THE COMPARISON OF EMISSIONS OF THE B5 TO B50 SOY AND CORN BIODIESEL BLENDED WITH DIESEL S50 FUEL

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Abstract. *A 3.8 kW MGD5000S Motomil diesel generator was used to compare the diesel S50 fuel to mixture B5 to B50 of soy and corn biodiesel emissions. It was evaluated the effect on emissions by varying the percentage of biodiesel to diesel from 0 to 50%, by volume. The carbon monoxide, carbon dioxide, nitrogen oxide and nitrogen dioxides emissions were analyzed. The S50 (B0) emissions were used as baselines to compare the emissions obtained using corn and soy biodiesels. First, the measurements were made at no load. The results using the engine at no load have shown that the overall effects by the increasing the BX mixtures were reduction on CO and* CO_2 *emissions and an increase in the nitrogen oxides emissions. It was verified that the engine load has a more significant effect on emissions than the amount of biodiesel in the diesel mixture. The higher is the applied load on the engine, the higher are the emissions of* NO_x*, CO and* CO_2*. Hence, with all results compiled the effect of increasing the percentage of biodiesel on the S50 diesel can be determined.*

Keywords*: biodiesel, biodiesel emissions, diesel, diesel generator*

1. INTRODUCTION (Times New Roman, bold, size 10)

Petrodiesel is a well-known fossil fuel used for transportation and electricity generation. However, its continuous use growth has contributed enormously to the augmentation of the world global warming and acid rain formation. New and reliable sources of fuels have been researched as a way to replace petrodiesel and reduce its harmful effects on the environmental. Due to economic, social and environmental reasons, since January 13, 2008, it is mandatory the use of biodiesel blended with all petrodiesel sold in Brazil. Initially, it was used a 2 % by volume mixture, called B2. But, since January 1, 2010, all diesel fuel has 5% biodiesel (by volume), the B5. The addition of biodiesel to petrodiesel affects the engine emissions, besides the amount of biodiesel and the type of biodiesel used in the biodiesel/petrodiesel mixtures (BX), and the load applied to the engine will affect the emissions of CO, CO_2, NO, NO_2 and NO_x in the flue gases. These gases are primary pollutants responsible for the global warming (CO and CO_2) and the remaining responsible for acid rain formation. In order to verify how the biodiesel type and engine loads affect the flue gases emissions, experiments were made using initially, only the petrodiesel S50 type A, i.e., pure petrodiesel with a 50 ppm sulfur content in order to have a baseline for comparison with the emissions when soy and corn biodiesels were used. The soy and corn biodiesel were mixed to petrodiesel in different proportions, 5%, 10%, 20%, 30%, 40% and 50% (BX), by volume, and were used as fuel in a 3.8 kVA diesel motor-generator running at partial and full loads. The S50 diesel is a sold in the Recife metropolitan area. Hence, this work reports the effect on CO, CO_2, NO, NO_2 and NO_x emissions when different proportions of corn and soy biodiesel were used on a 3.8 kW diesel generator operating at no load, partial load and full load conditions.

2.0 2. LITERATURE REVIEW

Biodiesel is a biodegradable fuel obtained by esterification or transesterification processes, the latter being the most common one. The transesterification process is a reaction between vegetable oils or animal fats with a short chain alcohol (methanol or ethanol), in the presence of a catalyst, which yields biodiesel and glycerin (Peres, 2009). Pure biodiesel, or B100, is obtained after the removal of contaminants such as catalysts, alcohol and glycerin residues.

The Brazilian National Agency of Petroleum, Natural Gas and Biofuels (ANP), on the Act 42 (2008) defines pure biodiesel as a fuel comprised of long-chain fatty acids alkyl esters derived from vegetable oils or animal fats, whose characteristics should meet the specifications described on this Act. Also, it defines BX as the mixture diesel / biodiesel composed of X % biodiesel and (100-X) % diesel oil (by volume). Thus, the B5 biodiesel, which is used in Brazil, has 5 % biodiesel in petrodiesel, by volume.

One of the major disadvantages in using biodiesel is a greater fuel consumption compared to petrodiesel. Peres et al (2010) show that most biodiesels have a 13% lower heating value than the petrodiesel ones. The benefits of using biodiesel in Brazil are focused on the social and environmental areas, besides the reduction of oil imports. According to Azevedo (2010), for every 1 % biodiesel added in the petrodiesel it would generate 180,000 new jobs in Brazil, in which 45,000 would be rural and 135,000 urban jobs. He also stated that with B5, more than one million jobs would be created: 270,000 in rural areas and 810,000 in urban ones. Azevedo describes also on his work that the benefits of biodiesel in the environment would be by reducing the emissions of air pollutants. He stated that the use of soy biodiesel B100 could reduce emissions of carbon monoxide (CO) by 48%, particulate matter (PM) by 47 %, sulfur oxide (SOx) in virtually 100 %; and, total hydrocarbons (HC) nearly 70 %. A study to validate the use of B5 in engines and vehicles sponsored by the Ministry of Sciences and Technology – MCT, used few types of biodiesel (castor and soy beans as feedstocks) and their blends with petrodiesel S2000, which is not used in the state of Pernambuco. In Pernambuco, only petrodiesel S50 and S1800 are commercialized mixed with 5% biodiesel. When castor biodiesel was used as feedstock, the percentages varied from 5 to 20%, due to its high viscosity. However, for soy biodiesel the MCT reported results using soy biodiesel (transesterified using the methanol and ethanol routes) in percentages varying from 5 to 100%. Even though, that report produced interesting results, it was limited to only two types of biodiesel feedstocks mixed to only to S2000. Almost no reports could be found on comparing emission from different types of biodiesel on S50. Hence, as Brazil´s biodiesel has a numerous feedstocks and not many results could be found on emissions using them as engine fuel, this served as motivation to carry out experiments comparing the emissions of S50 mixed with soy and corn biodiesel, which resulted in this work.

3. EQUIPMENT AND METHODS

The soy and corn biodiesel were made in the Combustion and Fuels Laboratory of the University of Pernambuco. In order to determine their composition a Gas Chromatograph GC Master, equipped with FID was used. Their heating values were determined using an IKA C-2000 calorimeter and, the Cetane index were calculated using the four variable method described in the NBR 14759. The emissions tests were carried out on a Motomil generator mod. MDG5000S, at the following percentages of the nominal loads: 0%, 25%, 50%, 75% and 100% for corn biodiesel and 0%, 25%, 50%, 75% and 90% for soy biodiesel. An analyzer Tempest 100 was used for the flue gases analysis. The tests were conducted using B0, B5, B10, B20, B30, B40 and B50 mixture with soy and corn biodiesels. The B0, i.e., no biodiesel was mixed to S50, for the construction of a base line for comparison. Then, there were used the soy and corn biodiesels in different proportions and loads to collect the data for make the emissions comparisons with S50 and between the two types of biodiesels.

4. RESULTS AND DISCUSSION

The soy and corn biodiesels were made and characterized at POLICOM. The results of their composition and heating values are shown on Table 1.

Table 1. Soy and Corn Biodiesels - Chemical Composition, Heating Values and Cetane Index .

FAME	Soy Biodiesel (%)	Corn Biodiesel (%)
C12:0	-	3.1
C14:0	-	1.0
C16:0	12.7	12.7
C18:0	2.9	1.9
C18:1	21.1	33.5
C18:2	57.2	46.9
C18:3	6.1	0.9
Saturated	15.6	18.7
Unsaturated	84.4	81.3
HHV(1) (MJ/kg)	39.91	39.77
LHV(2) (MJ/kg)	39.7	39.58
IC(3)	57.9 ± 0.8	57.84 ± 0.4

(1)HHV-Higher heating value; (2)LHV- Lower heating value; (3)IC- Cetane index

The effect of using the soy and corn biodiesels, in different % mixtures with S50 and engine loads, on the emissions of CO, CO_2, NO, NO_2, NO_x and SO_2 are shown in the next subsections. It has to be mentioned that even though the soy and corn biodiesel has a little differences on the amount of saturated and unsaturated compounds, this seems to affect the emission results. However, it will be observed that the loads applied have the major effect on the emissions, as higher the load, more amount of fuel will be consumed resulting in a higher emission on some flue gas components and in the reduction of others. The figures 1 to 10 illustrate the results obtained for each specific gas emitted when operating the Motomil MDG5000 S diesel generator.

4.1 Effect on CO emissions

The figures 1and 2 show the effect of using corn and soy biodiesels on CO emissions.

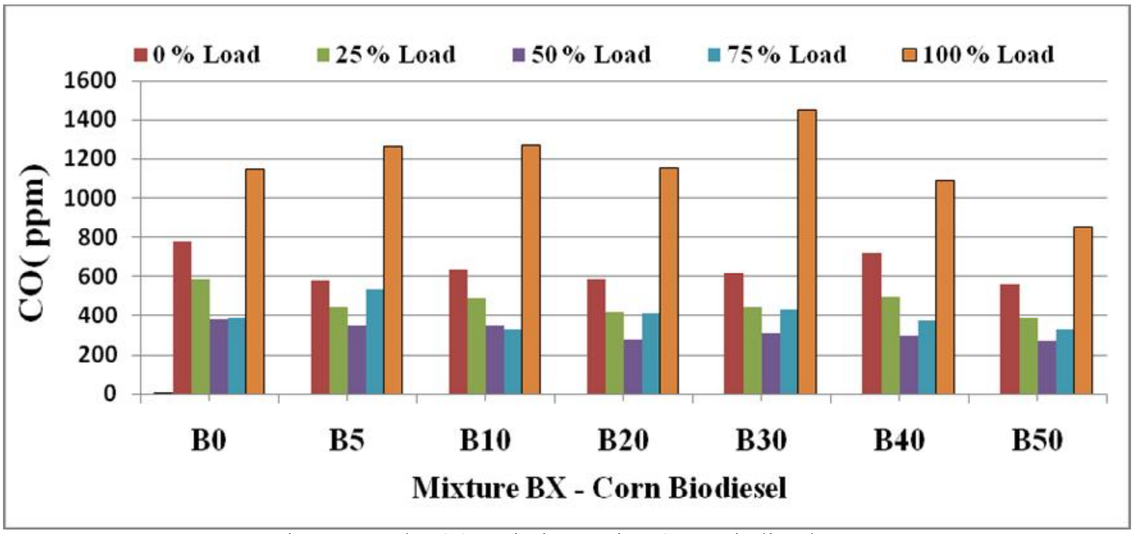

Figure 1 – The CO emissions using Corn Biodiesel

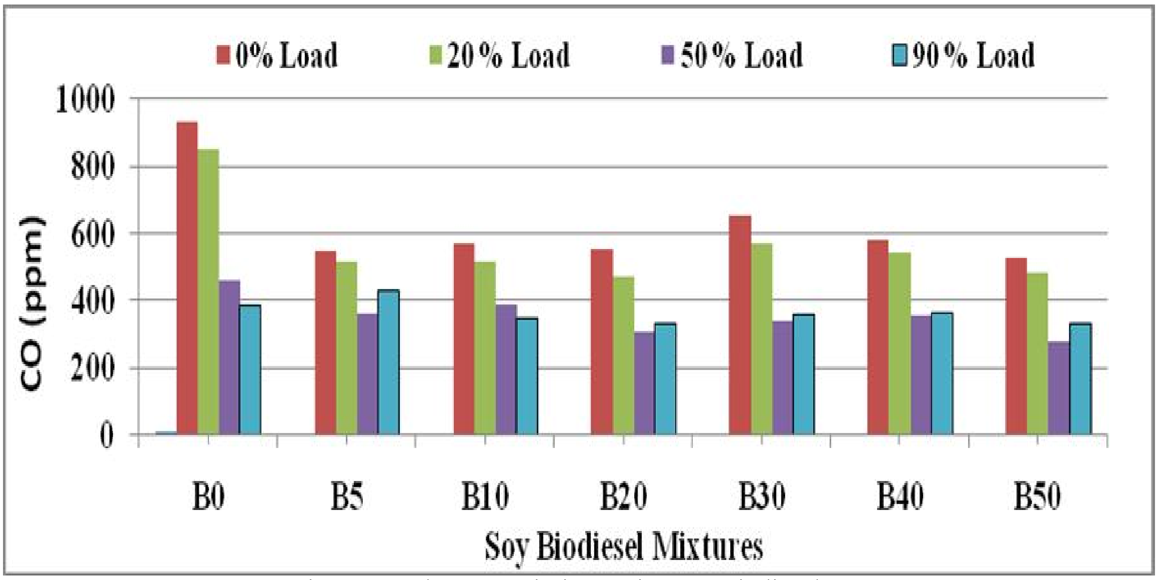

Figure 2 – The CO emissions using soy Biodiesel

From the figures above, one´s can see that using corn biodiesel the emissions were higher than for soy biodiesel. There were majors differences on the emissions when soy and corn biodiesels were used when compared to S50. For soy biodiesel, there was a decrease on CO emission with load. It seems that the fact the there is an oxygen fuel born for biodiesel helped to reduce the CO emission at 0% load. As the load increased, the temperature in the combustion chamber also increased. This seemed to have helped to obtain a more efficient combustion, what can be observed for the soy biodiesel. However, the same behavior was not observed for the corn biodiesel, as the CO emissions at full load were much higher than the one´s obtained for soy biodiesel.

4.2 Effect on CO_2 emissions

The figures 3 and 4 show the effect of using corn on CO_2 emissions.

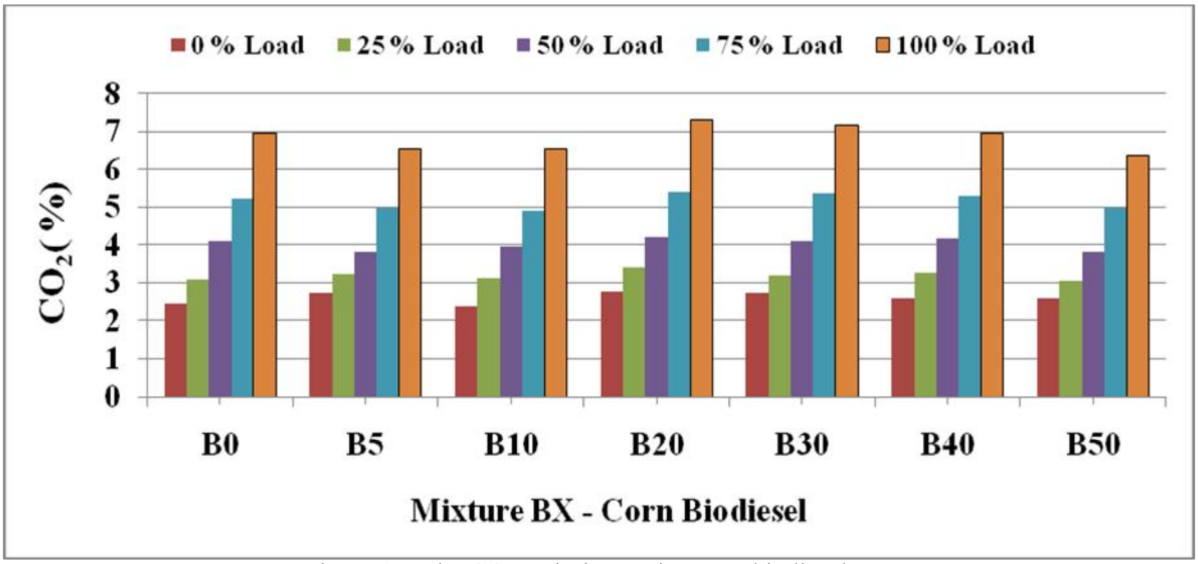

Figure 3 – The CO_2 emissions using corn biodiesel

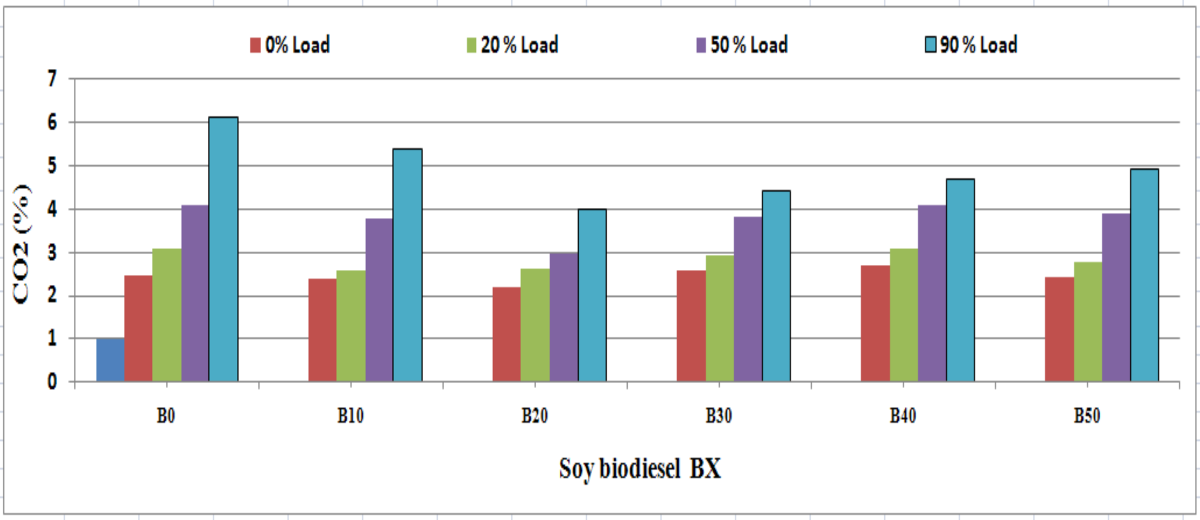

Figure 4 – The CO_2 emissions using soy biodiesel

These pictures show that the CO_2 emissions increases directly with the engine load. When corn biodiesel was used, there was a small reduction on the CO_2 emissions using B5 and B10, but there were no significant changes when the amount of biodiesel on diesel varied. However, as the load increased, so did the fuel consumption and the efficiency of combustion, simultaneously with the reduction on the CO emissions. For the soy biodiesel, there was a significant change on CO_2 emissions when increasing the amount of biodiesel up to B20, after that the CO_2 emissions increased but they are significantly lower than for B0. Also, it can be observed that the emissions for corn were higher than for soy biodiesel.

4.3 Effect on NO emissions

The figures 5 and 6 show the effect of using corn on NO emissions.

As can be observed in figure 5, the amount of NO emitted increased steeply with load, however it is possible to observe that there was an increase in NO emissions when corn biodiesel was used in comparison with the emission obtained using the S50 petrodiesel. However, there was no significant change when the volume of biodiesel in the mixture increased. The only exception was for B5, when the NO emission for full load was smaller than the one for pure petrodiesel.

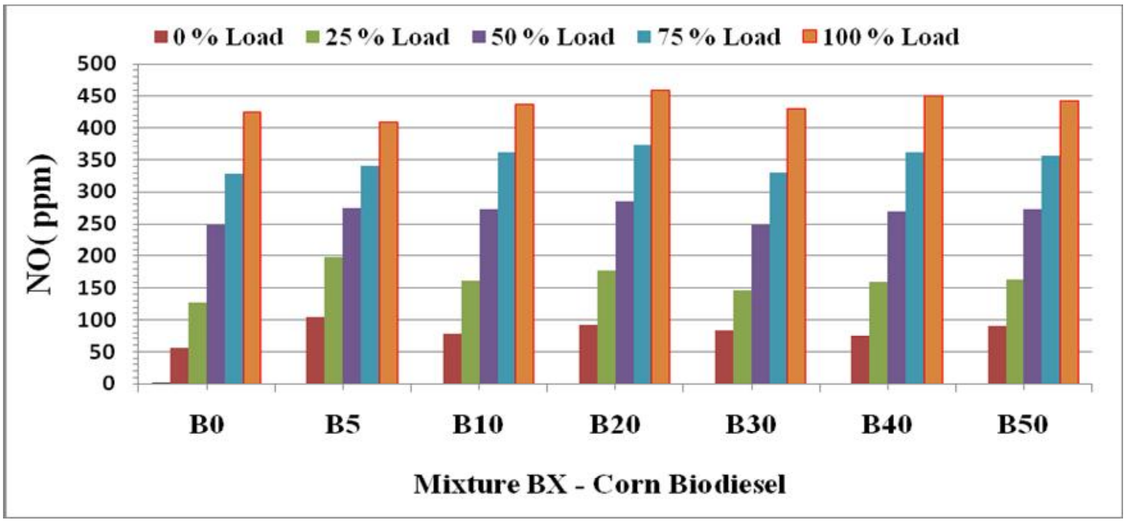

Figure 5 – The NO emissions using corn biodiesel

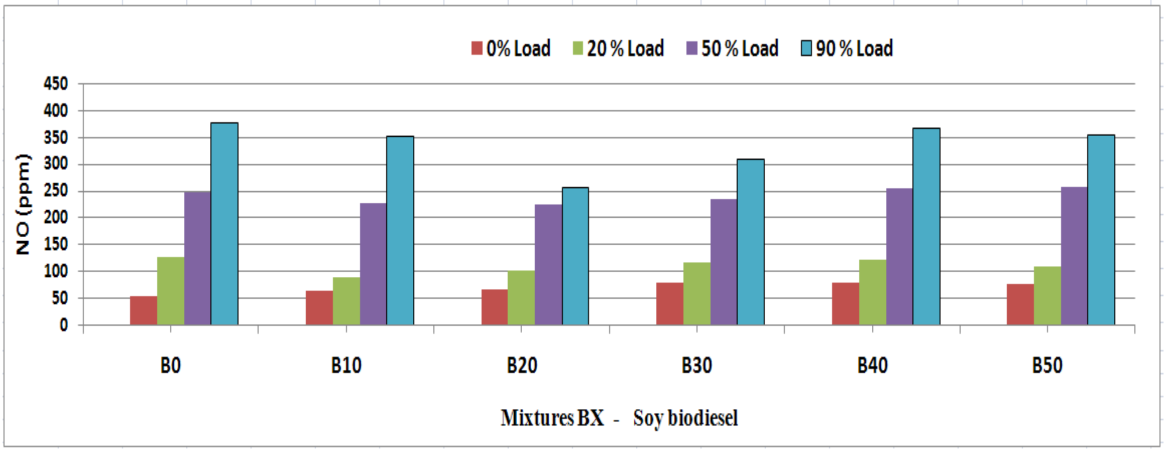

Figure 6 – The NO emissions using soy biodiesel

However, when soy biodiesel was used, the NO emissions were lower than the ones for petrodiesel at full load. However, it showed a slighlty increase at 0% load. The greatest reduction was otained when using B20.

Even though for corn biodiesel there was a small increase in NO emissions at full load if compared to S50 at same load, for soy biodiesel there were a little lower. When comparing the NO emissions using corn and soy biodiesel, it was observed that soy biodiesel emitted less NO than the corn biodiesel. More investigation shoul be done in order to verify the effect of the unsaturated and saturated esters content in the biodiesel on the emissions. Also, it was observed that the effect of load on emissions are much greater than for increasing biodiesel content on petrodiesel.

4.4 Effect on NO_2 emissions

The figures 7 and 8 show the effect of using corn and soy biodiesel on NO_2 emissions. The emissions using only S50 were lower than the using biodiesel in almost all load conditions. It was noticed that higher the engine load the smaller were the NO_2 emissions in all biodiesel mixtures on petrodiesel.

At full load, the corn biodiesel emissions have not varied much, when compared the petrodiesel´s. The highest emission at full load was obtained when B20 was used. However, even though that was an increase in the NO_2 emission when soy biodiesel was used, the emissions at full load varied between 20 to 40 ppm, similarly to the corn biodiesel ones.

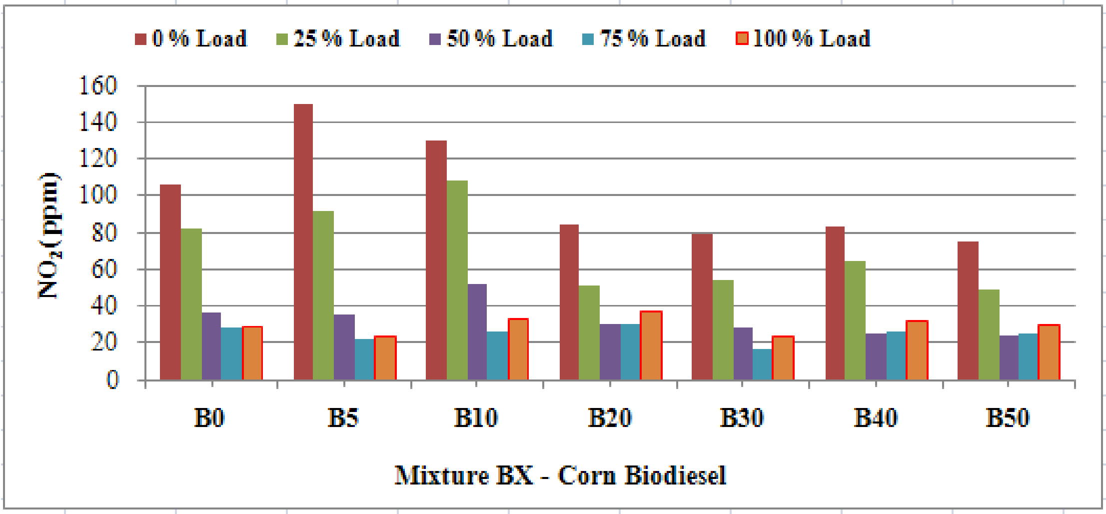

Figure 7 – The NO_2 emissions using corn biodiesel

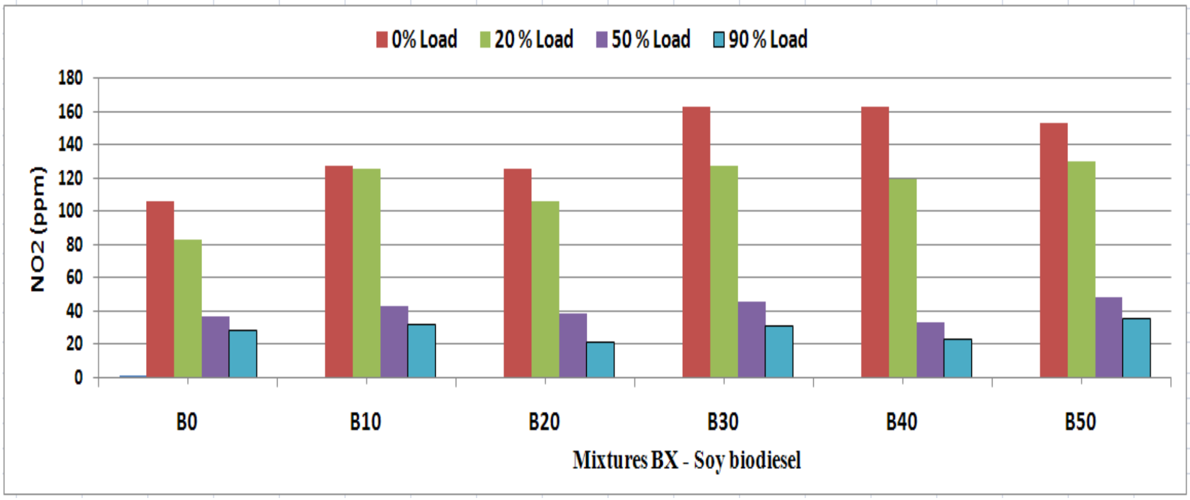

Figure 8 – The NO_2 emissions using soy biodiesel

4.5 Effect on NO_x emissions

The figures 9 and 10 show the effect of using corn on NO_x emissions.

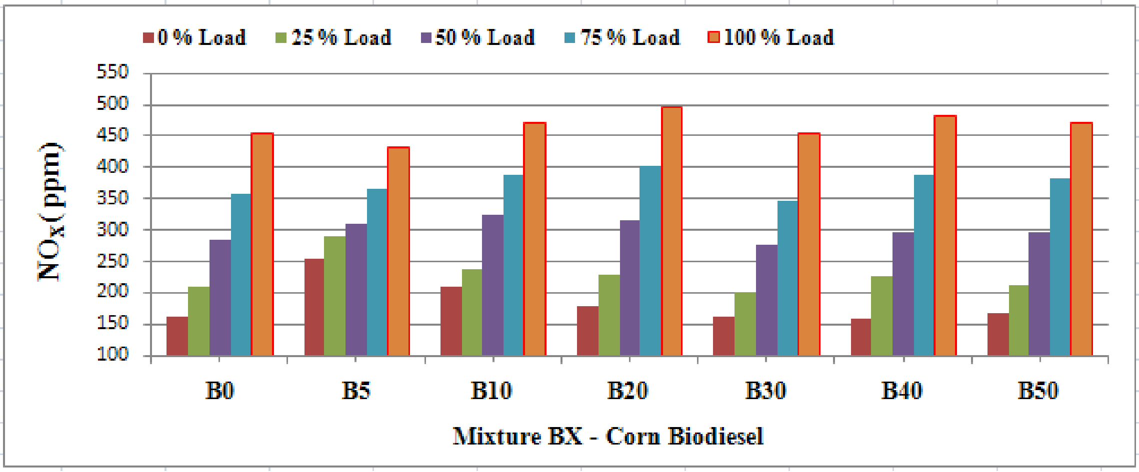

Figure 9 – The NO_x emissions using corn biodiesel

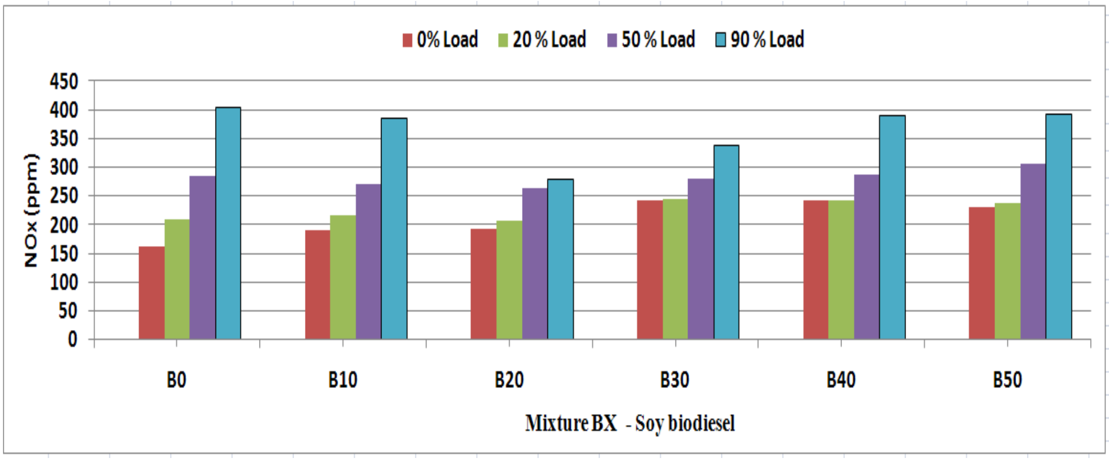

Figure 10 – The NO_X emissions using soy biodiesel

When a comparison between soy and corn biodiesels for the oxides of nitrogen overall emissions was made, it was noticed that the emissions grew with load and the no significant change was observed when there was an increase on the biodiesel content in the fuel. However, it was noticed that the NO_x emissions using corn biodiesel was about 10% higher than the ones for soy biodiesel, in almost all BX mixtures and loads.

5. CONCLUSIONS

The effect of load on emissions was more significantly observed than the increment of biodiesel content in the petrodiesel. It was observed that CO emissions decreased with load at the same time that the CO_2 emissions increased. However, the effect of adding more biodiesel on diesel S50 was less noticeable. On the other hand, it was noticed that the CO_2 emissions when using corn biodiesel were greater than when corn biodiesel was used. The NO emissions increased with engine load while the NO_2 emissions decreased, however, the overall NO_x emissions increased with the increment of load in the motor generator. At 0% load, the NO_x emissions increased about 40% using biodiesel in comparison to S50 only. At high loads the emissions with corn biodiesel were bigger than the ones with soy. However, more investigations have to be made in order to verify the effect of the unsaturated and saturated esters content on biodiesel emission of CO, CO_2, NO, NO_2 and NO_x.

6. ACKNOWLEDGEMENTS

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