Effect of Compression Ratio on Performance and Emission Characteristics of Spark Ignition Engine Fueled with Blends of n-Butanol and Gasoline

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Contents

Abbreviations

- BMEP Brake Mean Effective Pressure
- BSFC Brake Specific Fuel Consumption
- BP Brake Power
- BTE Brake Thermal Efficiency
- CI Compression Ignition
- CO Carbon Monoxide
- CO_2 Carbon Dioxide
- CR Compression Ratio
- CV Calorific Value
- IC Internal Combustion
- I.P. Indicated Power
- m_f Mass Flow Rate of Fuel
- NO_x Nitrous Oxide
- SI Spark Ignition
- UHC Unburnt Hydrocarbons
- VCR Variable Compression Ratio

Nomenclature

- B0 n-Butanol 0% + Gasoline 100% by volume
- B5 n-Butanol 5% + Gasoline 95% by volume
- B10 n-Butanol 10% + Gasoline 90% by volume
- B15 n-Butanol 15% + Gasoline 85% by volume
- B20 n-Butanol 20% + Gasoline 80% by volume
- B25 n-Butanol 25% + Gasoline 75% by volume

Introduction

The increasing motorisation of the world led to steep rising demand of petroleum products. But petroleum products are

- Finite
- Highly concentrated in certain region of the world
- Source of environmental pollution

Cont…

Reasons for promoting Alternative fuels are

- To contribute to the security of energy supply;
- To contribute to the reduction in environmental pollutions
- To promote a greater use of renewable energy;
- To diversify agricultural economies into new markets.

Alternative fuels for SI engines

- Methanol
  - From lignite or coal
  - From municipal or solid waste
- Ethanol
  - From grains
  - From sugarcanes
- Butanol
  - From agricultural crops
  - From lignocellulosic biomass

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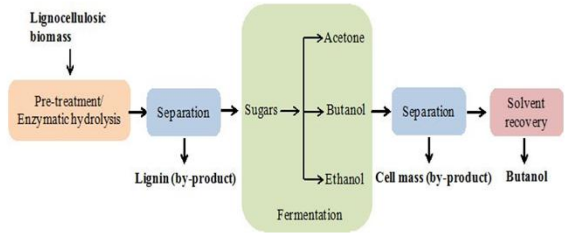

Figure: Schematic diagram for butanol production from biomass

Performance Parameters of Engine

- Thermal efficiency
- Brake specific fuel consumption

Emission Parameters

- CO
- CO_2
- NO_x
- UHC

Effect of compression ratio on Efficiency

$$\eta_T = (1 - \frac{1}{{r_c}^{\gamma - 1}})$$

Increasing the compression ratio of an engine can improve the thermal efficiency of the engine by producing more power output.

Objectives of The Work

- To study the performance and emission characteristics of SI engine fueled with different blends of n-butanol and gasoline at different compression ratios.
- Find out the optimum combination of blend and compression ratio (CR).

Suggestions Based on Literature Review

From the review of 16 research papers, it is suggested that

- Using n-butanol as a blend fuel in an SI engine, the BTHE and BSFC slightly affected while the exhaust emitted from the engine was reduced to a large extent compared with those of gasoline.
- It has been observed that effect of compression ratio on engine performance and emission characteristics of SI engine fueled with n-butanol is yet to be discovered.

Experimental Set-up

- Engine
- Auxiliary Head
- Data Logger
- Eddy current dynamometer
- Exhaust gas analyser

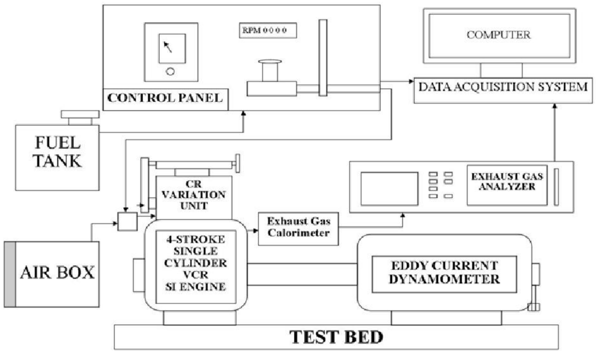

Figure: Schematic diagram of the engine test rig

1. Engine
2. Air Box
3. Auxiliary Cylinder
4. Dynamometer
5. Exhaust Syphon
6. Battery
7. Gas Analyser
8. Torque Controller
9. Burette
10. Computer Interface
11. Data Logger
12. Fuel Tank

Figure: Realized engine test rig

Cont…

Specification of the Engine

Make & Model	Greaves Cotton & MK-25
Type of the Engine	Vertical, four stroke cycle, single acting, totally enclosed, high speed, SI engine
Fuel	Petrol(Gasoline)
No. of Cylinders	1
Bore x Stroke (mm)	70 x 66.7
Clearance Volume (CC)	54.800
Total Displacement (CC)	256
Compression ratio	4.67:1
Rated Power	2.2 kW/ 3 HP @ 3000 rpm
Starting Method	Rope and Pulley - (Recoil Optional)
Direction of Rotation	Anticlockwise @ Drive End

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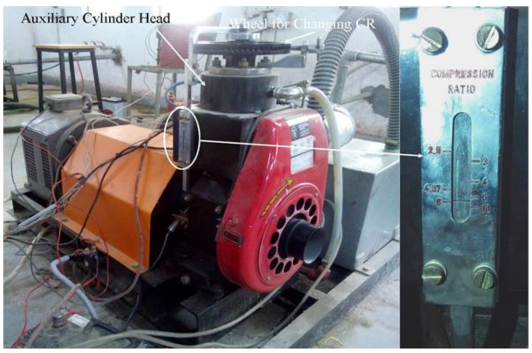
Auxiliary Cylinder Head



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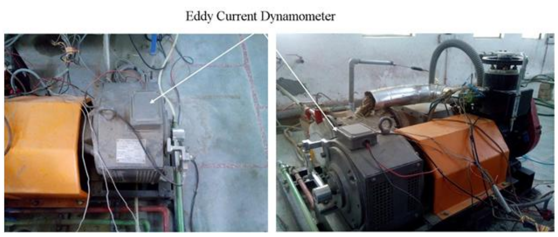
Eddy Current Dynamometer



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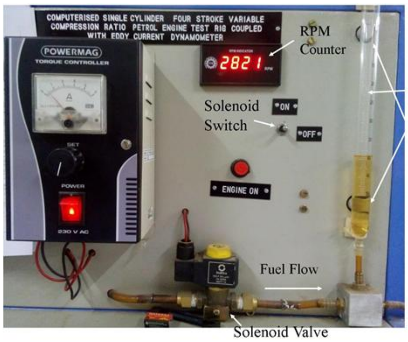
Exhaust Gas Analyser

Evaluations & Measurement

- Measurement of fuel flow rate
- Measurement of load
- Measurement of air flow rate
- Measurement of water flow rate
- Measurement of temperature
- Measurement of engine speed
- Measurement of cylinder pressure
- Measurement of Emission Characteristics
- Measurement of Calorific Value
- Measurement of Viscosity

Cont…

Measurement of Fuel Flow Rate



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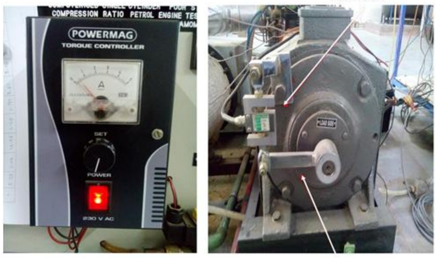
Measurement of Load Applied

Load Cell



Load Arm @ 125 mm

Experimental Sequence

	Blends			
CR 4.67:1	B0, B5, B10	B15, B20, B25	→ Best A	
CR 6:1	B0, B5, B10	B15, B20, B25	→ Best B	→ Optimum CR & Blend
CR 8:1	B0, B5, B10	B15, B20, B25	→ Best C	

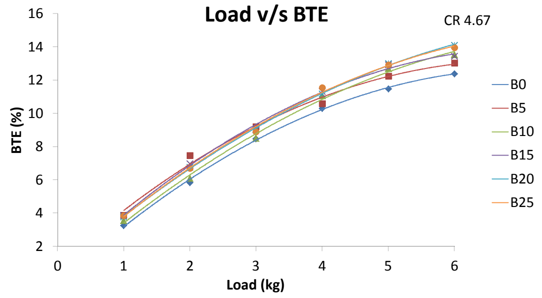
Cont…

- When the engine is running on the CR of 9:1, the cylinder pressure rises to 110 bar. The engine is very noisy and vibration of the engine reaches very high.
- These conditions are representing the detonation of the engine. So all the tests are made up to 8:1 CR.

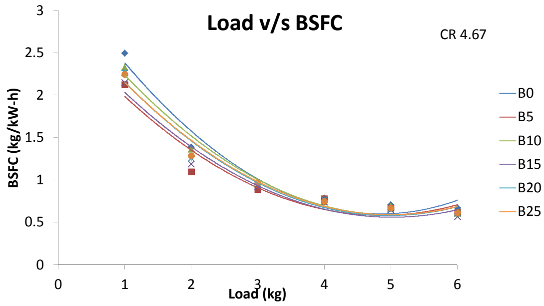
Results and Discussion

- Performance and emission characteristics (CR 4.67:1)
- Performance and emission characteristics (CR 6:1)
- Performance and emission characteristics (CR 8:1)
- Optimum compression ratio with best fuel blends

Performance and emission characteristics (CR 4.67:1)



Performance and emission characteristics (CR 4.67:1)



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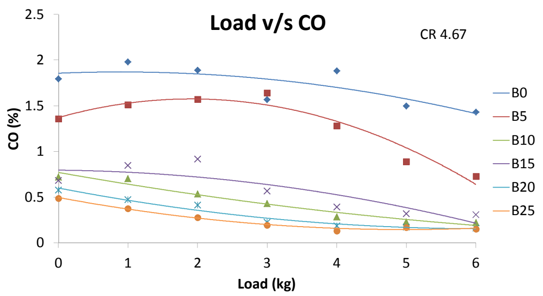

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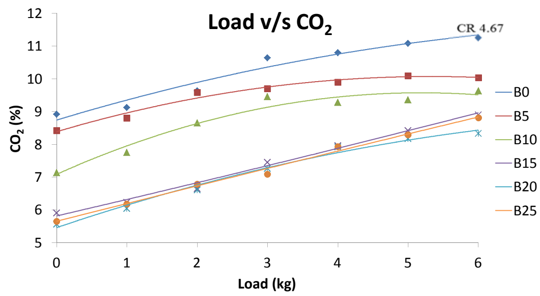

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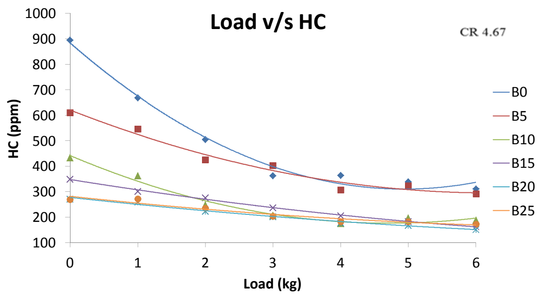
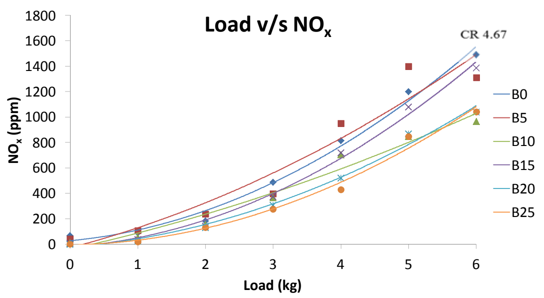
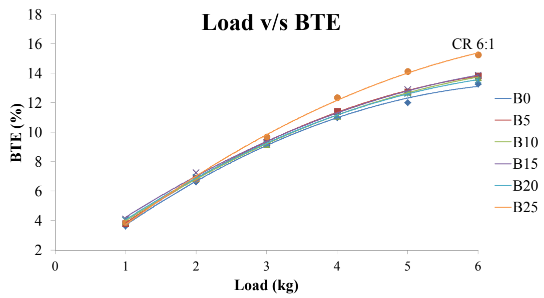


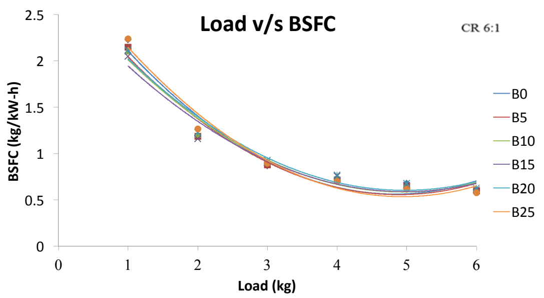
Performance and emission characteristics (CR 4.67:1)



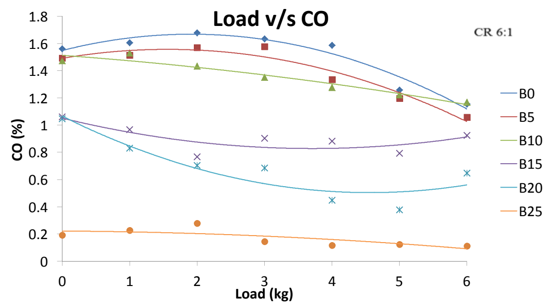
Performance and emission characteristics (CR 6:1)



Performance and emission characteristics (CR 6:1)



Performance and emission characteristics (CR 6:1)



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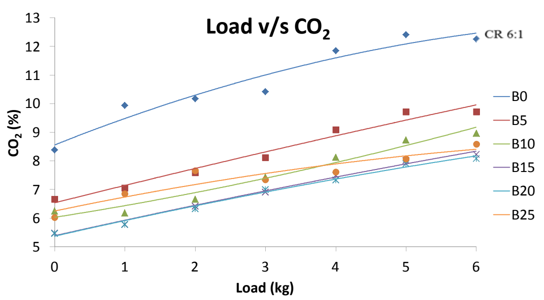

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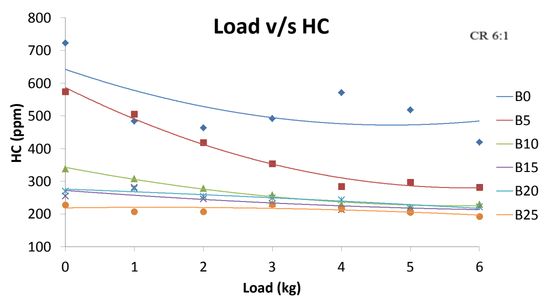

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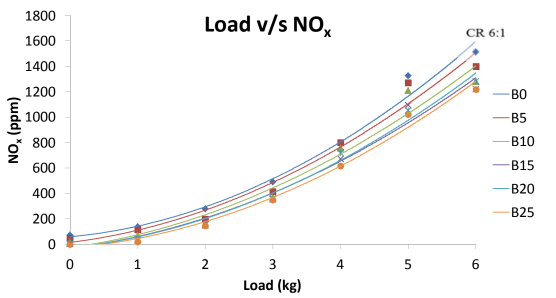
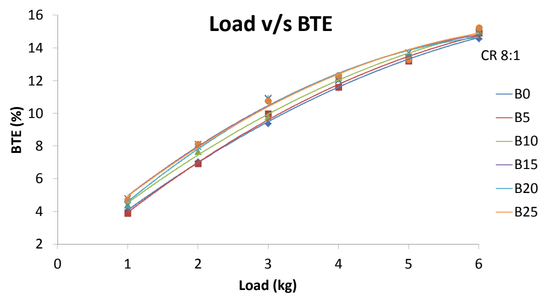
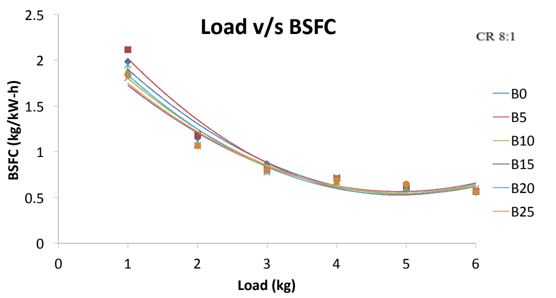


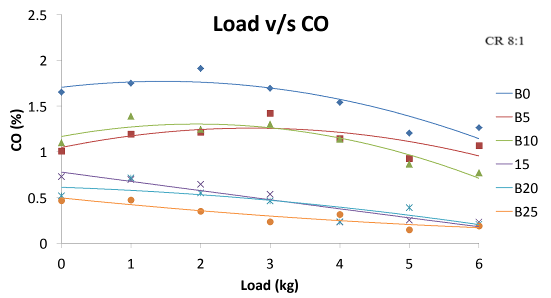
Performance and emission characteristics (CR 8:1)



Performance and emission characteristics (CR 8:1)



Performance and emission characteristics (CR 8:1)



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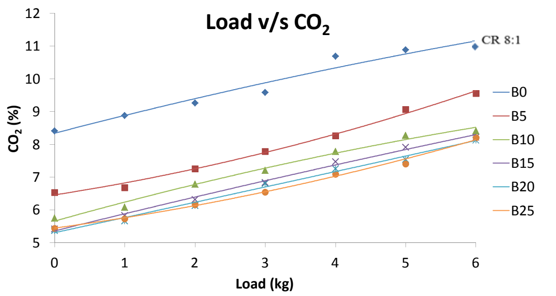

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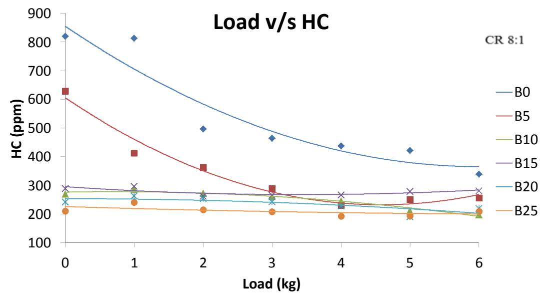

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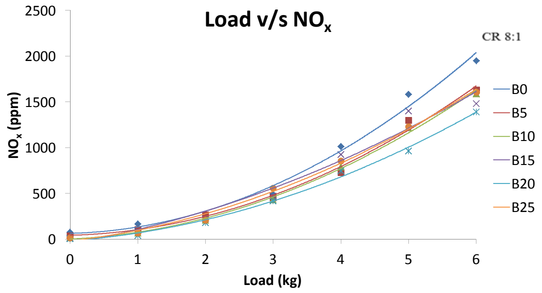
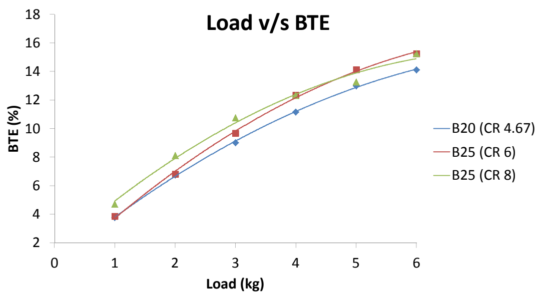
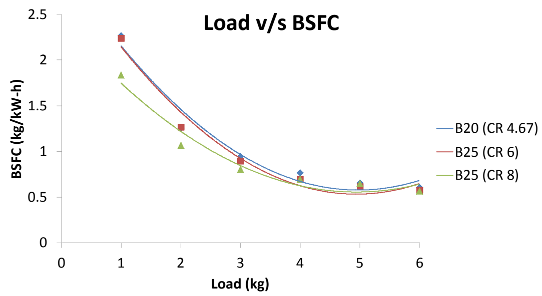


	Blends			
CR 4.67:1	B0 B5 B10	B15 B20 B25	→	B20
CR 6:1	B0 B5 B10	B15 B20 B25	→	B25
CR 8:1	B0 B5 B10	B15 B20 B25	→	B25

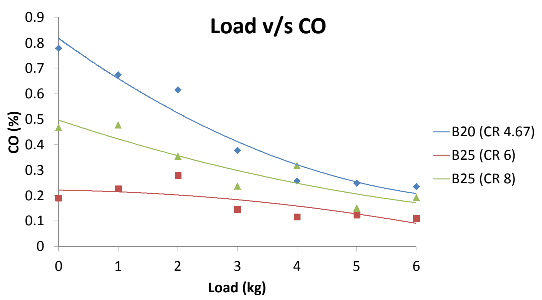
Optimum compression ratio with best fuel blends



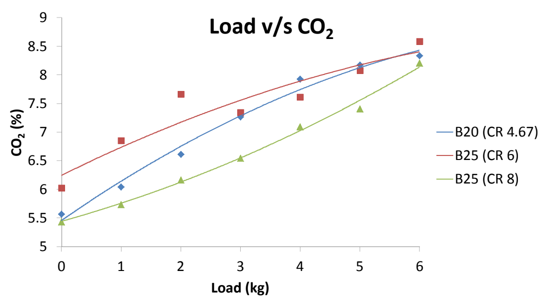
Optimum compression ratio with best fuel blends



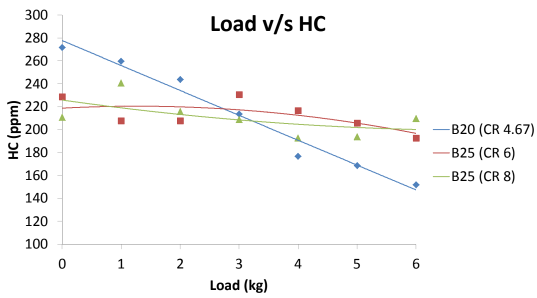
Optimum compression ratio with best fuel blends



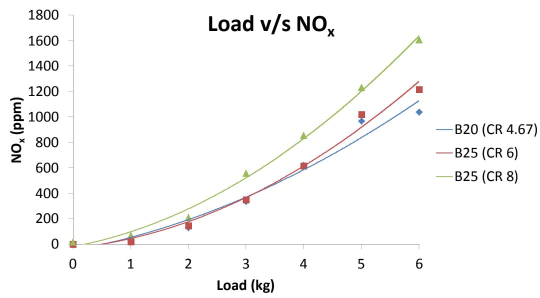
Optimum compression ratio with best fuel blends



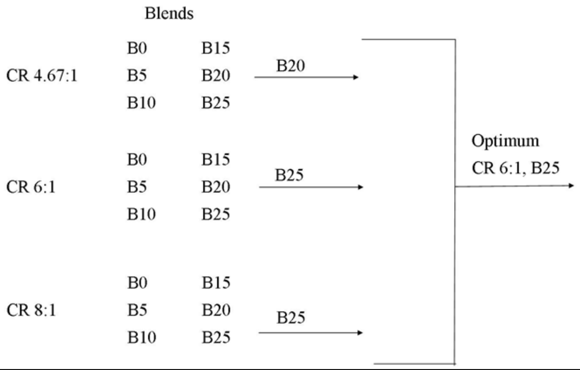
Optimum compression ratio with best fuel blends



Optimum compression ratio with best fuel blends



Conclusion & Future Scope



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- The best performance and emission characteristics are observed by the engine running with test fuel of B25 at CR 6:1.
- As the compression ratio increases, the BTE of gasoline engine rises by 18.63% with gasoline at full load and by adding 25% of n-butanol in the gasoline, the BTE is increases by 23.24% at CR 6:1.
- The BSFC is just reverse of the BTE. Due to higher density and oxygenated n-butanol, the BSFC of B25 is reduced by 13.43% at CR of 6:1 from BSFC of gasoline at original CR.

Cont…

- At original CR, test fuel of B25 gives 89.11% reduced CO emissions from gasoline fuel. 92.18% reduced emissions of CO are obtained by the test fuel of B25 at CR 6:1 from that of gasoline at original CR.
- The emissions of CO_2 are very high from the engine running with gasoline at all test compression ratios. By adding 25% of n-butanol in the gasoline at CR 6:1, CO_2 emissions are reduced by 23% at CR 6:1.
- The emissions of HC of B25 are reduced by 38.14% at CR of 6:1 from that of gasoline at original CR.

Cont…

- The NO_x emissions from the engine running with gasoline at original CR exhausted 1492 ppm. With increasing the CR, the NO_x emissions are also increased by 30.83% from the original CR. By adding the 25% n-butanol in the gasoline, the NO_x emissions exhausted by the engine running at CR 6:1 is 1219 ppm. It is -18.29% from the NO_x emitted by gasoline at original CR.

Future Scope

Cont…

- EGR (Exhaust Gas Recirculation) system can be used.
- More fuel blends of n-butanol and gasoline can be used.

- Paper Published
  - A. Agarwal and S. L. Soni, "Effect of Variation of Compression Ratio and Injection Pressure on Performance and Emission Characteristics of CI Engine Using Various Alternative Fuels: A Review," *IJERT - International Journal of Research in Engineering and Technology*, vol. 4, no. 1, pp. 40-45, Jan. 2015.
- Paper In-progress
  - A. Agarwal, A. Nayyar, A. Srivastava, and S. L. Soni, "Effect of Compression Ratio on Performance and Emission Characteristics of SI Engine Fueled with Blends of n-Butanol and Gasoline," *International Journal of Recent advances in Mechanical Engineering (IJMECH)*.

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Thank You!
Your Queries Please!!!