USING BIODIESEL IN ENGINES – WHAT DO ENGINES NEED? AN EMISSION AND PERFORMANCE EVALUATION.

Serrano, LMV
University of Coimbra
lserrano@estg.ipleiria.pt

Câmara, R
University of Coimbra

Carreira, V
University of Coimbra

Silva, MCG
University of Coimbra

Abstract

Several tests, simulating the urban utilization of a diesel engine, were conducted in an chassis dynamometer to acknowledge the indirect injection engine performance and emissions when using several percentages of biodiesel, from lean diesel (B0) to 100% biodiesel (B100),. After these preliminary tests, some blends of this soybean based fuel were rejected. The remaining fuels were tested more accurately, following the prescriptions of the regulation, with some extra-urban test conditions. The purpose is to know the differences regarding consumption and emissions results. Considering these results, the goal is to evaluate what the most efficient fuel for this kind of engine is, crossing the performance tests results with the extra urban tests results.

The base perspective is that thereôs no need to study neat biodiesel. The only reason why the use of this particular fuel is tested is to have the perception of the end of the scale results. Reinforcing this idea, the worst data was obtained using B100. Thinking globally, thereôs no way to get enough vegetable oil to replace completely the diesel use, without causing ambient and social irreparable damages.

The specific fuel consumption results were somewhat surprising, giving hope to the biodiesel use. One must consider the fact that these tests were made on engines that have been developed to get a bigger efficiency out of diesel and not biodiesel. There is still a long way to go in order to achieve this kind of performance using biodiesel blends.

The goal of this project is to get a deeper knowledge on the origins of the differences and work on that to achieve better engine performance when using some biodiesel blends.

Keyword: *biodiesel, fuel consumption, engines, energy*

5. Introduction

Having in mind that the perspectives of energy needs are increasing, and the consequential consumption of energy fossil reserves, the search of new solutions that can help to support the world's energy demands is crucial being biofuels one of the possible solutions.

For a proper utilization of biodiesel in engines, as a source of energy, it is necessary to understand how to make the best out of its efficiency, knowing beforehand engines were submitted to decades of development in order to consume diesel with some particular properties, and that biodiesel can not match exactly these properties. This implies a long way to go to understand the engine behavior when biodiesel is used, and to acknowledge the aspects which one must know and understand in order to get a better performance and lower consumption and emissions. To make a contribution to this research, a 4 cylinder indirect injection diesel engine, from a Ford Taunnus vehicle was used, in a 740kW capacity chassis dynamometer.

6. Urban Tests Cycles

The tests made, which simulated the circulation of vehicles in urban conditions, allowed the comparison between different fuel blends, from lean diesel (B0) to 100%biodiesel (B100), in a indirect injection engine through its consumptions and emissions analysis. It was necessary to change a little the conditions of the test, because it was verified that, there was not enough time to stabilize the vehicle in order to acquire the correspondent data needed for the test imposed conditions. The solution adopted was to multiply by 3 the time spent on the stabilized area of the cycle.

According to figure 1, it is possible to notice that the consumption of different fuels in same cycle conditions is affected by the biodiesel proportion in diesel. However, this engine behavior is not proportional to the biodiesel percentage, giving a interesting insight. The higher heating value changes proportionally to the blend used. This value is of 43MJ/kg for diesel and lowers to about 37,5MJ7kg for biodiesel, implying that there are other factors which alters the fuel consumption.

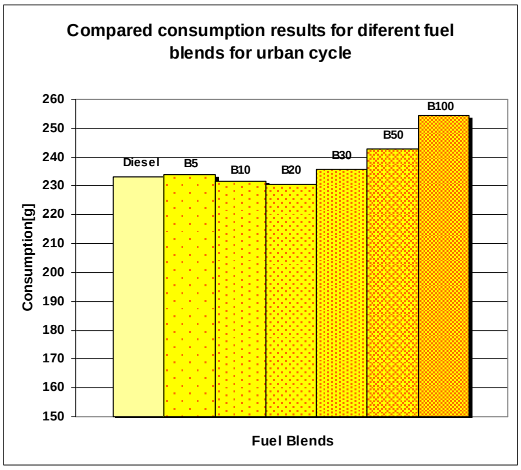


Fig.1 – Consumption Different Results for Urban Condition Tests, with different fuel blends.

7. Extra-Urban Tests Cycles

After these preliminary tests, some blends of this soybean based fuel were rejected. The methodology used to select the rejected fuel combinations was to choose the ones where a revealed tendency was follow (B10, B30), and the ones where no significant changes were noticeable (B5). The remaining fuels were tested more accurately, following the prescriptions of the regulation with some extra-urban test conditions. The purpose is to know the differences regarding consumption and emissions results.

Using the same procedure as before, now with different cycle conditions, simulating extra-urban vehicle circulation, some more tests were done, obtaining the results showed on fig. 2.

Comparing figures 1 and 2, it can be seen that the changes in conditions of engine operation promotes a change in fuel consumption relative analysis. For extra urban conditions, the differences obtained for fuel consumption are more close to high heating value differences for several fuels considered. This suggests the idea that several other aspects have to be considered to explain the revealed differences in consumption, besides the energy contained in the fuel, one should also considerer the engine operation and the different combustion conditions. Both aspects are also affected by several other factors, like density, viscosity and lubricant properties of fuel, moisture with air and oxygenate atoms contained in fuel, cetane number, among others.

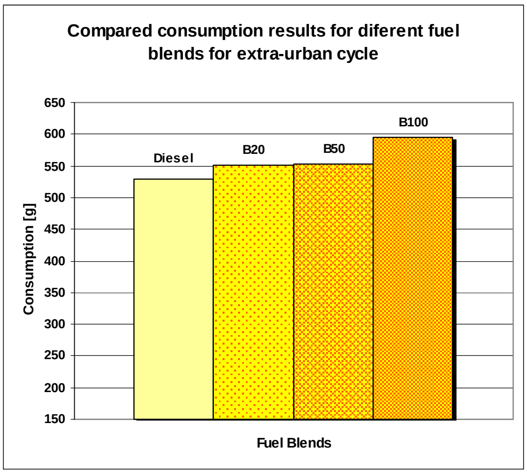


Fig.2 – Consumption Different Results for Extra-Urban Condition Tests, with different fuel blends.

The highest consumption verified in all tests was the one obtained from the highest percentage of biodiesel (B100), while the best values were obtained for B0 on extra-urban conditions and B20 for urban conditions. This may reveal that, for a more stop and go engine behavior, the properties of biodiesel can have a stronger effect than the lower energy contained. Logically, this effect becomes more diluted for higher percentages of biodiesel, when the smaller heating value becomes dominant in contrast with other properties.

From another point of view, the oxygen contained in biodiesel can improve the combustion reaction rate, and that brings a better engine performance when B20 is used. This is not as relevant for some higher levels of biodiesel. In fact this is one aspect that need to be studied more deeply because, the level of oxygen contained "inside" the biodiesel changes the ratio air/fuel. This could have a positive impact for a small percentage, since the introduction of oxygen atoms on fuel domain improves the mixture of the combustion reactants, increasing thermal efficiency. For higher oxygen content on fuel, by higher percentages of biodiesel, it is possible that the contribution of pouring the mixture has a negative effect that promotes the annulment of a better mixture of combustion reactants effects.

8. Emissions

The emissions analysis can help to confirm the assumptions made based on consumption comparisons. In fact, it becomes clear that the relation of the evolutions of CO2 and O2, reveals that the oxygen content in biodiesel and the consequential effects on air/fuel relation and on a better mixture of this two reactants, affects the thermal efficiency and the performance of those fuels on engine behavior, when consuming that fuel.

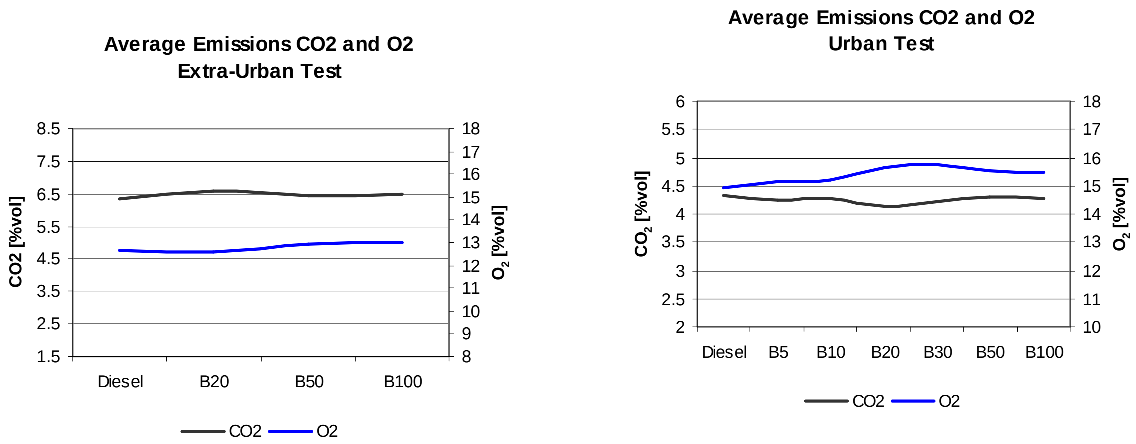
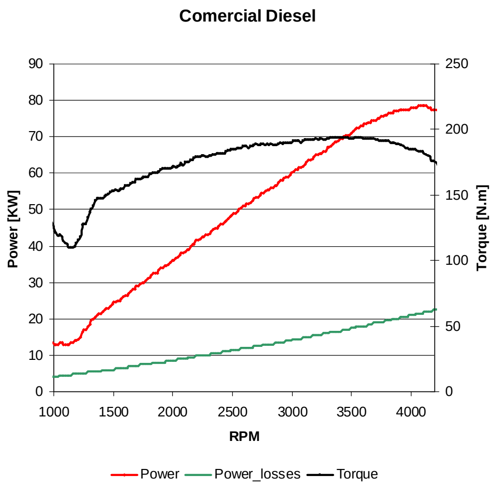


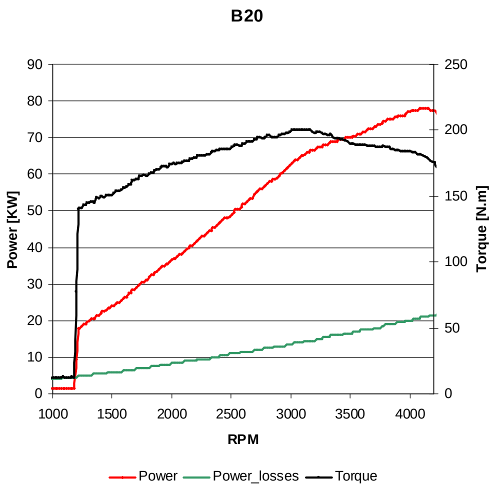
Fig.3 – CO2 and O2 emission analysis for several diesel blends and for urban and extra-urban tests

There are two aspects that should be highlighted. On one hand it is clear that for B20, in both test conditions, there's a tendency to a noticeable change in curve trajectory, with another change in results for higher biodiesel levels in diesel, which reveals some differences in combustion reaction. On another hand, it is visible the higher oxygen content for higher biodiesel blends, what is confirmed by the slight increase in O2 emissions corresponding to no changes in CO2 emissions, for B30 to B100.

9. Performance Tests



Engine Max. Power	77,0 kW
Max. Torque	194 N.m @ 3330 RPM



Engine Max. Power	76,5 kW
Max. Torque	200 N.m @ 3020 RPM

Fig.4 – Performance Tests for Diesel and B20 fuels. It is possible to detect the differences on Power and Torque curves for engine capacities at full load.

The performance curves clearly show that, there are reasons to believe that the use of biodiesel can contribute in some way to changes on the work of the engine, giving a different torque value at a different rotation, curiously with the same power. It is also clear that the torque curve for the B20 fuel reaches a peak value at about 2000rpm, instead of a more flat one for the diesel fuel reaching its maximum 300rpm later.

Once there are no changes in the injection pump delivery time and flow, it is possible that the use of biodiesel bringing a higher cetane number, can affect the time of ignition, giving a higher torque value for a lower rotation, since the injection timing is rotation dependent.

Another possible reason for the causes of the effects considered in fig 4, and that needs better acknowledgement is the viscosity increase by the biodiesel use. This rise in viscosity affects the flow by the losses in circulation, but a major effect is the contribution to lower the leak losses in pump injection of fuel. This losses in pump injection are also rotation dependent and also contribute to the changes pointed out in the performance curves.

10. Conclusions

In short, it is obvious that this represents the choice of a path to follow. In fact the results obtained, and the research of other published papers, leads to a clear conclusion that there are a supported knowledge on engines working with diesel fuel, however the differences made by the use of different biodiesel blends and vegetable origins leads to an unknown new world for engines.

The results obtained are very consistent on showing that the consumption of an indirect injection engine when using biodiesel at some percentage mixed with diesel, doesn't change in a direct dependence of the heating value of the fuel used.

Another aspect that is interesting to see is the fact that the regime imposed to the engine, clearly affects the way that engine deals with this fuel, taking a better or a worst profit of it.

The use of another engines and a more detailed study of the significance of each of the parameters revealed, specially the ones that involve the injection pump operation and control, appears now as the next relevant step necessary to pursuit knowledge on what engines like when they are fueled by some kind of biodiesel in any blend with diesel.

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