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Green Engine Working on Coal Water Fuel (CWF)

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Abstract: ***Innovative thinking leads to development of new technologies. The paper includes introduction to Green Engine, its technical features and working of Green engine using Coal Water Fuel (CWF) as fuel. This engine is one of the piston less engine with its extraordinary features like high expansion ratio, strong swirling, sequential variable compression ratio, direct intake etc. Due to six phase of working, super air-fuel mixing and constant volume combustion with controllable time is achieved. So the Green engine becomes the only real multi-fuel engine in our planet and hence makes a good choice to use Coal Water Fuel (CWF) as fuel for the Green engine. GREEN ENGINE is the ENGINE of FUTURE and CWF is the FUEL of FUTURE.***

Keywords: pistonless, super air-fuel mixing, multi-fuel engine, efficiency, future engine

1. Introduction

Green engine is an actual six phase internal combustion engine with much higher expansion ratio. CWF is an alternative to conventional petroleum-derived diesel fuel and is a slurry made by mixing pulverized coal with water. Thus, the solution to the problems like increasing pollution and decreasing deposits of the petroleum fuel and its high prices is that the coal water fuel can be used to run the Green engine. Brief testing of the two-cylinder engine on CWF was achieved in April 2004. Development of Green Engine burning CWF would decrease our dependence on imported crude oil while using our most abundant domestic fuel-coal and decreasing the pollution.

Addressing wide ranges of problems is what a Green engine does or tries to do. And the CWF used for the engine makes it more advantageous and applicable.

2. Technical Feature

Green Engine has six independent or separate working processes: intake, compression, mixing, combustion, power and exhaust due to which we get high air charge rate, satisfactory air-fuel mixing, complete burning, high combustion efficiency and full expansion.

2.1 Direct Air Intake

In direct air intake, there is no air inlet pipe, throttle and inlet valves on the air intake system. Air filter is directly connected to intake part of the engine, thus high volumetric efficiency is achieved. Due to which engine produce a high torque of output on all speed range is achieved and pump loss which consumes the part of engine power is eliminate.

2.2 Strong Swirling

Between combustion chamber and compression chamber there is a tangential air duct, by which a very strong swirling of air is achieved. Consequently, the air fuel mixing & the combustion process can have a satisfying working condition.

2.3 Sequential Variable Compression Ratio

This innovative concept can provide most acceptable compression ratio for the engine whatever operation made it works on with burning variety of fuels. Therefore, an excellent combustion performance is attained.

2.4 Direct Fuel Injection

Direct fuel injection can provide higher output and torque, which it can also enhance the response time for acceleration.

2.5 Super Air-Fuel Mixing-

As the independent air-fuel mixing phase having enough time for mixing air and fuel by strong swirling and hot situation the engine can be made to run on any liquid or gas fuels. Due to centrifugal effect came from both strong swirling and rotation of the burner makes the air-fuel mixture denser near the spark plug, it is advantageous for cold engine starting and manage lean burning and allowing the engine use of mass control for output.

2.6 High Expansion Ratio

High expansion ratio can make burnt gases to release much more power. That is the waste gases while they run out of the engine are only bringing much less energy with them. As a result, the engine has high efficiency.
Other such technical features are

2.7 Lowest Surface to Volume Ratio

2.8 Constant Volume Combustion

2.9 Multi Power Pulse

2.10 Self-Adapting Sealing System

Due to this beneficial technical features and requirements of the Green engine, we conclude that Coal Water Fuel (CWF) can be used for the Green Engine.

3. Coal Water Fuel (CWF)

CWF is slurry made by mixing pulverized coal with water in approximately a fifty-fifty mixture. It is black with an appearance similar to crude oil has complex flow and combustion characteristics. Important properties of an acceptable CWF include low settling rate of solid particles, tolerance to flow at high shear rates encounter in diesel injection systems, adequate atomization and evaporation of slurry sprays and a small enough particle size for ignition and combustion at conditions achievable in diesel engines.

Additives may be used to improve CWF properties.

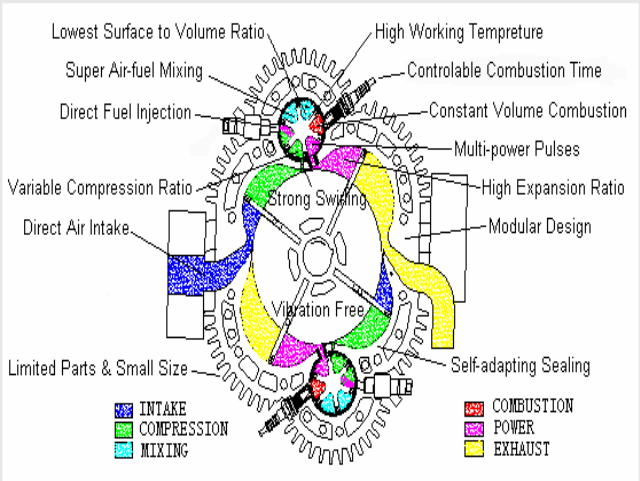
CWF properties are dependent on particle size distribution and mass loading of coal rank the types and concentrations of additives. From experiments we conclude that the mean particle size distributions in the range of 3to 20 microns are acceptable with maximum sizes up to 85 microns.

Table 1: Range of CWF Properties Tested

Effect	*Coal Property*	*Range Test*	*Results*
Combustion Performance	Volatile Content	27-41 %	Satisfactory
	Rank	Bituminous & Subbituminous	Both Satisfactory
	Heating Value	10,000-15,000 Btu/lb. (Dry)	Satisfactory
	Particle Size	3-20 microns mean 10-85 microns max	Satisfactory
Emissions	Sulfur Content	0.7-1.0 wt.%	<2% is O.K.
	Nitrogen Content	1.2-1.8 wt.%	TBD
Handling	Solids Content	48-55 wt.%	Satisfactory
	Viscosity	200-400 cP	Satisfactory
Wear	Ash Content	0.5-3.8 wt.%	<1.8% is O.K.
	Hard Mineral Content	---	TBD

4. Working

As earlier mentioned, Green engine with much higher expansion ratio. The term „phase" is used instead of „stroke" because stroke is actually associated to the movement of the piston. But, in this piston is absent and thus, the term „phase" is used. The six phases are via- intake, compression, mixing, combustion, power and exhaust.



4.1 Intake

The air is admitted directly into the compression chamber. The air filter is directly connected to the intake of engine. The amount of the air intake can be varied as per the fuel used.

4.2 Compression

The rushing air from the duct is pushed by the blades into the small chamber in the rotor whose volume is comparatively small due to which high compression is obtained.

4.3 Mixing

When rotating chamber comes in front of the fuel into the compressed air. This results in deletion of CO emissions. And also because of strong swirling and centrifugal effect makes the air-fuel mixing more effective.

4.4 Combustion

At the end of the path of rotation of chamber a spark flies from the plug into air-fuel mixture. Because of the mixing phase, the air-fuel mixture is denser near spark plug, thereby, enabling lean burning of the charge and also a uniform flame front.

4.5 Power

The expanded gas rushes out of the chamber through thenarrow opening. Hence, the sudden increase in volume ensures that more power is released, i.e. the thermal energy is fully utilized.

4.6 Exhaust

As a result of fully utilization of the thermal energy, the exhaust gases bring along comparatively less heat energy. This helps in increasing thermal efficiency and poisonous gases like CO are absent in the exhaust emissions.

5. Technical Performance

Technical performance of CWF used to run the Green engine noted from the tests. Comparison between operating conditions of the engine on fuel used as Diesel and CWF is given in table below.

Table 2: Summary of Engine Operating Conditions DuringTesting

Operating Parameter	*1st Test*	*2nd Test*	*1st Test*	*2nd Test*
Fuel	Diesel	Diesel	CWF	CWF
Engine Load,%	50	25	25	17
Engine Power, bhp	503	254	254	168
Engine Speed, rpm	506	506	506	506
Pilot Fuel,%	3.6	4.7	11.6	12.4
BMEP, psi	55.8	28.2	28.2	18.7
Fuel Rate, lb./hr.	227	173	629	588
Specific Fuel Consumption	8,105	12,281	10,663	15,031
Fuel Conversion Efficiency,%	31	21	24	17
Air Rate, lb./hr.	7,532	6,232	---	5,240
Air/Fuel Ratio, lb./lb.	33.3	36	---	18.7
Fuel/Air Ratio, lb./lb.	0.03	0.028	---	0.053
NO, ppm	1.100	430	150	142
CO_2,%	6.4	5.1	6.3	5.9
CO, ppm	463	385	>1,000	>1,000
O_2, %	11.8	13.9	13.3	13
Total Hydrocarbons (C_3H_8)	406	---	---	910

Combustion while operating on CWF was excellent on most engine cycles, but some cycle-to-cycle variability was observed. Pilot ignition timing had not been optimized, so combustion should improve following tuning. On the amount of net power produced. Combustion of coal slurry was over 95% complete. No unburned coal buildup in the cylinder or on the liner walls.

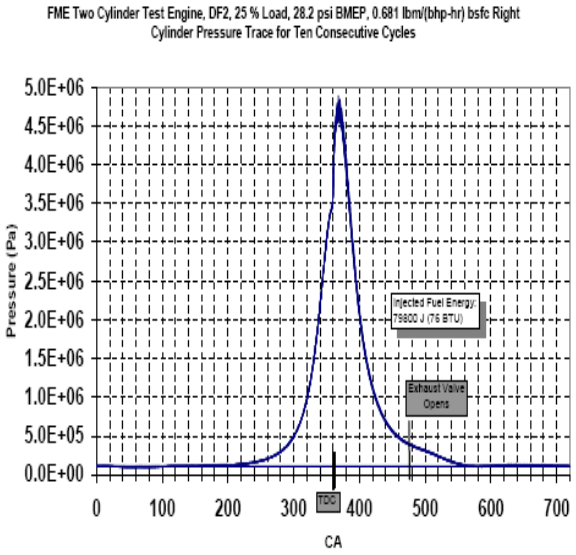


Figure 1: Cylinder Pressure Trace for Operation on Diesel Fuel

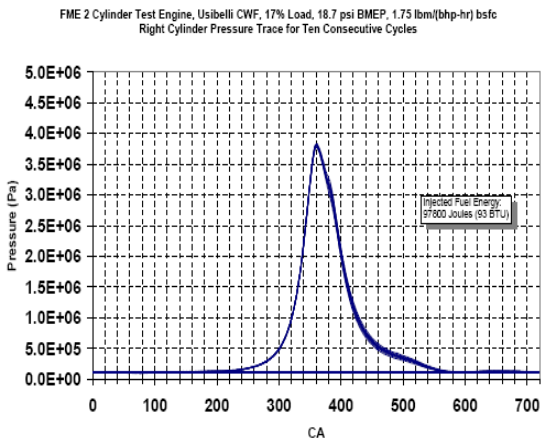


Figure 2: Cylinder Pressure Trace for Operation on CWF

The slow mixing controlled combustion of the CWF is evidence by the 6 to 7 degree longer burn time of the mixture, with the ignition delay of the CWF being twice as long as that of diesel fuel. The diesel fuel pressure traces presumably had a higher peak pressure due to the timing of injection being better matched to burn rate than for CWF with diesel fuel pilot injection. This should be correctable with tuning. For the more successful CWF combustion events, where the majority of injected fuel energy was released, the energy release with CWF was comparable to diesel fuel energy release (90 to95 percent). There was no evidence of build-up of unburned coal in the cylinders.

6. Advantages

1) As green engine is very compact with power pulses the size and weight would be only 1/5 to 1/10of the conventional piston engine on same output and thermal efficiency could be potentially as high as 65%.
2) Due to six phase of working principle, super air-fuel mixing process and constant volume combustion with controllable time the Green engine become the only real multi-fuel engine on our planet. Thus the CWF is good choice for the Green engine.
3) Green engine burning on CWF would decrease the emission of harmful waste gases and decrease our dependence on the imported crude oil.
4) Limited parts, small size, light in weight and depended upon current mature materials and manufacture technologies, it means that it would be to being done on the much lower cost on manufacture, transportation, installing to other devices, and maintenance.

7. Applications

The Green engine could be used as the ideal power plants on a very wide range of applications in transportation, communication, farm, mine, engineering, military uses, such as automobiles, aircrafts, boats, ships, hovers, locomotives, generators, helicopters, etc.

8. Conclusion

The Green Engine prototypes have been recently developed, due to its extraordinary technical features and unique design, its limitations have not been identified still. The system

which utilizes coal-water fuel (CWF) will demonstrate high efficiency, cost competitive, environmentally compliant electric power. The idea of running the Green engine by using coal-water fuel (CWF) as fuel can be a great success with its least limitations and can be applied in future with further inventions.

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