PERFORMANCE AND EMISSION CHARACTERISTICS OF A SINGLE-CYLINDER FOUR-STROKE DIESEL ENGINE FUELED WITH DIESEL–RICE BRAN METHYL ESTER–ISOBUTANOL BLENDS

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Abstract : The increasing demand for energy and the depletion of fossil fuels have led to the search for alternative and renewable fuels for diesel engines. Biodiesel derived from vegetable oils and alcohol-based fuels are considered promising substitutes due to their renewable nature and lower emissions. In this study, the performance and emission characteristics of a single cylinder four-stroke diesel engine fueled with diesel blended with rice bran methyl ester biodiesel and isobutanol are investigated. Rice bran oil is converted into biodiesel through the transesterification process to produce rice bran methyl ester (RBME). The prepared biodiesel is blended with diesel and isobutanol in suitable proportions and tested in a diesel engine without any engine modification. The engine performance parameters such as brake thermal efficiency and brake specific fuel consumption are evaluated under different load conditions. Emission parameters including carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NO_x), and smoke opacity are also measured. The objective of this study is to analyze the suitability of rice bran biodiesel and isobutanol blends as an alternative fuel for diesel engines and to assess their impact on engine performance and environmental emissions.IndexTerms — Biodiesel, rice bran methyl ester, isobutanol blends, engine performance, emissions, transesterification.

IndexTerms **- Component,formatting,style,styling,insert.**

1.INTRODUCTION

The rapid growth of industrialization and transportation has led to a significant increase in the consumption of conventional fossil fuels such as diesel and petrol. The continuous use of these fuels has resulted in the depletion of petroleum reserves and an increase in environmental pollution due to harmful exhaust emissions. Diesel engines are widely used in transportation, agriculture, and power generation because of their high efficiency and reliability. However, the emissions produced from diesel engines, such as carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), and particulate matter, contribute to serious environmental and health problems. Therefore, there is a growing need to find alternative, renewable, and eco-friendly fuels for diesel engines.

Biodiesel is considered one of the most promising alternative fuels for diesel engines. It is produced from vegetable oils or animal fats through a process called transesterification. Biodiesel is biodegradable, non-toxic, and contains oxygen, which helps in improving the combustion process and reducing certain harmful emissions. Ricebran oil is one of the potential sources for biodiesel production, especially in agricultural countries where rice is widely cultivated. Rice bran methyl ester (RBME) biodiesel can be blended with diesel and used in conventional diesel engines without major modifications.

In addition to biodiesel, alcohol fuels such as isobutanol are also gaining attention as fuel additives. Isobutanol has good fuel properties such as higher energy content, better miscibility with diesel, and improved combustion characteristics compared to other alcohols. The addition of isobutanol to diesel–biodiesel blends can enhance fuel atomization, improve air–fuel mixing, and help reduce certain exhaust emissions. The present study focuses on the performance and emission characteristics of a single cylinder four-stroke diesel engine fueled with diesel blended with rice bran methyl ester biodiesel and isobutanol. The engine is tested under different load conditions to evaluate parameters such as brake thermal efficiency, brake specific fuel consumption, and exhaust emissions including CO, HC, NOx, and smoke opacity. The objective of this study is to analyze the suitability of rice bran biodiesel and isobutanol blends as an alternative fuel for diesel engines and to assess their impact on engine performance and environmental emissions.

2. EXPERIMENTAL SEP UP:

The experimental setup consists of a single cylinder, four-stroke, direct injection diesel engine used to evaluate performance and emission characteristics. The engine is coupled with an eddy current dynamometer to apply and measure different load conditions. Fuel consumption is measured using a burette and stopwatch arrangement for accurate readings. Air intake is measured with the help of an air box and manometer setup. An exhaust gas analyzer is used to measure emissions such as hydrocarbons (HC), carbon monoxide (CO), oxygen (O_2), and oxides of nitrogen (NOx). A smoke meter is used to determine smoke opacity and particulate emissions. A pressure transducer is fitted to the cylinder to measure in-cylinder pressure variations. The pressure data is recorded using a data acquisition system for combustion analysis. The engine is operated at constant speed under varying loads to observe performance changes. Proper calibration and steady-state conditions are maintained before recording readings to ensure accurate results.

2.1 IsoButanol

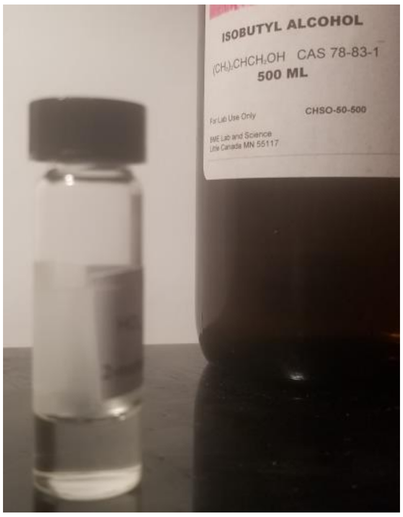

Fig: 2.1.1 IsoButanol

2.1.2 Properties of Iso-Butanol

Chemical formula: $C_4H_{10}O$ Boiling Temperature: 108°C Density: 0.802 g/ml
Molar mass: 74.12 g/mol
Melting point: -89.8

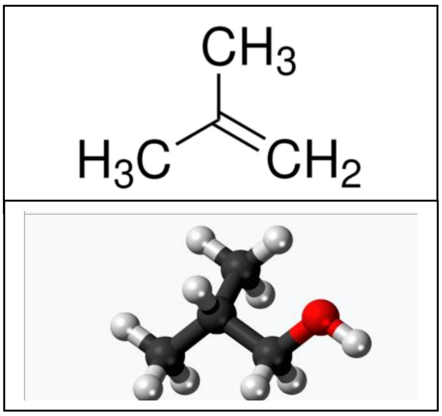

Fig: 2.1.2 Crystal Structure (ref: 3)

2.2. TRANSESTERIFICATION PROCESS

The transesterification process is used to produce biodiesel from rice bran oil. This process converts the raw oil into Rice Bran Methyl Ester (RBME), which has properties similar to diesel fuel and can be used in engine applications. Initially, the raw rice bran oil is filtered to remove dust and solid impurities, and then it is heated to remove any moisture content present in the oil.

Fig: 2.2.1 Transesterification Process

Fig:2.2.2 Base Treatment

Fig:2.2.3 Decantation to remove

Fig:2.2.4 Water washing

2.3.EXPERIMENTAL ENGINE SETUP OF ENGINE

The engine setup consists of single cylinder, four stroke, Diesel engine connected to eddy current type dynamometer for loading. It is provided with necessary instruments for combustion pressure and crank angle measurements. These signals are interfaced to computer through engine indicator for Pressure crank angle-PV diagrams. Provision is also made for interfacing airflow, fuel flow, temperatures and load measurement. The set up has standalone panel box consisting of air box, fuel tank, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator. The engine setup consists of single cylinder, four stroke, Diesel engine connected to eddy current type dynamometer for loading. It is provided with necessary instruments for combustion pressure and crank angle measurements.

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3. RESULT AND DISCUSSIONS

3.1 BLENDS USED

- D100 – Pure Diesel
- RBME10D90 – Mixture of 10% Rice Bran Methyl Ester Biodiesel and 90% Diesel
- RBME15D80IB5 – Mixture of 15% Rice Bran Methyl Ester Biodiesel, 80% Diesel, and 5% Isobutanol
- RBME20D75IB5 – Mixture of 20% Rice Bran Methyl Ester Biodiesel, 75% Diesel, and 5% Isobutanol
- RBME25D70IB5 – Mixture of 25% Rice Bran Methyl Ester Biodiesel, 70% Diesel, and 5% Isobutanol

Table of 3.1.1-D100Pure Diesel

S.NO	W (kg)	SPEED (N)	TIME IN CC	BP (kW)	IP (kW)	FCH (kg/h)	BSFC (kg/kWh)	BTE (%)	ITE (%)	ME (%)
1	1.7	1500	74	0.4	2.03	0.052	0.131	8.46	8.46	19.7
2	3.4	1500	70	0.8	2.43	0.116	0.145	14.34	14.34	32.9
3	5.1	1500	69	1.2	2.8	0.314	0.262	18.39	18.39	42.9
4	6.8	1500	62	1.6	3.19	0.451	0.282	23.25	23.25	50.2

3.1.2 Brake Specific Fuel Consumption

The ratio of the mass flow rate of the fuel delivered to the engine to the braking power obtained at a crankshaft is known as brake specific fuel consumption, and it reflects how efficiently the fuel is used to produce brake power.

The BSFC specifies the efficiency with which a certain amount of gasoline is turned into brake power. Thus, regardless of other parameters such as engine capacity, engine size, number of cylinders, etc., it is simple to compare the efficiencies of different engines on this basis.

Table 3.1.2 - Load Vs Brake Specific Fuel Consumption

S.NO	BLENDS	BSFC (kg/kwh)			
		25% of full load	50% of full load	75% of full load	100% of full load
1	D100	0.131	0.145	0.262	0.282
2	RBME10D90	0.106	0.131	0.238	0.267

3	RBME15D80IB5	0.095	0.103	0.204	0.224
4	RBME20D75IB5	0.087	0.094	0.181	0.198
5	RBME25D70IB5	0.081	0.087	0.093	0.187

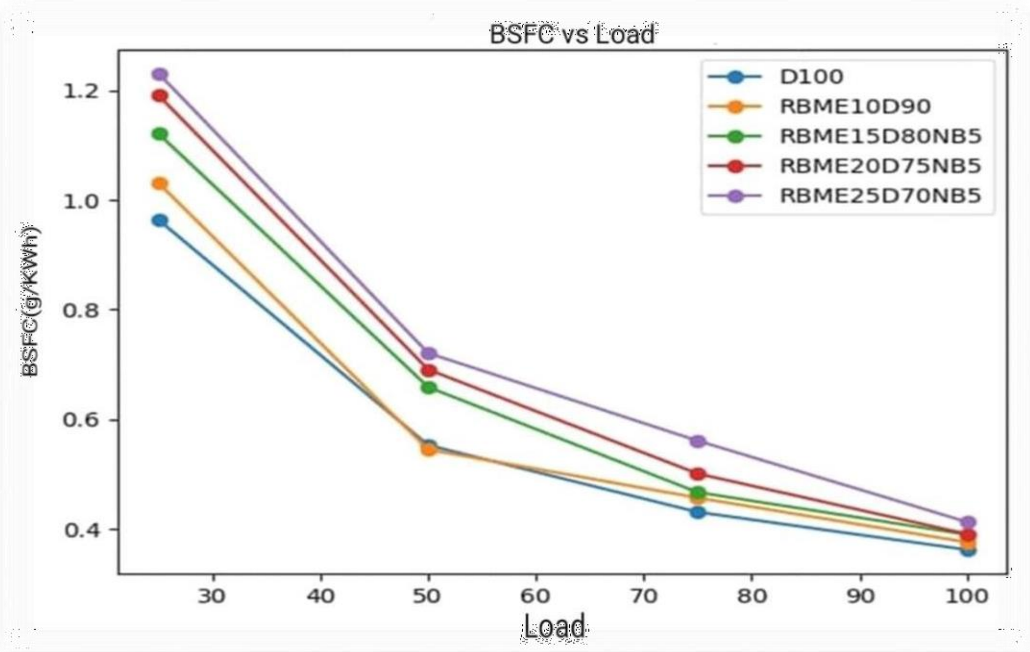


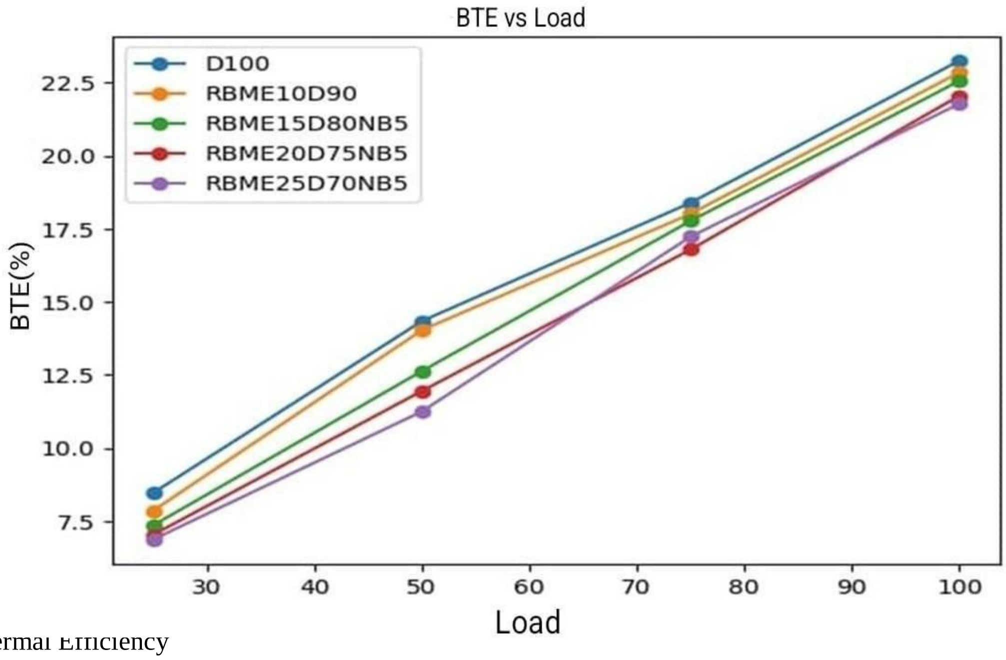
Fig: 3.2.2 Load Vs Brake Specific Fuel Consumption.

3.2.3.Brake Thermal Efficiency

The amount of power available at the crankshaft of the engine is referred to as brake power. It's also determined by the product of the available torque at the crankshaft and the crankshaft's angular speed. The brake thermal efficiency is a type of engine thermal efficiency that is defined as the ratio of brake power at the engine crankshaft to power generated by fuel combustion. The amount of power taken by the engine crankshaft out of the total power created by the burning of the fuel is shown by the brake thermal efficiency.

Table 3.2.3 - Load Vs Brake Thermal Efficiency

S.NO	BLENDS	BTE (%)			
		25% of full load	50% of full load	75% of full load	100% of full load
1	D100	8.46	14.34	18.39	23.25
2	RBME10D90	7.85	14.03	18.01	22.85
3	RBME15D80IB5	7.35	12.63	17.77	22.56
4	RBME20D75IB5	7.03	11.95	16.79	22.05
5	RBME25D70IB5	6.87	11.25	17.23	21.78



3.2.4.Indicated Thermal Efficiency

The amount of power developed inside the engine cylinder is referred to as indicated power. It is also determined by the pressure of the gases acting on the piston during the power stroke. The indicated thermal efficiency is a type of engine thermal efficiency that is defined as the ratio of indicated power developed inside the engine cylinder to the power generated by fuel combustion. The amount of power produced within the engine cylinder out of the total power created by the burning of the fuel is shown by the indicated thermal efficiency.

Table 3.2.4 - Load vs Indicated Thermal Efficiency

S.NO	BLENDS	ITE (%)			
		25% of full load	50% of full load	75% of full load	100% of full load
1	D100	42.9	43.58	43.89	48.58
2	RBME10D90	41.68	43.21	43.68	48.35
3	RBME15D80IB5	41.32	43.02	43.58	46.23
4	RBME20D75IB5	41.02	42.05	42.86	46.02
5	RBME25D70IB5	40.89	42.58	42.78	45.86

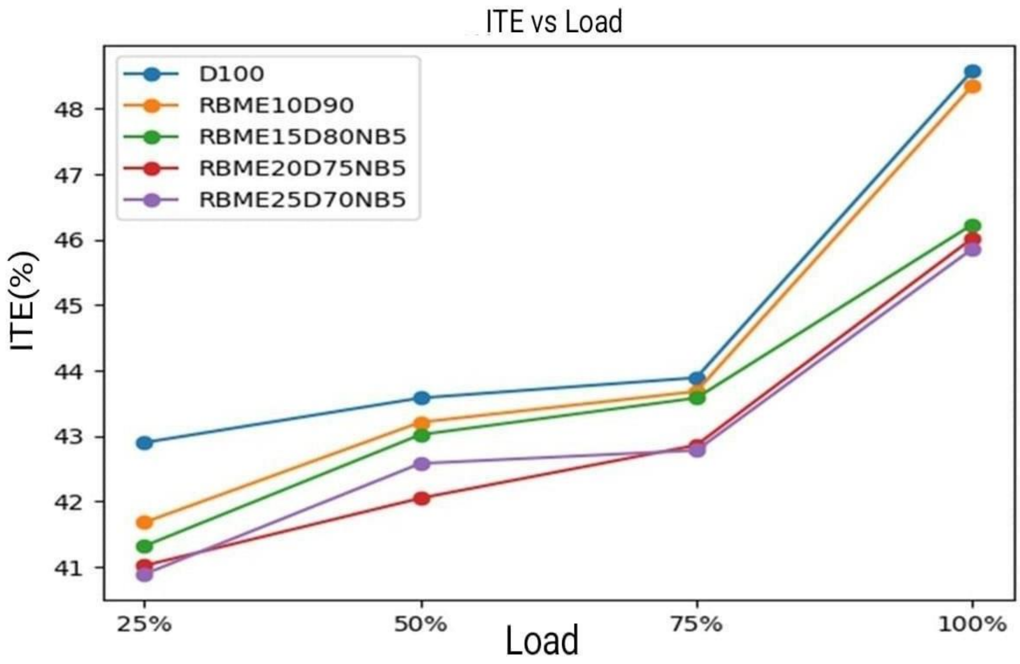


Fig: 3.2.4 Load Vs Indicated thermal efficiency

3.2.5.Mechanical Efficiency

The Mechanical efficiency is measure of the effectiveness with which a mechanical system performs. It is usually the ratio of the power delivered by a mechanical system to the power supplied to it, and because of friction, this efficiency is always less then one. Mechanical efficiency increases with increase in engine load for all the tested fuel blends. This is mainly because frictional losses become less significant compared to the useful power output at higher loads.

Table 3.2.6 - Load Vs Mechanical Efficiency

S.NO	BLENDS	ME (%)			
		25% of full load	50% of full load	75% of full load	100% of full load
1	D100	19.7	32.9	42.9	50.2
2	RBME10D90	18.8	32.3	42	49.2
3	RBME15D80IB5	17.1	29.1	38.2	45.1
4	RBME20D75IB5	14.6	25.5	34.3	40.7
5	RBME25D70IB5	13.5	23.8	32	38.5

Fig: 4.4 Load Vs Mechanical efficiency

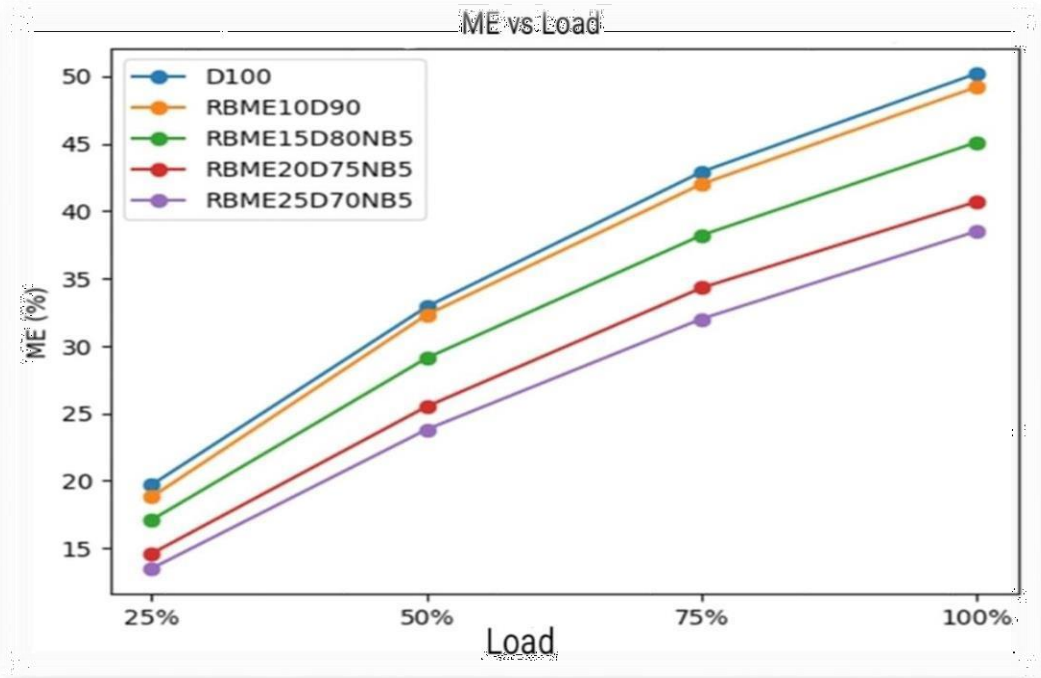


Fig: 3.2.6 Load Vs Mechanical efficiency

4.References

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