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INJECTION ANGLE EFFECT ON PERFORMANCE AND EMMISIONS OF BIODIESEL FUELED COMPRESSION IGNITION ENGINE

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Abstract

In recently, both relationship of supply-demand and high efficiency expectation, diesel engines has played an important role in transportation and industrial application areas that some of these are listed like; internal combustion engines, aircrafts, marines, generators, irrigation pumps and etc. Therefore diesel engines can combust with any other biofuels like biodiesel. Biodiesel has significant advantages like, domestically produced, clean-burning, great renewability and biodegradability, which provide good lubricity and it contains very small amounts of sulfur. With parallel of improvements of these alternative and renewable fuels, diesel engines have developed their technologies too. The advancement of these technologies has increased the importance of simulation during manufacturing which becomes a necessity. Today the widespread use of computer-aided simulations during the manufacturing minimized the challenges and irreversible errors. In this theoretical study, effects of different injection angles on the engine performance and emissions were investigated by using two different fuels which are standard diesel (D2) and SME (Soybean Methyl Ester). Simulations were carried out with DIESEL-RK software that calculates the parameters of engine power, torque, specific fuel consumption and the emissions of CO2 and NOx. Increased injection angles affected the engine power and torque positively; while the specific fuel consumption and CO2 emissions were *changed negatively in all engine and fuel conditions. Additionally, an increase in injection angle resulted with an increased NOx emissions.*

Keywords: *Injection angle, DIESEL-RK, Soybean biodiesel, Performance, Emissions*

1. INTRODUCTION

The limited petroleum resources and increasing in prices canalize the researchers to study alternative energy resources. In recently, developments in engine technologies, provide opportunity to alternative fuels to be used in internal combustion engines. Diesel engines are the most preferable machines which converts chemical energy of fuel to mechanical energy. Due to the increase in the petroleum prices and the environmental concerns about exhaust emissions, alternative diesel fuels becoming a famous topic for scientists.[1] Diesel engines which can operate flexibly with one or more fuels (Petro-diesel, biodiesel etc) are getting more sensitive by these developments. Basically, the biodiesel is produced from vegetable oil, animal oil/fats or waste cooking oil with alkaline and alcohol. Pure or mixture of biodiesel with petro-diesel or some additives can be used in Diesel engines without any modification. Among the many advantages of the use of the biodiesel are the great renewability and biodegradability, which it presents good lubricity and it contains very small amounts of sulfur. Not to mention that it has a higher flash point than diesel. On the other hand, it can be found in the literature a mention of some technical problems related to its use, such as the increase of NO_x gas emission compared with diesel, which should be examined with more caution [5]. There are some methods of producing biodiesel but the most common method is transesterification.

The improvement in ICE is undeniable and that allows the diesel engines to work with alternative fuels. In spite of not to develop full scale engine block change, the requirements oblige the system to change in little parts. Injection system is one of the most important systems in diesel engine which must be developed more and affects parameters which make the combustion stable. Also, the complicated construction of engines, forces the researchers to simulate the entire systems before the engine block cast. This is the main methodology of engineers and producers to create optimum engines.

2. MATERIAL AND METHOD:

2.1. Material:

2.1.1. Properties of various fuel and engine parameters: The aim of prepared work is, determine the performance and emission values were examined for two different piston bowls that they are powered by different fuels which are injected at different injection angles. For this purpose, two different fuels have been chosen for the experiment. And the fuel properties of these fuels are illustrated in table 1. [2]. Additionally the specifications of engine have shown in Table 2.

Table.1- Properties of diesel fuel and SME B40

Property	**Diesel No:2**	**SME B40**
Mass composition of fuel C H O	 0.870 0.126 0.004	 0.8297 0.1230 0.0473
Low heating value (MJ/kg)	42,5	39.89
Cetane number	48	49.37
Fuel density (kg/m3)	830	852
Dynamic viscosity (Pa.s)	0.00300	0.00368
Molar mass (kg/kmol)	190	232.5
Critical Temperature (K)	710	734

Table.2 - Specification of Engine

Engine Type	Four Stroke Diesel Engine
Number of Cylinders / Valves	4 Cylinders / 4 Valves
Bore x Stroke	150mm x 180mm
Compression Ratio	15
Nominal Engine Speed	1500 rpm
Engine Design	In Line
Cooling System	Liquid Cooling

2.1.2 Biodiesel Production: SME (Soybean Methyl Ester) is a member of biodiesel family so; it also produced by general biodiesel production techniques. Generally, there are three basic routes to biodiesel production from oil and fats.

1- Base catalyzed transesterification of the oil

2- Direct acid catalyzed transesterification of the oil

3- Conversion of oil to its fatty acids and then to biodiesel.

Almost all biodiesel is produced using base catalyzed transesterification as it is the most economical process requiring only low temperatures and pressures and producing a 98% conversion yield. The transesterification process is the reaction of triglyceride (fat/oil) with an alcohol to form esters and glycerol. During the transesterification process, the triglyceride is reacted with alcohol in the presence of a catalyst, usually a strong alkaline like sodium hydroxide. The alcohol reacts with the fatty acids to form the mono-alkyl ester, or biodiesel and crude glycerol. In most production methanol or ethanol is the used as alcohol, either potassium or sodium hydroxide as is used as catalyst, rapeseed oil, sunflower seed oil, soybean oil etc. waste frying oil, animal oil is used as oil.[3]

2.2. Method:

2.2.1. Diesel RK: Diesel-RK is full cycle thermodynamic engine simulation software. Development of the DIESEL-RK software core has been started in 1981-82 in the department of Internal Combustion Engines (Piston Engines), Bauman Moscow State Technical University. And furthermore, this program developed itself until nowadays. One is designed for simulating and optimizing working processes of two and four-stroke internal combustion engines with all types of boosting. The program can be used for torque curve and other engine performances prediction, fuel consumption prediction and optimization, combustion and emission analysis and optimization and research and optimization of fuel injection profile including multiple injection, sprayer design and location as well as piston bowl shape optimization in models of DI Diesel engines, including PCCI and engines fueled by biofuels [4].

For this simulation study, Diesel-RK was used for calculation of performance and emission values for two different piston bowls which they are powered by Diesel 2 and SME B40 fuels which are injected at different injection angles. In figure 1, a schematically picture is shown about the simulation of piston bowls choosing.

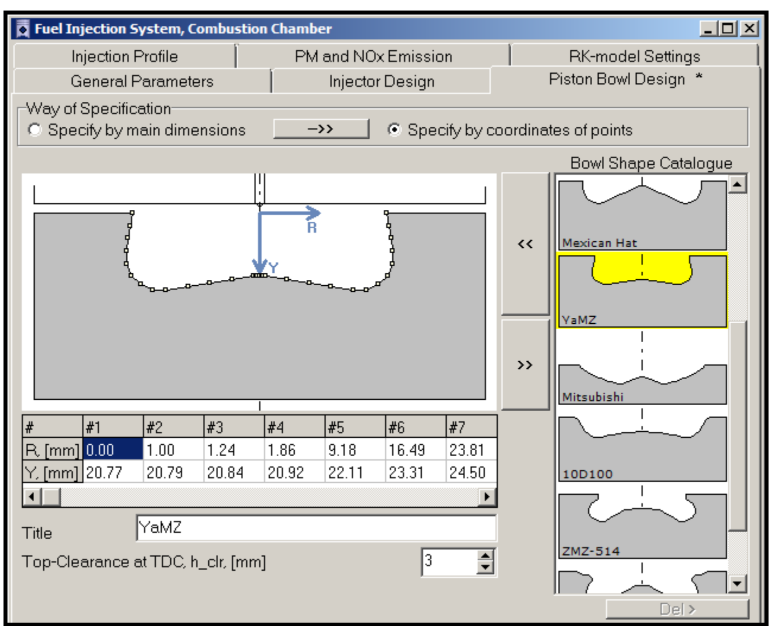


Fig.1 Piston bowl design with Diesel RK

3. RESULTS AND DISCUSSION

The parameters, which were calculated to find the engine performance are; brake power, engine torque, specific fuel consumption, CO_2 and NO_x emissions. These parameters were calculated by changing various parameters which seen below:

- Two different piston bowls: Mitsubishi and Yamz
- Two different fuels: Diesel No:2 and Biofuel SME B40
- Four different injections angles: 20^o, 30^o, 40^o, 50^o

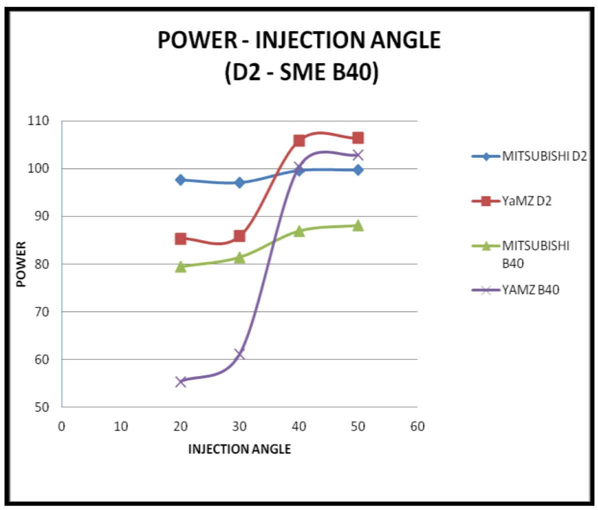
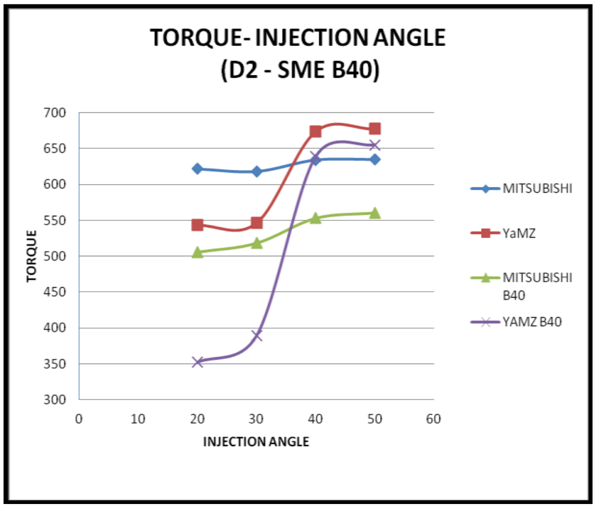


Figure-2. Power versus injection angle

In Figure 2, brake power vs. injection angle parameters had simulated for Mitsubishi and YAMZ both D2 and B40 fuel. As seen in figure; the maximum power is handled with YAMZ D2 in 50^o injection angle. For B40 fuel the optimization rate of power vs. injection angle is approximately 50^o injection angle.

In Figure 3, engine torque vs. injection angle parameters had simulated for Mitsubishi and YAMZ both D2 and B40 fuel. More likely the power vs. injection angle parameters had shown the approximately values. As seen in figure; the maximum engine torque is reached with YAMZ D2 in 50^o injection angle and for B40 fuel the optimization rate of power vs. injection angle is approximately 50^o injection angle as Figure 2.

In Figure 4, the minimum specific fuel consumption was calculated at YAMZ piston bowl with D2 fuel injected 50^o injection angle. It is an important point that; increasing injection angle is affected very positivly values for YAMZ B40 fuel which can be seen clearly in figure 4. Also this phenmone is under detailed same confitions as all fuel types and incrasing i,njection angles.



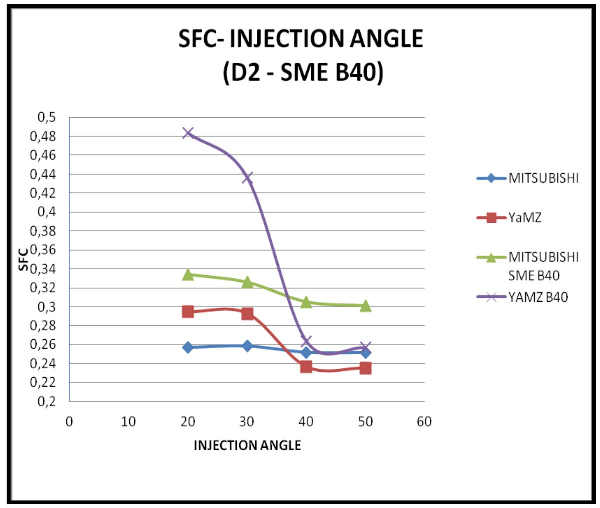


Figure-3. Torque versus Injection Angle/Figure-4. Specific fuel consumption versus injection angle

In Figure 5 and Figure 6, the exhaust emmission parameters CO_2 and NO_x were illastruated respectively. In figure 5, CO_2 emission value vs. injection angle parameters had simulated. As seen in the figure, the minimum CO_2 emission calculated at YAMZ piston bowl with D2 fuel injected 50^o injection angle.

In Figure 6, minimum level of NO_x emission was calculated at 20^o injection angle with SME B40 biofuel injected at YAMZ piston bowl. On the other hand it can be seen in figure that, for 50° injection angle, Mitsubishi D2 and SME B40 fuels received the lowest NO_x values.

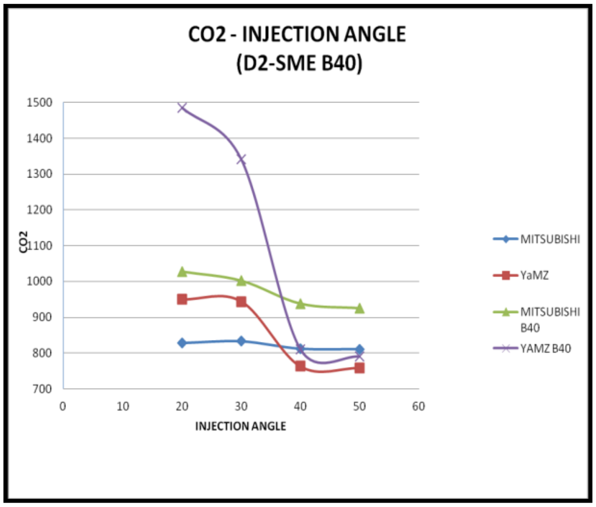


Figure-5. CO_2 emission versus injection angle

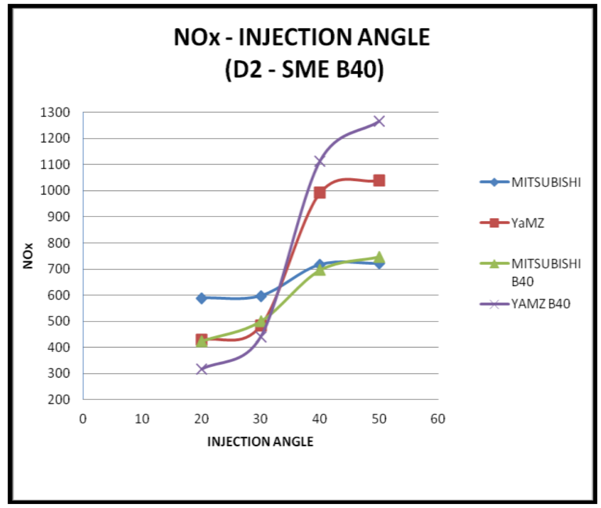


Figure-6. NO_x emission versus injection angle

4. CONCLUSIONS

In this study, some extreme points were seen for 16 different experiments which are the 4 different injection angles, 2 different piston bowls with fueled Diesel No: 2 and SME B40 in diesel engine. The change of parameters how to affect the brake torque, engine power, specific fuel consumption, CO_2 and NO_x emissions were simulated by Diesel RK software, discussed and shown with figures above.

As a result of this study, increased injection angles affected the engine power, torque, specific fuel consumption and CO_2 positively; while the emissions of NO_x were changed negatively in all engine and fuel conditions. Meanwhile, the important point of the outcomes by this study which will be achieved the best optimization parameter is, YAMZ piston bowl with Diesel No:2 injected 50^o injection angle is considered as optimized parameters despite of high NO_x emission value.

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