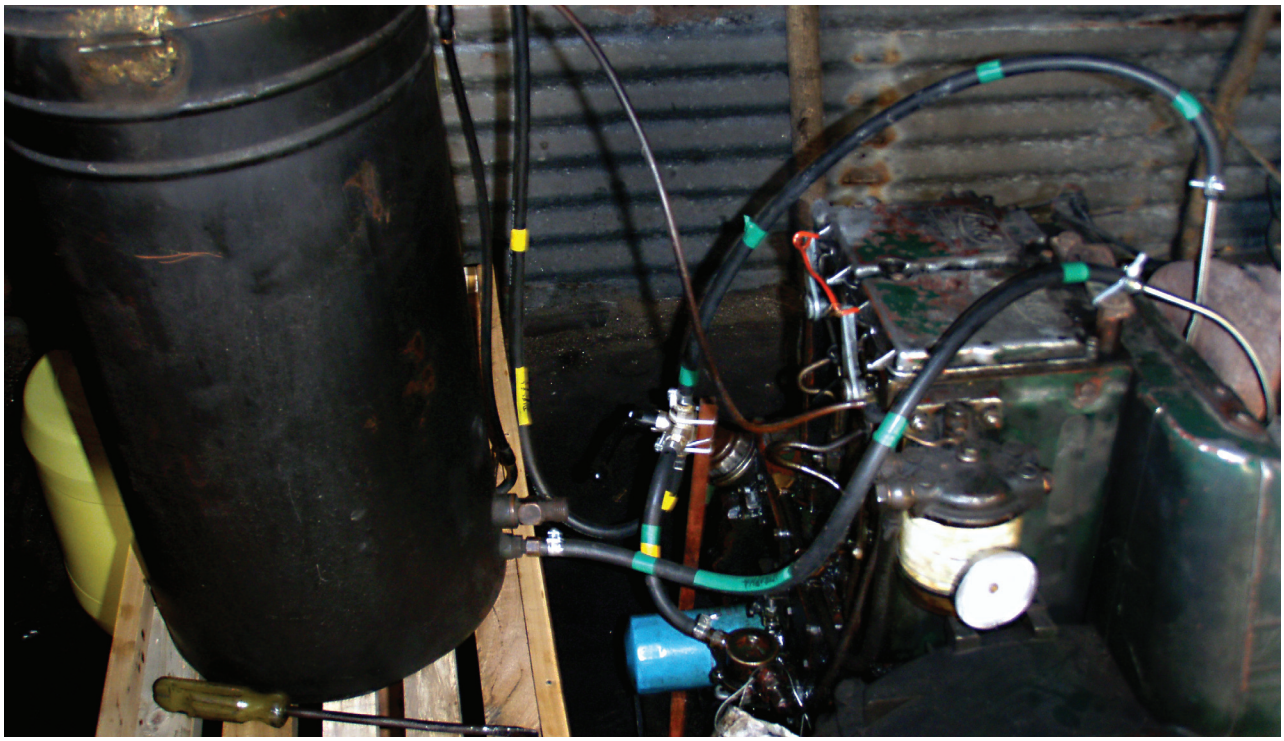
Parts and costs

The kit consisted of the following parts:	
Three-way ¼" valve with three 5/16" fittings	85 USD
4 meters of 8 mm fuel hose	14 USD
20 liter plastic tank for diesel	0 USD
Thermometer for the fuel filter	14 USD
Hose clamps, 8 pieces	7 USD
Stainless steel tube, 50 cm, 8mm Ø	40 USD
Total	**160 USD**

All parts needed for the conversion were obtained in Norway and brought to Kipini, Kenya. It is possible that some of the parts could be bought cheaper in Kenya, but a quick survey of hardware stores in Nairobi revealed that prices were not that different. The steel tube could easily have been replaced with one in brass, copper or aluminum, which would have been considerably cheaper and probably easier to obtain. The three-way valve could have been replaced with a T-fitting and a valve on each of the two tanks or even a clamp on the hose to restrict the flow from the tank not currently in use. The cost of parts could probably have been reduced to half of that of the initial kit without affecting the quality of the conversion. As long as the basic principles of the two-tank system and the oil heater are kept, there should be plenty of room for creativity in similar conversions. The price of this conversion, 160 USD is considerably cheaper than the 700 USD for a ready-made kit.



The three-way valve that enabled switching between PPO and diesel, here seen in the diesel position. Turned upward, the valve cuts the diesel flow and opens the flow of preheated PPO.



The engine after conversion to PPO. PPO runs through the hose marked with green tape, the hose for diesel is marked with yellow tape.

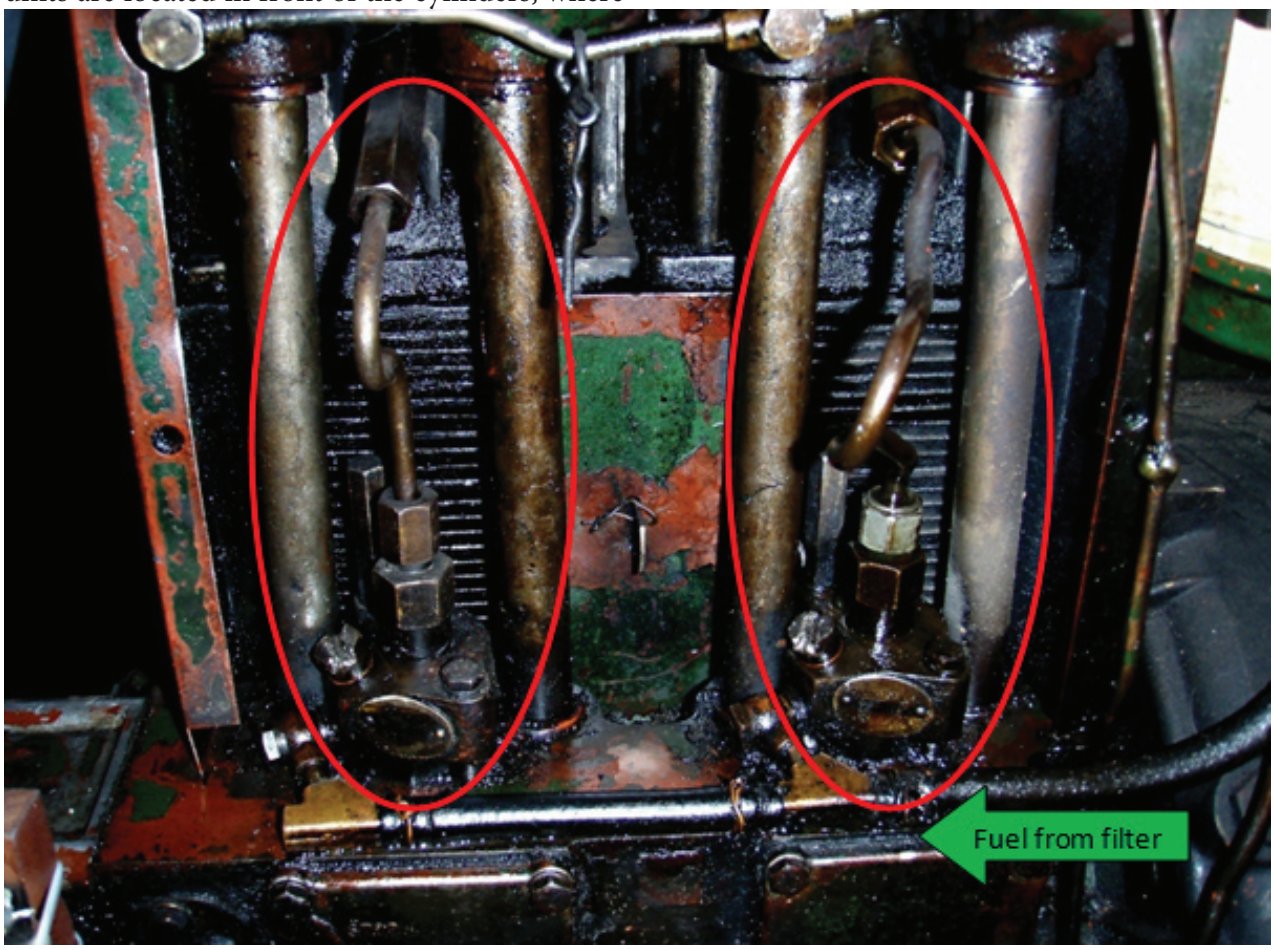
Test runs

The Lister engine belonging to KCPP was tested for 20 hours on PPO over the course of three days. During that time, five starts and stops where performed. When the engine was cold, it was run for 15 minutes on diesel fuel before switching to PPO. 15 minutes before stopping, it was switched back to diesel fuel in order to flush the system of PPO. Corn oil was used in the test.

During the test runs, the temperature of the fuel filter was measured to around 70°C at normal load. On the last day of the testing period, the engine was only idling, due to technical problems with the generator unit. During idling, the temperature stayed around 50°C. This is of course an unusual operating situation for a generator. It will most likely newer occur that a generator is idling for a long period of time.

The fuel was distributed from the filter to the injector units for each of the two cylinders. These units are located in front of the cylinders, where hot air from the air cooling system is flowing out. The surface temperature of these units was constantly at 90 to 100°C after the engine reached normal working temperature, giving the PPO a final temperature lift before it was injected into the pre-combustion chamber. This procedure complies with most recommendations for preheating of PPO. However, on this specific engine, such a temperature would probably have been reached even without using the preheating devise fitted to the exhaust. This is due to the special design of the fuel injection system.
There were no signs of problems with the engines during test runs. However, it is important to note that most potential problems related to PPO in diesel engines will most likely not occur within the first 20 hours of use. The main purpose of this test was to check if the preheating of the PPO worked sufficiently. Additional long-term testing will be conducted.

It was not possible to observe any measurable difference in fuel consumption during the test runs.



Circled in red in the image is the fuel injection units. Here, the temperature reached 90-100 °C during test runs, due to the flow of hot air from the engine.

Conclusion

The modification of the Lister engine seems to have been successful. During the test period, the engine worked fine. The oil injected into the engine reached around 100°C, a desired temperature for PPO in a diesel engine. This temperature was achieved without the preheating device, but the devise would have helped the fuel to reach its desired temperature quicker and improved the flow through the fuel pump and filter. Preheating will reduce the time needed to run similar engines on diesel fuel before switching to PPO.

Preheating PPO with the heat from the exhaust manifold on engines seems feasible. The temperature of the PPO used in the test described here was relatively stable, ranging from 50°C at the lowest load to 70°C at a high load (measured at the fuel filter). This indicates that the risk of overheating the fuel with this type of design is relatively low. In other types of engines, where the fuel doesn't get the additional heating from the hot air passing the injector units, the temperature should range between 100 and 150°C. This could easily be achieved through a larger contact surface between the manifold and the fuel pipe or a longer retention time of the fuel. The latter could be achieved either with a longer or a thicker pipe. The way the pipe is fitted to the manifold also matters.

The type of conversion design demonstrated in this report is cheap and would probably work fine on most diesel engines, especially stationary equipment that runs on steady loads. It would make a good solution for air-cooled engines with no cooling liquid. It would be equally suitable in water-cooled engines with relatively low water temperatures – like boat engines – and passive systems with a large water tank instead of a radiator.

Abbreviations

KCPP – Kipini Community Power Project
PPO – Pure plant oil (same as SVO)
SVO – Straight vegetable oil (same as PPO)
NCA – Norwegian Church Aid
ZERO – Zero Emissions Resource Organization
ESD – Energy for sustainable development
USD – US dollars. An exchange rate of 1:7,5 was used in calculating between USD and NOK
CS – Cold Start, referring to a diesel engine that is started cold on diesel. No prior heating.
IDI – Indirect injection, referring to a type of fuel injection system used in diesel engines.
DI – Direct injection, referring to a diesel engines type of fuel injection system.

Jensen, P. (2003). Short note on Pure Plant Oil (PPO) as fuel for modified internal combustion engines. European Commission, DG JRC/IPTS. http://valenergol.free.fr/dossiers/IPTS/Short%20note%20on%20pure%20plant%20oil.pdf.

Jongh, J. D. (2006). Jatropha Handbook. Fact Foundation. http://www.fact-fuels.org/media_en/jatropha_handbook_march_2006.

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