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Monitoring Exhaust Emissions of A Direct Injection Diesel Engine Fueled With Linseed Oil Biodiesel - Hydrogen Dual Fuel

K. Udaya Sri, B S N Murthy, N. Mohan Rao

***Abstract** This study presents an experimental and analytical investigation on the effects of using methyl ester of linseed oil (MELO)-diesel blend of B10, B20, and B30 with hydrogen injection of 5%, 10%, and 15% in a VCR (Variable Compression Ratio) diesel engine, operated with the compression ratios (CRs) of 15, 16, 17, and 18 on DFM (duel fuel mode). This study also gives emphasis on the optimized emissions of CO, CO_2, NO, and smoke, when the engine was operated with MELO-diesel blends, and hydrogen injections with the variation in engine load, crank angle (CA), using response surface methodology (RSM) with the help of MINITAB programming. During the analysis it was observed that the emissions of CO, CO_2, O_2, NO, and smoke were found to be a function of biodiesel blends, compression ratios, load, and percentage of hydrogen injection. The research results report that, the dual fuel mode of diesel MELO 20% blend with hydrogen injection of about 10% gave optimized results in terms of performance and exhaust emissions, while the optimized CR was 17. The engine was smoothly operated with B20-H10-CR17 over lower emissions compared to diesel, throughout the load spectrum.*

***Keywords:** Diesel Engine; Methyl ester of linseed oil (MELO); Response surface methodology (RSM); Hydrogen; Dual fuel.*

I. INTRODUCTION

Energy has become one of the basic needs in day to day life and plays an important role in automobile, locomotive, power plants, public sectors and various categories of industries. Advances in technology made the human life more comfortable, which created lots of energy demand, which is basically dependent on fossil fuels in the global market. But, fossil fuels are non-renewable sources of energy and there's an alert on petroleum diesel in coming decades because, the consumption has drastically gone up because of rapid industrialization. The consumption of mineral diesel can be reduced drastically by the use of biodiesel fuels [1].

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Biodiesel is a clean burning and renewable fuel alternative to mineral diesel made predominantly from various type vegetable oils. Biodiesel physical and chemical properties are closely similar to normal diesel; hence it can be mixed and used as a blend with diesel. Biodiesel has better ignition and combustion characteristics due to a high cetane index, which allows the engine to run more smoothly with less of the knocking compared to typical diesel engines. Biodiesel substantially reduces exhaust emissions such as unburned hydrocarbons (UHC), carbon monoxide (CO) and particulate matter (PM). It contains naturally occurring oxygen, which enables the fuel to burn more completely, but eliminates the black smoke normally associated with diesel engines. Biodiesel operated engines may offer a slight increase in NOx emissions, but this is dependent on the engine type and its operating environment. Apart from this, biodiesel is biodegradable and nontoxic, which makes it a safer and more environmentally friendly fuel to handle, particularly in sensitive areas. Biodiesel is naturally free of Sulphur and produces no Sulphur dioxide (SO_2), which is considered to be one of the main precursors to acid rain [2-4]. Biodiesel is made from renewable resources, which means it reduces the contribution of carbon dioxide, which is one of the main greenhouse gases to the atmospheres. Biodiesel as a 5% blend with mineral diesel, referred to as B5 is now permitted within the EN590 mineral diesel specification across Europe. In the UK, the recommend blend percentage is B20 which is universally accepted by the end users. Similarly, American truck and bus operators prefer a blend of B20 according to US biodiesel standard ASTM D6751. The B20 blend currently provides commercial vehicle operators in various countries in the world with the optimal cost versus benefit balance [5].

The use of hydrogen with biodiesel gives two fold benefits over the only diesel operation. Hydrogen with its significant combustion characteristic seems to be ascertained itself as the preeminent transportation fuel for the future [6, 7]. Hydrogen finds application as a fuel in CI engines in dual fuel mode (DFM), without any major engine modifications, and without drop in output power. However, operating the CI engine with hydrogen is a big challenge because; hydrogen has a high auto-ignition temperature of about 840 ^{0}C and low fire limit. Also, it has some critical issues concern to its safe handling due its high burning speed [6, 8]. This difficulty can be eliminated by the use of fuel having the high auto-ignition property [9]. For this purpose, biodiesel is a righteous option. Because, high cetane number of biodiesel can drastically reduce the ignition delay [10, 11].

At present, the use of hydrogen in CI engines on DFM is an emerging research theme for many researchers [12-19].

In the recent past, some of the researchers had investigated the critical issues associated with the use of hydrogen in diesel engines. The research results revealed that the use of hydrogen drastically reduces the emissions of CO, HC, CO_2, and smoked, but it contributed an increase in NO emission [6-8, 11, 13, 16-19]. Chintala and Subramanian [6] investigated the use of hydrogen in a diesel engine of rated power 7.4 kW run at 1500 rpm on dual fuel. Their investigation indicated that dual fuel operation gave an improved performance (i.e., BTE increased by about 14-20%) and the combustion characteristics of the engine were also excellent without any knocking phenomenon at a higher compression ratio of 19.5. Another investigation carried by Saravanan et al. [18] on the use of hydrogen in a 3.7 kW, single cylinder CI engine operated on dual fuel mode indicates that the BTE of the engine increased by about 20%, and the NO emission was higher by about 13% compared to diesel. A drastic reduction in the CO, CO_2 and smoke emission was observed, but the HC emission was marginally higher in comparison with diesel throughout the load spectrum. De-Morais et al. [20] investigated the use of hydrogen in a four-cylinder CI engine. They observed that a maximum of about 20% hydrogen energy share is possible to operate the engine smoothly. Beyond this limit, the ignition delay will be longer, and the heat loss to the surrounding through the exhaust will increase drastically. Masood et al. [21] computationally and experimentally investigated the combustion of hydrogen in a CI engine on dual fuel mode with diesel as the pilot injected fuel. Their investigation reveals that, the efficiency of the engine increased to 30% at a compression ratio of 24.5. Also, they reported that, the emission of CO, CO_2 and smoke decreased, but NO emission increased. This study presents an experimental and analytical investigation on the effects of using methyl ester of linseed oil (MELO) blend of B10, B20, and B30 with the hydrogen induction of 5%, 10%, and 15% in a VCR diesel engine with the compression ratio (CR) of 15, 16, 17, and 18 on DFM. This study also gives emphasis to the optimized emissions of CO, CO_2, NO, and smoke, when the engine was operated with B10, B20, B40 and hydrogen induction of 5%, 10%, and 15% with the variation in engine load, crank angle (CA), and the CR using Response Surface Methodology (RSM) concept by the use of MINITAB.

II. MATERIALS AND METHODS

A. Fuels used

The fuels used in the present investigation are diesel, linseed biodiesel, and hydrogen. The fuels were procured from the local supplier in Moinabad, Telangana, India. The physio-chemical properties of the fuels were examined to check its suitable application in a VCR engine. The detailed properties of diesel and MELO are given in Table 1. The properties of hydrogen are given in Table 2.

Table 1: Properties of diesel and MELO

Properties	Test method (ASTM)	Diesel	MELO	B10	B20	B40
Density, kg/m^3	D 4052	830	870	834	838	846
Cetane number	D 613	50	56	50.6	51.2	52.4
Calorific value, kJ/kg	D 4809	43800	40870	43507	43214	42628
Auto-ignition temperature °C	E 659	210-350	150-330	175-340	160-310	155-300
Fire point, °C	D 93	56	245	180	190	215
Flash point, °C	D 93	50	210	140	150	167

Table 2: Properties of hydrogen

Properties	Test method, ASTM	Hydrogen
Density, kg/m^3	D 3588	0.089
Octane number	D 2699	130
Calorific value, MJ/kg	D 1945	141.79
Auto-ignition temperature, °C	-	570
Fire point, °C	-	-240.2
Flash point, °C	-	-253

B Experimental setup

The engine used in the present investigation was of single cylinder, four stroke, constant speed, water cooled, and diesel engine with a cylinder bore of 87.5 mm, stroke length of 110 mm, connecting rod length 234 mm, compression ratio 17:1, swept volume 661.45 cm^3 and output power of 3.5 kW @ 1500 rpm. The engine run for different CRs like 15, 16, 17, and 18 with MELO blends of conventional diesel, B10, B20, and B40 along with H_2 addition for 5%, 10%, and 15% to test the exhaust emissions. Total five input parameters are chosen to run the engine and the emission results were captured. The layout of the experimental setup is shown in Figure 1. The engine was coupled with an eddy current dynamometer for loading, and the data were captured in a computer. First the engine was set at a CR of 15 and the engine was run with conventional diesel.

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The base readings are taken for CR 15. The readings are taken for different loading conditions ranging from no load to full load at constant speed of 1500 rpm. For emission measurement of the engine was carried out with the use of multi gas analyzer MN-05 and the smoke emission was measured with a diesel smoke meter MODEL SM-05. Then 5% hydrogen gas was passed into the intake manifold. Again the readings were taken for different percentages of hydrogen of 10% and 15% at constant speed of 1500 rpm for blend B10. The experimental results for B10-H_2 5%, B10-$H_2$10%, and B10-$H_2$15% were recorded for CR of 15. The experiments were repeated in similar was for CRs of 16, 17, and 18 with MELO blends of B20, and B40 along with H_2 addition for 5%, 10%, and 15%. The test matrix and the acronyms used for diesel, MELO and MELO-H_2 operation are given in Table 3.

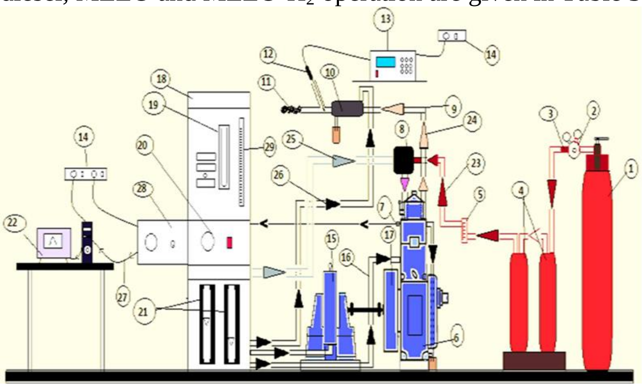

Fig 1: Layout of experimental setup.

1 Hydrogen cylinder, 2 Hydrogen regulator, 3 Flash back arrestor, 4 Flame arrestor, 5 Hydrogen flow meter, 6 Engine, 7 Clinker pressure sensor, 8 Mixing chamber, 9 Exhaust flow pipe, 10 Calorimeter, 11 Exhaust gas, 12 Exhaust gas analyzer probe, 13 Exhaust gas analyzer, 14 Power supply, 15 Eddy current dynamometer, 16 Engine water inlet pipe line, 17 Flywheel, 18 Fuel tank, 19 U-tube manometer, 20 Loading unit, 21 Rotameter, 22 Computer, 23 Hydrogen gas flow pipe, 24 Exhaust gas, 25 Air supply, 26 Calorimeter water inlet, 27 NI-6210 USB multifunction line, 28 Control panel, 29 Burette.

Table 3: Test matrix and the acronyms used

1	Mode	Fuel	CR	D-MELO blend, %	H_2, %	Acronyms used
2	Diesel	Diesel	15	B0	-	Diesel
3	Dual	Diesel-MELO-H_2	15	B10	5	B10-$H_2$5-CR15
4	Dual	Diesel-MELO-H_2	15	B10	10	B10-$H_2$10-CR15
5	Dual	Diesel-MELO-H_2	15	B10	15	B10-$H_2$15-CR15
6	Dual	Diesel-MELO-H_2	15	B20	5	B20-$H_2$5-CR15
7	Dual	Diesel-MELO-H_2	15	B20	10	B20-$H_2$10-CR15
8	Dual	Diesel-MELO-H_2	15	B20	15	B20-$H_2$15-CR15
9	Dual	Diesel-MELO-H	15	B40	5	B40-$H_2$5-CR15

10	Dual	Diesel-MELO-H_2	15	B40	10	B40-$H_2$10-CR15
11	Dual	Diesel-MELO-H_2	15	B40	15	B40-$H_2$15-CR15
12	Dual	Diesel-MELO-H	16	B10	5	B10-$H_2$5-CR16
13	Dual	Diesel-MELO-H_2	16	B10	10	B10-$H_2$10-CR16
14	Dual	Diesel-MELO-H_2	16	B10	15	B10-$H_2$15-CR16
15	Dual	Diesel-MELO-H_2	16	B20	5	B20-$H_2$5-CR16
16	Dual	Diesel-MELO-H_2	16	B20	10	B20-$H_2$10-CR16
17	Dual	Diesel-MELO-H_2	16	B20	15	B20-$H_2$15-CR16
18	Dual	Diesel-MELO-H_2	16	B40	5	B40-$H_2$5-CR16
19	Dual	Diesel-MELO-H_2	16	B40	10	B40-$H_2$10-CR16
20	Dual	Diesel-MELO-H_2	16	B40	15	B40-$H_2$15-CR16
21	Dual	Diesel-MELO-H_2	17	B10	5	B40-$H_2$5-CR16
22	Dual	Diesel-MELO-H_2	17	B10	10	B10-$H_2$10-CR17
23	Dual	Diesel-MELO-H_2	17	B10	15	B10-$H_2$15-CR17
24	Dual	Diesel-MELO-H_2	17	B20	5	B20-$H_2$5-CR17
25	Dual	Diesel-MELO-H_2	17	B20	10	B20-$H_2$10-CR17
26	Dual	Diesel-MELO-H_2	17	B20	15	B20-$H_2$15-CR17
27	Dual	Diesel-MELO-H_2	17	B40	5	B40-$H_2$5-CR17
28	Dual	Diesel-MELO-H_2	17	B40	10	B40-$H_2$10-CR17

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29	Dual	Diesel-MELO-H_2	17	B40	15	B40-$H_2$15-CR17
30	Dual	Diesel-MELO-H_2	18	B10	5	B10-$H_2$5-CR18
31	Dual	Diesel-MELO-H_2	18	B10	10	B10-$H_2$10-CR18
32	Dual	Diesel-MELO-H	18	B10	15	B10-$H_2$15-CR18
33	Dual	Diesel-MELO-H_2	18	B20	5	B20-$H_2$5-CR18
34	Dual	Diesel-MELO-H_2	18	B20	10	B20-$H_2$10-CR18
35	Dual	Diesel-MELO-H_2	18	B20	15	B20-$H_2$15-CR18
36	Dual	Diesel-MELO-H_2	18	B40	5	B40-$H_2$5-CR18
37	Dual	Diesel-MELO-H_2	18	B40	10	B40-$H_2$10-CR18
38	Dual	Diesel-MELO-H_2	18	B40	15	B40-$H_2$15-CR18

III. RESULTS AND DISCUSSION

3.1 Response surface regression (RSR) for CO emission

CO emission in engine formed because of incomplete combustion of fuel. If a rich A/F mixture used in the engine, there is no sufficient air for complete combustion to take place resulting in emissions 0.000001D*D + 0.000122 H2*H2- 0.01691 CR*CR- 0.000002 CA*D- 0.000803 CA*H2 + of CO. High CO emissions occur due to leaking fuel injector and clogged air filters. Defective or worn piston rings, and low engine temperature. Fuel timing also takes a crucial role for the high CO emissions.

CO = -7.09 + 0.0079 CA + 0.001372 D + 0.0009 H2+ 0.2648 CR+ 0.03049 IOP+ 0.1194 L 0.000001D*D + 0.000122 H2*H2- 0.01691 CR*CR- 0.000002 CA*D- 0.000803 CA*H2 + 0.00028 CA*CR+ 0.000713 CA*L+ 0.000005 D*H2+ 0.000017 D*CR- 0.000014 D*L + 0.001373 H2*CR- 0.001165 H2*L- 0.00633 CR*L

Effect of compression ratios: Experimental test has been conducted by considering various CR's like 15, 16, 17, and 18 for neat diesel oil and blends B10, B20, and B40. The CO emission in the exhaust for diesel, B10, B20, and B40 are 0.6 g/kWh, 0.58 g/kWh, 0.3 g/kWh, and 0.46 g/kWh, respectively at CR of 15. For B20 at CR 17 the CO emissions are less when compared to diesel, B10, and B40.

Effect of load: Test procedure is carried on VCR Engine by varying loads from no load to full operating load as minimum and maximum loads at constant speed of 1500 rpm. The CO emissions are measured for diesel, B10, B20, and B40 throughout the load spectrum. Experimental results of CO emissions are 0.57 g/kWh for diesel, 0.47 g/kWh for B10, 0.34 g/kWh for B20, and 0.39 g/kWh for B40. CO emissions for the blend B20 shows better results when compared to diesel, B10, and B40. The RSR for CO emission is illustrated in Figure 3.

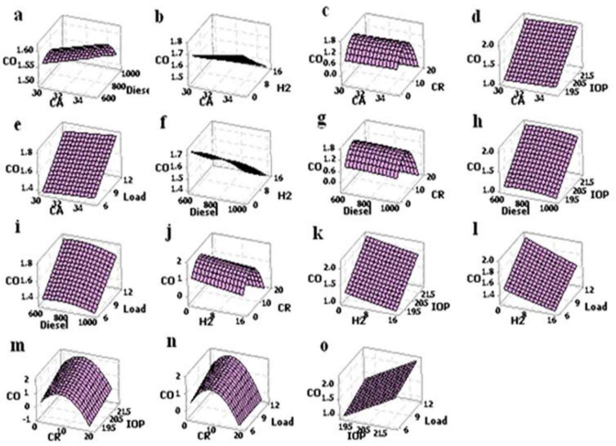

Fig 2: RSR for CO emission.

3.2 Response surface regression (RSR) for CO_2 emission

Causes of CO_2: when VCR engine setup is run with Diesel or any other biodiesel blends for total combustion process in the combustion chamber to attain maximum efficiency. Due to rich or lean fuel mixture's, fuel injection timings, effect of exhaust gas combined with fuel mixture, partial combustion takes place burning fuel partially resulting in harmful exhaust emissions. Daily 82,000 tons of CO_2 is being emitted into the atmosphere in 2 minutes. There exist the inconsistent conclusions; some researches indicated that the CO_2 emission reduces for biodiesel as a result of the low carbon to hydrocarbon ratio, and some researchers showed that the CO_2 emission increases or keeps similar because of more effective combustion. But in any event, the CO_2 emission of biodiesel reduces greatly from the view of the life cycle circulation of CO_2.

Effect of CR: CO_2 emissions are recorded for VCR engine run with 15, 16, 17, and 18 CR's for diesel, B10, B20, and B40 as 168 ppm, 156 ppm, 154 ppm, and 157 ppm. At CR 17 for B20, the CO_2 emissions are far less when compared to other blends and diesel.

CO_2 = -20.33 + 0.070 CA + 0.00513 D - 0.0230 H 2+ 0.967 CR + 0.746 L- 0.000005 D*D+ 0.000824 H2*H2-0.0464 CR*CR+ 0.000071 CA*D- 0.00298 CA*H2- 0.00713 CA*CR+ 0.00395 CA*L + 0.000009 D*H2+ 0.000039 D*CR- 0.000040 D*L -0.00027 H2*CR + 0.00029 H2*L- 0.01789 CR*L.

At full load and full speed for CR 17, B20 gives CO_2 exhaust emissions are 9.62%, whereas for diesel it is 10.11%, for B10 10.07%, and for B40 11.16%.

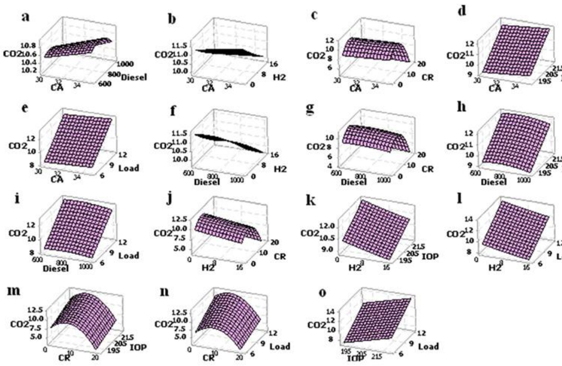

Fig 3: RSR for CO_2 emission.

3.3 Response surface regression (RSR) for O_2 emission

Causes of O_2: The very basic cause of O_2 in exhaust emission is O_2 Sensor. The O_2 sensor is heart of modern fuel injection system. O_2 sensor produces its own voltage based on the difference between the amounts of oxygen inside the exhaust stream as compared to the amount of oxygen outside the exhaust stream. If a lot of oxygen means it's a lean mixture where lot of fuel is not burnt. During the combustion inside the engine O_2 is left over or not left over depends on the amount of fuel burnt. Similarly vies versa, if lot of O_2 is seen in exhaust emissions it shows that it's a lean mixture with voltage less than 0.5 volts. The voltage produced by sensor falls between 0.0 to 1.0 volt.

Effect of CR: Experimental tests are conducted for varying CR's for studying O_2 emissions in the exhaust. O_2 emissions depend on the combustion rate in the combustion chamber. B20 has a high percentage of O_2 emissions of 13.75, whereas for diesel it is 12.87, for B10 13, and for B40 it is 10. The RSR for O_2 emission is illustrated in Figure 6. The RSR model for O_2 emission is given below:

O_2 = 36.2 - 0.596 CA - 0.00239 D - 0.041 H2 -1.44 CR + 0.027 IOP - 1.168 L+0.000003 D*D-0.00212 H2*H2 - 0.0024 CR*CR - 0.000244 CA*D+ 0.00565 CA*H2+ 0.0430 CA*CR+ 0.00586 CA*L+ 0.000085 D*H2+ 0.000154 D*CR+ 0.000216 D*L- 0.00401 H2*CR - 0.00597 H2*L+ 0.0037 CR*L.

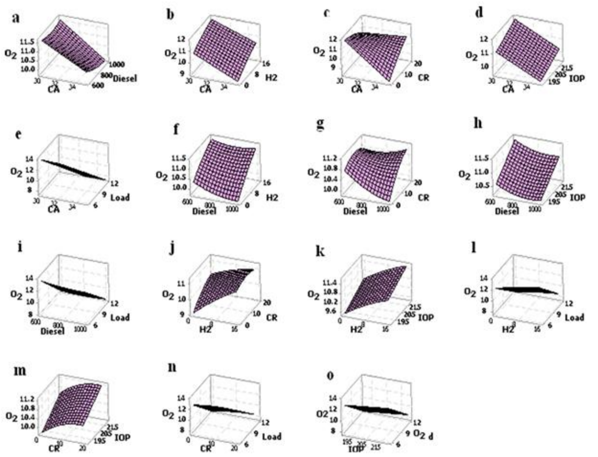

Fig 4: RSR for O_2 emission

3.4 Response surface regression (RSR) for NO emission

Cause of NO: Emissions of NO are due to combustion takes place at high temperatures. This situation occurs when cooling system does not work effectively, because of the lean A/F mixture availability of fuel is less when compared to presence of high ratio of air in the charge. Partial combustion takes place, resulting in incomplete fuel burnt tending to release high NO components in exhaust emissions. The EGR valve is specifically designed to control high temperatures. If the catalytic converter is in bad condition also results in very high levels of NO. EGR fails if speed of engine is greater than 2500 rpm and EGR pass if speed is less than 2500 rpm. Over advanced fuel timing causes more NO emissions in the exhaust.

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Effect of CR: As experimental test is conducted for various CR's 15, 16, 17 and 18, the NO emissions are recorded. For CR 17, NO emissions are 10.35% for B20, 10.71% for Diesel, 10.75% for B10, and 31% for B40. NO emissions are maximum for B40.

Effect of Load: If the speed of Engine increases NO emissions also increases. At full load the NO emissions obtained for diesel is 135.93 ppm, for B10 131.25 ppm, for B20 127.69 ppm, and for B40 147 ppm. While comparing the NO emissions of other blends B20 has minimum emissions and B40 gives maximum emissions. The RSR for NO emission is illustrated in Figure 7. The RSR model for NO emission is given below:

NO =21996- 347.8 CA+ 2.08 D- 82.9 H2- 1220 CR-65.3 IOP- 78.5 L+ 0.002142 D*D+ 0.784 H2*H2+37.9 CR*CR- 0.0937 CA*D+ 0.934 CA*H2+ 26.37 CA*CR+ 4.13 CA*L+ 0.0100 D*H2-0.1311 D*CR- 0.0667 D*L- 0.42 H2*CR+5.058 H2*L + 1.82 CR*L.

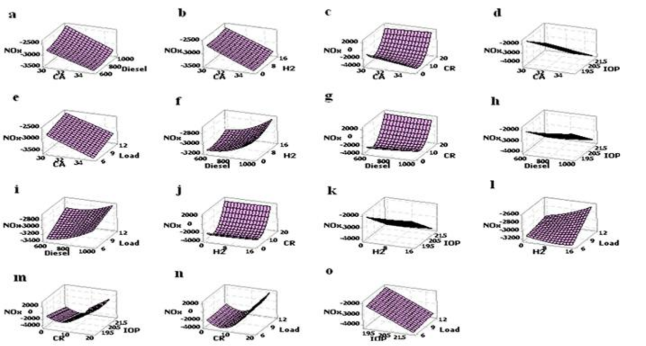

Fig 5: RSR for NO emission.

3.5 Response surface regression (RSR) for smoke emission

Smoke emission: When any engine is run with neat oil or any other blends, emissions are released into atmosphere like, exhaust emissions, and evaporate emissions and crankcase emissions. Smoke is a part of exhaust emission. Engine condition is diagnosed from the color of smoke, i.e. Brown, dark black, white and gray. When smoke is in the brown color vehicle is said to be in good health condition. Dark black color smoke is due to more fuel in the combustion chamber where there is less air flow. Partial fuel undergoes combustion and the other remains as unburned fuel, mileage of vehicle is less. When fuel is mixed with water i.e. fuel stored in any container is used for combustion moisture gets mixed up with moisture in atmosphere and results in white smoke. Injector and fuel tank are faulty also causes white smoke. Grey color smoke is the combination of white and blue smoke where oil and water are burnt along with fuel to assist combustion. For finding the smoke density at various testing models of Engine Model SM-05 smoke meter is used.

Effect of CR: Testing models of VCR engine are done for various compression ratios like 15, 16, 17, and 18 to find smoke density. The optimal values are noticed for CR-17 when compared to other CR's. Diesel operation gives smoke of 13.5%, for B10 smoke is 13.1%, for B20 smoke is 10.5%, and for B40 smoke is 14.2%. When engine is run for no load and full load, the smoke emission observed for no load and full load at CR 17 with blend B20. The RSR for smoke emission is illustrated in Figure 8. The RSR model for smoke emission is given below:

Smoke = -239+ 5.17 CA-0.1105 D- 0.72 H2+ 15.45 CR+0.772 IOP+3.58 L0.000030 D*D+0.0594 H2*H2-0.414 CR*CR+ 0.00362 CA*D+0.0182 CA*H2- 0.431 CA*CR- 0.1881 CA*L-0.000329 D*H2+0.00162 D*CR+0.00048 D*L-0463 H2*CR0.0311 H2*L+ 0.260 CR*L.

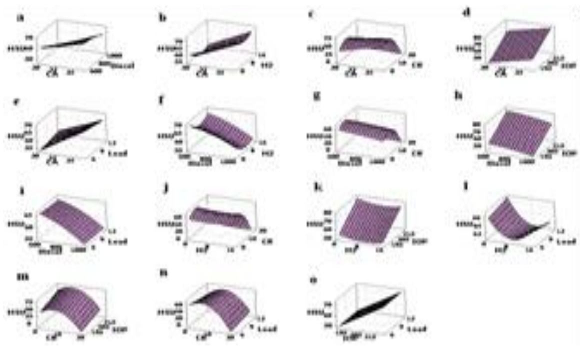

Fig 6: RSR for smoke emission

Optimization results

The following optimization plots indicate the response surface regression of various parameters. Figure 9 shows the optimized results of the emission.

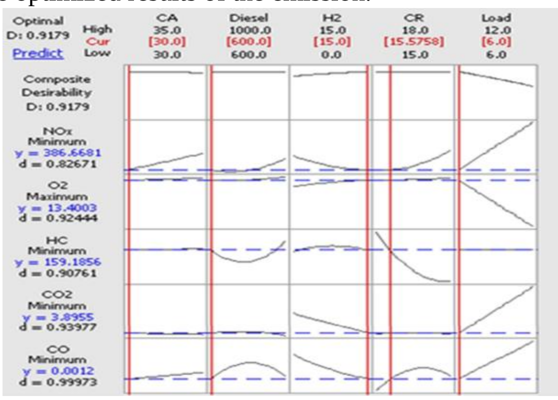

Fig 7: Optimization plots of emissions.

IV. CONCLUSIONS

- Based on the results of this study, it can be concluded that the CO, CO_2, O_2, HC, NO, and smoke emissions of VCR research engine setup in general, were found to be a function of biodiesel blend, compression ratio, load, and hydrogen induction percentage.
- For the same operating conditions, exhaust emission of the engine reduced with increase in the blend. With an increase in compression ratio, load, and hydrogen injection the difference was reduced and the engines exhaust emission and smoke densities at par with neat diesel.

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- More precisely, biodiesel blended could be safely blended with neat diesel in 20% at compression ratio 17, full load with constant speed and hydrogen injection of 10% tested for getting low exhaust emissions and smoke when compared to diesel.

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REFERENCES

1. Gyorgy Szabados, Akos Bereczky. Experimental investigation of physicochemical properties of diesel, biodiesel and TBK-biodiesel fuels and combustion and emission analysis in CI internal combustion engine. Renewable Energy 2018;121:568-578.
2. Chandra Sekhar Latchubugata, Raghu Vamsi Kondapaneni, Kiran Kumar Patluri, Usha Virendra, Sreepriya Vedantam. Kinetics and optimization studies using Response Surface Methodology in biodiesel production using heterogeneous catalyst. Chemical Engineering Research and Design 2018;135:129-139.
3. Indu Ambat, Varsha Srivastava, Mika Sillanpää. Recent advancement in biodiesel production methodologies using various feedstock: A review. Renewable and Sustainable Energy Reviews 2018;90:356-369.
4. Gerhard Knothe, Kevin R. Steidley. The effect of metals and metal oxides on biodiesel oxidative stability from promotion to inhibition. Fuel Processing Technology 2018; 177:75- 80.
5. S.N. Gebremariam, J.M. Marchetti. Economics of biodiesel production: Review. Energy Conversion and Management 2018; 168:74-84.
6. V. Chintala, K. A. Subramaniam. Experimental Investigation of Autoignition of Hydrogen Air Charge in a Compression ignition Engine under Dual-Fuel mode. Energy 2017; 138:197-209.
7. N. Saravanan, G.Nagarajan. Experimental investigation on a DI dual fuel engine with hydrogen injection. International Journal for Energy Research. 2008; 33:295-308.
8. S. Mohammad Hosseini, Rouhollah Ahmadi. Performance and emissions characteristics in the combustion of co-fuel diesel-hydrogen in a heavy duty engine. Applied Energy 2017; 205:911-925.
9. Mohammad O. Handan, Mohamed Y.E. Selim. Performance of CI engine operating with hydrogen supplement co-combustion with jojoba methyl ester. International Journal of Hydrogen Energy 2016;129;572-578.
10. Debabrata Barik, S. Murugan, Susmita Samal, N.M. Sivaram. Combined effect of Compression ratio and diethyl ether (DEE) port injection on performance and emission characteristics of a DI diesel engine fuelled with upgraded biogas (UBG)-biodiesel dual fuel. Fuel 2017;209;339-349.
11. I.T. Yilmaz, M. Gumus. Effects of hydrogen addition to the intake air on performance and emissions of common rail diesel engine. Energy 2018; 142:1104-1113.
12. I.T. Yilmaz, A. Demir, M. Gumus. Effects of hydrogen enrichment on combustion characteristics of a CI engine. International Journal of Hydrogen Energy 2017; 42, 10536- 10546.
13. Pavlos Dimitriou, Taku Tsujimura, A review of hydrogen as a compression ignition engine el. International Journal of Hydrogen Energy 2017; 42:24470-24486.
14. [14] Md. Atiqur Rahman, A.M. Ruhul, M.A. Aziz, Raju Ahmed. Experimental exploration of hydrogen enrichment in a dual fuel CI engine with exhaust gas recirculation. International Journal of Hydrogen Energy 2017; 42, 5400-5409.
15. Osama H. Ghazal. Performance and combustion characteristic of CI engine fuelled with hydrogen enriched diesel. International Journal of Hydrogen Energy 2013; 38:15469- 15476.
16. Venkateswarlu Chintala, K.A. Subramanian. A comprehensive review on utilization of hydrogen in a compression ignition engine under dual fuel mode. Renewable and Sustainable Energy Review 2017;70:472-491.
17. M. Masood, M.M. Ishrat. Computer simulation of hydrogen-diesel dual fuel exhausts gas emissions with experimental verification. Fuel 2008;87:1372-1378.
18. N. Saravanan, G. Nagarajan, G. Sanjay, C. Dhanasekaran, K.M. Kalaiselvan. Combustion analysis on a DI diesel engine with hydrogen in dual fuel mode. Fuel. 2008; 87:3591-3599.
19. J.H. Zhou, C.S. Cheung, W. Z. Zhao, C.W. Leung. Diesel-hydrogen dual-fuel combustion and its impact on unregulated gaseous emissions and particulate emissions under different engine loads and engine speeds. Energy 2016; 94:110-123.
20. André Marcelino de Morais, Marco Aurélio Mendes Justino, Osmano Souza Valente, Sérgio de Morais Hanriot, José Ricardo Sodré. Hydrogen impacts on performance and CO_2 emissions from a diesel power generator. International Journal of Hydrogen Energy 2013;38:6857-6864.
21. M. Masood, M.M. Ishrat, A.S. Reddy. Computational combustion and emission analysis of hydrogen–diesel blends with experimental verification. International Journal of Hydrogen Energy 2007; 32:2539-2547.

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