BIOFUEL ENGINE LONGIVITY TEST (B.E.L.T.) RESEARCH COOPERATIVE

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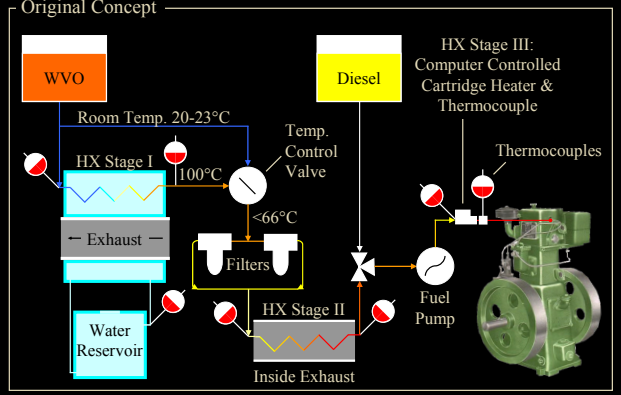
Abstract

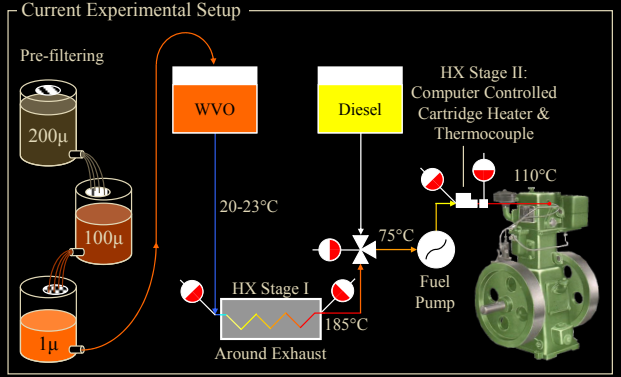
This study reports an ongoing effort to investigate the degradation rate of a low-speed Lister diesel engine running on filtered waste vegetable oil (WVO). It aims to measure the performance, wear rate, and emissions of the engine over the course of a 1,000 hour longevity test. Exhaust gas is used to heat the oil, reducing its viscosity close to that of diesel at the point of injection. Heating WVO reduces engine power loss, pumping losses, head losses, carbonization and coking, which ultimately increases longevity. When completed, the technical methods developed, data collected, hardware, and lessons learned will all be used to make a prefabricated, stand-alone, cost-efficient, field conversion kit for the Lister engine. The results of this study will be beneficial in actualizing the widespread and practical use of WVO and straight vegetable oil (SVO) fuels in developing countries.

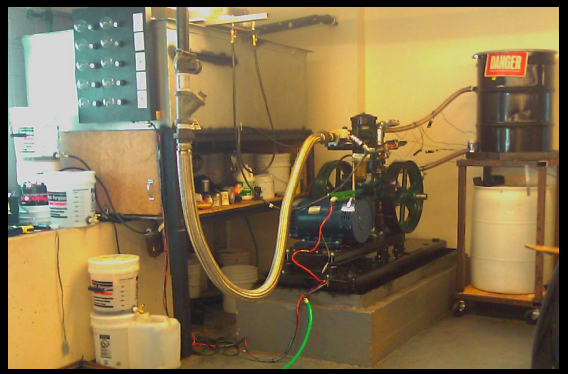
Experimental Evolution

Original Concept



Current Experimental Setup





The original concept included many recommendations from previous research, but proved overly complicated.

- Heating before filtration
- Dual, parallel in-line filters
- Elevated WVO tank
- Minimizing bends in plumbing
- Insulating plumbing
- Reheating after filtration

The materials, tools, and skills required to service or reproduce both the Stage I and Stage II heat exchanger inside the exhaust made them inadequate candidates for long term, 3rd world or remote, "off-grid" operation. Where possible, improvements were maintained.

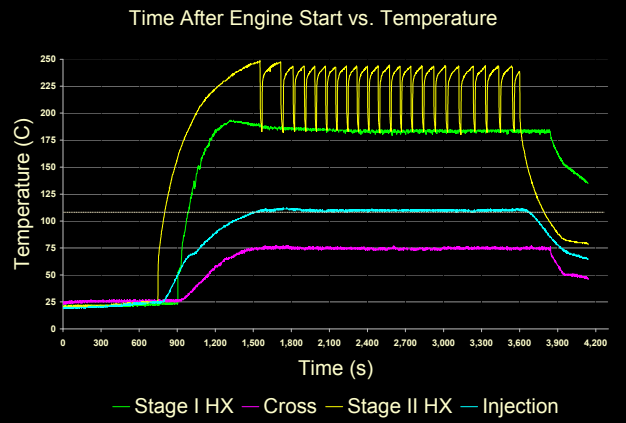
In-line filtration was removed due to the enormous temperature drop across the filter and the additional time required to reach steady state temperature. The WVO is pre-filtered down to 1 micron (the size of bacteria) and remains uncontaminated until placed into the closed fuel tank. Disposable filter bags can be replaced with minimal exposure of the oil to the environment. The filtration system can be scaled up to and beyond 55 gallons, as needed.

As shown below, we verified the WVO injection temperature was significantly deficient (74°C) and required an external, 100W heater.

Trial	Modifications	Stage I Temp (°C)	Injector Temp (°C)
1	None (5 turns of ¼" copper tube)	57	30
2	45% more turns (7.25) to gauge effect	84	30
3	340% more turns (17)	102	31
4	Light insulation	113	32
5	1st thermal putty application (moderate)	132	34
6	2nd thermal putty application (liberal) and heavy 1" fiberglass insulation	170	36
7	Stage II operational (100W)	170	103
8	¼" copper tubing replaced with 3/8" (same axial length) and insulate Stage II	185	110+ !
9	All improvements with Stage II turned off	185	39

Preliminary Data

With all necessary engine and fuel line modifications, WVO steady state injection temperature of 110°C was maintained by oscillating the cartridge heater temperature from 185-245°C. This range was determined experimentally and manually. These values will be used in the cartridge heater controls from LabView and the DAQ board.



What's Next

- Prior to the 1,000 hour longevity test, several short duration water fumigation tests will be performed. These will determine the effects of load, fuel type, and water fumigation rate (percentage of fuel flow rate) on engine emissions.

Water Spray Effects on Emissions at 33-66-100% Engine Load					
	Fuel				
Emission	Diesel	WVO	WVO & Water (% of Fuel Flow Rate)		
			5%	20%	35%
NO_X, CO_X, Opacity, etc.					

- Monitor power generation, coolant (water) inlet, outlet, & exhaust temps.
  - Determine relationship between water temperature, load, and engine steady state time.
- Automate cartridge temperature cycle to stabilize injection temperature.
- Incorporate/investigate modifications made by Columbia such as varying injection pressure, using the COV plug as the method of preheating, varying compression ratio.
  - Develop an optimized set of engine parameters taking into account efficiency, load, emissions, opacity, etc.