A COMPARATIVE STUDY OF THE PERFORMANCE OF A LOW HEAT REJECTION ENGINE WITH TWO DIFFERENT LEVELS OF INSULATION WITH ALTERNATE FUELS

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Need for alternate fuels

- Depletion of fossil fuels

- Increase of pollution levels with fossil fuels

- Impact on economy

Which fuel is to be conserved

- Diesel

  Or

- Petrol

Diesel is used not only in transportation but also in agriculture sector

Probable candidates for alternate fuels

- Alcohol

- Non-Edible Vegetable oils

Advantages of alcohol as fuel in diesel engine

- High volatile fuel
- Increases homogeneity
- Decreases pollution levels

Methods of Introducing Alcohol in Diesel Engine

- Emulsification
- Dual fuel technique
- Carburetion technique
- Spark glowing technique

Disadvantages of alcohol as fuel in diesel engine

- Low cetane number
- Engine modification is necessary to use alcohol as fuel

Advantages of vegetable oils as fuel in diesel engine

- High cetane number
- Engine modification is not necessary
- Fuel can be injected directly into the engine

Drawbacks of vegetable oil as fuel in diesel engine

- Low volatility

- High viscosity

Cause injection problems

Concept of LHR engine

- To minimize heat loss to the coolant by providing heat resistance in the heat flow to the coolant

Various forms of LHR engines

- Ceramic coated engine
- Air gap insulated piston engine
- Air gap insulated piston and air gap insulated liner engine
- Air gap insulated piston, air gap insulated liner, ceramic coated cylinder head engine

Ceramic coated engine

- Partially stabilized zirconium of thickness 500 microns is applied on inner side of cylinder head
- Low degree of insulation

Air gap insulated piston engine

- The piston is made into two parts-the crown made of low thermal conductivity material is threaded to the body of the piston and the gasket made of low thermal conductivity material is provided in between the crown and body of the piston . Air is bad conductor of heat. The combination of two low thermal conductive materials decreases heat flow to the coolant which results LHR engine

Air gap insulated piston and air gap insulated liner engine

- Insulation is provided in the piston with low thermal conductivity material crown and air gap is provided in between body and crown with gasket
- Insulation is also provided in the liner with low thermal conductivity material insert

Air gap insulated piston, air gap insulated liner and ceramic coated engine

- The combination of air gap insulated piston, ceramic coated cylinder head and air gap insulated liner engine results high degree of insulation of LHR engine

Non-edible vegetable oils

- Crude jatropha oil
- Crude pongamia oil

Properties of vegetable oils

PROPERTIES OF THE NON-EDIBLE VEGETABLE OILS AND DIESEL

Test Fuel	Viscosity at 25 ° C (centi-poise)	Density at 25 ° C	Cetane number	Calorific value (kJ/kg)
Diesel	12.5	0.84	55	42000
Jatropha oil (crude)	125	0.90	45	36000
Jatropha oil (esterified)	53	0.87	55	35500
Pongamia oil (crude)	125	0.91	48	37100
Pongamia oil (esterified)	50	0.885	55	36980

Jatropha oil

- Botanical Features
- Family- Euphorbicese
- Plant- Jatropha Curcas
- Root System- Taproot System
- Flowers- Inflorescence
- Flowers-Unisexual (Male and Female are separate on the same plant)
- Fruit- 3Seeds
- One kg of fruits- 1300-1400 seeds
- Oil content of seeds- 30-50% by weight
- Solubility of oil- Diesel, hexane slightly soluble in alcohol
- Molecular composition – $C_{20} H_{24} O_3$

Availability of JC plant

- Applications other than a Engine fuel in Worldwide
  - Thailand- Used for fences and animal cages
  - Madagscar- Support for venila plants to keep of certain insects
  - Ghana- Soap Production
  - China- Varnish Production
  - England- Wool-spinning
  - Brazil- Oil Production
- Burma, Indonesia, Malaysia,Philippines, Srilanka, Sudan, S-Africa, Venezuela, Peru,Afghanistan, Colombia, Jamaica etc.,

Availability of JC plant in India

- Kerala, Rajasthan, Madhya Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu etc,.
- Jatropha Curcas was probably introduced into India by PORTUGUESE in 16th –17th Centuries

Plantation of JC plant

- Agricultural /Watershed Boundary Bunds
- Mixed Crop e.g. with Caster, to improve the soil fertility, to reduce insect attack
- Reforestation Species in Waste lands due to drought resistance
- JEM- Joint Forest Management , a approach for forest regeneration , JC can be incorporated as one of the plant species

Harvesting of JC plant

- 1 kg of fruits- 1300-1400 seeds
- Oil recovery from seeds-21.25%
- Maximum seed yield per plant-(Dry land)- 165 g
- Maximum seed yield per plant
- (Irrigated)- 345 g
- Oil cake- Fertilizer
- Hectare land- 1.5 –2 tones of seeds
- Yielding – After 3 years of plantation and continue for next 25 years

Ecological significance of JC Plantation

- Soap making
- Medicinal value
- Fire wood,
- Cosmetics and dye industries
- Cake-Fertilizer
- ✓ Fast growing
- ✓ Not grazed by animal
- ✓ Easy to propagate by cutting/seed
- ✓ Fixation of CO_2 levels
- ✓ Erosion control
- ✓ Improves the soil quality
- ✓ Highly drought resistance

Pongamia oil

- Pongam→ Karanji, a commercial name
- Plant name-Pongamia Glabra Vent
- Yield of kernel per tree- 8-24 kg
- Oil yield per kernel – 3027-39%
- Moleculer Composition- $C_{19} H_{12}O_6$

<u>Applications</u>

- Raw material for soap manufacturing
- Lather tanning industries
- Curative effect on skin problems
- Cure of bad sores and wounds
- To prevent grains, books, clothes from insect damage with the leaves of the plant

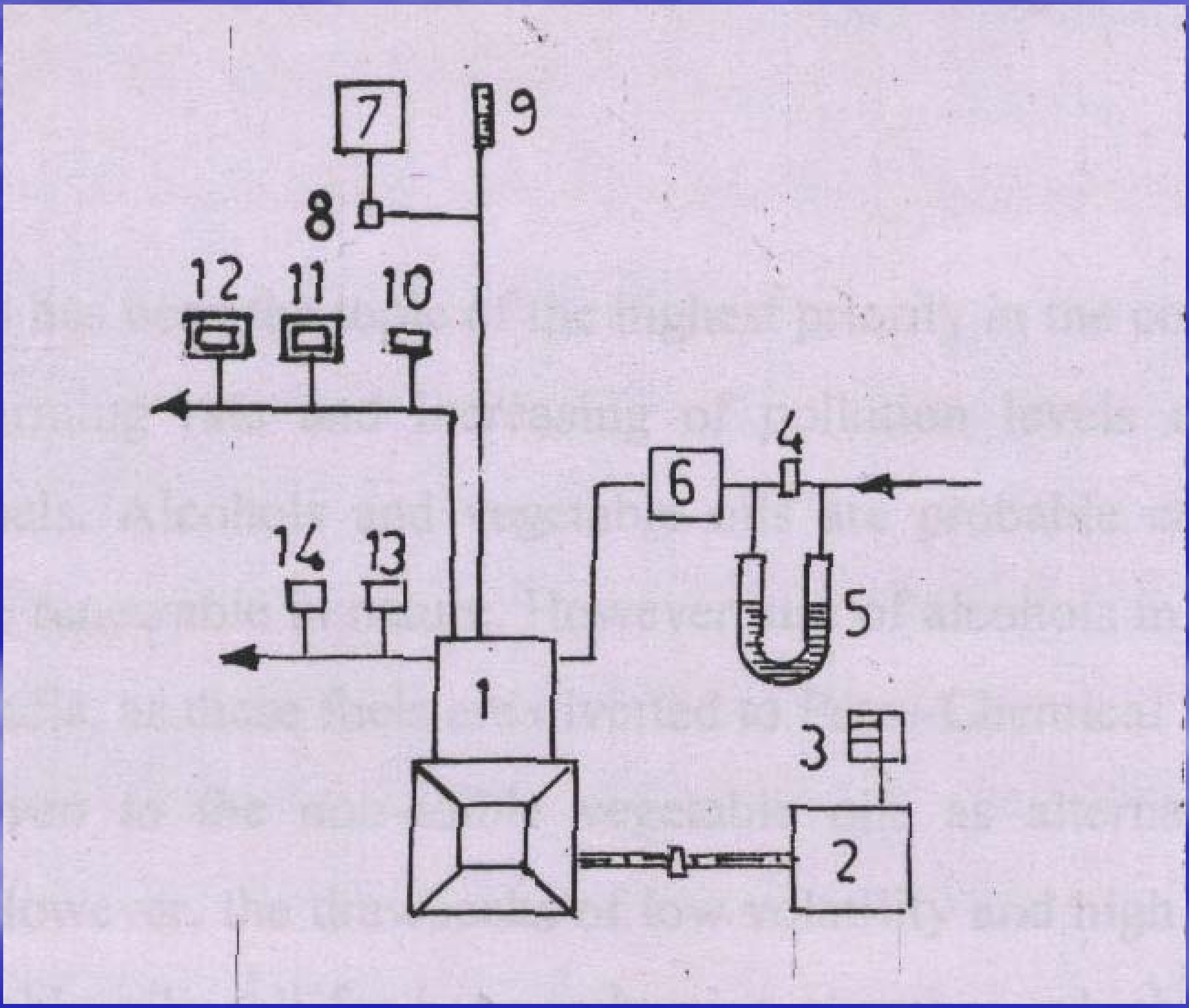
Photographic view of air gap insulated piston

TE.3.1. PHOTOGRAPHIC VIEW OF THE AIR GAP INSULATED PISTON

Photographic view of liner

TE.3.2.PHOTOGRAPHIC VIEW OF THE AIR GAP INSULATED LINER

Experimental Programme



Peak BTE

Table-1 Data of Peak brake thermal efficiency (BTE) with different versions of the engine with different test fuels

Engine Version	Peak Brake Thermal Efficiency (%)								
	Pure Diesel operation			Crude Jatropha oil operation			Crude Pongamia oil operation		
	Injection Pressure (bar)			Injection Pressure (bar)			Injection Pressure (bar)		
	190	230	270	190	230	270	190	230	270
CE	28	29	30	24	25	26	25	26	27
LHR-1	29	30	30.5	28.5	29	29.5	29	29.5	30
LHR-2	28.5	29.5	30.2	30	31	32	31	31.5	32

CE- Conventional engine, LHR-1 Low heat rejection engine- Air gap insulated piston and air gap insulated liner,

LHR-2 Low heat rejection engine- Air gap insulated piston, air gap insulated liner with ceramic- coated cylinder head

BSEC

Table-2 Data of brake specific energy consumption (BSEC) with different versions of the engine at peak load operation with different test fuels

Engine Version	Brake Specific Energy Consumption (kW/kW)								
	Pure Diesel operation Injection Pressure (bar)			Crude Jatropha oil operation Injection Pressure (bar)			Crude Pongamia oil operation Injection Pressure (bar)		
	190	230	270	190	230	270	190	230	270
CE	4.0	3.92	3.84	4.90	4.70	4.65	5.00	4.80	4.70
LHR-1	4.16	4.08	4.00	3.96	3.92	3.88	3.98	3.94	3.90
LHR-2	4.08	4.04	3/96	3.88	3.84	3.76	3.84	3.76	3.72

CE- Conventional engine, LHR-1 Low heat rejection engine- Air gap insulated piston and air gap insulated liner,
LHR-2 Low heat rejection engine- Air gap insulated piston, air gap insulated liner with ceramic-coated cylinder head

EGT

Table-3 Data of exhaust gas temperature (EGT) with different versions of the engine at peak load operation with different test fuels

Engine Version	EGT at peak load (Degree Centigrade)								
	Pure Diesel operation			Crude Jatropha oil operation			Crude Pongamia oil operation		
	Injection Pressure (bar)			Injection Pressure (bar)			Injection Pressure (bar)		
	190	230	270	190	230	270	190	230	270
CE	425	410	395	515	490	480	525	500	490
LHR-1	475	460	445	465	460	455	475	470	465
LHR-2	490	475	460	450	445	440	460	455	450

CE- Conventional engine, LHR-1 Low heat rejection engine- Air gap insulated piston and air gap insulated liner;
LHR-2 Low heat rejection engine- Air gap insulated piston, air gap insulated liner with ceramic-coated cylinder head

Volumetric efficiency

Table-4 Data of volumetric efficiency with different versions of the engine at peak load operation with different test fuels

Engine Version	Volumetric Efficiency (%)								
	Pure Diesel operation			Crude Jatropha oil operation			Crude Pongamia oil operation		
	Injection Pressure (bar)			Injection Pressure (bar)			Injection Pressure (bar)		
	190	230	270	190	230	270	190	230	270
CE	85	86	87	79	80	81	78.5	79.5	80.5
LHR-1	78	80	82	76	77	78	75.5	76.5	77.5
LHR-2	76	78	80	78	79	80	74	75	76

CE- Conventional engine, LHR-1 Low heat rejection engine- Air gap insulated piston and air gap insulated liner,
LHR-2 Low heat rejection engine- Air gap insulated piston, air gap insulated liner with ceramic- coated cylinder head

Smoke levels

Table-5 Data of smoke levels with different versions of the engine at peak load operation with different test fuels

Engine Version	Smoke Levels (Hartridge smoke units, HSU) Pure Diesel operation Injection Pressure (bar)			Crude Jatropha oil operation Injection Pressure (bar)			Crude Pongamia oil operation Injection Pressure (bar)		
	190	230	270	190	230	270	190	230	270
CE	48	38	34	68	65	58	70	65	60
LHR-1	55	50	45	63	58	53	65	60	55
LHR-2	60	55	50	58	53	48	60	55	50

CE- Conventional engine, LHR-1 Low heat rejection engine- Air gap insulated piston and air gap insulated liner,
LHR-2 Low heat rejection engine- Air gap insulated piston, air gap insulated liner with ceramic- coated cylinder head

NOx levels

Table-6 Data of NOx levels with different versions of the engine at peak load operation with different test fuels

Engine Version	NOx Levels (ppm)								
	Pure Diesel operation Injection Pressure (bar)			Crude Jatropha oil operation Injection Pressure (bar)			Crude Pongamia oil operation Injection Pressure (bar)		
	190	230	270	190	230	270	190	230	270
CE	850	890	930	700	720	730	740	750	780
LHR-1	1300	1280	1260	1245	1230	1180	1265	1235	1200
LHR-2	1350	1330	1310	1270	1255	1205	1290	1275	1225

CE- Conventional engine, LHR-1 Low heat rejection engine- Air gap insulated piston and air gap insulated liner,
LHR-2 Low heat rejection engine- Air gap insulated piston, air gap insulated liner with ceramic- coated cylinder head

Conclusions

- Vegetable oil operation at 27^{o}bTDC on conventional engine showed the deterioration in the performance, while LHR engines showed improved performance, when compared with pure diesel operation on conventional engine.

Conclusions

- Increase of injection pressure increased efficiency and deceased pollution levels. Pongamia oil showed higher peak brake thermal efficiency however, at peak load operation
- It showed deterioration in the performance and increase of pollution levels marginally in comparison with crude jatropha oil operation.