# Experimental Investigation on Performance and Emission Characteristics of Tetra Hydro Furan Blended Diesel with Iron Nano Particles on Single Cylinder Variable Compression Ratio Diesel Engine

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## ABSTRACT

In the current work, by changing the load corresponding to each compression ratio, using different mixtures of tetra hydro furan, iron nano particles and diesel, the performance and emission characteristics of a single-cylinder variable compression ratio diesel engine are studied. The iron nanoparticles were prepared by the sol-gel method and analyzed by X-ray diffraction data and scanning electron microscopy. By adding iron nanoparticles, the performance of the fuel can be improved. By mixing tetra hydro furan with diesel fuel, it is also possible to increase engine operating parameters and reduce exhaust emissions. The tested operating characteristics are braking force, mechanical efficiency, thermal efficiency, volumetric efficiency and fuel consumption rate, and the tested emission characteristics are the emissions of nitrous oxide, carbon monoxide, carbon dioxide and unburned hydrocarbons. The results show that the blends reduce emissions of nitrous oxide, carbon monoxide and unburned hydrocarbons by 50%, 71.4% and 71.4%, respectively.

**Keywords**: Variable Compression Ratio engine, performance characteristics, emission characteristics, tetra hydro furan, iron nano particles

## Introduction:

Due to the rapid increase in the demand and cost of fossil fuels, an energy crisis has emerged. The emissions from the burning of fossil fuels have a serious impact on the ecosystem and human health. In order to overcome these shortcomings, many researchers have focused their attention on fuel modification methods and after-emission devices. Methyl furan is a second-generation biofuel, obtained from inedible biomass, such as cheap, abundant, and renewable corn cobs. The use of methyl furan containing iron oxide nano additives can improve engine performance and reduce emissions. The higher density and lower latent heat of vaporization of methyl furan can improve the mixture formation and cold start performance of the engine. Low-proportion diesel-methylfuran mixtures (M10, M20, and M30), as promising potential alternatives, exhibit better combustion and much lower soot emissions than pure diesel [1,2]. K. Ratna kumari et al. [3] The addition of iron nanoparticles and 2-methylfuran increases the calorific value of the fuel mixture to achieve finer ignition. The obtained results show that the emissions of NOx, CO and HC have been reduced by 50%, 71.4% and 71.4% respectively. Many researchers have conducted a lot of research on the formation of new fuels through metal additives. Metal-based additives include Fe[4-9], Mg[10],


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Pt[11], Ce[12], Mn and Ni[13], Fe-Mg[14], PtCe[15] and so on. However, the precipitation of these particles in the fuel limits a wide range of long-term applications [16]. Hossain et al. [17] studied the transesterification process for the production of biodiesel from natural and waste sunflower oil. Through the use of PSCO and WSCO, the ignition and divergence angles of a single-cylinder direct injection engine were discovered. The results show that there is no significant difference in biodiesel production between PSCO and WSCO. Thirumarimurugan et al. [18] used sodium hydroxide as an alkaline catalyst to produce fatty acid methyl esters from sunflower oil. The variables that affect the yield and characteristics of biodiesel produced from these vegetable oils are studied. The variables studied are response time (1-3 hours), catalyst concentration (0.5-1.5 wt/wt%) and the molar ratio of oil to methanol (1:3-1:9). From the results obtained, using a methanol/oil molar ratio of 6:1 and sodium hydroxide as a catalyst achieves the best yield. Nadir Yilmaz et al. [19] constructed RSM and LSSVM models from preliminary results, especially to find overall performance and emission characteristics. These results are analyzed with experimental results. The results show that these are effective modeling techniques with a high degree of certainty. Prabu [20] evaluated the performance of three mixed fuel diesel engines. P.Sridhar et al. [21] B20+Ag80 can be used as an alternative fuel for diesel without any modification to the DI diesel engine. Ultimately reduce exhaust emissions and improve the overall performance of the engine. Many researchers focus their interest on fuel replacement technology that uses nano-components to achieve advanced overall performance and emission characteristics [22].M.Nasarullah et al.[23] Investigate the performance and emission characteristics of a direct injection (DI) diesel engine when fuelled with methyl ester of jatropha oil (MEJO) by adding ignition improver tetra hydro furan (THF) .The experimental results show that the maximum brake thermal efficiency was obtained with 20%Etanol-2%THF blended with MEJO when compared with pure MEJO and methyl ester of jatropha oil blends.

## 1. Synthesis of Iron Nano-Particles

In the sol–gel process, a system that started out as a colloidal dispersion of particles is transformed into a gelatinous network with additional post treatment and ultimate transformation into solid oxide. In the context of synthesis of composite nano powders, this solution-gel technique is quite good at providing access to both inorganic and organic-inorganic materials. In addition to preparation approaches differing from the classic process of fusion of oxides, the sol–gel process also permits the synthesis of ceramic materials of high purity and homogeneity by using diverse preparation processes. The most outstanding features of the sol-gel processing technology were the attainment of high purity and the ease of uniform nanostructures produced at low temperatures.

**Table 1: Materials of Sol-Gel Method**

| S.NO | MATERIAL/COMPOUND | QUANTITY |
|---|---|---|
| 1 | Ferric Nitrate Nano Hydrate | 16.16 gms |
| 2 | Citric Acid | 38.42 gms |

## 2. Characterization of Nano Particles

Parameters influencing the properties of nano liquids are particle size, pH value, particle material, particle concentration, Temperature, Stability and base fluid.

**SEM analysis of nanoparticles**

The images of substances are created by scanning the surface with a focused electron beam with the TESCAN-VEGA3 machine. Data on the surface topography of a substance and its composition are generated as a result of the interaction of electrons with atoms present in the sample

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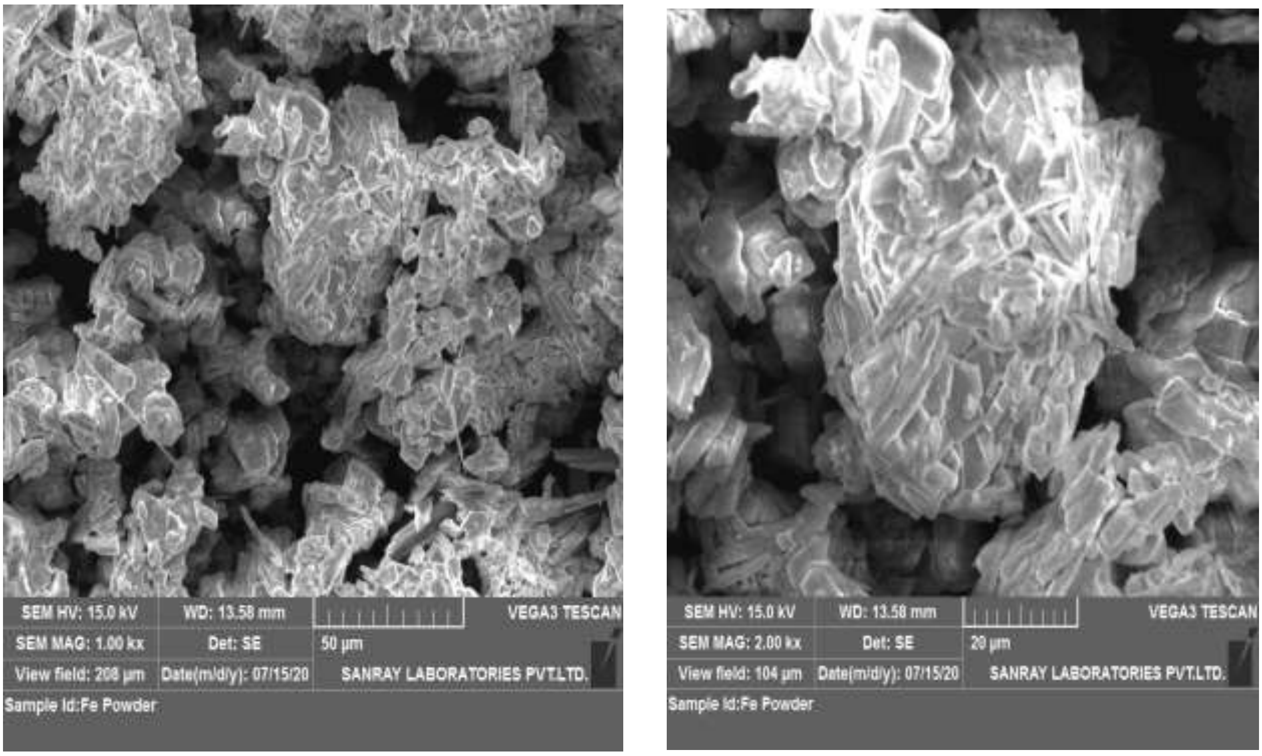


**Fig.1 : Sem analysis of iron nano particles**

A pH value of 11 is achieved .The average size of 52 nm is characterized by X-ray diffraction technique

## Zeta potential analysis

The difference in electric potentials between the dispersion medium and the stationary fluid layer is referred to as the zeta potential. It is used to illustrate the stability of colloidal suspensions. The zeta potential is directly proportional to the colloidal stability. XRD data and SEM analysis were determined by Sanray Laboratories Pvt Ltd, Kushaiguda. It has been observed that the zeta potential for the fuel blends is between 40 and 45.

**Table 2: Proportions for Bio-Diesel Blends:**

| S.NO | BLENDS | TETRA HYDRO FURAN | DIESEL | NANO PARTICLE |
|---|---|---|---|---|
| 1 | 100mlTETRA HYDRO FURAN +500 PPM IRON OXIDE+900mlDIESEL(INP700THF10) | 100ml | 900ml | 500ppm |
| 2 | 75ml TETRA HYDRO FURAN +600 PPM IRON OXIDE+925ml DIESEL (INP700THF7.5) | 75ml | 925ml | 600ppm |
| 3 | 50ml TETRA HYDRO FURAN +700 PPM IRON OXIDE+950ml DIESEL (INP700THF05) | 50ml | 950ml | 700ppm |


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**Table 3: Properties of blends**

| Property | Density(kg/m3) | Flash point (℃) | Fire point (℃) | Calorific value (kJ/kg K) | Kinematic viscosity (Cst) | Cetane Index |
|---|---|---|---|---|---|---|
| INP700THF10 | 847.4 | 48 | 50 | 43780.4 | 5.689 | 53 |
| INP600THF7.5 | 842 | 55 | 60 | 44214.72 | 6.437 | 52 |
| INP500THF05 | 845.2 | 65 | 70 | 45320.08 | 6.712 | 51 |
| D100 | 850 | 68 | 78 | 43000 | 2.6 | 46 |
| Measurement & apparatus | Hydro meter | Pensky Martens | Pensky Martens | Bomb calorimeter | Redwood viscometer | |
| Test method | ASTMD 941 | ASTMD 93 | ASTM D 93 | ASTMD 240 | ASTMD 445 | ASTM D613 |

## 3. Performance analysis of iron nano-additives with diesel-tetra hydro furan blend


**Fig.2: VCR engine test rig**


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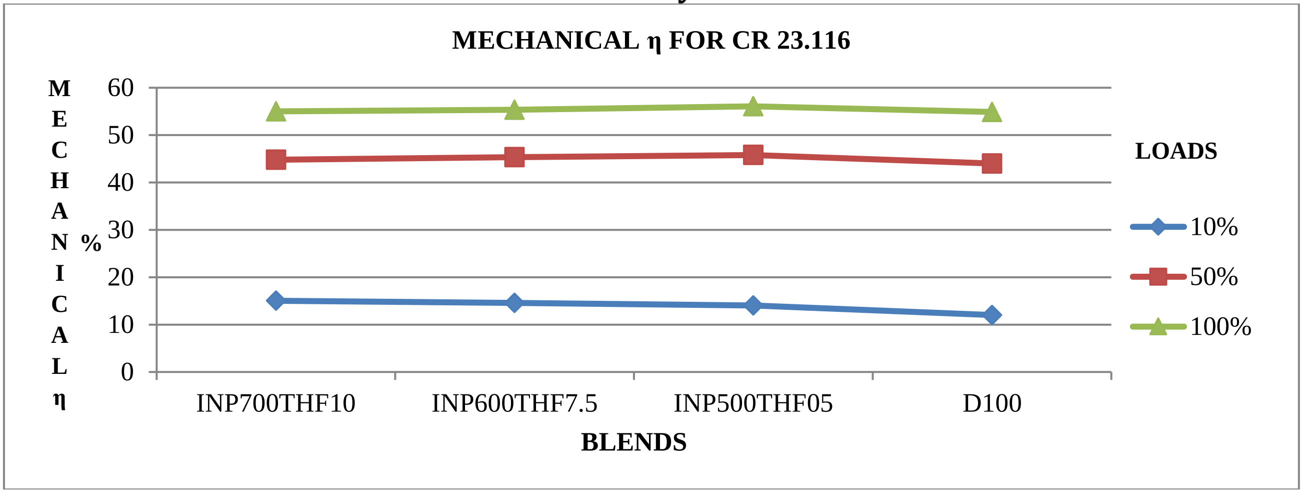
### 3.1 Effect of blends on Mechanical efficiency



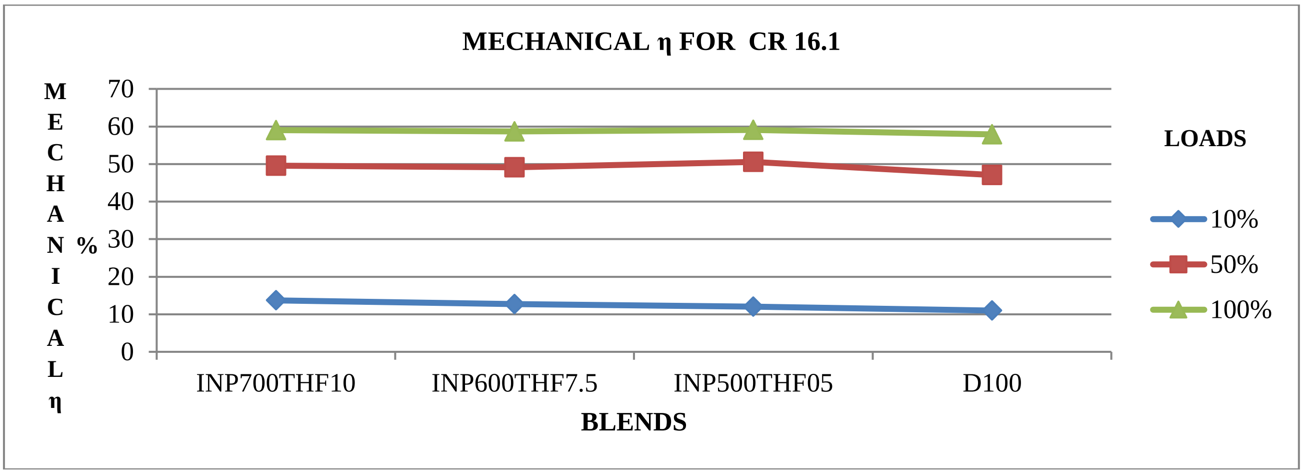




**Fig.3: Mechanical efficiency vs fuel blends corresponding to different compression ratios & loads**

Mechanical efficiency was observed maximum for full engine load and for a compression ratio of 16.1. Various emulsions were tested; D100 gave a mechanical efficiency of 57.89% for full load at compression ratio of 16.1. From fig 3, the maximum mechanical efficiency for full load is 59.17% for INP500THF05 fuel. The INP500THF05 fuel has high calorific value which resulted in an increase of combustion. Mechanical efficiency of fuels blended with nano particles, increased when compared with D100 fuel. Furthermore, the nano particles in general, hold an improved surface area and responsive surfaces which lead to developed chemical reactivity to perform as a catalyst.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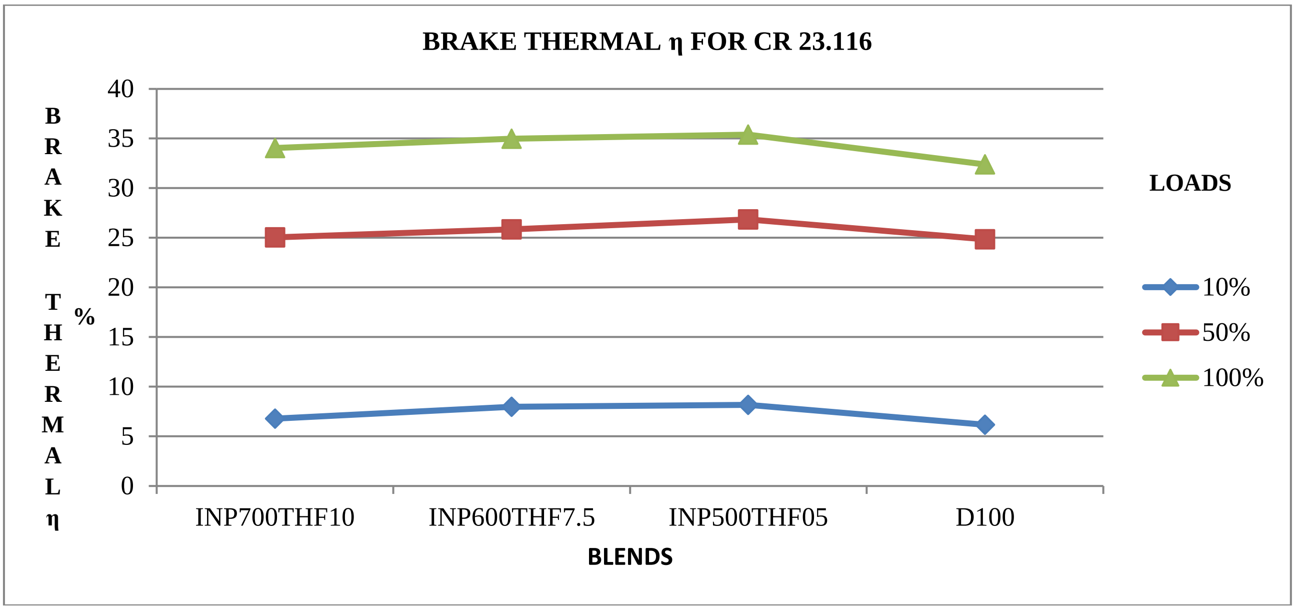
### 3.2 Effect of blends on brake thermal efficiency



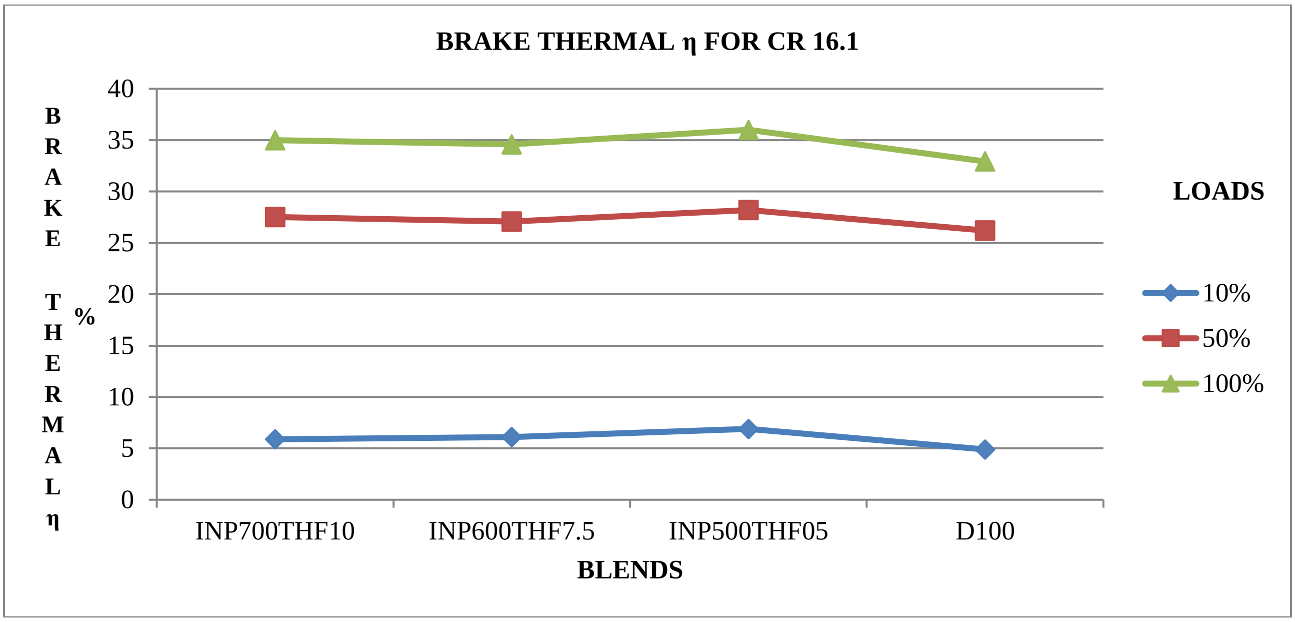




**Fig.4: Brake thermal efficiency vs fuel blends corresponding to different compression ratios & loads**

From fig 4, BTE was observed maximum for full engine load and compression ratio of 16.1. Various emulsions were tested, D100 showed maximum BTE of 32.929% for full load. The maximum BTE for full load was 36.01% for INP500THF05 fuel. The Brake thermal efficiency of fuels blended with nano particles increased when compared with D100 fuel.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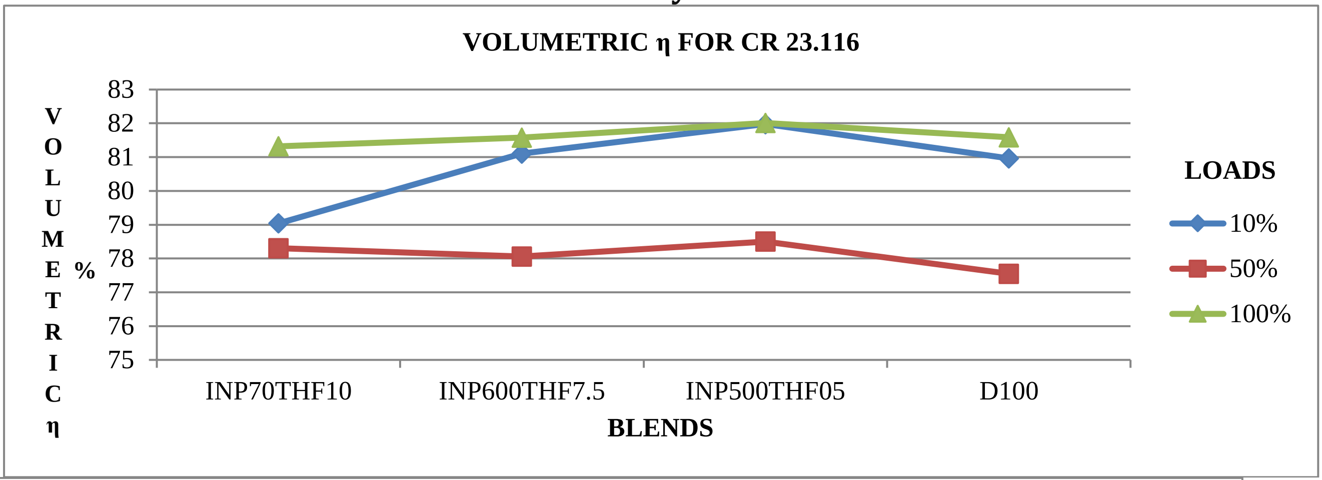
### 3.3 Effect of blends on volumetric efficiency



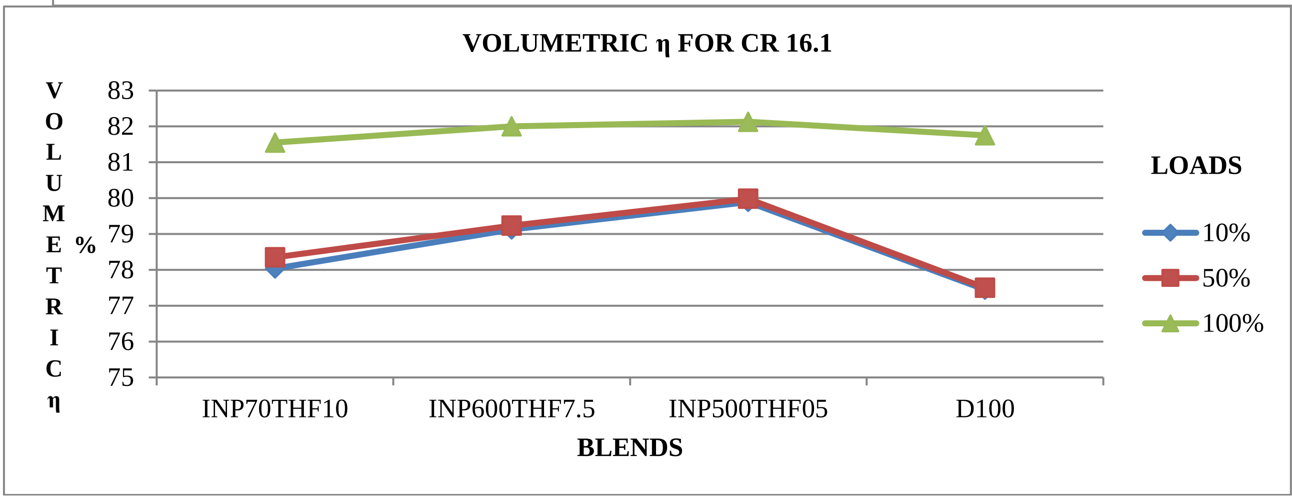
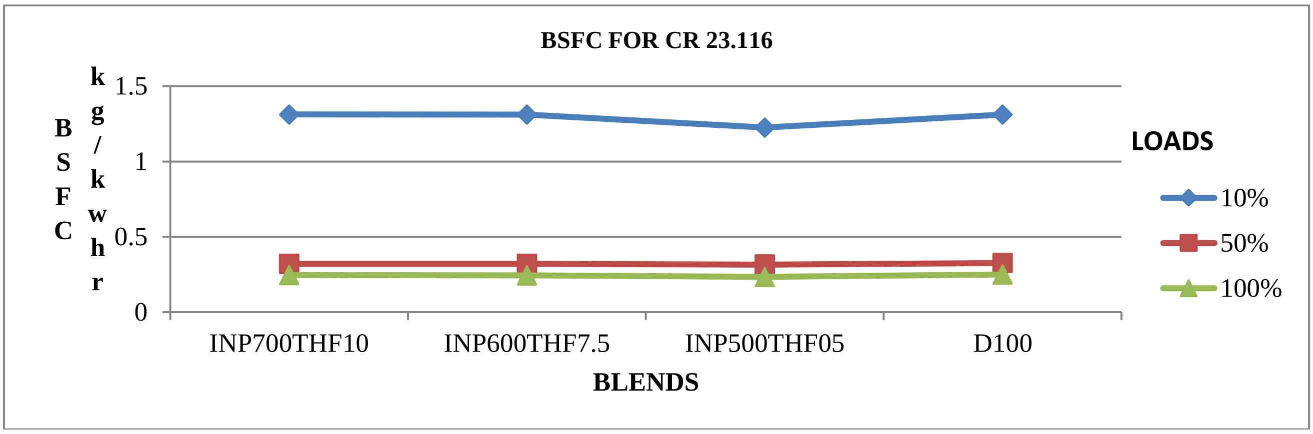




**Fig.5: Volumetric efficiency vs. fuel blends corresponding to different compression ratios & loads**

Volumetric η was observed maximum for full engine load and compression ratio of 16.1. Various emulsions were tested, D100 showed maximum of 81.75 for full load. The maximum volumetric η for full load was 82.13% for INP500THF05 fuel. From fig 5, it is observed that volumetric η of fuels blended with nano particles increased when compared with D100 fuel.

### 3.4 Effect of blends on brake specific fuel consumption

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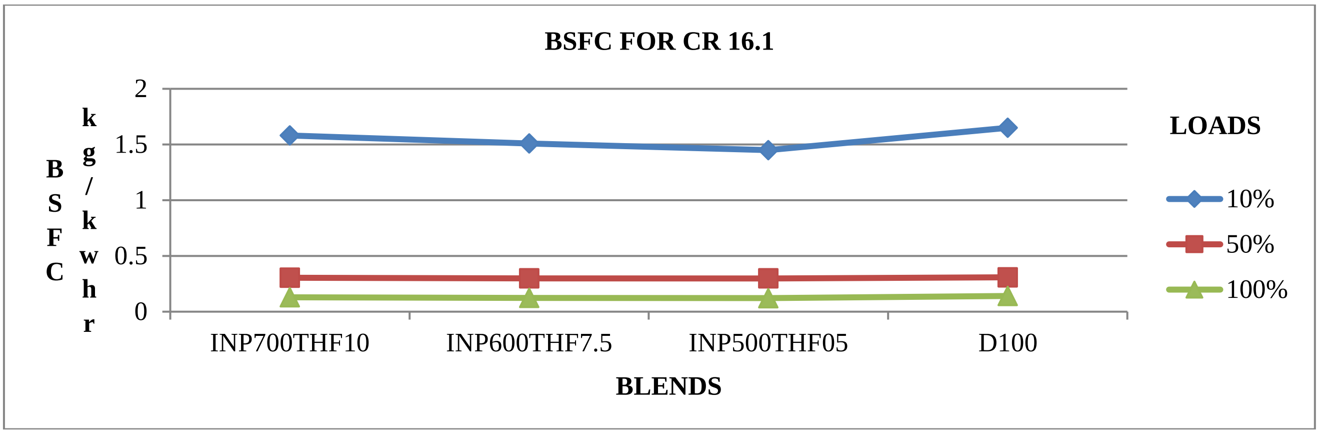
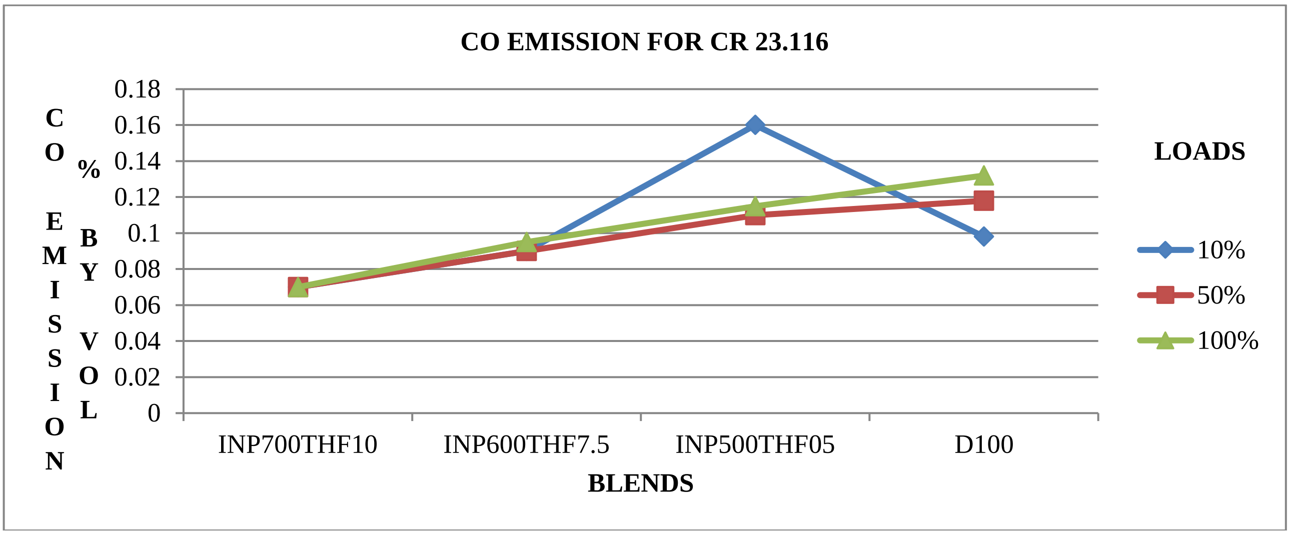



**Fig.6: BSFC vs. fuel blends corresponding to different compression ratios & loads**

BSFC is the ratio of the fuel spent by the engine to the engine power generated with respect to time. BSFC generally reduces with increase in the load; therefore the comparison with engine load is an important parameter. From fig 6, the increase in engine load from 10% to 100% for all test fuels reduces the BSFC..

## 4. Emission analysis of iron nano-additives with diesel-tetra hydro furan blend

### 4.1 Effect of blends on Carbon monoxide emission



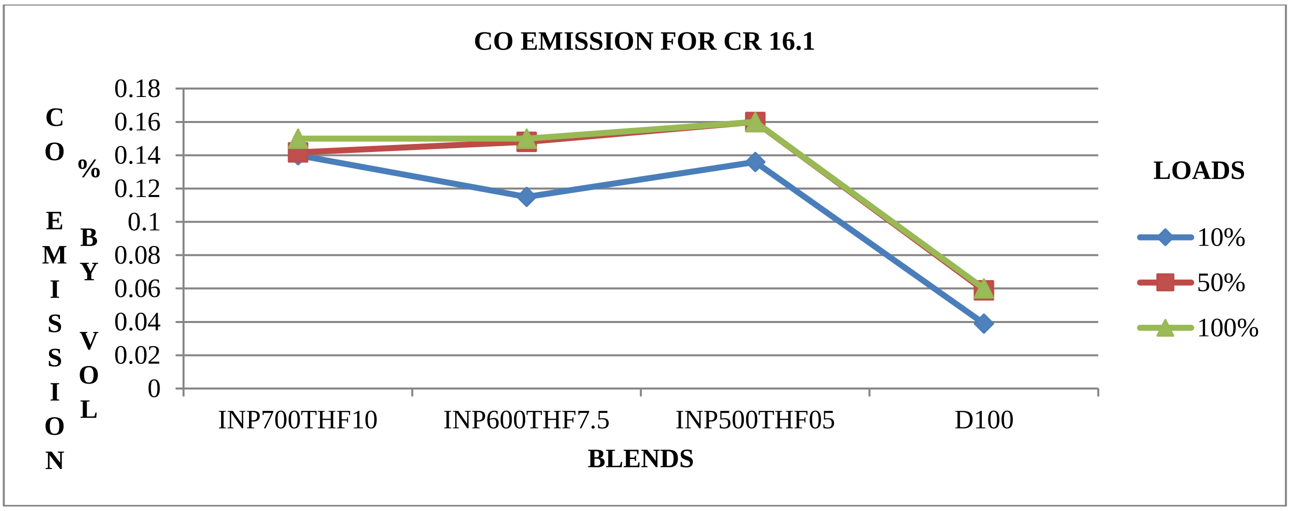




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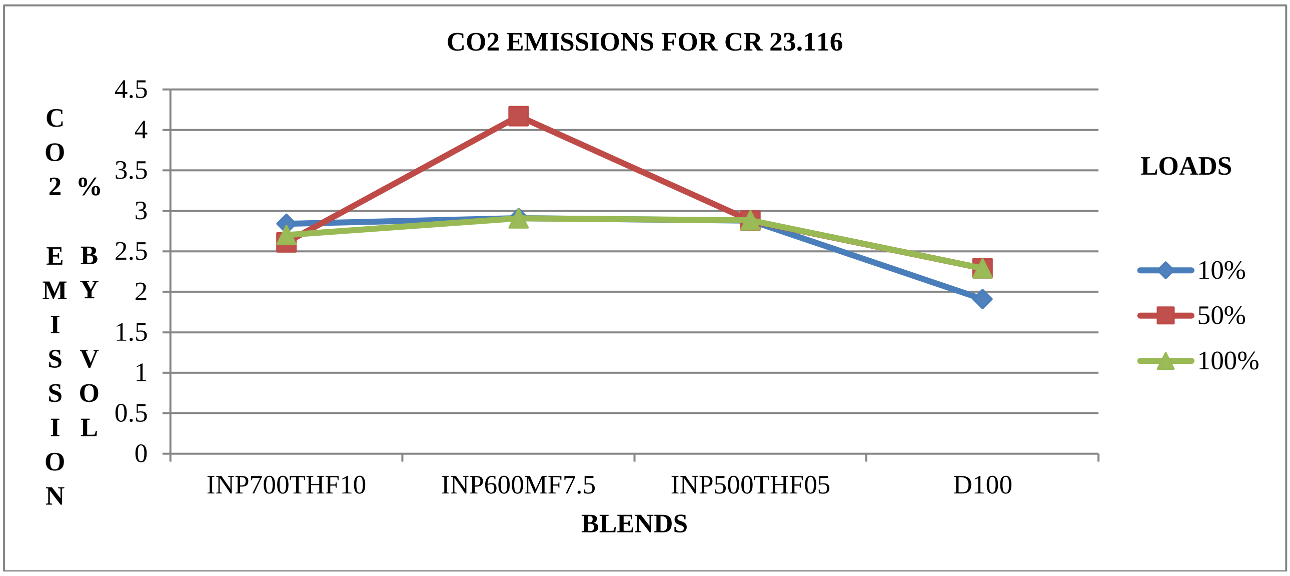
**Fig.7: Carbon monoxide emissions vs. fuel blends corresponding to different compression ratios &loads**

CO emissions for different blends corresponding to different CRs with varying loads have been displayed on emission analyzer. It is observed that for 23:1 CR, CO emissions of the blend INP700THF10 for 10%, 50% and 100% load are lower when compared with other blends which could be plotted on Fig. 7. It is also observed that for 16:1 CR, CO emissions of D100 for full load are lower when compared with other blends.

### 4.2 Effect of blends on Carbon dioxide emission



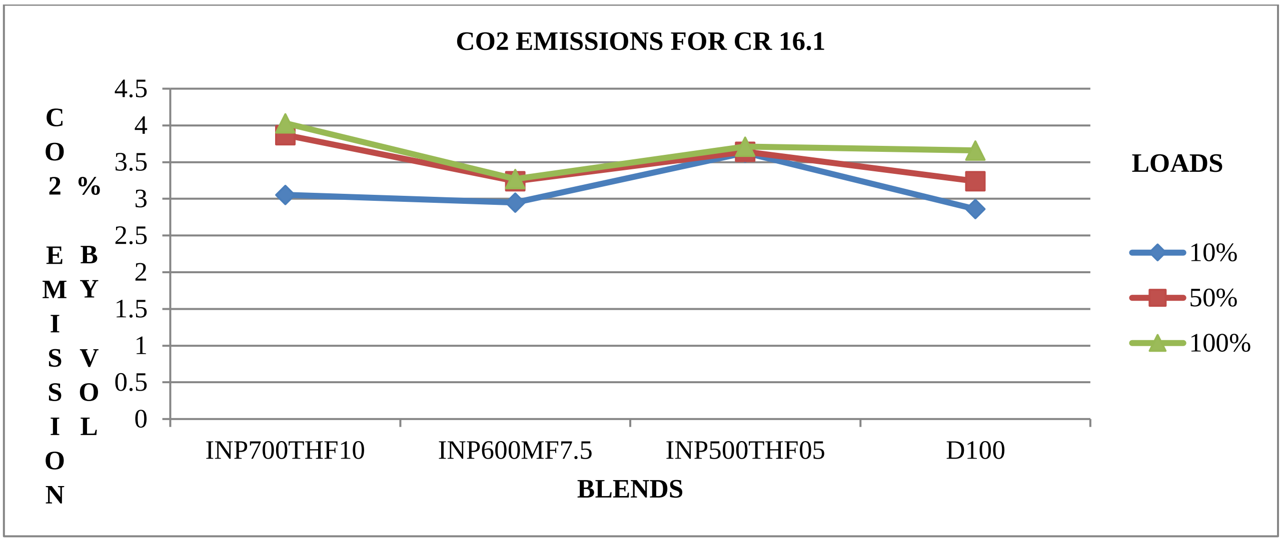




**Fig.8: Carbon dioxide emissions vs. fuel blends corresponding to different compression ratios &loads**

From fig 08 it is observed that for 23:1 CR, CO2 emissions of D100 for 10% load are lower when compared with other blends. It is also observed that for 16.1 CR. When compared with the 23:1 & 16:1 CR, it could be observed that CO2 emissions are lower for CR 23.1 for D100 for 10% load.

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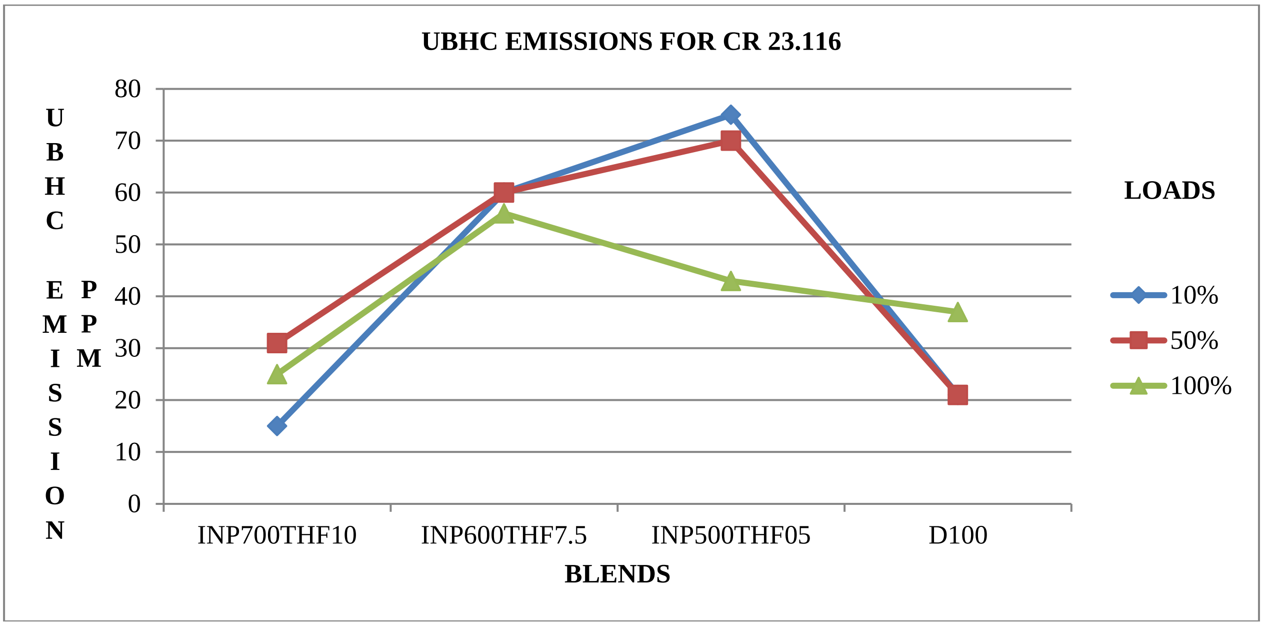
### 4.3 Effect of blends on unburnt Hydrocarbon emissions



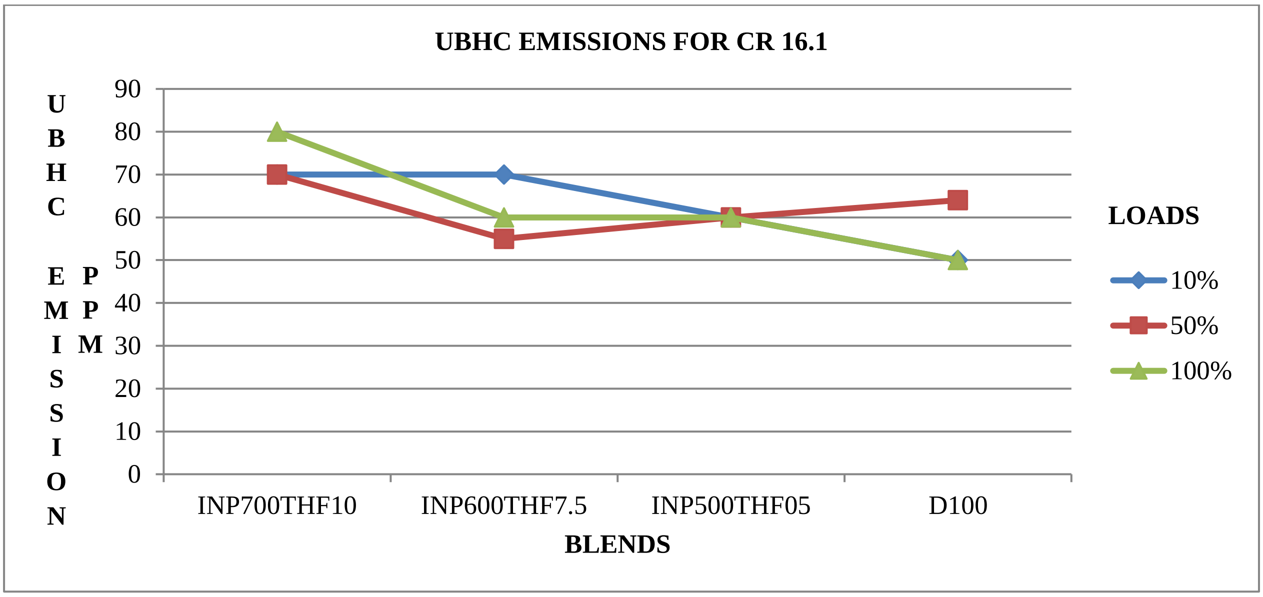




**Fig.9: Unburnt hydro carbon emissions vs. fuel blends corresponding to different compressionratios & loads**

Unburnt HC emissions for different blends corresponding to different CRs with varying loads have been displayed on emission analyzer. From fig 09 it is observed that for 23:1 CR, the unburnt HC emissions of INP700THF10 for 10% load are lower when compared with other blends. When compared with the 23:1 & 16:1 CR, it is observed that unburnt HC emissions are lower for CR 23:1 for INP700THF10 blend for 10% load.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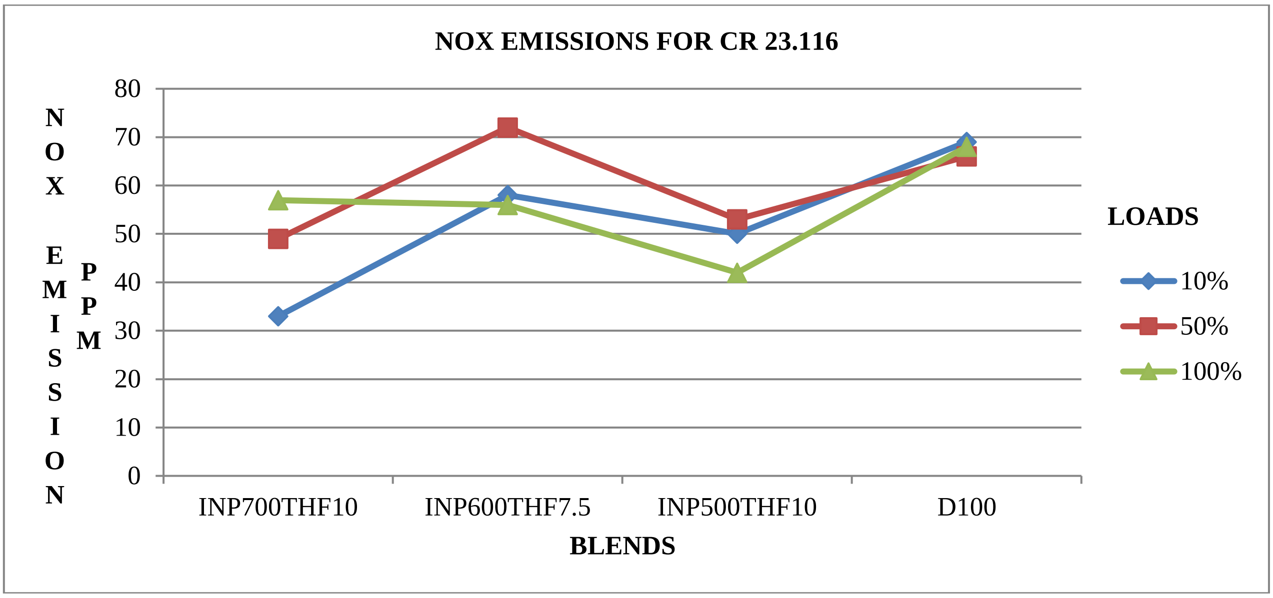
### 4.4 Effect of blends on Nitrogen oxide emissions



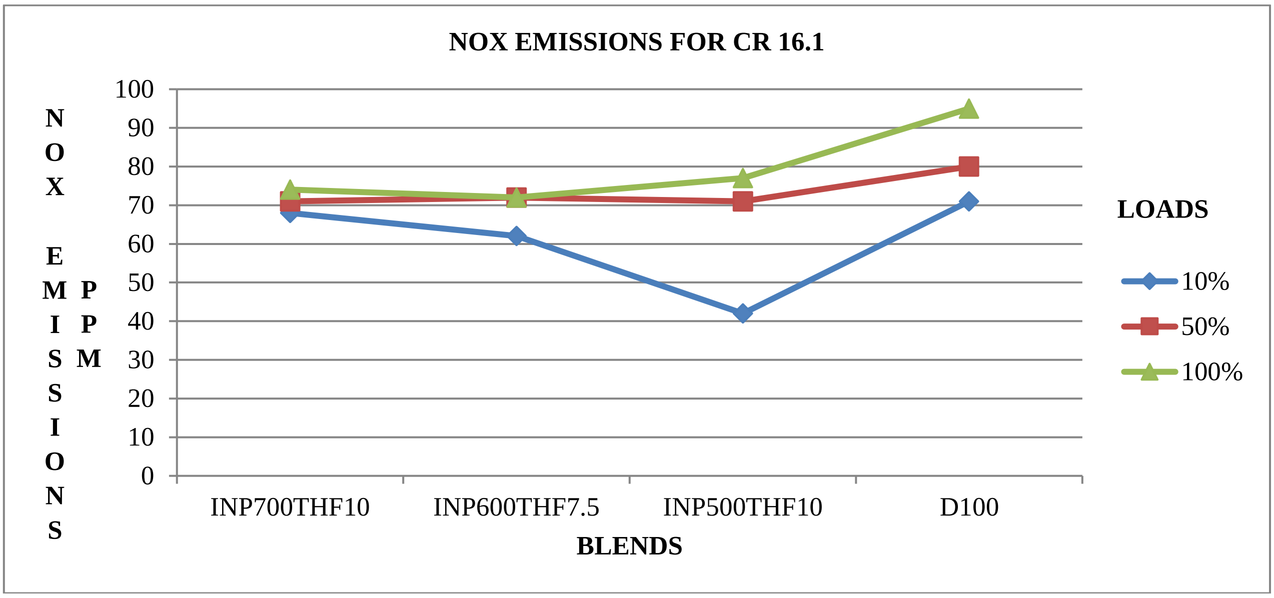




**Fig.10: Graph for nitrogen oxide emissions vs fuel blends corresponding to different compression ratios &loads**

NOx emissions for different blends corresponding to different CRs with varying loads have been displayed on emission analyzer. From fig 10, it is observed that for 23.1 CR, NOx emissions of INP700THF10 blend for 10% load are lower when compared with other blends. It is also observed that for 16.1 CR, NOx emissions of INP500THF10 blend at 10% load are lower when compared with other blends. When compared with the 23:1 & 16:1 CR, it could be observed that NOx emissions are lower for CR 23:1 for INP700THF10 blend for 10% loads.

### Conclusions

1. Reduction in exhaust emissions of unburned hydrocarbons (UBHC), carbon monoxide (CO) with the inclusion of iron nano particles in the diesel-tetra hydro furan blends due to enhanced ignition characteristics, higher oxygen content and presence of lower aromatic compounds in tetra hydro furan and NPs additives, that resulted in complete combustion.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2. The presence of metallic additives and oxygenated additives results in reduced BSFC due to higher calorific value, catalytic oxidation enhancement and complete combustion of the blended fuel.

3. The mechanical efficiency and Brake Thermal Efficiency is observed maximum for full load for INP500THF05 fuel. INP500THF05 fuel has high calorific value which resulted in an increase of combustion.

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