ANALYSIS OF THE PERFORMANCE OF A CI ENGINE OPERATING IN DUAL FUEL MODE WITH BIOGAS AND BIODIESEL

Mayur Jayant Gitay[1], Dr. Nilesh Diwakar[2], Dr. M. K. Chopra[3], Dr. Nikhil J. Rathod[4]

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Abstract

The demand for energy is rising daily throughout the world. Using coal and petroleum-based fuels to supply this high energy demand is exceedingly challenging. The entire world the focus on energy is currently changing to nuclear power and renewable energy of power due to the knowledge of the effects of global warming and environmental pollution the faster consumption of fossil fuels. However, the processing of raw materials and waste materials for nuclear energy needed caution, so the Renewable energy is the only choice of power. The finest alternative fuels are biogas and biodiesel. Diesel engines can consume the fuel directly, with or without modifying the current engine. In the proposed effort, investigations will be performed using a 4 -stroke, single-cylinder diesel engine made by Kirloskar (AV1model). Diesel and biodiesel pilot fuel were combined with biogas as the main fuel. The experiment was carried out to measure a number of factors, including brake power, energy conversion efficiency, and emission, including the amount of CO, CO2, HC fine particles, and NOx in Exhaust gases. Additionally, the impact of replacing emissions from diesel was investigated.

Keyword: CI Engine, Diesel, Biodiesel, Biogas

[1]PhD Scholar, Department of Mechanical Engineering, Sarvepalli Radhakrishnan University, Bhopal, Madhya Pradesh, India
Email: [1]mjgitay.gitay@gmail.com
[2]Principal, RKDF IST, Bhopal, Sarvepalli Radhakrishnan University, Bhopal, Madhya Pradesh, India
[3]Professor, RKDF IST, Bhopal, Sarvepalli Radhakrishnan University, Bhopal, Madhya Pradesh, India
[4]Engineer, Department of Mechanical Engineering, SRS Valuetech System Pvt Ltd, Nasik, Maharashtra, India

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1. Introduction

In India, agriculture-related activities are performed by 75% of the population. Some of the members of this population reside in extremely isolated places that are rural. The centralized energy production systems are inadequate to supply the decentralized communities in rural India with the electricity they require. Diesel engine utilization has increased dramatically in rural regions during the past few years. Pumps for irrigation and tractors, machines for crushing, milling, and chaff-cutting and other rural equipment all frequently use diesel engines to generate electricity. The need for traditional fuel, such as diesel, is rising as well in rural regions. Then again, the massive worldwide strain regarding energy issues and pollution, and climate change brought on by the burning of fossil fuels has compelled researchers, businessmen, and authorities to hunt for alternative sources of power. This caused it crucial to bring electricity in a sustainable and environmentally friendly manner to rural communities. Local fuel and energy production is a viable solution for rural electrification, which only can help with rural areas' economic growth and decrease of poverty. The most dependable and effective combustion device is the diesel engine, and there is an increasing must be adopted or modification of such diesel engines for effective operation using gaseous fuels derived from biomass without issue. due to biomass is abundant Specifically, it might be useful to produce these obtaining fuels locally and utilize them to power engine diesel. Furthermore, these fuels environmentally benign because methane has far less carbon than regular diesel fuel and because they boost the use of renewable fuels in transportation. There may be two justifications for using those fuels. the initial possibility is since the fuel may be used instantly in a without a diesel engine requiring any modifications to the current engine, and the second is that these fuels can be used with very minor engine modifications. In the current situation, there are numerous diesel engines employed in villages for a variety of uses, whereas petrol engines or petrol-powered generator sets are practically nonexistent.

In this study, Yungjin Kim et al. [1] compare comparing the outcomes with a 40% CO2 content to those with 100% methane content. They looked at the impact of CO2 on the fuel usage and NOx emissions of biogas. Using a lean burn approach results in increased thermal efficiency and decreased NOx. He came to the conclusion that utilising biogases with CO2 should result in a large reduction in NOX emissions, but that there would inevitably be a rise in fuel usage. Burning lean strategies are virtual at cutting fuel use and emitting NOX; But using biogas with a stoichiometric air-fuel ratio appears to be efficient at reducing NOX emissions and can enhance fuel economy at higher loads. Guven Gonca et al. [2] investigated the experimental and theorized outcomes of effective power and efficiency with regard to variation engines load for various engine types. As engine load increases, effective power rises as well, peaking at 100% load. The findings indicated it is true that several compression ratio ideal values for various engine loads as well as optimum compression ratios that offer the greatest performance gain a greater engine load. Bhasker Bora et al. [3] in comparison to the performance analysis In comparison to diesel mode, the EGT rises by at 26° BTDC. As CR rises, the biogas air combination burns more quickly. As a result, the time needed for complete combustion decreases, which results in less EGT. Combustion analysis: In contrast to diesel mode, the maximum NHRR under DFM reduces at 26° BTDC with a BMEP. Emission evaluation When IT is advanced from 26° to 32° BTDC for a CR of 18, there is an average increase of 13.64% in CO2 emissions. The average increase in CO2 emissions for the same range of IT for CR of 17.5, 17 and 16 is 8.89%, 7.76%, and 4.7%, respectively. Conclusion: For an RBB-biogas driven dual fuel diesel engine, a high CR yields improved performance, combustion, and pollution. J. Li, W. M. Yang, et al. [4] have studied the characteristics of combustion.- With C-SOI SOI timings, the effect of the petrol ratio behaves differently. The C-SOI's combustion characteristics are less responsive to those of the A-SOI when variable petrol ratios are used. Therefore, A-SOI may offer more precise controllability by altering the petrol ratio. emissions of NOx It is conceivable to assume that reductions in NOx emissions could result from general increases in the petrol ratio. It makes sense that increases in petrol would lead to lower maximum temperatures because temperature plays an important part in the creation of NOX emissions. Research by Cenk Sayin, Metin Gumus, et al. [5] indicates that nitrogen oxides (NOx) emissions frequently lead to an elevation of NOx concentration. the differences in NOx emissions between various biodiesel-blended diesel fuels at various CRs. Increased CR caused a 15.56% increase in NOx emissions compared to the ORG CR values for B50, whereas decreased CR caused a 12.45% decrease. Reduced CR lowers internal cylinder temperatures, which lowers the combustion flame temperature and lowers Releases of NOx. The emitting HC -enhanced lower CR them by when compared to ORG CR, while the lowered CR increased them by 35.50%. At lower CRs, the heat produced by compression is insufficient, delaying ignition and increasing HC emissions. Bhaskar J.Bora et al. [6] carried performed an innovative study in order to assess performance analysis. In comparison to diesel mode, at load, the BSEC under DFM. The BSEC normally falls by 12.85% when the

CR rises from 17 to 18. As previously mentioned, it is discovered that both for diesel and DFM, the VE falls as the load rises. Combustion analysis: the highest NHRR within DFM at load is found to be as contrasted to CA in diesel mode. Consequently, it is evident that the highest NHRR. According to a study by Kyunghyun Ryu et al. [7], the engine's output and exhaust emitted are influenced by the time of the auxiliary fuel injection during dual fuel combustion. By delaying pilot injection timing at high loads and advancing it at low loads, DFC's BSEC increases. 1.6–4.4 CAD longer per combustion than diesel with a single fuel, the ignition delay in DFC. In the dual fuel combustion of CNG and biodiesel, longer pilot injection times result in less smoke and more NOx. Mohammed EL-Kassaby et al. [8] investigated the outcome of replacing diesel with biodiesel in its blended form on diesel engines' thermal efficiency when braking tested. The thermal efficiency of the brakes increased, when the compression ratio was changed from 14 to 18average increases in CO2 emissions, decreases in HC emissions, drops in CO emissions, and increases in NOx emissions. Senthil Ramalingam et al. [9] investigated if higher performance when TDC injection timing was combined with compression ratio, reduction of emissions and combustion than conventional injection timing of TDC and compression ratio. A20 has the greatest results for BTE, higher heat release rate, and lower emissions of HC, CO, and NOx for all tested values. As a result, A20 can be successfully used as a substitute biodiesel in tested engines with an injection timing of 30_bTDC and a compression ratio of 19.5. This will somewhat lessen the shortage of pure diesel, even if only 20% of Annona methyl ester is added to 80% pure diesel. When compared to other options, Annona is more affordable. According to Datta Bharadwaz et al. [10], To get the best performance and lowest emissions from methanol mixes, the engine runs best at load, compression ratio, and methanol blend. At optimised conditions, responses for with increasing methanol percentage in the blend, it has been discovered that both brake thermal effectiveness and fuel usage particular to brakes are rising. Additionally, it should be noted that using methanol mixes causes NO and Smoke emissions to decrease while CO and HC emissions rise. Pisarn Sombatwong et al. [11] examined how pilot fuel affected the output and emissions of a two producers of gas a diesel motor. The primary fuel was biogas, while the aviation fuel was diesel. Both natural aspiration mode and turbocharged mode were used in the tests, with the latter using a mixing process that was 10 times longer. It was found that the second scenario's thermal efficiency had gone up by 8%. It was found that by maintaining a steady flow rate of biogas while lowering the pilot flow rate, the pilot amount could be shortened to as little as 10% in the second stage. This also resulted in a drop in the the exhaust gas temperature with the turbocharger system. Mohd Hafizil Mat Yasin et al. [12] investigated the performance of a diesel motor with an EGR system (exhaust gas recirculation) running on palm-based biodiesel. Investigative work was carried out using a diesel engine with many cylinders and EGR and using Diesel-RK while maintaining a 2500 rpm engine speed under conditions of full load. According to palm biodiesel results markedly increased NOx emissions, greater fuel use and somewhat lowered other pollutants as Unburned hydrocarbons (UHC), CO2, and CO. But the application of EGR results in significant reductions in emissions of NOx and exhaust temperature, while exhibiting gains pertaining to fuel efficiency, CO, CO2, and UHC emissions. Saket Verma et al. [13] examined the outcomes of various biogas compositions pertaining to the output and emission characteristics of the compression ignition engine using exergy analysis. With reference to engine crank angles, Under full load, combustion analysis of the in-cylinder pressure and heat release rate data for the diesel and dual fuel combustion modes. The peak cylinder pressures were discovered to with the two fuels biogas mode were consistently more than those with the engine mode. It can be argued that biogas with a high methane fraction can perform fairly well. Bhaskor J. Bora et al. [14] claim that an intake manifold-connected venturi gas mixer can be used to convert a Water-cooled, direct-injection, single-cylinder, 3.5 kW engine with variable compression ratio diesel engine to run on biogas. An analysis of the performance reveals that BTE operating in dual mode is improved and the CR is increased. This is due to the fact that when CR grows, so do the temperature and pressure. As a result, more biogas is likely to burn all the way through, which has the opposite effect.

The literatures mentioned above demonstrate that an investigation into single-cylinder diesel engines operating the use of dual fuel has been scrutinized in an effort to reduce the use of diesel fuel, and to reduce emissions. The topics covered in this research range from the effects of the mixing system to the source of the biodiesel, long-term operation, and oxygen enrichment of the incoming air. These techniques usually involved making substantial changes to the original single-cylinder diesel engines, like adjusting the rate of compression and installing engines with pilot fuel injection. It is difficult to return to pure diesel mode in the absence of biogas. In isolated places, it will be challenging to put such techniques into practice. This study proposes an investigation of diesel engines with a single cylinder operating utilizing two fuels without major modification. Without modifying the engine, a compact single-cylinder diesel engine will have its performance and emission characteristics examined.

Methane content and biogas flow rate will be examined for their impacts. The goals are to investigate the functionality and emission propertiesand look for the best circumstances for an unmodified, tiny, diesel engine with a single cylinder operating utilizing two fuels. The outcomes are anticipated to provide the required data for developing a different approach to improve biogas utilization.

Objectives

The purpose of this study is to look into engine performance.

- Experimental analysis for Performance, combustion and Emission Characteristics of Biogas-diesel and biogas - biodiesel fuel and its blends and optimizing the best blend ratio based on engine performance and emission characteristics.
- Diesel and biodiesel fuel performance against biogas diesel and biogas biodiesel fuel performance will be used to compare engine performance.

Experimental Set Up

An experimental device has been created and built in order to conduct the study, as illustrated in Fig. 1. It is made up of a single diesel engine with one cylinder, a power plant, a number the lamps, a tank for biogas, the gas mixer and measurement equipment. Table 1 lists the single-cylinder diesel engine's specifications. It has a single cylinder and runs on diesel fuel. The single-cylinder diesel engine's maximum output power is 3.5 K W, respectively. For agricultural tasks like those requiring a micro tractor, this sort of single-cylinderdiesel engine is often found in small farmers in Indonesia. Both single-fuel mode and On the engine, tests in dual-fuel mode were performed. The single- cylinder diesel engine was put through its paces in the single-fuel mode at various loads and speeds. Measurements were made on the fuel usage and electric output power. A gas mixer has been created and is being used in the dual-fuel mode to combine biogas and fresh air. In a specially made tank, the biogas is compressed and stored. Fresh air was combined with biogas produced by the tank while it was being pumped through the intake manifold. The single cylinder engine received an injection of a biogas and fresh air mixture. The biogas' concentration of methane and the flow rate was adjusted, and it was put to the test. at various engine loads and speed. A pulley was used to connect the single-cylinder diesel engine to the single-phase synchronous generator. The generator's specifications are the following. The maximum power and frequency of rating are 3.5 kVA, 115-230 V, and 50/60 Hz, respectively. The current biogas was created through the anaerobic breakdown of cow manure using a digester. Gas chromatography was used to measure the biogas' methane content. Boiler ash is used to filter the unprocessed biogas generated at an oil mill for palm to boost the methane content. The subsidized fuel store from Indonesia, is where the diesel fuel ispurchased. The diesel oil's LHV is calculated before to usage. For all loads and fuels, the engine ran at a speed between 1200 and 1700 rpm. The following details the experimental processes. The single- cylinder diesel engine is only powered by diesel in the first mode. The engine runs between 1200 and 1700 revolutions per minute, and the load varies from 600 W to 1500 W. The measurement is done for 5 minutes for each load and speed while the diesel engine's solitary cylinder is stable. While using two fuels, the mixer combines fresh air and biogas from the tank. Using a gas regulator, the biogas's pressure coming within the tank is lowered to 1.8 bars. The biogas can flow at different rates between 2 and 6 litres per minute (L/min). Changingthe load from 500 W to 1400 W, and from 1200 rpmto 1700 rpm, the engine speed is adjusted for each biogas flow rate. The same measurements are also made with the engine operating in mono fuel mode.Thus, 180 experiments have been conducted in all, with each experiment being run three times and the findings averaged.

Figure 1 Test rig setup showing engine

Table 1 technical details of the TV1 engine

Make	TV1 Oil Engines
Type	Four-stroke engine, constant speed, compression ignition Cooled water,
No. of cylinder	Single
BORE x STROKE	86.5 MM x 110 MM
Cc	0.651 lit.
C R	18:1
Peak Pres.	76.5
Maximum speed	2100 rpm
Min. Idle sp.	850 rpm
Ope. Speed	1500 rpm
Fuel injection timing (Standard)	23 BTDC
BMEP at 1500 rpm	6.35 Kg/cm^2
Rat. Power	2.5 kW @1500 rpm

2. Results and Discussion

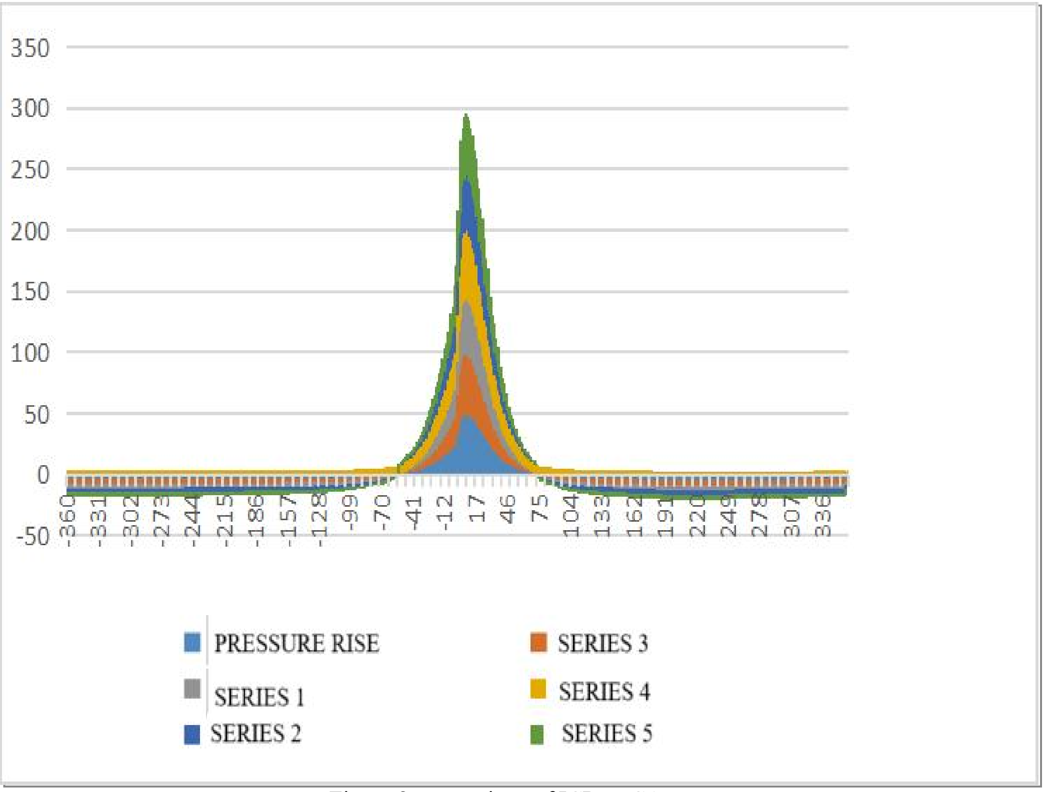

Figure 2 comparison of ICP vs CA

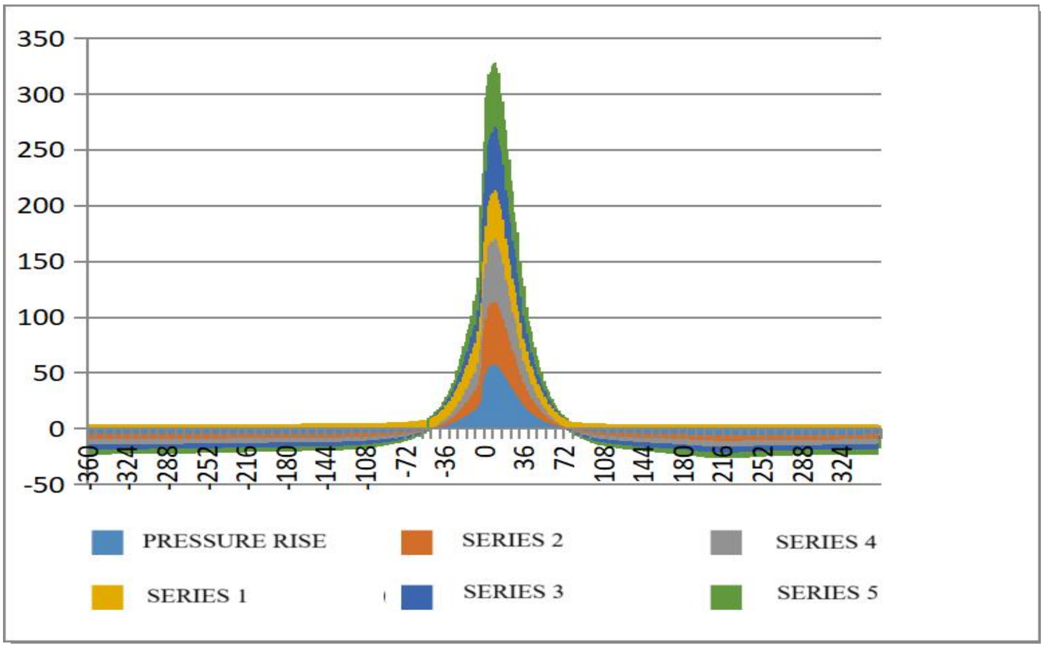

Figure 3 comparisons of ICP vs CA

Figures 2 and 3 show that the diesel and biodiesel modes both experience the highest pressure rise. During operation of the engine in dual fuel mode, the pressure rise is reducing as more biogas is used.

4.1 Brake Power

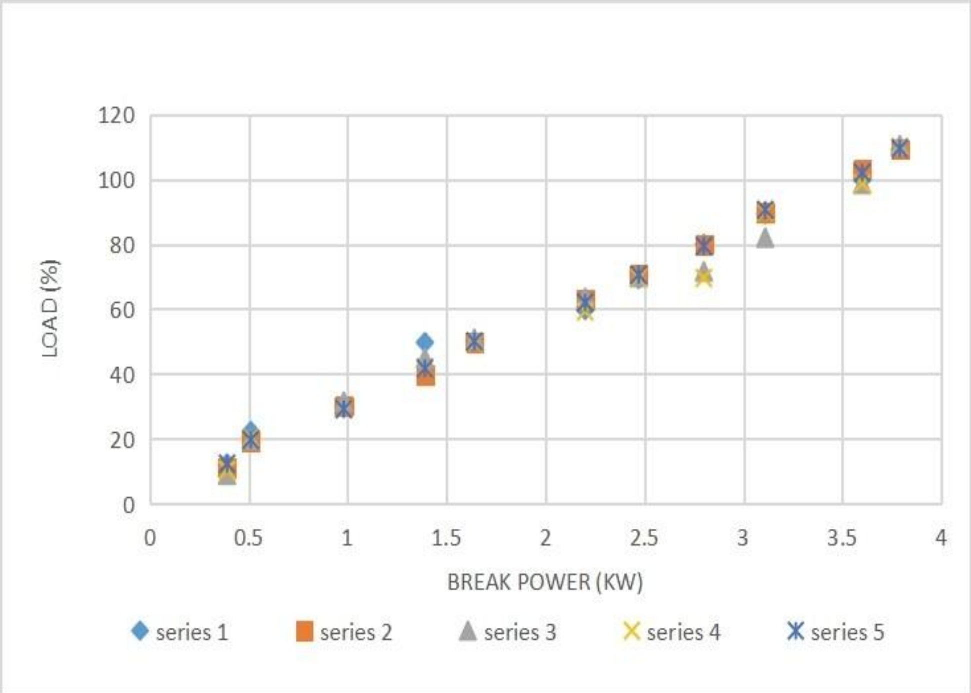

Figure 4 Variation of Brake power

Figure 4 depicts how brake power changes as a percentage of full loads. the two fuels mode is seen to progress brake power which is comparable to the dual-only diesel mode. The strength evolved in the various ways of working is almost same under lower loads. Due to the little difference, it can be seen which the dual fuel mode creates somewhat more power than utilizing diesel at greater loads.

2.2 Mechanical Efficiency

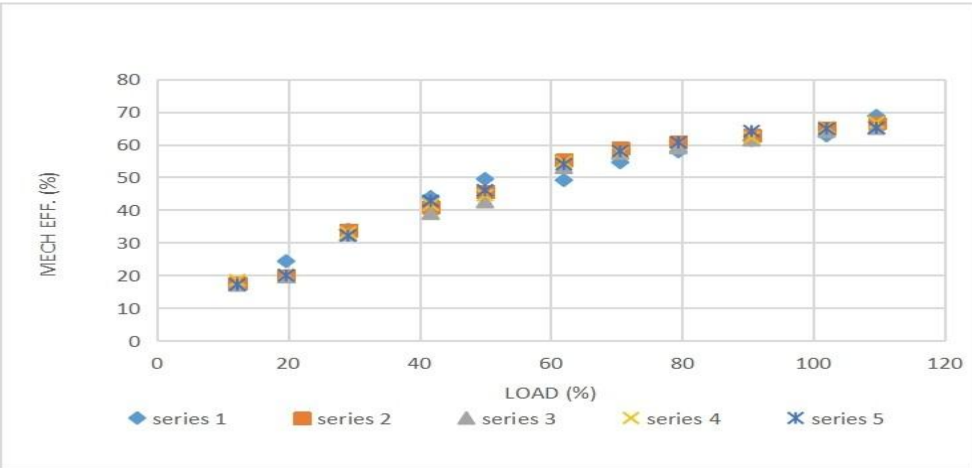

Figure 5 Mechanical Efficiency Variation

The fluctuation of the engine's mechanical efficiency at % full load is shown in fig. 5. The engine was run in dual fuel and diesel engines. The engine produces the same amount of power in two-fuel mode as it does when using diesel. A careful examination reveals that, with a few exceptions, mechanical efficiency is slightly higher than diesel. The situation that produced the highest mechanical efficiency, 68.91%, was slightly overloaded.

2.3 Brake Thermal Efficiency

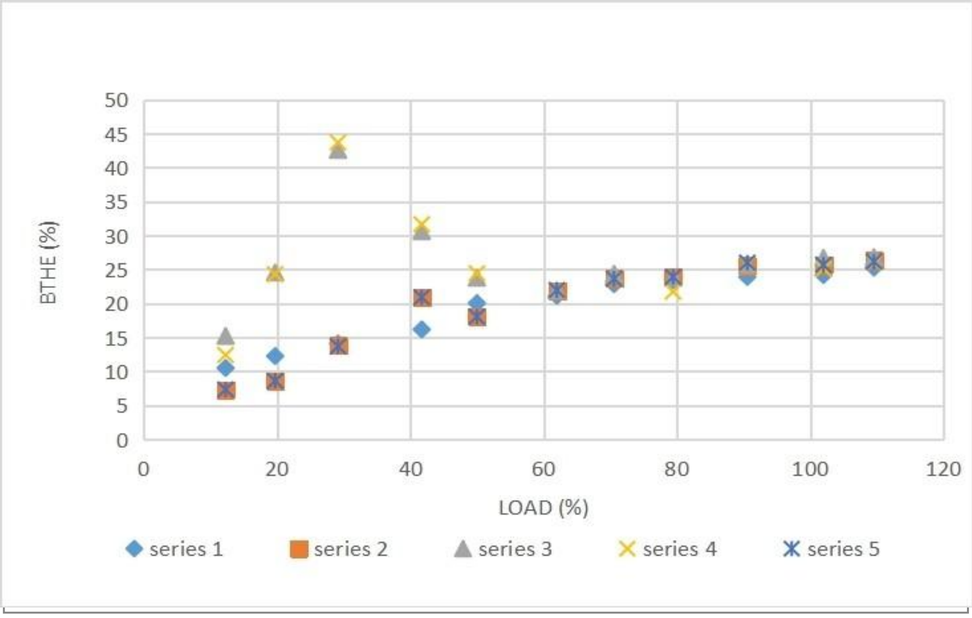

Figure 6 A variant of Bthe

This is made possible by the biogas, which has 95% methane. At all points, brake thermal effectiveness when using dual fuel is greater compared to diesel-only mode. This is one benefit of the methane in biogas. It burns entirely and is a clean fuel. This is in line with all dual-fuel engines using petrol as their primary fuel.

2.4 Volumetric Efficiency

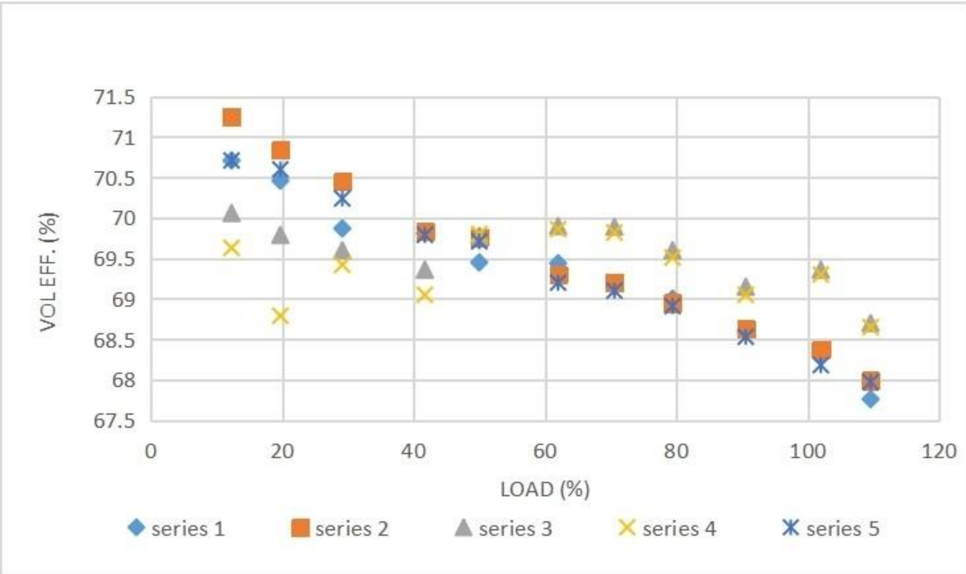

Figure 7 Vol eff variation

The fluctuation of the engine's volumetric efficiency at % full load is shown in fig. 7. The engine was run in dual fuel and diesel engines. In every situation, it falls as the load rises. The volumetric efficiency is declining as the load increases for each modes function, such as the diesel-only mode and two-fuel mode. This is due to the way the biogas induction process works. This is due to the way the biogas induction process works. T-joint mixer usage, biogas has direct replaced/displaced by air that is present in is expected to access the induction manifold when it is fumigated.

2.5 Hydrocarbon Emission

Figure 8 HC variant with break power

Figure 8 depicts how the engine's HC emission changed as brake power increased. The engine was running in dual fuel and diesel modes. Uncompleted combustion results in unburned hydrocarbons. The graph demonstrates that unburnt HC emissions grow with greater biogas flow rates and are lowest in diesel-only operations.Since methane is the sole component of biogas, it follows that the fuel's unburned portion will have a higher methane content.

2.6 Carbon monoxide (CO) emissions

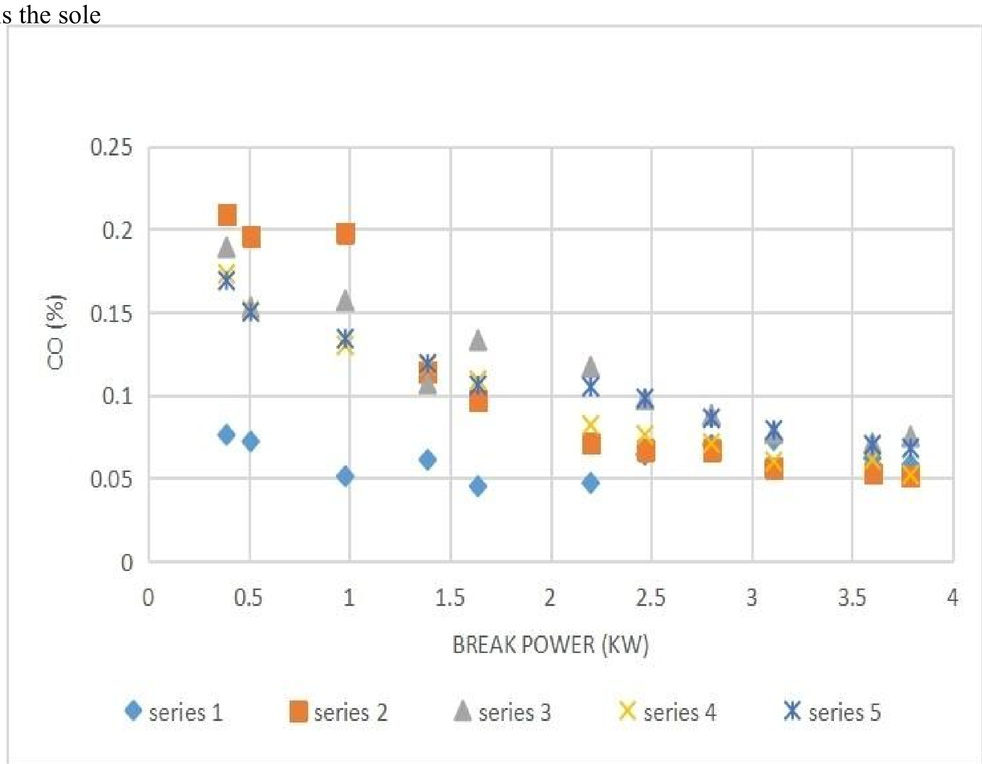

Figure 9 Variation of CO with Break power

Since the uniform mixture plainly forms beyond the combustion chamber in this experiment, the second justification inevitably stands cancelled. The graph demonstrates that diesel operation has the lowest CO emissions. CO emissions in the dual fuel mode are greater for a flow of biogas and fall as the biogas flow rate rises. For all biogas flow rates, it uniformly reduces the rise in braking power as well.

2.7 Carbon dioxide (CO_2) emissions

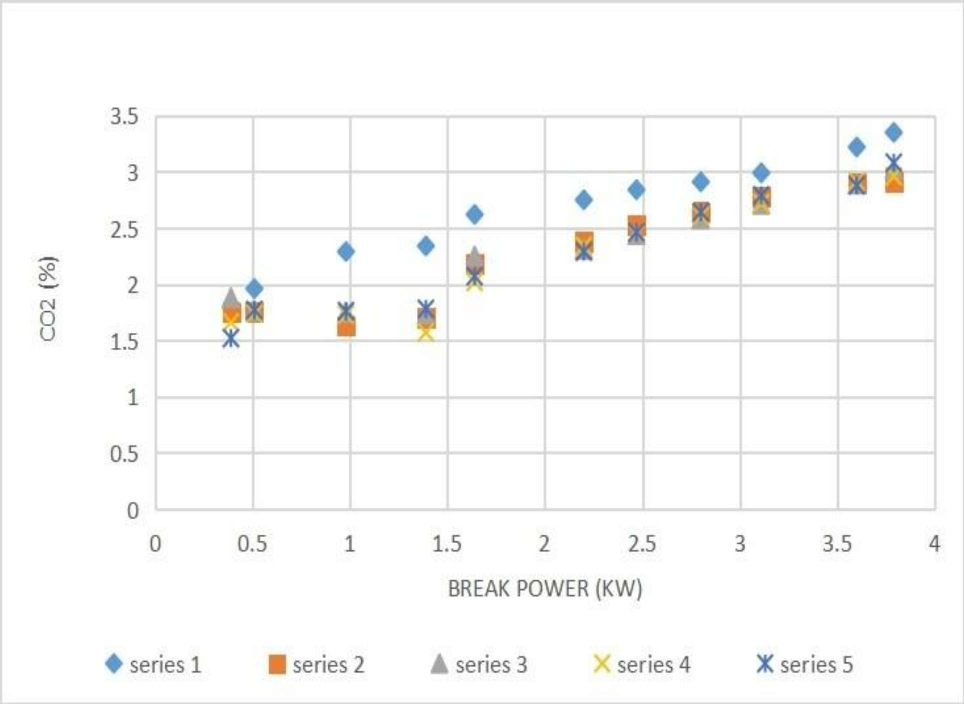

Figure 10 Variation of CO_2 with Break power

Figure 10 depicts how the engine's CO2 emissions changed as brake power increased. The engine was running in dual fuel and diesel modes. Figure illustrates the reduced level of CO2 emissions caused by the flow of biogas. However, the engine's performance in this mode was jarring, abrupt, and sporadic. The CO2 level is higher in the emissions for various flows of biogas. Due to the fact that both the biogas, and the exhaust both contain CO2.

3. Conclusion

The goal of this research was to examine how well a diesel engine with a single cylinder performed when used in two-fuel mode using both biogas and diesel. It was investigated by tracking various diesel engine parameters. The short pres findings of this investigation are reported in the following paragraphs. It was discovered that the engine produces roughly the same amount of power when run in the Dual fuels using biogas and both biogas and biodiesel modes as it does when run in the neat diesel mode. The brake power generated in two-fuel mode is equivalent to that generated by a clean operating on diesel when the load is close to full. The engine's mechanical effectiveness was also evaluated. It was observed that the mechanical efficiency of the dual fuel options for biogas and diesel was equivalent to that of the neat diesel mode. Both part load and full load operations follow this tendency. With rising loads, it was discovered that the engine's volumetric efficiency was declining. Due to the direct the induction manifold with injection and begins to partially replace the air being drawn, it further lowered in fuel mode. When using diesel dual fuel instead than neat diesel, the engine's thermal efficiency was greater. This is because biogas contains high-quality methane, which burns well. Before entering the combustion chamber, biogas creates a homogenous mixture. This aids in getting the charge to almost completely burn. This is a significant benefit of this system.

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