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The impact of alternative fuels to diesel in reducing pollution from vehicles

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Abstract

The main source of energy for vehicles is currently internal combustion engines. These engines emit the main pollutants carbon oxide, carbon dioxide, hidrocarbons, nitrogen oxides, and particles matters into the atmosphere. The biggest polluter of nitrogen oxides and particles are diesel engines. For this purpose, the addition of alternative fuels ethanol, methanol, biodiesel, and Fisher-tropsch fuel to conventional diesel fuel in the amount of 5-15% has been studied, to see their impact on the reduction of carbon dioxide and pollution. For this, the analytical method of carbon dioxide calculation, experimental data from the literature and experimental measurements of the opacity coefficient were used. From the obtained results, it results that in reduction of CO_2 affect more the fuels B15 up to 11.5%, M-15 up to 9%, FT 15 up to 7.5% and E-15 up to 6%. Also, M 15 has the greatest impact on the reduction of particles and nitrogen oxides with a reduction of 45% and 30% respectively, followed by E 15 with 30% and 20% and B15 and FT15 with 30% and 25%. Experimental measurements of the opacity coefficient confirm that the use of M15 and E15 fuels reduces pollution by 35% and 25%.

Introduction

In recent years, it has been determined that the acceptable limit of the level of CO_2 without causing serious consequences for the environment is 450 ppm [1], while if the limit value of 750 ppm is exceeded, we will have an irreparable environmental crisis, which is thought to be reached around the year 2100, if this rate of CO_2 production continues.

Several studies have determined that to meet the energy needs of an ever-growing population, energy needs in 2040 will double, in 2070 they will triple and in 2100 they will quadruple. The result of this forecast indicates an increase of more than 300% of CO_2 gas in the atmosphere [2]. At the world level in 2014, more than 30 billion tons of CO_2 were produced, which comes from the production of electricity in 45% and from transport in 18% [3].

Conventional fuels consisting of hydrocarbons extracted from fossil oil are mainly used in transport vehicles. From the use of these fuels in vehicle, mainly carbon dioxide and other polluting gases such as CO, CH, NOx and carbon particles are released into the atmosphere. Carbon dioxide before it was considered harmless to humans, but in the last years after 2010 it is considered dangerous, because it affects the global warming of the atmosphere. Diesel engines have a higher degree of pollution than engines with gasoline, because they release high amounts into the atmosphere of nitrogen oxides, and carbon particles. Nitrogen oxides affect the greenhouse effect of the atmosphere, while PM particles affect human lung damage and cancer.

Under these conditions, the International Energy Agency (IEA) predicts the forced use of biofuels in vehicles, up to 5% in 2030 [4]. This attention for biofuels is related to the fact that the use of biodiesel reduces emissions net of CO2 _ with 78.45%, particles with 32%, CO with 35% and NOx with 8%, in compared with diesel [5,6].

Based on the needs to reduce the amount of CO_2 produced by vehicles and pollution caused by vehicles, we have undertaken this study for diesel fuels mixed with alternative fuels, in order to reduce the pollution.

Material and Method

To carry out the study, the analytical method of calculating the carbon dioxide released by alternative fuels during combustion in the engine and experimental measurements performed for 3 cars with diesel engines.

Diesel fuels used in vehicles

The fuel that is commonly used in diesel engines is called diesel and is a mixture of heavy hydrocarbons, which have a large molecular mass, with carbon atoms 12-22, with boiling points from 149-399^0 C. According to the molecular mass, 2 categories of diesel are used [9]:

Light diesel with chemical formula $C_{12.3}H_{22.2}$ with a molecular weight of about 170, which has a low viscosity and is easily injected, but is more expensive and is used in engines with high pressures.

Heavy diesel with chemical formula $C_{14.6}H_{24.8}$ with a molecular weight of about 200, which has a higher viscosity and is injected with some difficulty but is less expensive and widely used in vehicles. The density of diesel varies in 0.83-0.86 kg/dm^3 and the calorific power, in 9500-10500 kcal/kg.

Compound fuels with additives of alternative fuels in fossil diesel

We have formed several fuels of mixing of diesel with alternative fuels ethanol, methanol, biodiesel and Fischer-Tropsch, in a percentage of 5%, 10% and 15%, which we named with the brands: E-5, E-10, E-15; M-5, M-10, M-15; B-5, B-10, B-15 and FT-5, FT-10, FT-15. In additions of alternative fuels, we have stopped up to 15%, so that their use in diesel engines does not damage the engine's work and does not require.

The alternative fuels used in the study have the following characteristics [9]:

a) Ethanol is known as ethyl alcohol or wheat alcohol, is a chemical compound with the formula C_2H_5-OH. Ethanol has a calorific value of 6400 kcal/kg, lower than diesel.

b) Methanol, known as methyl alcohol, or wood alcohol, is a chemical compound with the formula CH_3-OH. Methanol has a low calorific value of 4200 kcal/kg.

c) Biodiesel fuel is a renewable fuel that can be produced from vegetable oils, animal fats, or recycled restaurant fats. Its characteristics are in accordance with the specifications of the standards for use in diesel engines. Biodiesel is a clean fuel, which does not release polluting emissions during combustion. The creation of carbon is almost 4 times less than conventional diesel [5].

*d)*Fischer-Tropsch synthetic fuels are produced from fossil products or biomass using CO and H2 extracted in a process similar to hydrogenation, producing gasoline and diesel. They have the same characteristics and performance as diesel and burn cleanly, reducing the level of greenhouse gases to 80%, CO_2 to 50% and carbon particles to 20-50% [9].

Estimation of the amount of carbon dioxide released by the burning of fuels

To determine the amount of carbon dioxide, we will use the equation of the chemical reaction of fuel combustion,[12] that we will use for mixtures that are:

a) Diesel. In the study we are taking the second most used category. The combustion process is expressed by:

$$C_{14.6}H_{24.8} + 20.8\,O_2 + N_2 = 14.6\,CO_2 + 12.4\,H_2O + N_2 \quad (1)$$

So during the burning of 1 kg diesel, will be released : 14.6x44/200=3.21 kg CO_2.

b) Ethanol. The combustion equation of pure ethanol is expressed as:

$$2C_2H_5\text{–}OH + 6O_2 + N_2 = 4CO_2 + 6H_2O + N_2 \quad (2)$$

So, during the burning of 1 kg ethanol, are released: 4x44/2x46=1.91 kg CO_2.

c) Methanol. The combustion equation of pure methanol is expressed as:

$$2CH_3\text{–}OH + 3O_2 + N_2 = 2CO_2 + 4H_2O + N_2 \quad (3)$$

So, during the burning of 1 kg methanol, are released: 2x44/2x32=1.37 CO_2

d) Biodiesel fuels. Pure biodiesel (B100) during combustion releases 4 times less CO_2 [5], so 0.8 kg CO_2

e) Fischer-Tropsch synthetic fuels. Clean fuel (FT100) during combustion releases 50% of the CO_2 of diesel [10], thus releasing 1.6 kg CO_2.

The amount of CO_2 released by burning 1 kg of composite fuel will be calculated:

$$G_{CO2} = G_K \times P_i + G_D \times P_i' \quad (5)$$

Where:
G_K – Amount of CO_2 produced by the alternative fuel (100%), obtained from estimates b,c,d,e
G_D - The amount of CO_2 produced by the second type of diesel, obtained from the estimate a .
P_i - The percentage that the alternative fuel occupies in the composite fuel, which are: 0.05, 0.1 and 0.15
P_i' - The percentage of diesel in the composite fuel, which are respectively 0.95, 0.9 and 0.85

The results of the calculations performed for the composite fuels are shown in Figure 1.

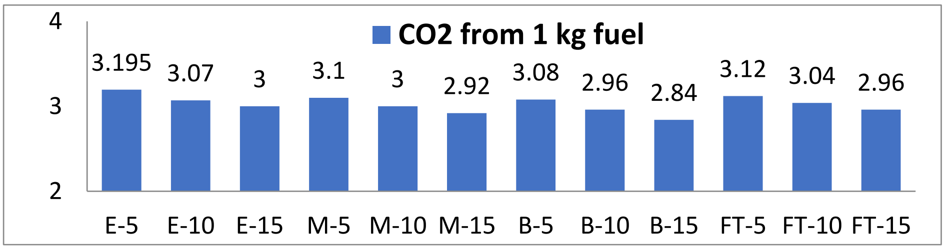

Figure 1. Amount of CO_2 for brands of formed fuels.

Experimental determination of the degree of vehicles pollution

For vehicles with diesel engines, the evaluation of the degree of pollution is done by the opacity coefficient, which indicates the degree of turbidity caused by the combustion gases escaping into the atmosphere.

Thus, for fuels composed with ethanol and methanol, experimental measurements of the opacity coefficient were performed at the vehicle technical control center for 3 vehicles with diesel engines equipped with the 3 types of fuel systems currently used in diesel engines.

For the above three vehicles, the measurements were carried out according to the relevant methodology [10] for fossil fuel and for mixed fuel brands E-5 E-10 E-15 M-5 M-10 M-15.

The results of the measurements performed for the 3 mixtures ethanol and methanol are shown in Figure 2.

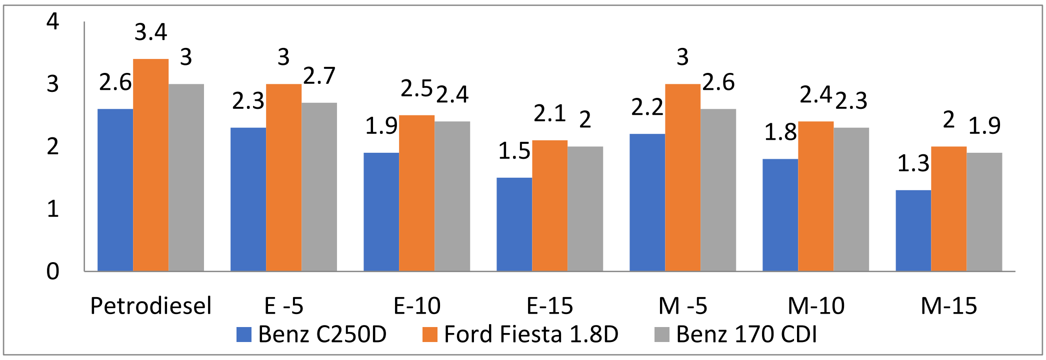

Figure 2. Opacity coefficient for the 5 fuels formed with alternative fuels

Results

The results of the calculations show that ethanol produces 1.5 times less carbon dioxide than diesel, methanol 2.2 times less, biodiesel 4 times less and Fischer-Tropsch fuel 2 times less than diesel. While the results for the amount of carbon dioxide produced by the fuel blends, biodiesel, Fischer-Tropsch, methanol and ethanol, up to 15%, reduce carbon dioxide by 11.3%, 7.5%, 8.7% and 6% respectively. And the results of experimental measurements from fig. 3, show that fuel M 15 and E15 affect the reduction of the opacity coefficient by 35% and 25%, respectively.

Based on the above results, we propose mixed fuels with 10 to 15% Biodiesel, Fischer-Tropsch, methanol and ethanol, because this provides us a total reduction of greenhouse gases (CO_2) up to 11.5%, but also a significant reduction of environmental pollution from particles around 30-45%.

Conclusion

The use of Fischer-Tropsch diesel fuel in vehicle achieves a reduction of carbon dioxide up to 2 times and pollution from nitrogen oxides and carbon particles by 80% and 50%, respectively, compared to conventional diesel.

The use of M15 and E 15 fuels achieves a reduction of carbon dioxide by 8.7% and 6% respectively, and the degree of pollution by NOx and carbon particles up to 35% and 25% compared to conventional diesel.

The use of M15 and E 15 fuels reduces the opacity coefficient by 35% and 25%, respectively compared to conventional diesel.

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