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Performance Evaluation of Diesel Engine with Oxygenated Bio-Diesel Fuel Blends

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ABSTRACT:

Automobile engines are usually petrol, diesel or gasoline engines. Petrol engines are Spark Ignition engines and diesel engines are Compression Ignition engines. Blended fuels are mixtures of traditional and alternative fuels in varying percentages. In this thesis, the effect of diesel and blended fuels in combustion chamber is studied by mathematical correlations applying thermal loads produced during combustion. Blended fuel considered in this thesis is biodiesel blended in different percentages. Percentages vary from 5%, 15% and 20%. FEA analytical approach is performed to validate the mathematical correlations. Boundary conditions to be taken are thermal loads i.e temperature, heat generated, heat transfer coefficient. FEA thermal analysis is done in ANSYS. The parametric model is done in Pro/Engineer.

INTRODUCTION TO AUTOMOBILE ENGINES:

Normally a fossil fuel occurs with an oxidizer (usually air) in a chamber that is an integral part of the working fluid flow circuit. In an internal combustion engine (ICE) the expansion of the high-temperature and high-pressure gases produced by combustion apply direct force to some component of the engine. The force is applied typically to pistons, turbine blades, or a nozzle. This force moves the component over a distance, transforming chemical energy into useful mechanical energy. The first commercially successful internal combustion engine was created by Etienne Lenoir.The term internal combustion engine usually refers to an engine in which combustion is intermittent, such as the more familiar four and two-stroke piston engines, along with variants, such as the six-stroke piston engine and the Winkle rotary engine.

A second class of internal combustion engines use continuous combustion: gas turbines, jet engines and most rocket engines, each of which are internal combustion engines on the same principle as previously described. The ICE is quite different from external combustion engines, such as steam or Stirling engines, in which the energy is delivered to a working fluid not consisting of, mixed with, or contaminated by combustion products. Working fluids can be air, hot water, pressurized or even liquid sodium, heated in some kind of boiler. ICEs are usually powered by energy-dense fuels such as gasoline or diesel, liquids derived from fossil fuels. While there are many stationary applications, most ICEs are used in mobile applications and are the dominant power supply for cars, aircraft, and boats.

APPLICATIONS:

Internal combustion engines are most commonly used for mobile propulsion in vehicles and portable machinery. In mobile equipment, internal combustion is advantageous since it can provide high power-to-weight ratios together with excellent fuel energy density.Generally using fossil fuel (mainly petroleum), these engines have appeared in transport in almost all vehicles (automobiles, trucks, motorcycles, boats, and in a wide variety of aircraft and locomotives). Where very high power-to-weight ratios are required, internal combustion engines appear in the form of gas turbines. These applications include jet aircraft, helicopters, large ships and electric generators.

LITERATURE REVIEW:

PAPER1 - INFLUENCE OF COMPOSITION OF GASOLINE – ETHANOL BLENDS ON

PARAMETERS OF INTERNAL COMBUSTION ENGINES by Alvydas Pikūnas, Saugirdas Pukalskas, Juozas Grabys

The purpose of this study is to investigate experimentally and compare the engine performance and pollutant emission of a SI engine using ethanol–gasoline blended fuel and pure gasoline. The results showed that when ethanol is added, the heating value of the blended fuel decreases, while the octane number of the blended fuel increases. The results of the engine test indicated that when ethanol–gasoline blended fuel is used, the engine power and specific fuel consumption of the engine slightly increase; CO emission decreases dramatically as a result of the leaning effect caused by the ethanol addition; HC emission decreases in some engine working conditions; and CO_2 emission increases because of the improved combustion.

PAPER 2 - Composition and Reactivity of Fuel Vapor Emissions from Gasoline-Oxygenate Blends by Robert L. Furey and Kevin L. Perry

Laboratory bench tests were conducted to simulate both the diurnal and the hot-soak (carburetor only) parts of an evaporative emissions test with gasolines containing various alcohols and ethers. The mass of vapor generated during each test and the detailed composition of the vapor were determined for each fuel. Using published atmospheric reactivity scales, the ozone-forming potential of the vapor was estimated. Based on the scale of maximum incremental reactivities, which the California Air Resources Board has proposed for future emissions standards, the diurnal test results showed that the addition of methyl tertiary-butyl ether (MTBE) or ethyl tertiary-butyl ether (ETBE) to gasoline resulted in about the same or lower total vapor reactivity compared to the gasoline alone. A blend of gasoline with ethanol or with a methanol-ethanol mixture also produced diurnal vapor with lower total reactivity, but only when the vapor pressures of the gasoline-oxygenate blends did not exceed that of the gasoline.

At equal oxygenate concentrations in the fuel, MTBE was the most effective in reducing the reactivity per gram of vapor.

PAPER 3 - Fuel Injection Components Developed for Brazilian Fuels by Eugênio P.D. Coelho, Cláudio Wilson Moles, Marco A.C. dos Santos, Matthew Barwick, Paulo M. Chiarelli

Brazil's use of oxygenated fuels (pure ethanol - E93 and gasoline with 22% anhydrous ethanol - E22) has led local car manufactures to develop components and testing procedures that can withstand the aggressive characteristics of these types of fuel. This paper will present the methods used by Ford ELD-Brazil (currently part of the Ford Automotive Components Division - ACD) together with its suppliers and Autolatina (former joint venture between Ford and Volkswagen in South America) to validate and select suitable components to work in this environment.

PAPER 4 - Surface Corrosion in Ethanol Fuel Pumps by David W. Naegeli, Paul I. Lacey, Matthew J. Alger, and Dennis L. Endicott

Catastrophic failures of fuel pumps used to transport ethanol have occurred in various facilities. Failures occurred in as little as 50 hours on pumps with a 2000 hour life expectancy. Post-failure inspection of the pumps showed corrosive pitting of the metal in the areas of sliding contact. Several potential causes, including cavitation, thermal expansion of pump parts, and fuel contaminants such as acetic acid were ruled out. Fuel samples from facilities with high pump failure rates passed all D 4806 specification tests for fuel-grade ethanol, including titratable acid by D 1613. However, pH readings as low as 2.0 indicated potentially corrosive fuels. Controlled tests on pumps and corrosion tests showed that pump failures correlated with fuel pH. Corrosive fuels were found to contain ethyl sulfate, which correlated with fuel pH. It appears that ethyl sulfate originates from sulfur

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dioxide, which is used as an antioxidant and antiseptic in the production of ethanol.

PAPER 5 - The Influence of Gasoline/Ethanol Blends on Emisssions and Fuel Economy by F. M. Salih, G. E. Andrews

A 1117cc Ford Valencia SI engine was used to investigate the influence on emissions of relatively large (10-30%) additions of ethanol to gasoline. The ethanol was shown to extend the lean burn range and improve the specific energy consumption in the lean burn region. Addition of ethanol significantly reduced NO_x and Co by over 50% and increased slightly HC and condensible hydrocarbons, but had little effect on NMHC.

PAPER 6 - Experimental investigation on varying the compression ratio of SI engine working under different ethanol–gasoline fuel blends by A. A. Abdel-Rahman, M. M. Osman

Using different ethanol–gasoline fuel blends, a VARICOMP engine was used to study the effect of varying the compression ratio on SI engine performance. The performance tests were carried out using different percentages of ethanol in gasoline fuel, up to 40%, under variable compression ratio conditions. The results show that the engine indicated power improves with the percentage addition of the ethanol in the fuel blend. The maximum improvement occurs at 10% ethanol–90% gasoline fuel blend. © 1997 by John Wiley & Sons, Ltd.

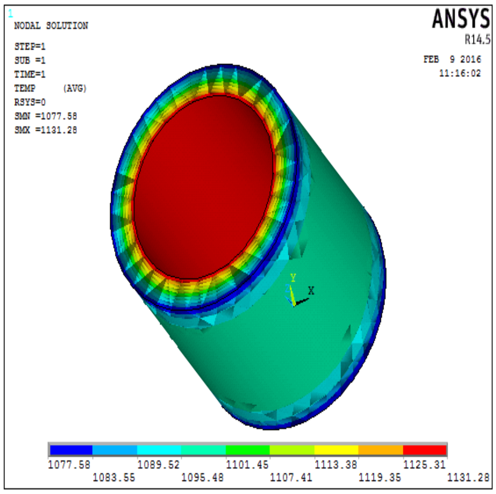
FUEL – DIESEL + 5% OXYGENATED BIODIESEL

Loads

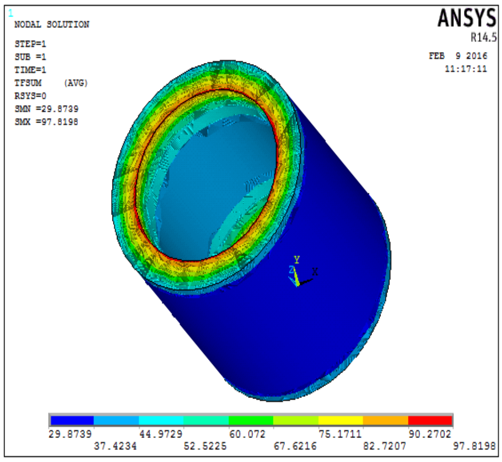
Apply Thermal-Temperature- on Area=1131.28 K

Convections – on Area-Film Co-efficient – 0.039w/m^2 k

Bulk Temperature – 303 k



General post processer- contour plot-Thermal Flux –Thermal Flux Vector Sum



FUEL – DIESEL + 15% OXYGENATED BIODIESEL

Loads

Apply Thermal-Temperature- on Area=1159.18 K

Convections – on Area-Film Co-efficient – 0.039w/mmk

Bulk Temperature – 303 k

General post processer- contour plot- nodal solution- Nodal Temperature

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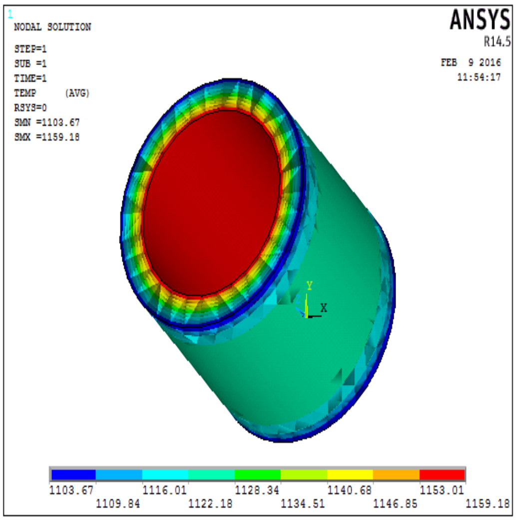

RESULTS AND DISCUSSIONS

	Nodal Temperature (K)	Thermal Gradient (K/mm)	Heat flux (W/mm^2)
DIESEL	1117.86	8.5051	96.1171
DIESEL+5% O	1131.28	8.65662	97.8198
DIESEL+15%O	1159.18	8.94821	101.115
DIESEL+20%O	1173.78	9.1008	102.839

- Using Diesel as fuel, the input temperature is 1117.86K. The temperature distribution is max of 1117.86K, the rate of change in temperature over a distance is 117.8574K/mm and the rate of heat transfer over an area is 22.7603W/mm^2.
- Using Diesel as fuel, the input temperature is 5013.21K. The temperature distribution is max of 5013.21K,the rate of change is temperature over a distance is 5013.21K/mm and the rate of heat transfer over an area is 131.564W/mm^2.
- Using Diesel as fuel, the input temperature is 5014.01K. The temperature distribution is max of 5014.01K,the rate of change is temperature over a distance is 5014.01K/mm and the rate of heat transfer over an area is 131.586W/mm^2.
- Using Diesel as fuel, the input temperature is 5012.81K. The temperature distribution is max of 5012.8K,the rate of change is temperature over a distance is 551.466K/mm and the rate of heat transfer over an area is 131.553W/mm^2

HEAT FLUX CALCULATIONS

Temperature in Kelvin=T_1=1117.8574k

Ambient temperature=T_2=303k

Outer dia of hollow cylinder D_1=79.5mm

r_1=39.75mm

Inner dia of hollow cylinder D_2=59.5mm

r2=27.75mm

length of the hollow cylinder L=80mm

Surface area of hollow cylinder=A=2779.0965mm^2

heat transfer rate "Q"

$$Q=\frac{t1-t2}{\ln\left(\frac{r2}{r1}\right)/2\pi kL} \quad W$$

K=thermal conductivity =0.0113W/mm K

$$Q=\frac{1117.8574-303}{\ln\left(\frac{37.25}{39.75}\right)/(2\times3.14\times0.0113\times80)} \quad W$$

Q=71216.0262watts

Heat flux=$\frac{Q}{A}$ W/mm^2

$$=\frac{71216.0262}{2779.0965}$$

=25W/mm^2

Thermal gradient= $\frac{dt}{dx}$

dt =change in temperature

dx =thickness=$\frac{t2-t1}{x}$

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$=\frac{1117.8574-303}{80}$

=10.87 K/mm

BLENDED FULES

Oxygenated **=5%** **diesel =95%**

Temperature=T1=1131.28 K

Ambient temperature=t2=303K

heat transfer rate "Q"

$Q=\frac{t1-t2}{\ln\left(\frac{r2}{r1}\right)/2\pi kL}$ W

k=thermal conductivity

K=0.0113w/mmk

$Q=\frac{1131.28-303}{\ln\left(\frac{39.75}{37.25}\right)/(2\times 3.14\times 0.0113\times 81)}$ W

Q=72389.12 W

Heat flux=$\frac{Q}{A}$ W/mm^2

$=\frac{72389.12}{2779.09}=$ 26.0477 W/mm^2

Thermal gradient= $\frac{dt}{dx}$

dt =change in temperature

dx =thickness

$=\frac{t2-t1}{x}$

$=\frac{5013.21-303}{80}=$ 10.353K/mm

Oxygenated=15% **Diesel =85%**

Temperature=T1=1159.18 K

Ambient temperature=T2=303K

heat transfer rate "Q"

$Q=\frac{t1-t2}{\ln\left(\frac{r2}{r1}\right)/2\pi kL}$ W

k=thermal conductivity

K=0.0113w/mmK

$Q=\frac{1159.18-303}{\ln\left(\frac{39.75}{37.25}\right)/(2\times 3.14\times 0.0113\times 80)}$ W

Q=74827.49 W

Heat flux=$\frac{Q}{A}$ W/mm^2

$=\frac{74827.49}{2779.0965}=$ 26.925 W/mm^2

Thermal gradient= $\frac{dt}{dx}$

dt =change in temperature

dx =thickness

$=\frac{t2-t1}{x}=\frac{5014.01-303}{80}=$ 10.7K/mm

Oxygenated=20% **diesel =80 %**

Temperature=T1=1173.78K

Ambient temperature=T2=303K

heat transfer rate "Q"

$Q=\frac{t1-t2}{\ln\left(\frac{r2}{r1}\right)/2\pi kL}$ W

k=thermal conductivity

K=0.0113w/mm K

$Q=\frac{5012.813-303}{\ln\left(\frac{39.75}{37.25}\right)/(2\times 3.14\times 0.0113\times 81)}$ W

Q=76103.48914W

Heat flux=$\frac{Q}{A}$ W/mm^2

$=\frac{76103.4891}{2779.0965}=$27.384 W/mm^2

Thermal gradient= $\frac{dt}{dx}$

dt =change in temperature

dx =thickness

$=\frac{t2-t1}{x}=\frac{5012.813-303}{80}=$10.88 K/mm

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DIESEL ENGINE

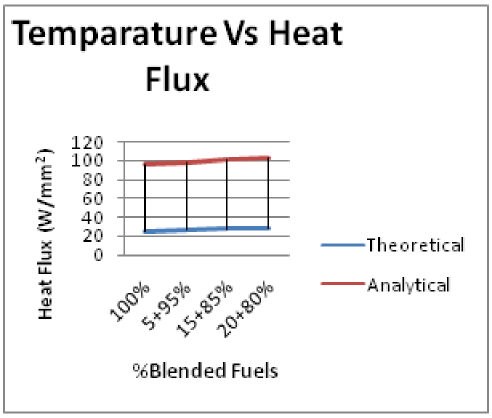
	Thermal Gradient (K/mm)	Heat flux (W/mm^2)
DIESEL	10.87	25
DIESEL+5%O	10.353	26.0477
DIESEL+15%O	10.7	26.925
DIESEL+20%O	10.88	27.384

OUT PUT WAVE FORMS : RESULTS AND DISCUSSIONS

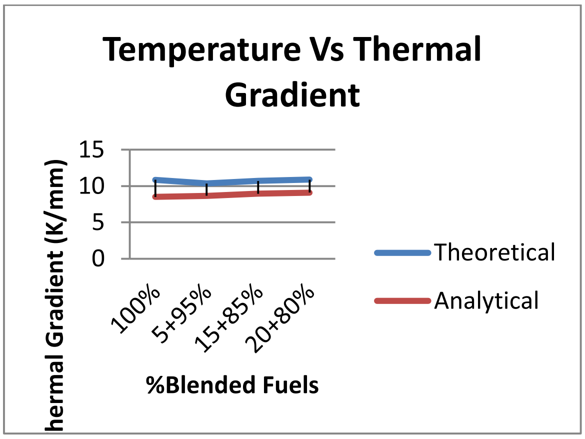
	Nodal Temperature(K)	Thermal Gradient(K/mm)	Heat flux (W/mm^2)
DIESEL	1117.86	8.5051	96.1171
DIESEL+5%O	1131.28	8.65662	97.8198
DIESEL+15%O	1159.18	8.94821	101.115
DIESEL+20%O	1173.78	9.1008	102.839

	Thermal Gradient(K/mm)	Heat flux (W/mm^2)
DIESEL	10.87	25
DIESEL+5%O	10.353	26.0477
DIESEL+15%O	10.7	26.925
DIESEL+20%O	10.88	27.384

COMPARISON OF RESULTS BETWEEN ANALYTICAL AND THEORETICAL VALUES



DIESEL



CONCLUSION:

In this thesis, the effect of petrol, diesel and blended fuels in combustion chamber is studied by mathematical correlations to calculate thermal loads produced during combustion. Fuels considered are Diesel, Blended fuels. Blended fuel taken is oxygenated bio diesel fuels blended in different percentages. Percentages vary from 5%, 15% and 20%. Material used for cylinder is Cast Iron. Theoretical calculations are done to calculate the temperature produced for combustion when fuel is changed. Thermal analysis is done on the cylinder applying temperature by changing the fuels used for combustion. The cases considered are Diesel, Diesel + 5% Bio diesel, Diesel + 15% Bio diesel, Diesel + 20% Bio diesel. By observing the analysis results, by using only diesel as fuel the heat transfer rate is more percentage by taking blended fuels.

When the blended fuels are considered, by increasing the percentage of bio diesel, the heat transfer rate is increasing. Theoretical calculations are also done to calculate thermal gradient and thermal flux. By comparing both analytical and theoretical results, the values are almost same.So it can be concluded that, for blending fuels, more percentage of bio diesel is better.

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