OPTIMIZATION OF PERFORMANCE AND EMISSION PARAMETERS OF DIRECT INJECTION DIESEL ENGINE FUELLED WITH PROSOPIS JULIFLORA SEED OIL - RESPONSE SURFACE METHODOLOGY APPROACH.

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ABSTRACT: Now a days the emission from the diesel engine is the main factor for pollution and increasing the global temperature.It's results acid rain due to high pollution and high temperature. But without these diesel the World can't run. Instead of using diesel, run the diesel engine with biodiesel. By using these biodiesel can decrease the usage of diesel and pollution, also using these biodiesel achieve the complete combustion of the fuel and reduce emissions like HC, CO2, CO, and NOX. In this project using CRDI engine fuelled with Prosopis Juliflora Seed oil as biodiesel and to find out the performance, emissions and combustion characteristics of the diesel engine. This CRDI engine ran at a speed of 1500rpm, injection timing at 16 degree and kept the compression ratio at 16, 17,17.5,18 with the blend of 20%. For B20 the emissions were decreased and the performance increased.

ABBREVIATIONS: CRDI – common rail direct injection,CO- carbon monoxide, HC- hydrocarbon, CO2- carbon dioxide, NOX- nitrogen oxides

INTRODUCTION

Diesel engine is the most widely used application for transporting & agriculture purposes. Because diesel engines have high efficiency , it also carries a high load purpose and it has high reliability. But depletion of fossil fuels such diesel, petrol we have to move for alternative fuels like biodiesel. Our government also planned to use biodiesel as an option for diesel in 2025. Lot of biodiesel was discovered in the past years like prosopis juliflora , sesame oil, pongamia oil, neem oil, waste cooking oil, microalgae etc. If we use the biodiesel it has pollutant free and non toxic because biodiesel has high oxygen content so in that combustion process the biodiesel is fully burned and gives only small amount of emissions. Senthil Kumar.K and Thundil kruppa Raj[1]conducted performance test on a Diesel engine using ethanol blended biodiesel, Experimental results showed that decreases in emissions like HC and CO. Sathish Kumar.R, et al [2] used ManilkaraZapotamethyl ester blend on Variable Compression Ratio (VCR) engine and obtained the results.That results shows increase the brake thermal efficiency(BTE) and decrease the brake specific fuel consumption(BSFC).Water emulsified hybrid Pongamia biodiesel was used by Varatharaju Perumal and Ilangkumaran.M[3] on single cylinder naturally aspirated diesel engine. The results show9% increase in BSFC, 5% decrease in BTE along with decreased emissions like smoke, CO and NOx. The experimental work carried by Prakash.T et al [4] using blends of bio-ethanol (30%), diesel (30%) and castor oil (40%) show that the BTE was comparable to diesel with increased smoke emission. Based on the literature review concluded that both edible and inedible fuel used in the diesel engine because of the oxygen and cetane number. The purpose of the research is to be find out the performance and emission parameters of direct injection diesel engine(CRDI) fuelled with Prosopis Juliflora.

MATERIAL AND METHODS

Preparation of Prosopis Juliflora Biodiesel

Initially the prosopis juliflora seed was bought from the market in the neighbourhood. On a bulk basis, raw Juliflora seed oil, 15% methanol, and 5% potassium hydroxide are required to make methyl esters through transesterification. Then the juliflora reacted with alcohol and got the biodiesel with the help of a catalyst. In the process glycerol was also produced, this glycerol used for several purposes.

Table 1. Properties of the fuel

EXPERIMENTAL SETUP

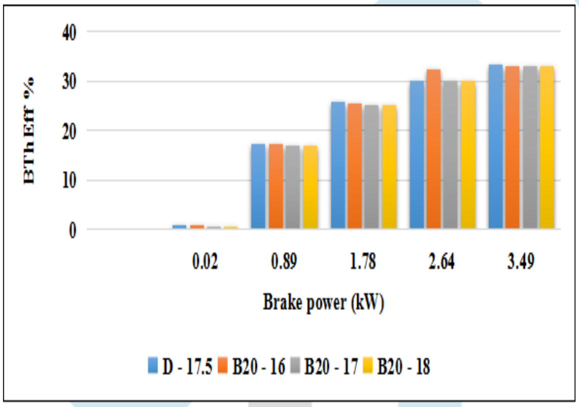
The necessary amount of Prosopis juliflora seed can be collected from prosopis juliflora plant throughout its seasonal time, and seeds were processed by cleaning and then drying in sunlight to remove the wetness of the seed.A transesterification process was used to make Prosopis juliflora biodiesel from Prosopis juliflora oil. This prosopis juliflora oil is blended with diesel by 20% and referred to as B20. To determine the stable blend, multiple quantities of diesel and bio-oil were tried.A single cylinder 4 stroke engine and alternator make up the engine setup. The engine was set at 1500 rpm, and a timer was used to time the amount of time it took to use 10 cc of fuel. The load cell regulates the load in order to simulate the alternator in terms of load application. The air is sucked into the intake plenum and then discharged via an airflow sensor that monitors the quantity of air.The fuel sensor aids in the measurement of fuel levels. The fuel measurement reading is fed into the data gathering system as an intake. The AVL444 gas detector and smoky metre are used to measure the combustion gases emitted from the tailpipe.

properties	Diesel	PJO	B20
Density(kg/m3)	830	873	821.32
Calorific value	45.5	40.36	44.813
Viscosity (mm2/sec)	3.62	4.83	2.616
Flash point (℃)	51	240	235
Cetane Number	45	49	51

RESULTS AND DISCUSSIONS

The results gained from conducting the experiment on the CRDI VCR engine, which is powered with PJO in a 20:80 biodiesel/diesel ratio, are presented in this paper. However, during the investigation, the biodiesel and diesel were combined in the ratio of 1 litre PJO to 4 litres diesel, which was 20:80 as previously stated. The combustion and emission characteristics are obtained, with the combustion characteristics consisting of findings such as crank angle versus cylinder pressure, net heat release of the engine calculated in temperatures, cumulative heat release of the engine cylinder, and the rate of pressure rise in the engine cylinder being reviewed. Then there are the emission results, such as CO emissions.

Performance characteristics



With brake power on the X-axis and brake thermal efficiency on the Y-axis, the engine's brake thermal efficiency is plotted. The BTE in CR 16 is better than the other compression ratios at 50 percent engine load. Throughout many cases, the BTE should be higher in order to achieve higher engine efficiency, as the BTE number determines the engine performance. As a result, for engine efficiency, the brake thermal efficiency should be increased.

When engine loads of 50 percent, 75 percent, and 100 percent are compared to BTE values, the CR 16 has the higher BTE with a little increase with diesel fuel at 100 percent load.meters.

Combustion characteristics

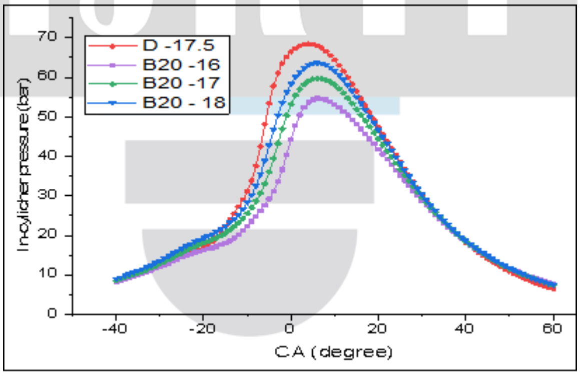


Fig 1

Figure 1 demonstrates that the in-cylinder pressure is higher for pure diesel with a compression ratio of 17.5:1 and a pressure of 69 bars, followed by 63 bars for 20:80 biodiesel blends with an 18 CR and a pressure of 63 bars. With 20% biodiesel blends, the peak pressure of the 17 CR is 58 bar, followed by a peak pressure of 55 for the 16 CR. Because the plots are using the same mix percentage of biodiesel, the difference will be the same.

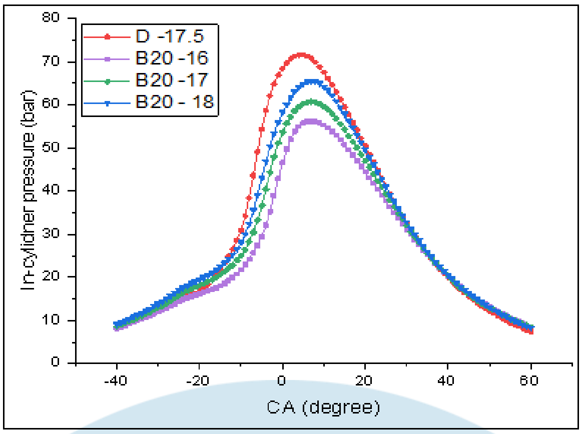
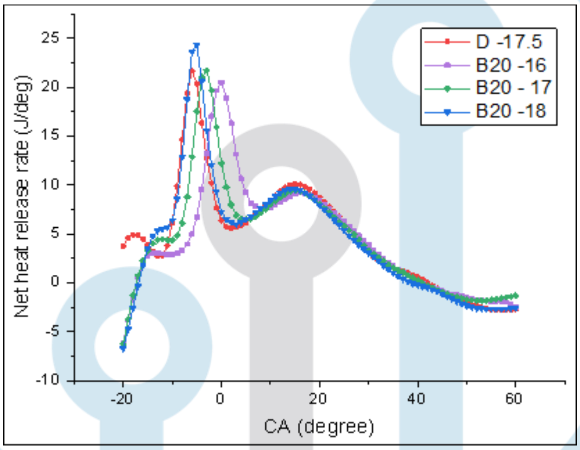


Fig 2

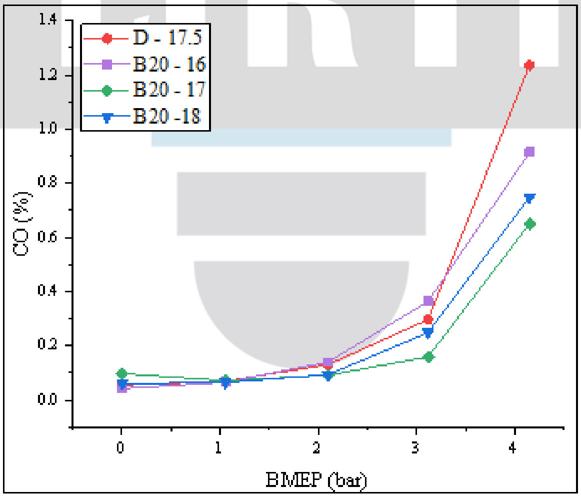
The result obtained at 75 percent engine load is presented in Fig.2. The graph illustrates a result that is nearly identical to that of Fig.1. However, due to the extra load on the engine, the peak pressure is marginally increased by 2% for the diesel and 6% for the 18 CR, followed by 4% and 1% increases for the 17 and 16 Compression Ratios, respectively, which are minor.

NET HEAT RELEASE:



In this net heat release except at 0% engine loads, the CR16 has an overall higher net heat release than the other compression ratios of biodiesel. The Net Heat Release is determined by the quick combustion of the blended fuel, which produces a large amount of heat

Emission Result CO emission:



The emissions of B20 at compression ratios of 16, 17, and 18 are lower than the emissions of normal diesel fuel. For all biofuels outcomes, the percentage change in CO emission between diesel and biodiesel is greater than 20%. This demonstrates that all biodiesel emit less CO2 than diesel fuel.

HC EMISSION

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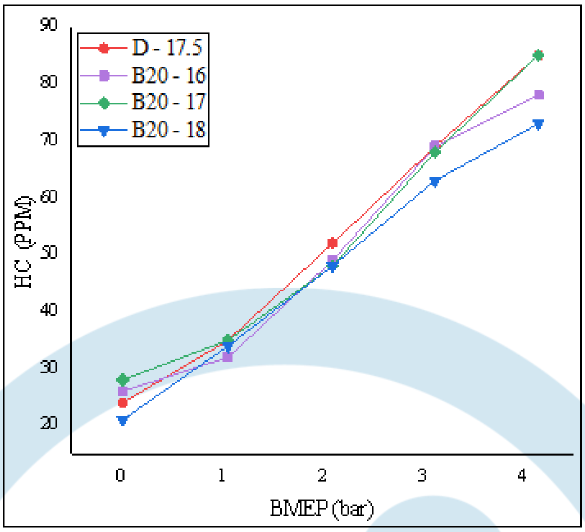
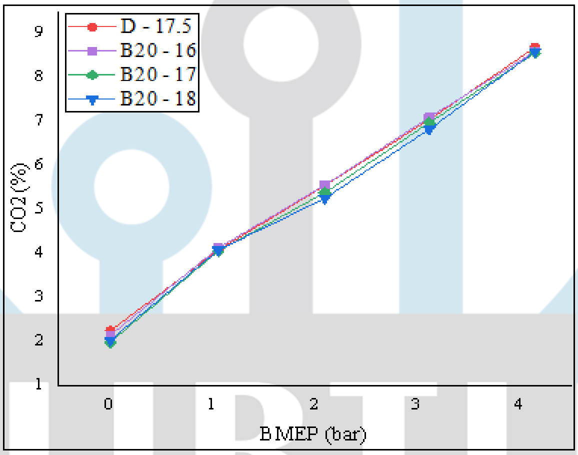


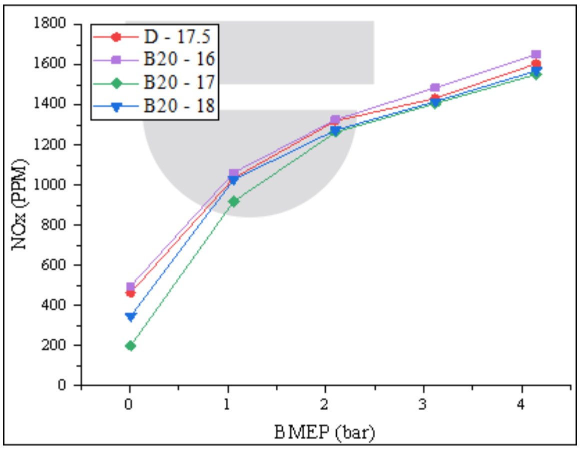
The biodiesel's larger oxygen level, poorer viscosity, and higher ignition delay result in greater premixed phase of combustion, resulting in higher hydrocarbon emissions with a compression ratio of 17 and nearly the same value as diesel fuel. The biodiesel mix with a compression ratio of 18 emits the least amount of HC compared to the other two biodiesel blends.

CO2 EMISSION



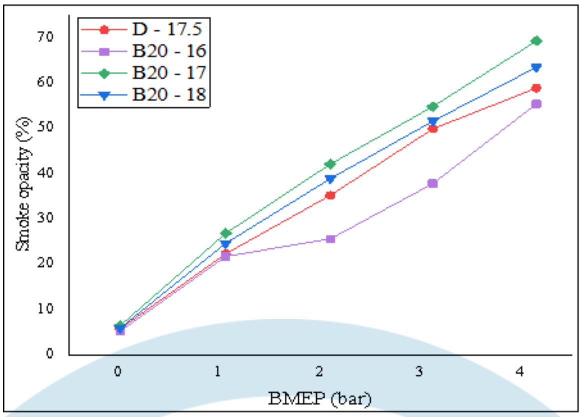
Because of its longer carbon chain, biodiesel emits more CO2 than diesel fuel. CO2 emissions grow as the quantity of carbon atoms in the fuel increases. Combustion is aided by the presence of oxygen in the fuel. CO2 emissions rise in tandem with improved combustion.

NOx EMISSION



When compared to the other compression ratios and diesel, the NOx emission for the 16 compression ratio with B20 biodiesel is higher. The 17 CR achieves the lowest value. When all of these factors are considered, the NOx emissions for each blend of biodiesel and diesel combinations are nearly identical. The NOx Emission varies with different loads and compression ratios, as seen in Fig.

SMOKE OPACITY

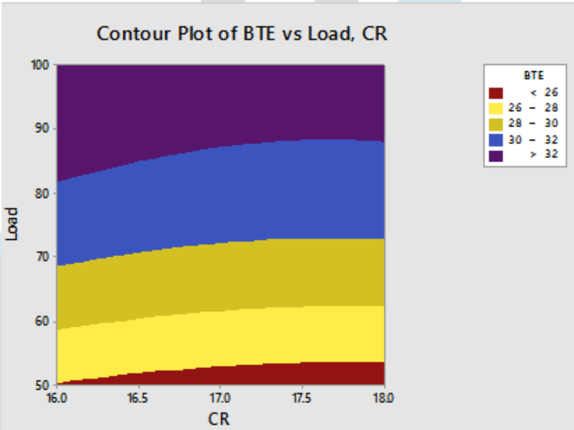


As a result, black smoke is produced. The smoke emission of the biodiesel mixture at CR is higher than that of any other blended fuels. Because of the oxygen in the blend, the CR 16 has a lower gas output with a higher difference.

RESPONSE SURFACE METHODOLOGY

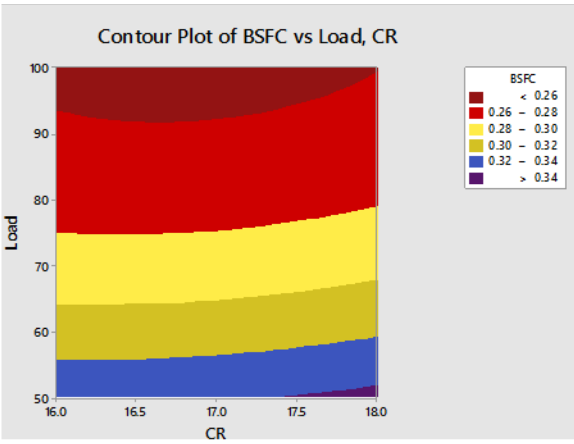
The response surface methodology (RSM) is a commonly used mathematical and statistical method for modelling and analysing a process in which the response of interest is influenced by a number of variables, with the goal of optimising the response.The fundamental goal of optimization is to get the best output outcomes by maximising or decreasing certain elements within certain constraints. Many applications are used for this purpose, and they can be optimised by combining inputs and outputs into a single solution. RSM is a mathematical statistics-based optimization tool that can model both the input and output parameters that are affected by input data at the same time.

Effect of Optimization on BTE



The BTE value is set as the level of the graph, and at 50% load with the 16 CR, the BTE value is lower than the 26 BTE value, and increasing the engine load with the same compression ratio results in a larger BTE value.

Effect of optimization on BSFC



The graph shows that the compression ratio

17 of the biodiesel blend has the highest BSFC value, while the diesel with the 17.5 ratio has the lowest BSFC value. The brake specific fuel consumption at 50% load on the 16 CR is 0.34, which is lower when compared to the other compression ratios of the biodiesel blend, and the CR 17 shares the same BSFC figure with this compression ratio.

COMPARISON OF EXPERIMENTAL AND PREDICTED VALUES
Experimental values

RESPONSE								
Process parameter		Experiment						
CR	Load	BTE	BSFC	CO	HC	CO_2	NO_X	Smoke
16	50	25.45	0.34	0.091	48	5.39	1264	42.1
16	75	32.14	0.27	0.159	68	6.98	1408	54.8
16	100	33.01	0.26	0.65	85	8.56	1553	69.3
17	50	25.18	0.34	0.093	48	5.26	1275	38.9
17	75	29.97	0.29	0.249	63	6.83	1418	51.6
17	100	32.98	0.26	0.748	73	8.59	1571	63.5
17.5	50	25.68	0.33	0.131	52	5.55	1321	35.2
17.5	75	30.07	0.28	0.297	69	7.05	1434	49.9
17.5	100	33.22	0.25	1.235	85	8.69	1606	58.9
18	50	25.09	0.35	0.14	49	5.56	1327	25.6
18	75	30.04	0.29	0.364	69	7.1	1486	37.8
18	100	32.93	0.26	0.913	78	8.59	1652	55.4

RSM (predicted) Values

RESPONSE								
Process parameter		Predicted						
CR	Load	BTE	BSFC	CO	HC	CO_2	NO_X	Smoke
16	50	25.9282	0.3353	0.07853	48.3909	5.35427	1269.25	42.4832
16	75	31.0798	0.28005	0.13441	68.1909	6.9438	1401.51	55.2271
16	100	33.5065	0.2573	0.65604	82.9909	8.60084	1553.02	68.146
17	50	25.2568	0.33781	0.12748	47.6545	5.37862	1278.44	38.9241
17	75	30.4559	0.28056	0.27014	65.8545	6.93302	1417.35	51.9623
17	100	32.93	0.25581	0.87854	79.0545	8.55491	1575.52	65.1755
17.5	50	25.1143	0.34111	0.1303	49.1273	5.45444	1301.76	33.8399
17.5	75	30.3371	0.28286	0.31634	66.5273	6.99126	1444	47.0253
17.5	100	32.8349	0.25711	0.96813	78.9273	8.59558	1605.5	60.3857
18	50	25.1006	0.34578	0.11869	51.8273	5.57267	1337.56	26.5528
18	75	30.3471	0.28653	0.34811	68.4273	7.09192	1483.13	39.8853
18	100	32.8686	0.25978	1.04329	80.0273	8.67867	1647.96	53.3928

CONCLUSION

The performance, combustion, and emission characteristics of operating the Four stroke single cylinder CRDI VCR engine with a 20% blend of PJO and the remaining 80% diesel are blended together and tested by varying the compression ratio of the engine with different engine loads using an eddy current dynamometer. The main plot of this study compares the performance, emission, and combustion value of the engine that is fueled with 20% PJO and the remaining 80% diesel and operated in real time to obtain the results and comparing it to the results of the optimised values that are fed with input parameters such as fuel blend percentage, compression ratio, and engine load.Using the Response surface methodology to design and perform an experiment in accordance with the Design of Experiment (DOE). To anticipate values, the response surface methodology is used in conjunction with the Mini tab V.18 programme. Three factorial data with three levels were used in the response surface methodology. The brake thermal efficiency of the engine fueled by PJO increases with engine load, and the highest BTE is achieved at a compression ratio of 16. The BSFC then achieves its lowest value of 0.24 at a compression ratio of 16. It can be concluded that 20% of PJO fuel has the potential for CRDI engine application, and further research can be expanded to various operation modes.

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