Effect of Nano Fuel Additives on the Characteristics of Diesel Engine Fed with Biodiesel Blended Fuel

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Abstract

A Numerical analysis for the effect of different Nano particles concentrations on the diesel engine characteristics fired with biodiesel blended fuel is investigated in the work. The simulation software Diesel-rk has been used in this work. The biodiesel under focus is castor methyl ester (CME) which is derived from castor oil via transesterification process. The impact of Nano particles is studied by using three doses of Al_2O_3 (25, 50, 100 ppm) mixed with B20% CME which is confirmed from previous studies as the best compromise ratio. Generally it's found that with use of Nano particles along with biodiesel fuel, the cylinder pressure, delay period, combustion temperature decreases. Noticeable enhancements in the brake thermal efficiency and fuel consumption have been recorded. The results reported dramatic reductions in smoke values, NOx emissions as well as Particulate matter (PM), hence this way can fight trade-off relation (PM-NOx). The findings showed, best concentration of Nano particles was 25 ppm as no dramatic effect was observed beyond this dose. The validity of the numerical results is checked out with other experimental results at the same condition of operation.

Keywords: Diesel engine, CME biodiesel, Al_2O_3 Nano fuel, Diesel –rk software.

Nomenclature

List of symbol	*Definition*
A_o, A_2,A_3	*Constants.*
B20%CME	*Volume blend contains 80 % diesel plus 20 % CME*
B100	*Volume blend contains 100 % CME*
BSN	*Bosch Smoke Number*
BSFC	*Brake specific fual consumption*
CME	*Castor methyl ester*
[C]	*cylinder concentration soot*
ºC	*degrees centigrade*
ºCA	*crank angle degrees*
CN	*cetane number of fuel*
DF	*Diesel fuel*
l	*spray length*
lm	*Penetration distance*
m_f	*Fuel mass*
NOx	*Nitrogen Oxides*
p	*cylinder pressure (pa)*
p_s	*fuel saturation vapour pressure*
PM	*Particulate Matter*
CME	*Castor methyl ester*
rpm	*revolutions / minute*
rps	*revolutions /second*
T	*temperature in the cylinder*

t	*time*
TDC	*Top Dead Centre*
U	*Instantaneous fuel velocity*
U_0	*Spray Initial velocity*
U_m	*The velocity of the spray's front*
V	*The cylindrical volume*
x	*heat release proportion*
x_o	*The fraction of the fuel vapour forming in the delay period.*
φ	*Solid volume fraction for the used nanoparticles*
m_p	*Mass of nanoparticle*
ρ_p	*Density of nanoparticle*
ρ_f	*Density of fuel*

1. Introduction

For many years, internal combustion engines have played a dominant role as major drivers in various sectors, especially in the field of transport and industry. This is for a simple reason that its performance is superior in light of longer durability characteristics. Rapid growth in urbanization has resulted in a sharp increase in the number of vehicles on urban roads, as well as an increase in the number of industrial plants and facilities in the world. There is a challenge to science and technology due to dwindling the resources of petroleum as fuel , the increase in the fuel demand and the increase in the stringent emission regulations. Therefore, many researchers have paid attention for conducting research on alternative fuels. As an important research topic, the use of biodiesel derived from vegetable oils and animal fats to be an effective alternative to petroleum-based diesel fuels.

S. Horikoshi, and N. Serpone [1] defined a nanoparticle as "the most fundamental component in the fabrication of a nanostructure, and is far smaller than the world of everyday objects that are described by Newton' s laws of motion, but bigger than an atom or a simple molecule that are governed by quantum mechanics". Recently, to further enhance the combustion and emission characteristics of internal combustion engines, the impacts of different oxygenated additions on biofuels have been investigated by many researchers. For instance, engine performance and combustion characteristics were enhanced using the addition of metallic oxides nanoparticles to fuel blends, as this addition increases the thermal efficiency and the heat release rate[2, 3]. The advantages of Metal-oxide nanoparticles additive are the ability for donation of oxygen atoms to the used fuel blend and the ability for creating high surface to volume ratio, therefore they perform as high reactive medium through the combustion. Moreover, the addition of nanoparticle increases fire point temperature, flash point temperature, thermal conductivity and reduced kinematic viscosity[2, 4]. The effect of the addition of Aluminum Oxide Al2O3 nanoparticles with Jatropha Oil Methyl Ester (JOME) on the performance and emissions of a naturally aspirated diesel engine was experimentally investigated by N. Shrivastava et al.[5]. In their experiment, nanoparticles were used to decrease the formation of nitrogen and high temperatures. An ultrasonicator was used to form nanostructures based on a separate addition of 50ppm and 150ppm of alumina nanoparticles to the pure diesel and pure JOME. JOME performance is relatively less efficient than diesel performance due to lower thermal value. However, the performance of alumina nanoparticle fuel was better than pure diesel fuel. The results indicated that the use of nanoparticles with diesel and biodiesel results in a more efficient, eco-friendly and economic engine operation.

C. R. Seela, et al. [6] produced Mahua Methyl Ester (MME) from crude mahua oil through a transestification process and mixed with zinc oxide (ZnO) nanoparticles as an additive, to study its emission characteristics and performance on a single cylinder CI motor. Different diesel, biodiesel and nanoparticles mixtures were prepared by changing the Nano concentration and biodiesel by 50ppm and 100 ppm by ZnO and 20% and 50% by volume. The results revealed that the proper mixture with the addition of nanoparticles resulted in better engine performance, the B20 with 50 ppm ZnO Nano-added. With this ratio, thermal efficiency was increased up to 3%, and all emissions of CO2, NOx, and HC were reduced.

V. D. Raju et al.[7] used the mixture of diesel with tamarind seed methyl ester at concentrations of 10%, 20% and 30% on volume basis. These fuel samples were tested in a diesel engine to choose the perfect combination for the addition of nanoparticles. The 20% of the biodiesel mixture was selected as the best to add nanoparticles at different concentrations to improve the performance, combustion and emissions. Multi-walled carbon Nano tubes and Alumina oxide nanoparticle are mixed with the optimized tamarind seed methyl ester at 60 ppm and 30 ppm concentrations to provide a comparative analysis. The results showed that using the addition of 60 ppm of Al2O3 increased the brake thermal efficiency by 1.6% compares to the tamarind seed methyl ester mixture. The tamarind seed methyl ester mixed with nanoparticle additive was shown to reduce unburned hydrocarbon emissions and carbon monoxide by 24–68% and 15–51% respectively. In addition, this mixture resulted in a reduction in NOX by 7–9%.

S. Radhakrishnan et al.[8] studied the influence of nanoparticles on the performance and emission parameters of cashew nutshell biodiesel (BD100). Biodiesel was prepared by transestification process with the addition of Nano-alumina particles called (BD100A). The experimental results showed that emission factors like HC, NOx, CO, and smoke reduced by 7.4%, 5.3%, 10.23% and 16.1% using BD100, 10.1%, 8.8%, 12.4% and 18.4% using BD100A, respectively by comparison to the pure diesel fuel. BTE decreased by 2.3% and 1.1% while BSFC increased by 5.1% and 3.8% using BD100 and BD100A, respectively, by comparing to that of diesel at full load.

The addition of copper oxide (CuO) nanoparticles to pongamia biodiesel to analyse the emissions and performance of the operating characteristics in a diesel engine was investigated by V. Perumal, et al.[9]. Experimental results showed that the mixture B20CuO100 decreased the BSFC by about 1.0%, and increased the BTE by about 4.01%. Considering greenhouse gases, CO, smoke, HC, and NOx emissions decreased to about 29%, 12.8%, 7.9%, and 9.8% respectively compared to B20 mixture.

D. S. Patil [10] used Cerium Oxide nanoparticles at a concentration of 50 ppm with cottonseed biodiesel mixtures (20CSBCeO250 and 10CSBCeO250). Experimental tests were performed on a one-cylinder D.I. diesel engine operating at 1500 rpm by the compression ratio from 14 to 18 and the load from 0 to 6 kg. The findings showed a significant enhancing in performance parameters and a decrement in nitrogen oxide emissions. The 10CSBCeO250 fuel mixture was found to be the best for all performance and emission parameters.

B. Paramashivaiah et al. [11] prepared nanobiodiesel using dispersing graphene with a combination of diesel and with Simarouba methyl. The dispersion was characterized by the UV-Vis spectrometer. Performance characteristics and emissions of nanobiodiesel were performed on a one-cylinder D.I. four-stroke, water cooling computerized diesel engine. Fuel properties were measured for 3 various levels of graphene nanoparticles. The result showed increasing the BTE of the engine by 9.1%, decreasing the UHC by 15.4%, NOX by 12.7% and CO by 42.9%. In addition, graphene nanoparticles additive resulted in a considerable decrement in combustion period with a small increase in cylinder peak pressure at different working conditions.

S. Nayak et al. [12] studied the mixture of silver nanoparticles (AgNPs) with Pongamia biodiesel in the mass fraction of 50 ppm and 25 ppm by the use of ultrasonicator for appropriate dispersion to enhance the stability of mixtures. Due to silver nanoparticle additive with biodiesel, a significant rise in BTE was obtained. The high dose level of AgNPs enhanced more the engine performance. The emissions of NOx and HC were higher using the biodiesel compared to conventional diesel at different operating loads.

A study focused entirely on nanoparticles scattered in diesel or biodiesel as a basic fluid was presented by S. Muthusamy et al.[13]. In this study, different prepared mixtures such as B20, B20Fe3O450 and B20Fe3O4100 were examined at different operating conditions. It was concluded that the addition of the iron oxide (Fe3O4) nanoparticles with biodiesel did not only improve the performance parameters but also resulted in lower harmful emissions of diesel engines.

T. R. Krishna, et al.[14] investigated experimentally the impact of Al2O3 nanoparticles additive to biodiesel, prepared from rice bran oil by a transestification process, on emission and performance of diesel engine. It was observed that the BTE is identical to that of the diesel with full load conditions. When the engine was fed with B60 and B80 with additives, a significant reduction was observed in the CO, CO2 and NOX emission components at both partial load and full load conditions. However, HC emissions increased. Due to performance and performance analysis, the B60 fuel mixture with 20 ppm of Al2O3 nanoparticles and 5% Di-Ethyl Ether (DEE) is the best combination.

This analysis based on the numerical solution, the multizone zone combustion model which is supported by the simulation software Diesel-RK was used. The conducted computational study consists of full investigation on combustion, performance and emission parameters of a diesel engine, fuelled with 20% CME blend which is selected as best blending ratio in previous findings of results[15]. For the purpose of improving performance and reducing emissions, separate addition of alumina nanoparticles to the best blending ratio is studied with different concentrations (25, 50 and 100 ppm). The numerical analysis was performed on a direct injection single cylinder diesel engine.

2. Biodiesel properties

The physical properties of the prepared biodiesel along with diesel fuel (DF) are measured accurately at ALDORA refinery factor according to the table reported below. Table 1. displays the characteristics of a different mix of DF and CME biodiesel. The engine specifications are displayed in Table 2. The alumina Nano particles used in this work is purchased from authorized company and having a properties listed in Table 3. The selection dose of nanoparticles relies on the information available in the literature. Three doses are used, namely 25, 50 and 100 ppm. Nanoparticles mass (m_p) requested for each dose is defined as in:

$$\varphi = \frac{\frac{m_p}{\rho_p}}{\frac{m_p}{\rho_p}+\frac{m_f}{\rho_f}} \quad (1)$$

3. Numerical simulation approach

The multizone combustion model has been used in this work. The fuel distribution is sprayed with 2 stages: free jet & wall jet as illustrated in Fig. 1. There are a specific condition of evaporation and combustion for each zone identified in the model.

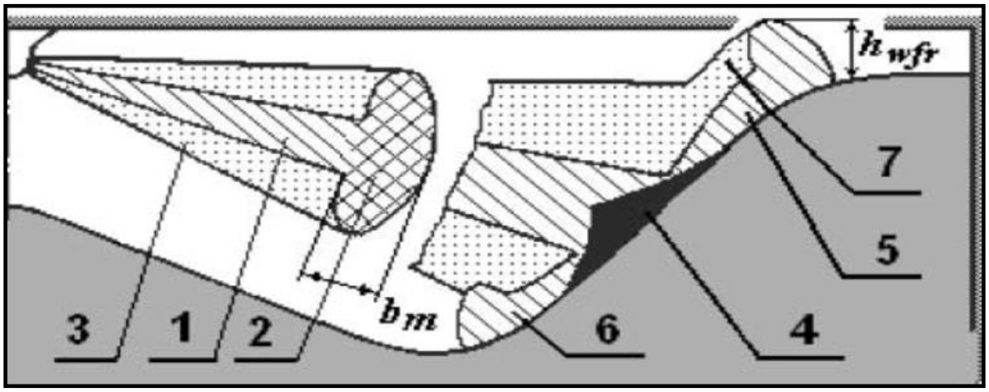

Fig. (1) Distinguishing areas of the fuel spray[17]

1. Free wall (before impingement)

- The conical nucleus of free spray
- Front dense spray free.
- The diluted outer shell of the spray.

2. After wall impingement another 4 zones are formed:

- The near-wall flow (NWF) nucleus
- The NWF is dense on the surface of the piston.
- Front dense of the NWF.
- NWF extensible out zone.

The current speed and location of the elementary fuel mass (EFM) from the injector to the tip of the spray is given by to [18]:

$$[U/U_{\circ}]^{(3/2)} = 1 - l/l_m \qquad (2)$$

Fig. 2. presents the variation of spray evolution parameters as functions of time. The Governing evaporating details are described in [19]. During the process of simulations, Woschni' s formula has used to predict coefficients of heat transfer in the cylinder[20].

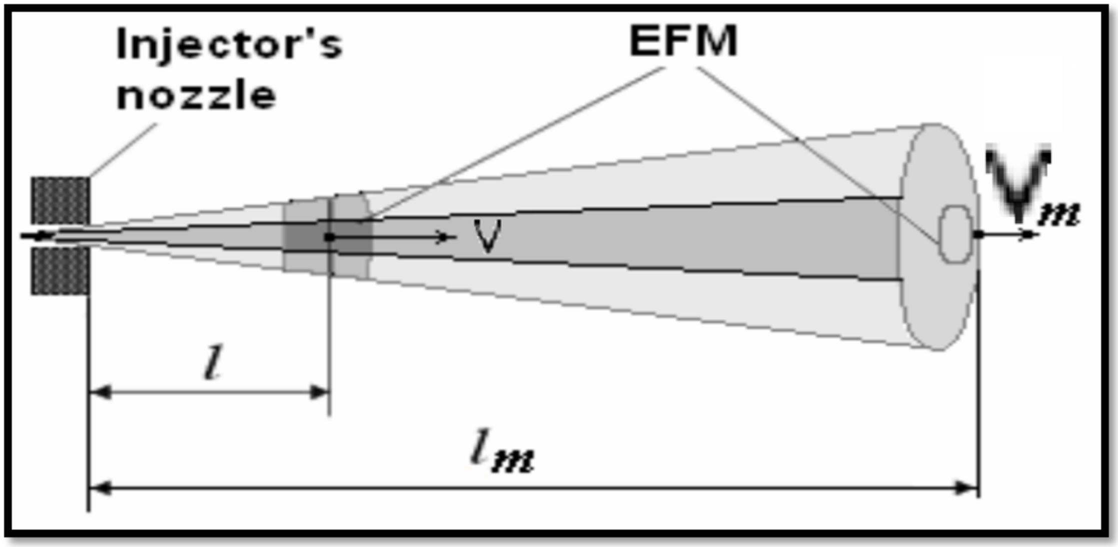

Fig. (2) Graphical shape of the fuel spray [21]

3.1. The Nitrogen oxides model

The nitrogen oxide reaction is[22]:

$$N + O_2 \leftrightarrow NO \ + O \tag{3}$$

The reaction is depended on the oxygen concentration. The volumetric of NO concentration is given by:

$$\frac{d[NO]}{d\theta} = \frac{2.33*10^7 \, p.e^{-\frac{38020}{T_Z}} [N_2]_e [O]_e \left(1-([NO]/[NO]_e)^2\right)}{RT_Z\left(1+(2365/T_Z).e^{\frac{3365}{T_Z}}.[NO]/[O_2]_e\right)} . \left(\frac{1}{rps}\right) \tag{4}$$

3.2. The soot concentration model

Soot particle forms grow and oxidizes due to chemical reaction occurring through combustion. It has a deep impact on the pollution of the environment the concentration of soot particle is calculated[19]:

$$[C] = \int_{\theta_B}^{480} \frac{d[C]}{d\tau} \frac{d\theta}{6n} \left[\frac{0.1}{P}\right]^{\gamma} \tag{5}$$

The Bosch smoke number (BSN) was obtained from Hartidge smoke equation given below[23]:

$$\text{Hartidge} = 100\left[1 - 0.9545 * e^{(-24226[C])}\right] \tag{6}$$

The PM emissions (are obtained from[23]:

$$[PM] = 565 \left[\ln \frac{10}{10-\text{Bosch}}\right]^{1.206} \tag{7}$$

One of the other important equations is the air pollutant emission equation (SE), as it represents the resultant of (NOx) and (PM) emissions [24]:

$$SE = C_{PM}\left[\frac{PM}{0.15}\right] + C_{NO}\left[\frac{NO_x}{7}\right] \quad (8)$$

where C_{PM} and C_{NO} - the experimental factors for (PM) and (NOx) respectively.

4. Basic equations of performance:

4.1. Brake thermal efficiency (BTE)

Using equation (11) to calculate the brake thermal efficiency

$$\text{BTE} = \text{BP} / (\dot{m_f} * \text{LCV}) \quad (9)$$

where: $\dot{m}_f$ = Fuel consumption rate , LCV- Lower heating value of blended fuel (kJ/kg)

4.2. Brake specific fuel consumption

The Brake Specific Fuel Consumption (BSFC) is calculated by using the equation (10).

$$\text{BSFC} = (\dot{m_f}/\text{BP}) * 3600 \quad (10)$$

5. Results and Discussion

5.1. Combustion Analysis

The variation of in-cylinder pressure with crank angle is shown in the Fig. (3). It was observed that peak pressure is reduced with the use Nano fuel compared with 20%CME biodiesel fuel. This could be due to high evaporation rate, enhanced surface area/ volume ratio, shorter delay period and hence less premixed fraction of combustion process. The cylinder peak pressure for the 20%CME at the full load observed is 86.65 bars compared to 81.18, 80.84 and 80.89 bars for 20%CME+25ppm AL2O3 Nano, 20%CME+50ppm AL2O3 Nano and 20%CME+100ppm AL2O3 Nano, respectively.

The variation of in-cylinder maximum temperature with the different percentages of Nano particles dose at full load is shown in the figure (4). It was observed that in-cylinder maximum temperature is reduced for nanoparticles mixed with biodiesel compared with 20%CME biodiesel fuel. This could be due to the shorter delay period and hence less premixed fraction of combustion process. The maximum temperature for the 20% CME at the full load observed is 2083.6 K compared to 2019, 2018.2 and 2018 K for 20%CME+25ppm AL2O3 Nano, 20%CME+50ppm AL2O3 Nano and 20%CME+100ppm AL2O3 Nano, respectively.

Figure (5) shows the variation of the delay period with the different concentration Nano particles in the fuel at full load. The massage from this figure says when the concentration of Al2O3 nanoparticle increases, the ignition delay is decreased. The reason is attributed to the higher surface area to volume ratio and higher thermal conductivity of the Al2O3 nanoparticles which enhanced the evaporation rate, resulting in a reduction in physical delay. In this work it has been proved that with adding nanoparticles to the biodiesel-diesel blends, the cetane number of blended fuel increases which causes a decrease in the ignition delay period. These findings were confirmed with other work cited in literatures[25, 26].

5.2. Performance Analysis

For different percentages of Nano particles in the fuel at full load, the (BTE) is shown in the figure (6). It has been observed that BTE slightly increased with increased Nano particles concentration. This can probably be attributed to better combustion characteristics of nanoparticles, which have influenced more amount of fuel to react with the air leading to enhancement in the BTE. The full load numerical results showed the maximum BTE for the 20%CME at the full load observed is 19.2% compared to 19.517%, 19.568% and 19.557% for 20%CME+25ppm AL2O3 Nano, 20%CME+50ppm AL2O3 Nano and 20%CME+100ppm AL2O3 Nano, respectively.

The variations of BSFC with the different Nano particles doses at full load are shown in the figure (7). It was observed that BSFC is reduced for nanoparticles mixed with biodiesel compared with 20%CME biodiesel fuel. This could be probably attributed to the presence of potential nanoparticles in the 20%CME biodiesel fuel (as it possess enhanced surface area/volume ratio) to ameliorate the catalytic effect, and less fuel consumption in the unit volume of the fuel during the combustion in the engine cylinder. The lower BSFC observed is 0.406 kg/kWh for the 20%CME+100ppm AL2O3 Nano, whereas it is 0.406409, 0.40621, and 0.411762 kg/kWh for 20%CME+25ppm AL2O3 Nano, 20%CME+50ppm AL2O3 Nano and 20%CME, respectively. It can be noticed that beyond 25ppm Nano no significant reduction in BSFC occur.

5.3. Emissions Analysis

It can be found from figure (8) that NOx emission is reduced with increase of concentration for nanoparticles mixed with biodiesel compared with 20%CME biodiesel fuel. Usually, the availability of oxygen and higher combustion temperature in CME blends produces a higher NOx formation. However, the NOx formation is reduced by the addition of nanoparticles in the 20%CME blend. It can be considered as one of optimization strategies to reduce the biodiesel NOX effect. The reduction in NOx emission is due to the reduced in-cylinder temperature which is caused by the increased convective heat transfer and thereby results in lesser NOx[27]. Moreover, the nanoparticles act as heat sink inside combustion chamber leads to reduce the temperature and avoids the hot spot region to reduce the NOx formation[7]. At full load condition, NOx emission for the 20%CME+25ppm AL2O3 Nano, 20%CME+50ppm AL2O3 Nano and 20%CME+100ppm AL2O3 Nano are 11%, 10.84% and 10.74% less than the standard 20%CME blend.

The variation of BSN with different concentration of the nanoparticles (AL2O3) blended with 20%CME is shown in the figure (9). It was observed that the BSN in the exhaust gases decreases with the increase in the concentration of the nanoparticles. The significant reduction in smoke can be attributed to AL2O3 nanoparticles in the fuel. The main cause of smoke is incomplete combustion of fuel in the diffuse combustion phase[3]. The BSN for 20%CME+25ppm AL2O3 Nano, 20%CME+50ppm AL2O3 Nano and 20%CME+100ppm AL2O3 Nano are slightly decreased by 2%, 3.1%, and 3.3% respectively as compared to 20%CME at full load.

The PM is calculated by equation (6) as a function of BSN. The variation of the PM with different concentrations of the nanoparticles (AL2O3) blended with 20%CME is shown in the figure (10). It was observed that the PM in the exhaust gases decreases with the increase in the concentration of the nanoparticles. The main source of the soot is the incomplete combustion of hydrocarbons since the BSN is reduced according to Figure (9), hence the decrease in PM is expected according to equation (6) [23]. The numerical results at full load condition calculated by Diesel-rk software showed a slightly decreased in PM emissions of 3.62%, 4.28% and 4.9% for 20%CME+25ppm AL2O3 Nano, 20%CME+50ppm AL2O3 Nano and 20%CME+100ppm AL2O3 Nano respectively as compared with 20%CME .

Figure (11) shows the effect of different concentrations of the nanoparticles (AL2O3) blends on the SE emission. The empirical equation of PM and NOx emissions (SE) (Eq.7) is calculated for different concentrations of the nanoparticles (AL2O3). Therefore, this equation summarizes PM and NOx emissions. The numerical results calculated by Diesel-rk software showed challenging reduction in SE emissions of 6.57%, 7.08% and 6.27% for 20% CME+25ppm AL2O3 Nano, 20%CME+50ppm AL2O3 Nano and 20%CME+100ppm AL2O3 Nano respectively as compared with 20%CME at full load. This indicates that the reductions in NOx emissions are more effective than PM emissions in relation to SE emission decrease. The figures (6 - 11) that recently discussed confirm that the best Nano additives is 25ppm.

5.4. Model Validity

The validity of the Numerical results is checked with the results obtained from experimental investigation of other researchers [28-30] at the same conditions. Figures (12) and (13) show the predicted cylinder pressure and the spray tip penetration with a crank angle. From the analysis, it was found that experimental results were in good agreement with the numerical values. By comparing the results, it's found a slight difference between the two is recorded which indicate accepted accuracy of the Diesel-RK results. Thus the proposed numerical solver Diesel-RK can be considered as an efficient tool which can be used for analysis of combustion, performance and emission.

6. Conclusions

1. By increasing the percentage concentration of Nano particles (AL_2O_3), it is noticed to increase the BTE slightly and reduce the BSFC, peak pressure and the ignition delay period as well.
2. The numerical results calculated by Diesel-rk software showed challenging reduction in SE emissions of 6.58%, 7.08% and 6.27% for 20%CME+25ppm AL_2O_3 Nano, 20%CME+50ppm AL_2O_3 Nano and 20%CME+100ppm AL_2O_3 Nano respectively as compared with 20%CME at full load**.**
3. The numerical results at full load condition calculated by Diesel-rk software showed a slightly decreased in PM emissions of 3.62%, 4.28% and 4.9% for 20%CME+25ppm AL_2O_3 Nano, 20%CME+50ppm AL_2O_3 Nano and 20%CME+100ppm AL_2O_3 Nano respectively as compared with 20%CME
4. It is found that the addition of nanoparticles (AL_2O_3) produces reduction in both NOx, emission by 11% and smoke opacity by 3 % as compared to 20% CME biodiesel.
5. Based on the findings of numerical results, the 25ppm AL_2O_3 was the best concentration of Nano addition as slight effect is noticed beyond 25%ppm for all parameters under study.
6. Even the use of Nano fuel acts as one dimension strategy to fight the NO_X effect from biodiesel but it leaves the doors open for multi-parametric optimization to decrease the trade-off relation (NO_X-smoke) as much as possible.

Conflicts of Interest

The author declares that they have no conflicts of interest.

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Table (1). Diesel and CME blends properties

Property	**Density at 15ºC (kg/m^3)**	**Viscosity at 40ºC (pa.s)**	**Calorific value (MJ/kg)**	**Surface tension (N/m)**	**Cetane number**
Diesel	830	0.002241	45.836	0.028	50
B20% CME	845.2	0.003925	45.556	0.03106	51.7
CME	900	0.01052	44.336	0.0433	53.4

Table (2) Engine Dimensions[16]

Engine Brand	**Kirloskar TAF-1**
Type of engine	4-Stroke, Diesel Engine, single cylinder
Bore	80 mm
stroke	110 mm
The cylinder capacity	0.553 L
The compression ratio	15.5
Rated power	3.7 kW , 1500 rpm
Orifice diameter	0.15 mm
Injection pressure	220 bar

Table (3) Physical properties of nanoparticles [5]

Particle	**Al_2O_3**
Density (kg/m^3)	3970
Specific heat (kJ/kg.K)	765
Thermal conductivity (w/m.C)	40
Average size(nm)	45
Shape	Spherical
Appearance	White

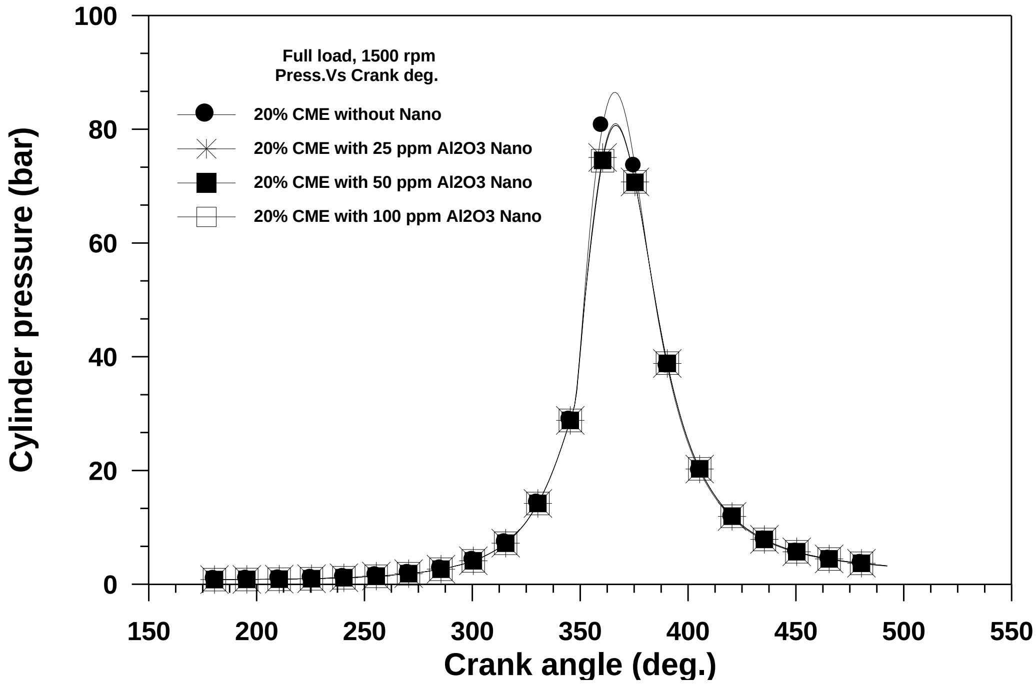

Figure (3) Variation of cylinder pressure with crank angle

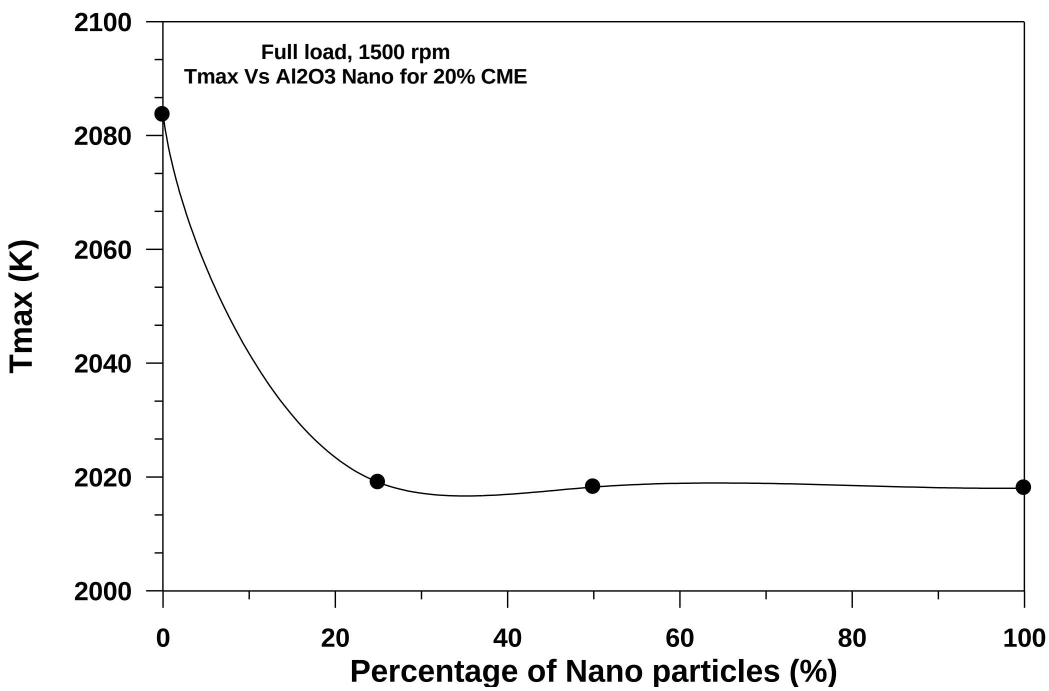

Figure (4) Variation of maximum cylinder temperature with percentage of Nano particles

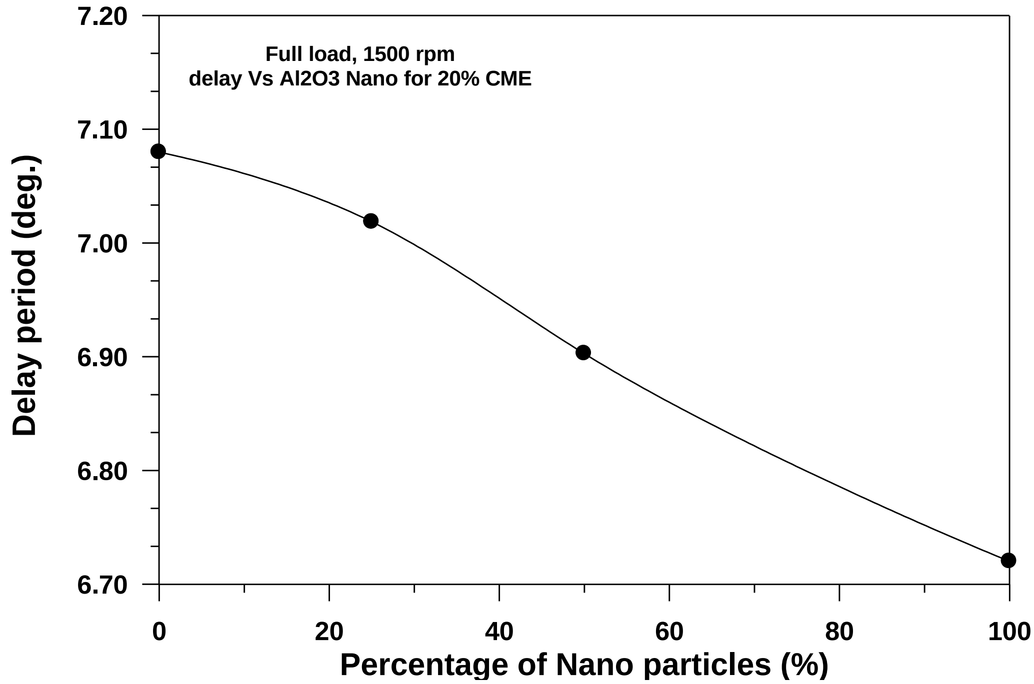

Figure (5) Variation of delay period with percentage of Nano particles

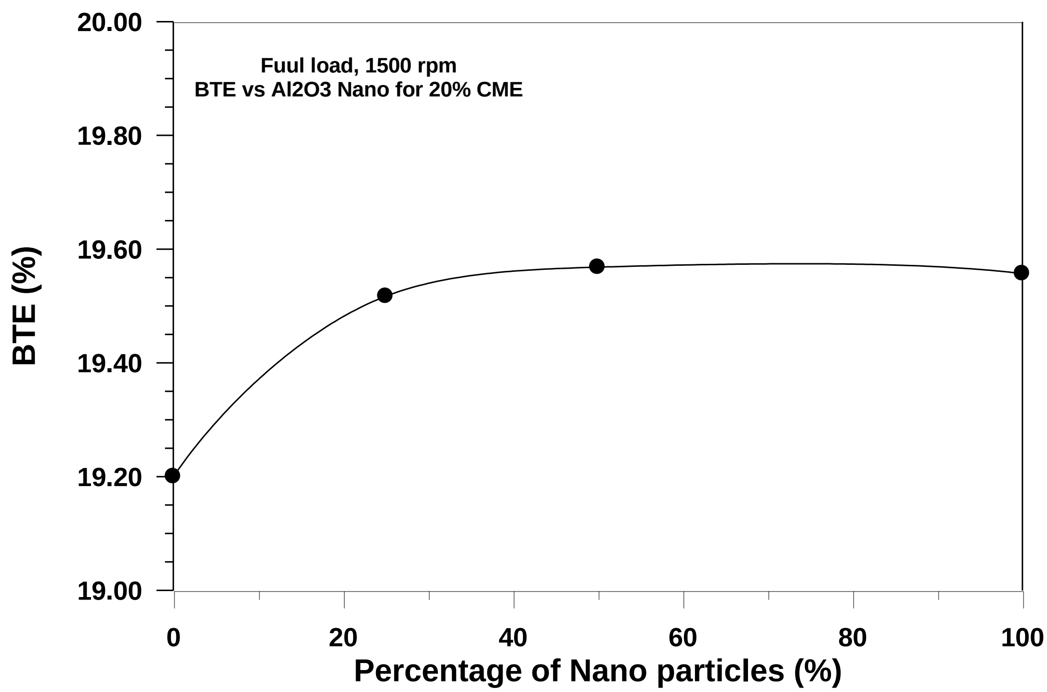

Figure (6) Variation of brake thermal efficiency with percentage of Nano particles

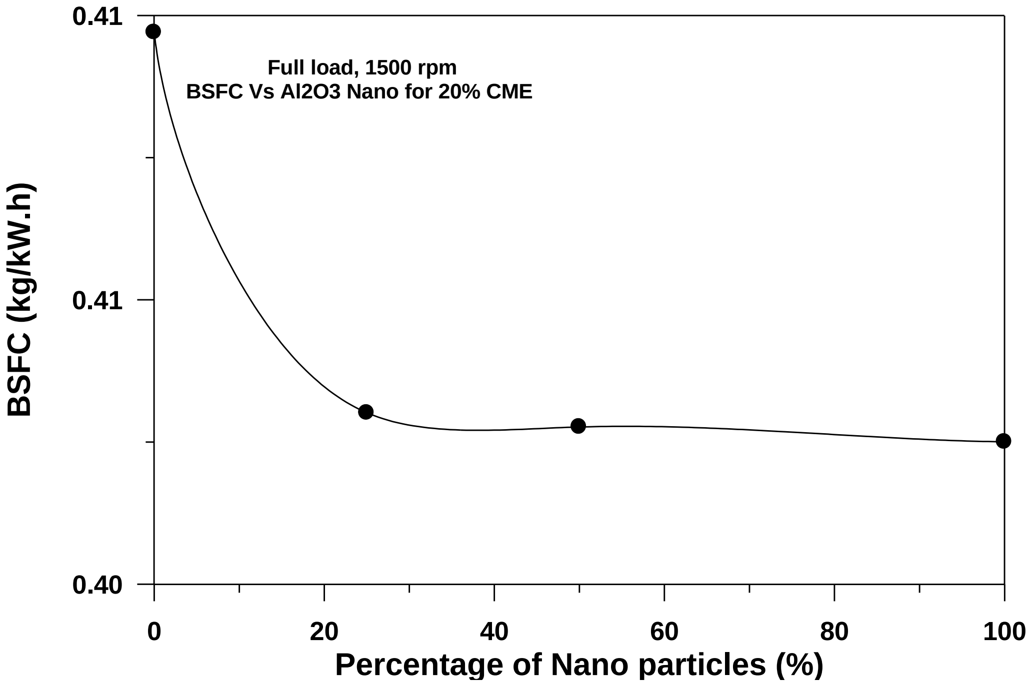

Figure (7) Variation of brake specific fuel consumption with percentage of Nano particles

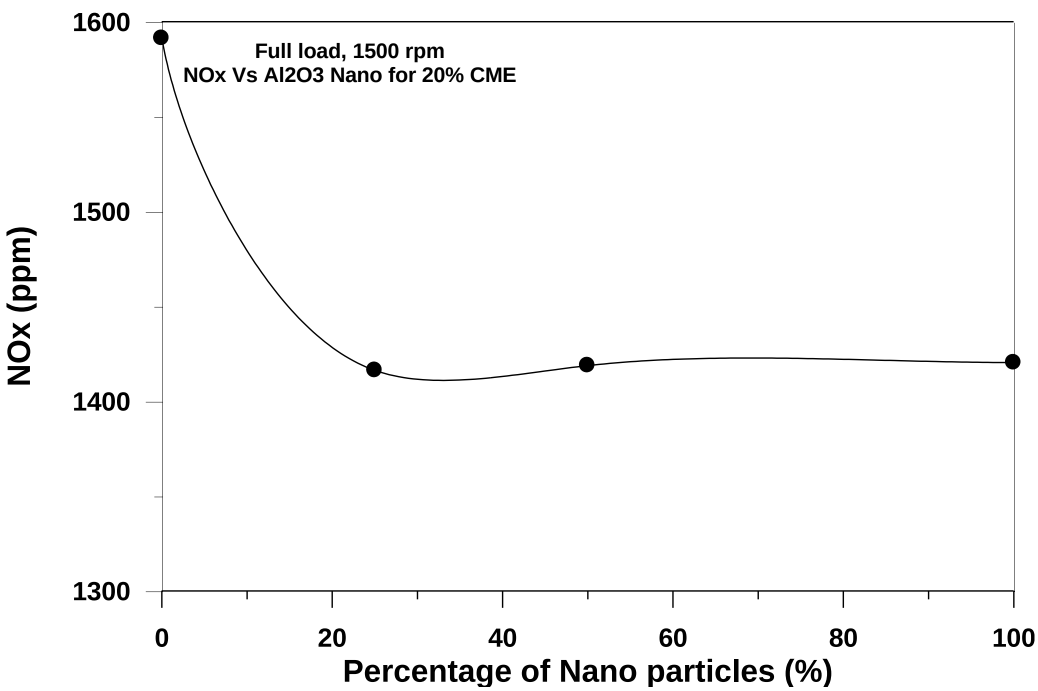

Figure (8) Variation of Nitrogen oxides emission with percentage of Nano particles

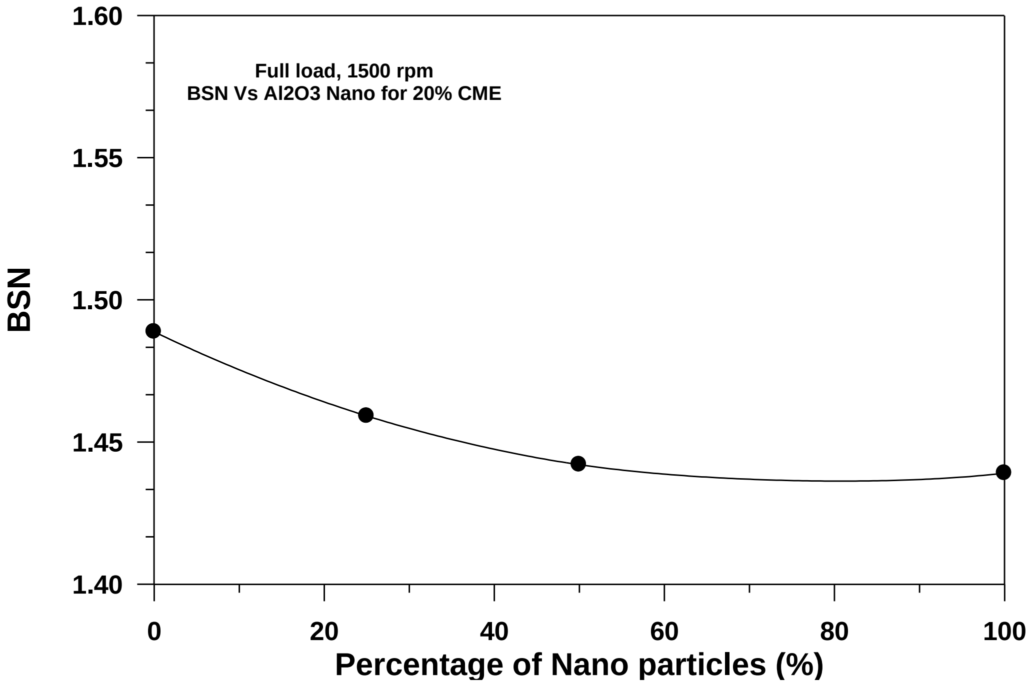

Figure (9) Variation of Bosch smoke number with concentration of Nano particles

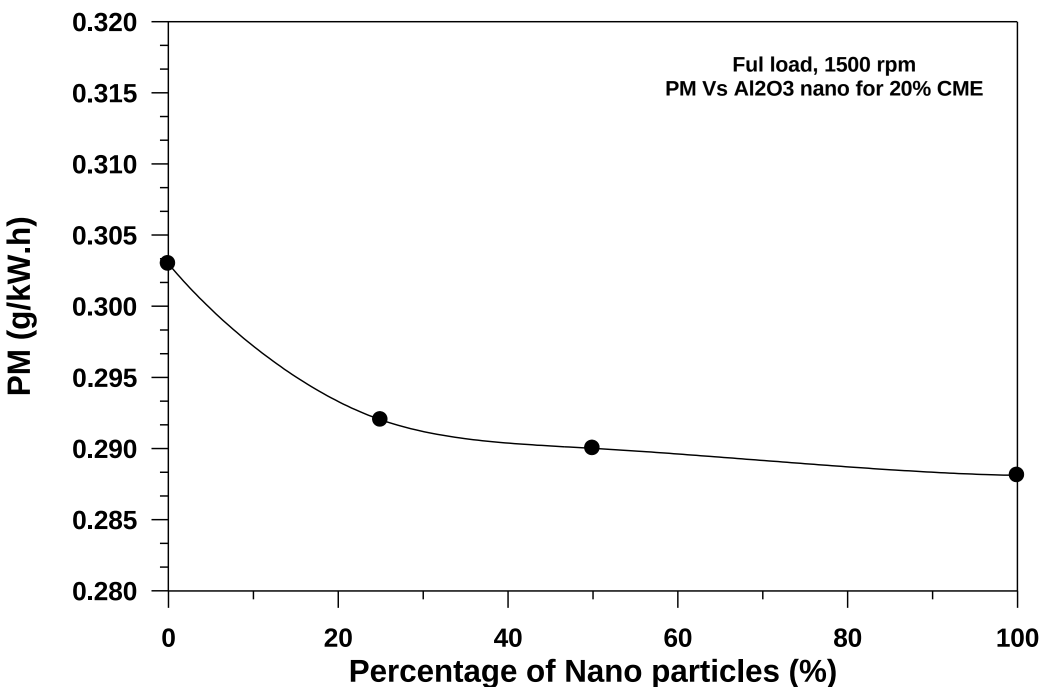

Figure (10) Variation of particulate matter with different concentration of Nano particles

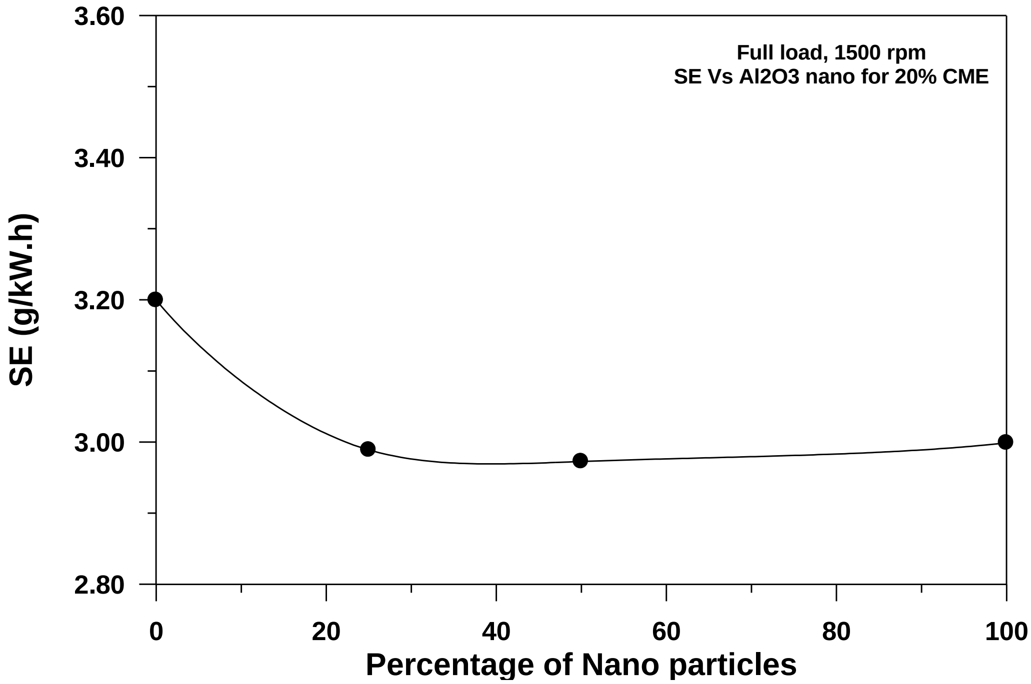

Figure (11) Variation of summary emission with different concentrations of Nano particles

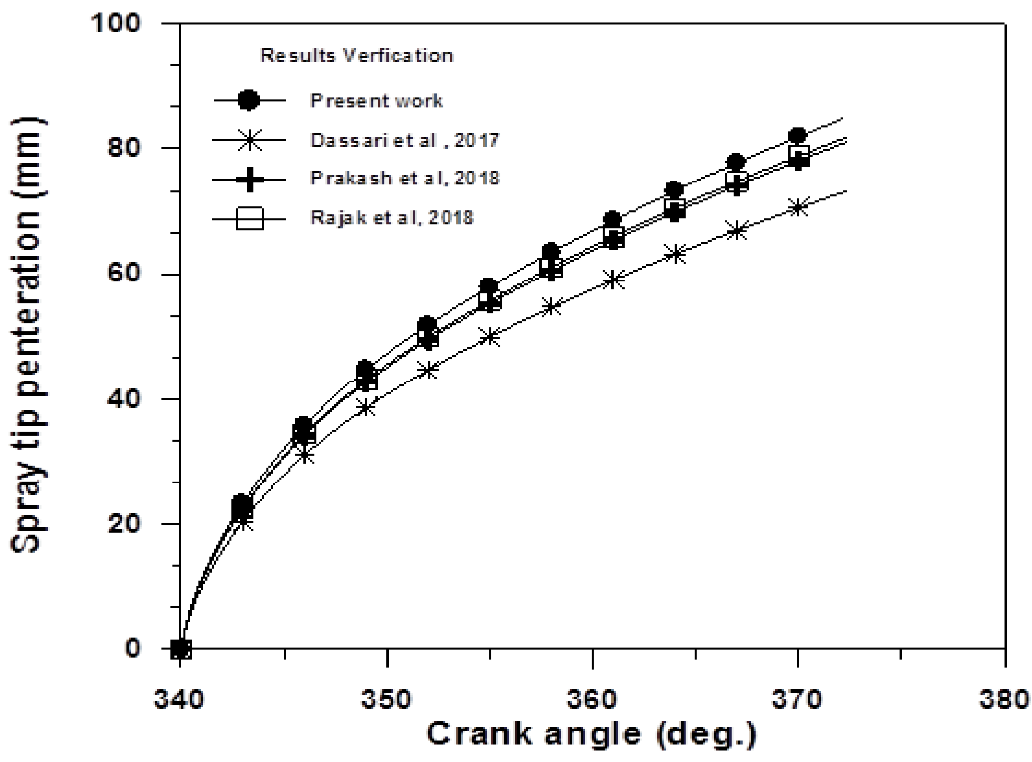

Figure (12) Variation of spray tip penetration with crank angle at full load

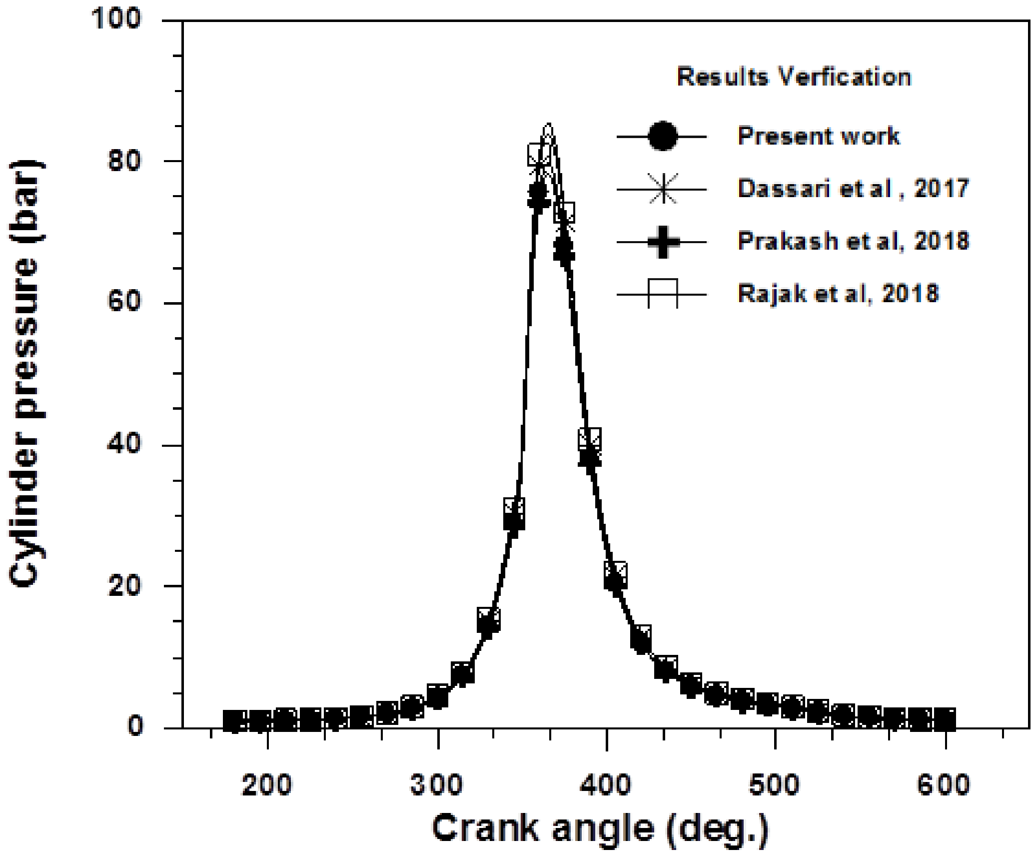

Figure (13) Variation of cylinder pressure with crank angle at full load

تأثير اضافة الوقود النانوني على خصائص محرك ديزل يعمل بخليط الوقود الحيوي

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الخلاصة

في هذا العمل تم اجراء تحليل عددي لتأثير تركيزات مختلفة من جزيئات النانو المخلوطة مع وقود الديزل الحيوي على خصائص محرك الديزل. تم استخدام برنامج المحاكاة Diesel-rk في هذا العمل. تم استخدام وقود الديزل الحيوي استر ميثيل الخروع (CME) والذي يتم تحضيره من زيت الخروع عن طريق عملية الاسترة. تم دراسة تأثير جزيئات النانو باستخدام ثلاثة تراكيز (25, 50، 100 جزء في المليون) من الالومينا ممزوجة بـــ B20%CME والتي تم تأكيدها من الدراسات السابقة باعتبارها أفضل نسبة معتمدة. عمومًا ، وجد أنه مع استخدام جزيئات النانو إلى جانب وقود الديزل الحيوي ، ينخفض ضغط الأسطوانة وفترة التأخير ودرجة حرارة الاحتراق. ادرجت تحسينات ملحوظة في الكفاءة الحرارية المكبحية ومعدل استهلاك الوقود. أظهرت النتائج انخفاضا كبيرا في قيم الدخان وانبعاثات أكاسيد النيتروجين وكذلك المادة الجسيمية (PM)، لذا يمكن اعتبارها طريقه لمحاربة التناقض بين (PM-NOx). أظهرت النتائج أن أفضل تركيز لجزيئات النانو كان ٢٥ جزء في المليون حيث لم يسجل أي تغير ملحوظ عند تجاوز هذا التركيز. تم التحقق من صحة النتائج العددية مع نتائج تجريبية أخرى في نفس ظروف التشغيل.

الكلمات الدالة: محرك الديزل، وقود الديزل الحيوي CME، وقود الالومينا النانوي، برنامج الديزل– RK.