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COMPARISON OF GLOBAL VIBRATION IN SINGLE CYLINDER DIESEL CYCLE USING DIESEL B5 AND BIODIESEL B100

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Abstract. *The global oil crisis, even as the growing concern for the environment, has been increased interest in renewable fuels. In the same way the market responsible for the production of automobiles is attentive to the matter more cautiously to sustainability and renewable resources, since the current century culture is adept to renewable source production. Therefore the use of engines that operate with traditional fuel (fossil) may without the need for major modifications be coupled to one implementation of the use of renewable fuels. Biodiesel is a fuel obtained by transesterification reaction of oils of vegetable or animal origin in the presence of an alcohol and a catalyst obtaining as by-product glycerol. In this work we present, experimentally, the comparison between the overall vibration levels in the radial direction (vertical and horizontal) and axial single cylinder of a diesel engine (Petter) diesel cycle. The signals collected by means of accelerometers installed in the engine using an integrated platform monitoring "online" SKF IMx. The results shows that levels obtained in the B100 biodiesel are similar to diesel B5 both the combustion chamber and in the mechanical components.*

Keywords*Biodiesel, diesel, motor and vibration*

1. INTRODUCTION

The search for technological innovations for replacing environmentally harmful products for clean sources is linked with the increasingly imminent shortage of oil reserves. With high oil prices making it highly feasible to search for energy sources from renewable resources.

Brazil is a country that 56% of all goods are transported within the country via road routes and globally the relentless increase in the world fleet of vehicles has great responsibility in increasing levels of pollution. This is due to the emission of greenhouse gases from burning fossil fuels such as diesel.

In this global context biodiesel is gaining more prominence among researchers because of concern over global warming. A second train of thought is due to the advantages of the use of the compound is blended with diesel or pure. As it unravels the properties of biodiesel better it is positioning itself against the diesel.

"Environmental issues seen in localized through quality engine emissions and form of global climate change by reducing CO_2 emissions and, consequently, in the reduction of greenhouse gases, is the real driving force for the production and consumption clean fuels derived from biomass, especially in the case of diesel, biodiesel" (PARENTE, 2003).

The use of vegetable oils for diesel production, set aside at the beginning of the last century by the abundance of oil and it's low cost, back up again. The so-called biodiesel brings the hope of a less polluting fuel in origin, and income equal to or higher than petroleum diesel, and can, given those requirements, replace it gradually into your applications.

According to Gerges (2005) little is known about the dynamic behavior of biodiesel in full operation in internal combustion engines. Therefore, the work focuses on vibration analysis, specifically a global level, since the total

ISSN 2176-5480

vibrations from the engine can be basically divided into two major groups: vibration due to the combustion process and vibration due to mechanical forces.

Brazil is being touted as a future leader in world production of biodiesel by the good climate and soil conditions, and also by large territory. Therefore, researches in the country have been intensified. Another advantage to Brazil is the use of ethanol, a renewable source also, the reaction for producing biodiesel, while anoother countries uses a more toxic alcohol, the methanol (VIANA, 2006).

This work will be focused on vibration due to the combustion process in an internal combustion engine of single cylinder four stroke diesel cycle. We conducted a comparison between the vibration levels using pure diesel fuel and Biodiesel B100 originally from soybeans.

2. DIESEL AND BIODIESEL

The diesel fuel is derived from petroleum and consists primarily of hydrocarbons. Diesel fuel is a compound made up primarily of carbon atoms, hydrogen and low concentrations of sulfur, nitrogen and oxygen. Is selected according to the characteristics of ignition and suitable flow operation of diesel engines.

According Obregón (2004), biodiesel is a renewable fuel derived from vegetable oils such as sunflower, rapeseed, soybean, and other babassu oil, or animal fats, used in diesel engines in concentration percentage mixed with diesel. Produced through a chemical process which removes glycerol from the oil.

According to Brazilian legislation biofuel is derived from renewable biomass for use in internal combustion engines with compression ignition. It can also be in accordance with the Regulation for generating another type of energy that can replace, partially or totally, the fossil fuels.

Biodiesel is the name of a clean burning alternative fuel, produced from domestic resources, renewable. Biodiesel does not contain oil, but it can be added to form a mixture. Can be used in a compression ignition engine (diesel) without modification. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics.

Biodiesel is made through a chemical process called transesterification in which the glycerin is separated from the fat or vegetable oil. The process yields two products, esters and glycerin (NETO, 2002).

2.1 Physical and Chemical Properties of biodiesel

The quality of biodiesel produced, in general, depends on the raw material and the process used for it's production (PARENTE*apud.*MACHADO, 2008). Biodiesel Castor escapes this rule when it comes to the viscosity always higher compared to other vegetable esters, maintaining equivalence as other properties (MACHADO, 2008). The minimum quality standards for biodiesel must be met regardless of the crude oil used and the production process (JULIATO, 2006).

The ANP Resolution 7 of 2008 establishes the limits of biodiesel properties and test methods to be imposed on the samples. This resolution is applied to the product made in Brazil and imported biodiesel.

Biodiesel is a renewable fuel source, biodegradable, with good lubricity, safe as explosions, and positively impact on the socio-economic capacity to generate employment and income for rural brazilian producers (SOTO PAU, 2010).

2.2 Cetane number

The cetane number (CN) is a measure that indicates the ignition quality of diesel fuels. A high cetane number indicates lower ignition delay, defined as the time between the start of injection and the flame's appearance ~~of the~~. The cetane number of biodiesel is generally bigger than the diesel oil. This dimensionless is obtained by comparing the two compounds: hexadecane (cetane number of maximum) and alfametilnaftaleno (Nº. cetane minimum). The higher and more saturated carbon chain molecules, the higher cetane number (BALA*apud.*DEMIRBAS, 2008).

2.3 Calorific Value

The calorific value indicates the amount of energy contained in the fuel Biodiesel has a lower value calorific. So, and in the combustion water present in the exhaust gases leaving the system in the vapor phase must consider the PCI of the fuel, which is debited the heat required to evaporate the water present in the fuel itself. Based on mass, energy reduction of biodiesel to diesel oil front is 12.5%. As biodiesel is denser and engines inject the same amount of fuel during the operation, there is an increasing power reduction about 8.4% when replacing diesel for biodiesel. In some cases the power reduction is smaller than this value due to increased viscosity of the biodiesel reduces losses due to leakage in the injection system by increasing the amount of fuel entering the cylinder (KNOTHE *et al.*, 2005).

ISSN 2176-5480

2.4 Viscosity

The viscosity indicates the resistance to fluid flow due to internal friction of a moving part over the other. In compression ignition engines viscosity has a strong influence on the atomization of the fuel at the time of injection into the combustion chamber. The high viscosity of esters, compared to fossil diesel, has been the major reason for discarding some vegetables as raw material for biodiesel (KNOTHE *et al.*, 2005).

According to Machado (2008), injection systems of MIC produced so far, were not prepared to produce the best condition for spraying fuel with higher viscosity, such as biodiesel. The author emphasizes that if there are appreciable differences in the physicochemical properties between the fuels adjustments must be made in the system of forming the mixture into the search engine as efficiently as possible. As the biodiesel differs considerably in viscosity of diesel, and other properties that will be described later, can't be said that changes in the engines are not required, especially when it aims for maximum efficiency.

R. Santos F. (2005) tested a diesel direct injection, turbocharged, 4-cylinder engine and analyzed the exhaust gases with a device brand Tecnomotor model TM131. One of the conclusions of this study was that the hydrocarbon emissions with biodiesel fell 72% under 2500 rpm compared to diesel. However, in the regime of 1500 rpm with biodiesel emissions were slightly higher. The author places as the cause of that effect the bulk viscosity of biodiesel, which in this situation influence the combustion process to produce droplets of larger diameter which reach the cylinder wall and extinguish the flame in this region, leading to incomplete combustion. Moreover, as reported Bueno (2006), change the dynamics of jet fuel during the injection influenced by this property increases the rate of preparing the mixture by adding the amount of turbulent movement which favors the combustion process.

Knothe *etal.* (2005) explain that most injection systems of MIC (motor a combustion intern) consist of a single-cylinder type pump piston clearance between the parts of approximately 0.025 mm. Even with this small clearance significant part of the fuel pump during the leak, causing power loss. If the fuel viscosity is too low the quantity of leakage, and consequently losses increase. If the viscosity is high, such as the crude vegetable oils, pump can't inject enough fuel in the cylinder occurs a poor atomization again has the effect of loss of power.

By adding biodiesel to diesel oil, its viscosity increases gradually as the volume of the mixture of esters is high. Such a conclusion can be made when looking at the data in Table 2, which brings some properties of diesel, biodiesel and certain blends of these fuels.

Table 1.Properties of diesel, biodiesel from soybeans and some of their mixtures.

Fuel	%Biodiesel (Volume)	Empirical formula	Viscosity [m^2/s @ 40°C]	N° of Cetano	PCI [MJ/kg]
Diesel	0%	$C_{10,80}H_{18,70}O_{0,00}$	2,60 10^{-2}	45,00	43,30
B5	5%	$C_{11,03}H_{19,16}O_{0,05}$	2,66 10^{-2}	45,33	43,00
B10	10%	$C_{11,27}H_{19,64}O_{0,11}$	2,72 10^{-2}	45,60	42,69
B15	15%	$C_{11,53}H_{20,15}O_{0,16}$	2,79 10^{-2}	45,80	42,38
B20	20%	$C_{11,80}H_{20,69}O_{0,22}$	2,86 10^{-2}	46,30	42,06
Biodiesel	100%	$C_{19,75}H_{36,59}O_{2,00}$	4,57 10^{-2}	48,20	37,20

Font: Adapted of Bueno (2006).

3. VIBRATION

The vibration response is a repetitive, periodic oscillation of a mechanical system.The rate of vibration cycles is called "frequency". Repetitive movements that are somewhat clean, regular and occur in relatively low frequencies, are commonly called oscillations, while any repetitive motion, even at high frequencies with low amplitudes, behave erratically and falls into the general class of random vibration, Santana (2010).

Vibrations occur in an engineering system and can be representative of their free dynamic behavior can be natural or forced through some form of excitation, which can be generated by the system or be transmitted from an external source.

When the excitation frequency coincides with the natural movement, the system will respond more vigorously, with increased amplitude this condition is known as resonance, and frequency associated and called the resonant frequency.

3.1 Vibration Analysis

Generally, in the industry, from all parameters that can be measured with no need to open the machineries, the signal that contains more information is the vibration signals (ART CRAWFORT, 1992).

The vibration is often a destructive process, causing failures in machine components for fatigue. The vibration of a machine is the result of the dynamic forces that excites. This vibration propagates through all parts of the machine, as

ISSN 2176-5480

well to the structures connected to it. Generally a machine vibrates at various frequencies and amplitudes thereof. The effects of vibration are severe wear and fatigue, which are certainly responsible for the equipment breaks definitive.

According to Brito (2002) every machine has a certain level of noise and vibration due to the operation and external sources. However, a portion of these vibrations is caused by small mechanical defects, disturbing secondary excitations, which act as the performance of the machine. Any increase in the level of the machine's vibration of a is the first sign of worsening of a defect: misalignment, feathering shaft, bearing wear, and others. The fact that the vibration signals of a the machine provides information related to its operation, indicates the health of the machine and the decision on intervention or not this machine. This increase in the vibration level is related to the study of the overall vibration's levels of the single cylinder engine, one of the goals of this research.

Each machine has a characteristic vibration in appearance and level. However, machines of the same type presentS variations on dynamic behavior. This is due to variations in settings, tolerances, and especially defects. Each machine element induces an excitation itself, generating a specific disorder. Generally, if those elements are single-cylinder motors bearings, gears, crank shafts, lubricant, and others.

The dynamic behavior of the machine is a composition of all components disorders, defects and excitations arising from the movements. Thus, a careful measurement of vibration may indicate the main causes (which elements or defects) are exciting machine. Therefore, in machine vibrations occurs at various frequencies due to various excitations. The movement at any point is the superposition of several harmonics.

3.2 Vibration in internal combustion engines

According to Rao (2000), vibrations from an engine can be divided basically into vibration due to the combustion process and vibration due to mechanical forces.

According to Stoeterau (2004), internal combustion engines, by their nature, are subject to extremely unfavorable conditions, such as high pressure and temperature, lubrication deficit in parts with relative motion schemes work variables, among others.

Whether internal combustion engine 2 or 4 stroke, automotive, stationary, for various applications, the conditions that affect the performance of those engines are the same.

In the process of combustion are generated vibrations due to high temperatures and pressure within the combustion chamber caused by the addition of heat in the cylinder, in the case of diesel cycle by compression of air. The type of fuel used has a direct influence by establishing special characteristics for this type of vibration."Normally in diesel engines, due to its high compression ratio, the vibrations are more intense compared to the engines of the Otto cycle." (GERGES, 2005).

4. MATERIALS AND METHODS

The Engine, model Petter AA1, single-cylinder, naturally aspirated air-cooled is shown in Figure 1.The other characteristics of the engine are shown in Table 1.Experimental tests were performed on a bench didactic Figure 2.

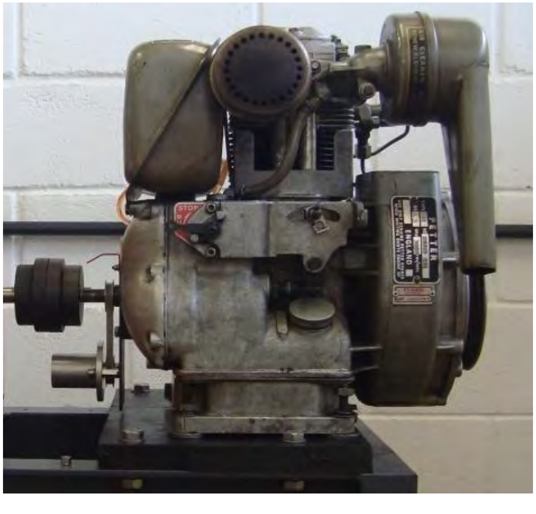

Figure1.Engine, model Petter AA1, single-cylinder, naturally aspirated air-cooled.

ISSN 2176-5480

Table 2. Construction features Diesel Engine Petter AA1.

characteristic	**Values**
Cylinder diameter	69,85 mm
Piston stroke	57,15 mm
Power	2,61 kW
Displaced volume	219 cm³
Compression ratio	17:1 *(17,68:1)**

Font: Manual's engine

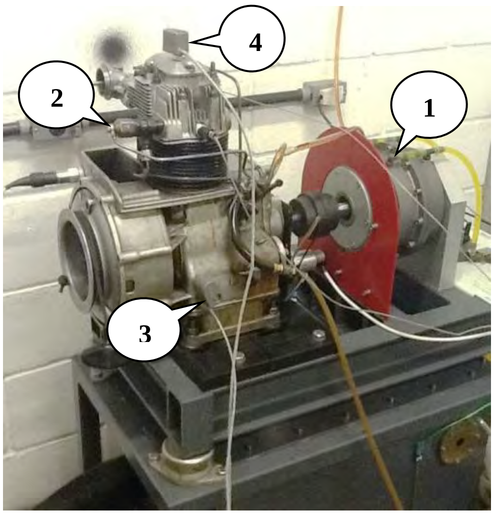

Figure2. Experimental bench.

Figure3.IMxSKF.

The didactic bench consists of a single cylinder internal combustion engine diesel, 4-pole HP, 3600 RPM and a brake (dynamometer water) [1].

The vibration signals were collected online monitoring system IMX-SKF, Figure 3. The vibrations signals are acquired by three piezoelectric accelerometers, SKF model CMSS2200, sensitivity of 100 mV at axial [2], horizontal [3] and vertical [4] positions. The vibration signals are transferred to the computer using the software @ptitude Analyst Human Machine Interface that has several options, among them: Temporal Signal Analysis, Vibration Analysis of the spectral (FFT) and Analysis of Envelope.

During the tests was reported the influence of B100 Biodiesel (derived from soy bean) and Diesel through the overall level of vibration of single cylinder engine. The goal was to determine if the level of vibration generated by Biodiesel is higher, lower or close to levels generated by diesel fuel, complementing the existing information with respect to the compound clean. The ethyl ester of soybean (B100) was provided by the School of Engineering of the University of São Paulo - USP, and the mixture of 5% by volume of biodiesel in fossil diesel (B S1800), as Resolution ANP Nº. 42, 2009, acquired the network gas stations.

Grouping the data was set up a database with overall levels of vibration in the vertical, axial and horizontal in three different levels of rotation: 1500 RPM, 2000 RPM and 3000 RPM. The variation and control of rotation is performed through the existing load valve dynamometer.

Chose to perform the tests in three regimes of operation, namely 1500, 2000 and 3000 revolutions per minute at full load. In the case of tests carried out in this work, the expression "full load" means the position of maximum flow in the injection pump to a condition of full throttle.

The power and torque curves presented in this figure were generated from the data collected in the tests with constant rotation. Therefore, trend curves are referenced in sections 1500, 2000 and 3000 revolutions per minute, on Figure 4, shows the curves of power and torque developed by the motor. We used the mean values of the replicates of tests in each operating regime.

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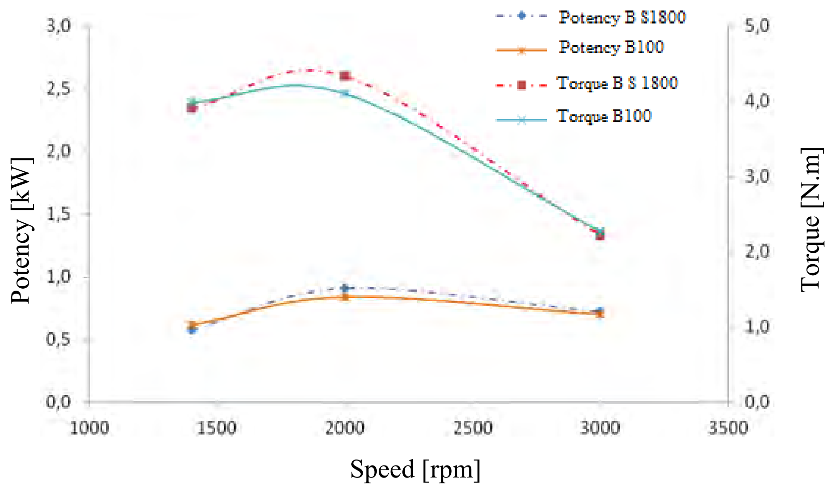

Figure 4. Engine performance at full load diesel use (S1800 B) and soybean ethyl ester (B100)
(Petter AA1 Performance Motor Full Load)

Font: own work

Heywood (1988) says that the internal cylinder pressure can be used to calculate the work of expanding gases transferred to the piston. According to the same author, the values of motor torque measure your ability to perform work, and the power is the rate at which the work is performed. Thus, the pressure inside the cylinder is closely related to the torque and power developed by the engine. The behavior of the pressure inside the cylinder observed in the tests for each speed is shown in Figure 5. Comparing the peak pressure curves with the power switch and it is noted the same trend with increasing evolutionary rotation, especially as regards the comparison between the fuels. In order to better visualize the peak pressure values were limited between -60 ° and 60 ° angle of rotation of the crank.

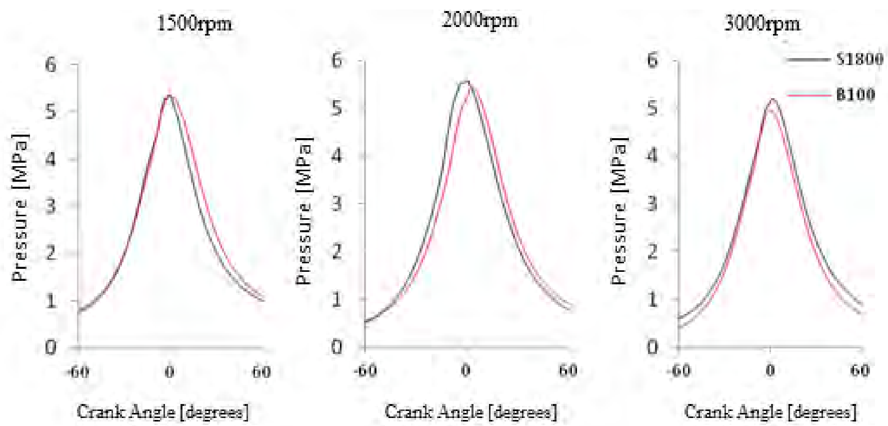

Figure 5. Internal pressure as a function of the angle of rotation of the crank.

Font: own work

5. RESULTS

The use of biodiesel in diesel cycle engines can lead to reducing the emission of harmful gases from the combustion of those engines, such as reducing emissions of particulate matter (PM), hydrocarbons (HC) and carbon monoxide (CO), and reducing the emission of carbon dioxide (CO_2) gas that directly related to the greenhouse effect. However, depending on the fuel used and the engine in which it was applied, this use can lead to increased emissions of oxides of nitrogen (NO_x) reduction in engine power and an increase of fuel consumption (SANTOS, 2005)

Based upon all literature reviewed it can be concluded that biodiesel can be used in diesel cycle engines. It was found that the overall vibration level, both as Biodiesel B100 and Diesel, remained similar in the vertical direction as shown in Figure6.

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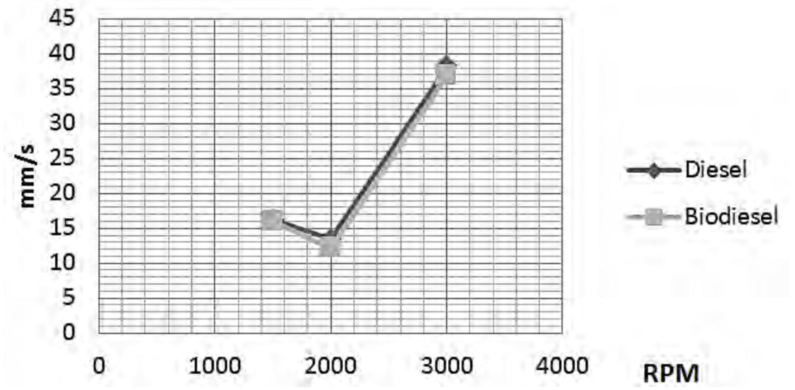

Figure 6. Vertical Vibration.

The similarity between the result of the B100 biodiesel vertical commercial diesel and characterized by not having any significant delay ignition, which is directly related to the cetane number of the fuel remained unchanged according analyzes indicated because the same number of cetane biodiesel is higher than that of fossil diesel, this variable affect other properties (viscosity, the diameter of the drop) and practically nullify this superiority.

Already vibration signals collected in the horizontal (Figure 7) and axial (Figure 8), showed a reduction in overall vibration level at 3% and 18.55% respectively when compared to fossil diesel, which apparently is associated with the lowest calorific power Biodiesel B100.

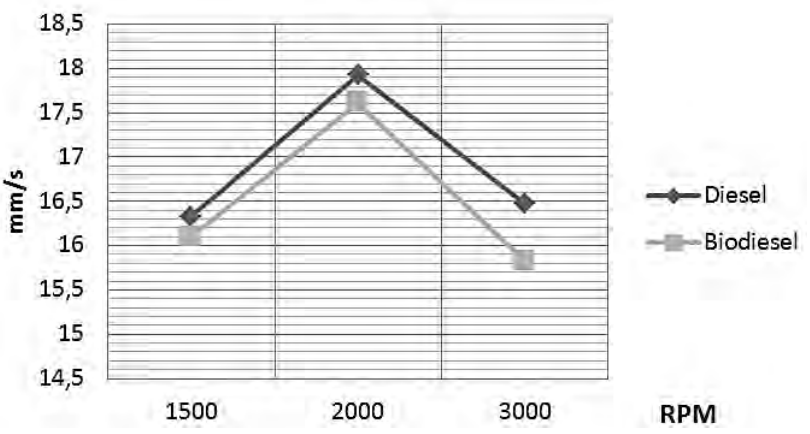

Figure7.Horizontal vibration.

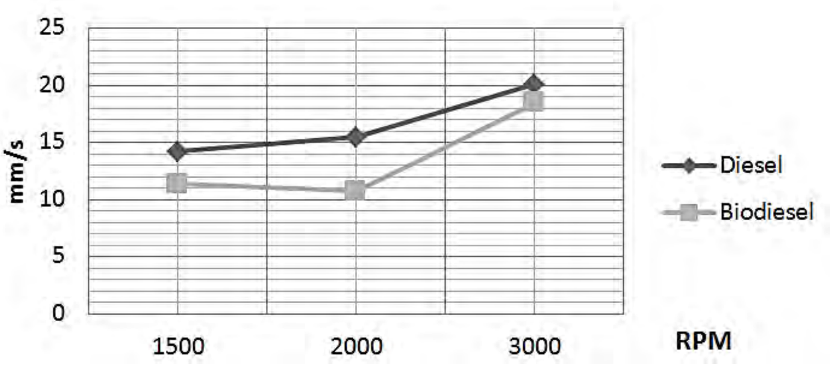

Figure 8.Axial vibration.

By operating conditions such as rotation, amount and type of fuel used, and the properties of the materials of which the engine components are global variations in vibrations, but satisfactory results in working regimes of the engine Petter AA1, i.e. the operating speed was convergence of levels of vibration at high speeds.

The results shown in Figures 7 and 8 are originally from vibrations of the components such as diesel engine connecting rod, crankshaft in addition to the actual combustion, among others generated by lateral forces.

It was found that the overall level of vibration in engines fueled with diesel engines is greater than the B100 biodiesel filled with approximately 9%. This is due to the fact that when working with diesel engine connecting rod is steeper due to the further advancement of the piston which increases the lateral forces.

6. ACKNOWLEDGEMENTS

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