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REVIEW ARTICLE

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THERMAL LOAD EFFECT ON VALVE BY USING CONVENTIONAL AND BLENDED FUELS

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ABSTRACT

The valves used in the IC engines are of three types: Poppet or mushroom valve or Sleeve valve or Rotary valve. Of these three types, Poppet valve is most commonly used. Since both the inlet and exhaust valves are subjected to high temperatures of 1930°C to 2200°C during the power stroke, therefore, it is necessary that the materials of the valves should withstand these temperatures. The temperature at the inlet valve is less compared to exhaust valve. Thus the inlet valve is generally made of nickel chromium alloy steel and exhaust valve is made of silchrome steel.

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 petrol, diesel and blended fuels on valve is studied by mathematical correlations applying thermal loads produced during combustion. Blended fuels are usually Ethanol fuels blended in different percentages. Percentages vary from 10%, 15% and 25%.

Internal combustion engines produce exhaust gases at extremely high temperatures and pressures. As these hot gases pass through the exhaust valve, temperatures of the valve, valve seat, and stem increase. To avoid any damage to the exhaust valve assembly, heat is transferred from the exhaust valve through different parts, especially the valve seat insert during the opening and closing cycle as they come into contact with each other.

In this thesis, a finite-element method is used for modeling the thermal analysis of an exhaust valve. The temperature distribution and resultant thermal stresses are evaluated. Detailed analyses are performed to estimate the boundary conditions of an internal combustion engine. In this thesis, Pro/Engineer is employed for modeling and ANSYS is used for analysis of the exhaust valve.

Keywords: Blended fuels, combustion, exhaust valve, transient thermal

1. INTRODUCTION

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.

All internal combustion engines depend on combustion of a chemical fuel, typically with oxygen from the air (though it is possible to inject nitrous oxide to do more of the same thing and gain a power boost). The combustion process typically results in the production of a great quantity of heat, as well as the production of steam and carbon dioxide and other chemicals at very high temperature; the temperature reached is determined by the chemical makeup of the fuel and oxidizers (see stoichiometry), as well as by the compression and other factors.

The most common modern fuels are made up of hydrocarbons and are derived mostly from fossil fuels (petroleum). Fossil fuels include diesel fuel, gasoline and petroleum gas, and the rarer use of propane. Except for the fuel delivery components, most internal combustion engines that are designed for gasoline use can run on natural gas or liquefied petroleum gases without major modifications. Large diesels can run with air mixed with gases and a pilot diesel fuel ignition injection. Liquid and gaseous bio fuels, such as as soybeanoil), ethanol and biodiesel (a form of diesel fuel that is produced from crops that yield triglycerides such can also be used. Engines with appropriate modifications can also run on hydrogen gas, wood gas, or charcoal gas, as well as from so-called producer gas made from other convenient biomass. Recently, experiments have been made with using powdered solid fuels, such as the magnesium injection cycle.

Internal combustion engines require ignition of the mixture, either by spark ignition (SI) or compression ignition (CI). Before the invention of reliable electrical methods, hot tube and flame methods were used. Experimental engines with laser ignition have been built.

2. THEORETICAL CALCULATIONS

TECHNICAL SPECIFICATIONS OF RxE Diesel 85 PS

Engine Type	K9K Diesel Engine
Engine Description	1.5-litre,83.8bhp 4Cylinder K9K Diesel Engine
Displacement (cc)	1461
Power (PS@rpm)	83.8bhp@3750rpm
Torque (Nm@rpm)	200Nm@1900rpm
No. of Cylinders	4
Valves per Cylinder	4
Fuel Type	Diesel
Fuel System	CRDI
Turbo Charger	Yes
Transmission	
Transmission Type	Manual
Gears	5
Gear Box Type	5 Speed
Drive Type	FWD
Fuel Economy	
Mileage Highway (km/liter)	20.46
Mileage City (km/liter)	18.0
Dimensions and Weights	
Overall Length (mm)	4315
Overall Width (mm)	1822
Overall Height (mm)	1695

Wheel Base (mm)	2673
Ground Clearance (mm)	205
Front Track (mm)	1560
Rear Track (mm)	1567
Gross Vehicle Weight (kg)	1758
No of Doors	5
Minimum Turning Radius (mt)	5.2
Front Brakes	Ventilated Disc
Rear Brakes	Drum
Wheels and Tyres	
Wheel Type	Alloy
Wheel Size	R16
Tyre Type	Tubeless Tyres
Tyre Size	215/65 R16

$P_{bmean} = \frac{n\,W}{\text{vd}\,N}$

P_{bmean}=break mean effective pressure in N/m^2

n= no. of power cycles

N=speed in rev/sec

v_d= Displacement in m^3

PV=MRT

V=induced volume=$\frac{capacity\ \times speed}{2}$

T=temperature in Kelvin

M =mass

R = universal gas constant=8.314 J/k mol

FOR BLENDED FUELS:

Ethanol=10% Diesel =90%

M_d=1.2× $\frac{90}{100} = 1.08 \times 0.233 = 0{,}25164$kg

M_e=1.2× $\frac{10}{100} = 0.12 \times 0.046 = 0.00552$kg

T=$\frac{PV}{MR}$

$=\frac{369249.41\times0.046}{\frac{1.08}{0.251}+\frac{\mathbf{0.12}}{\mathbf{0.00552}}\times8.314}$

=290.90k

Ethanol=15% Diesel =85%

M_d=1.2× $\frac{85}{100} = 1.02 \times 0.233 = 0{,}237$kg

M_e=1.2× $\frac{15}{100} = 0.18 \times 0.046 = 0.0082$kg

T=$\frac{PV}{MR} = \frac{369249.41\times0.046}{\frac{1.02}{0.237}+\frac{\mathbf{0.18}}{\mathbf{0..0082}}\times8.314}$

=288.54k

Ethanol=25% Diesel =75%

M_d=1.2× $\frac{75}{100} = 1.9 \times 0.233 = 0{,}2092$kg

M_e=1.2× $\frac{25}{100} = 0.3 \times 0.046 = 0.0138$kg

T=$\frac{PV}{MR}$

$=\frac{369249.41\times0.046}{\frac{0.9}{0.2097}+\frac{\mathbf{0.3}}{\mathbf{0..0038}}\times8.314}$

=291.03k

3. DESIGN OF EXHAUST VALVE

a. **Size of valve port**

$a_p\ v_p = aV$

$a_p = \frac{\pi}{4}(d_p)^2$

b .Thickness of valve disc

t = $Kd_p\sqrt{\frac{p}{\sigma_b}}$

c. Maximum lift of the valve

h = lift of the valve

h = $\frac{d_p}{4\cos\alpha}$

d. Valve steam diameter

$d_s = \frac{12.768}{8} + 6.35$ or

$d_s = 1.596 + 6.35$

MODEL OF EXHAUST VALVE

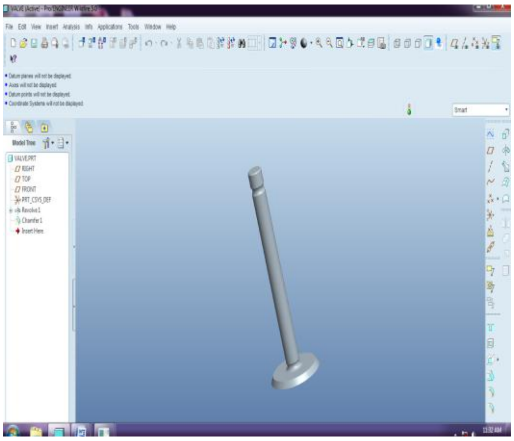

Fig1. Model of Exhaust valve

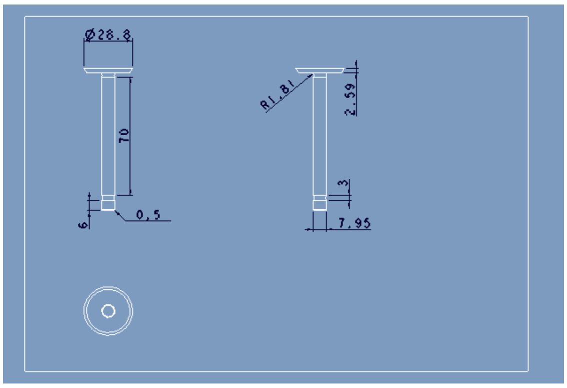

Fig2. 2D Drafting

THERMAL ANALYSIS OF VALVE

CONVENTIONAL FUEL – DIESEL

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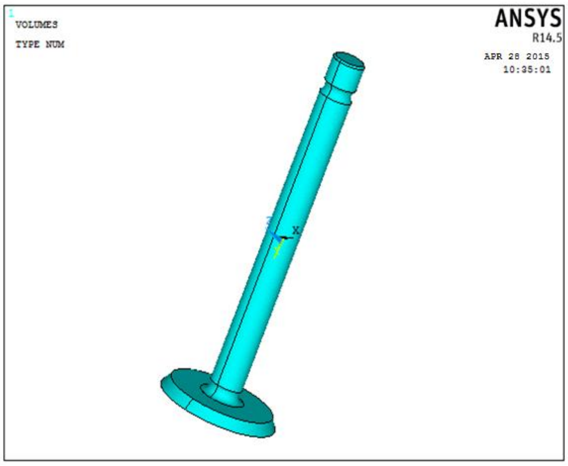

Fig3. Imported Model

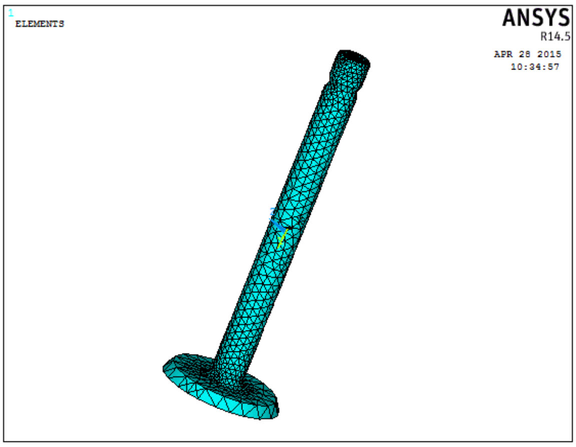

Fig4. Meshed Model

Material Properties: Thermal Conductivity – 0.03W/mmK

Specific Heat – 506 J/Kg K

Density - 0.00000789 Kg/mm^3

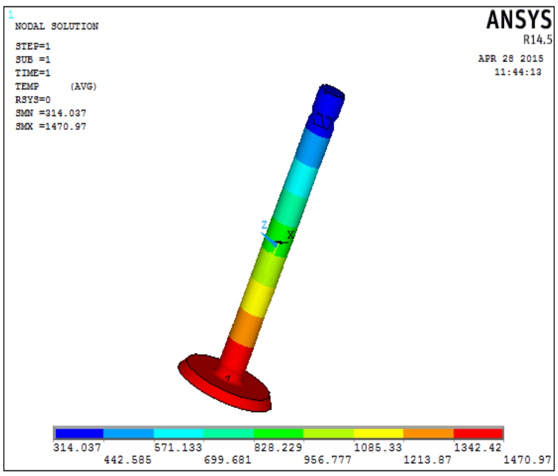

Fig5. Nodal Temperature

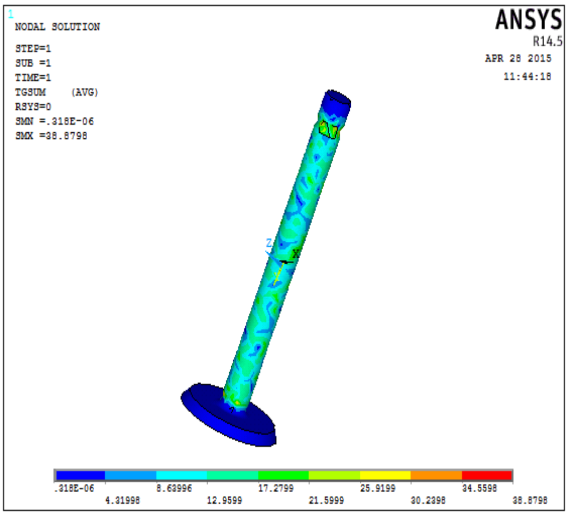

Fig6.Thermal Gradient

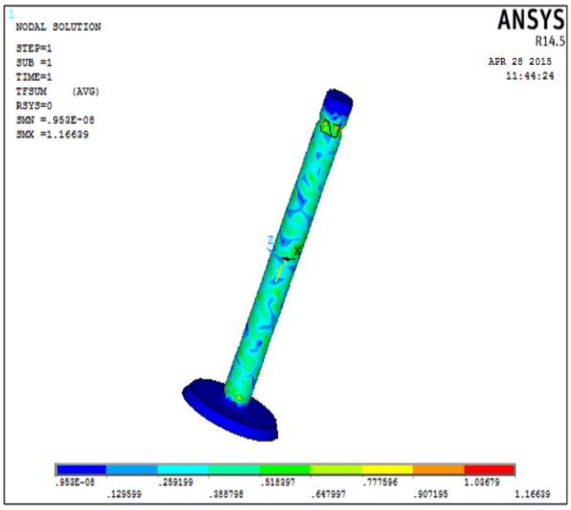

Fig7.Thermal Flux

RESULTS TABLE

	NODAL TEMPERATURE (K)	THERMAL GRADIENT (K/mm)	HEAT FLUX (W/mm2)
Conventional Fuel	1470.97	38.8788	1.166639
D – 90%, E – 10%	312.98	0.742026	0.022261
D – 85%, E – 15%	312.978	0.821	0.0246
D – 75%, E – 25%	312.98	0.737661	0.02213

CONCLUSION

In this thesis, the effect of diesel and blended fuels on exhaust valve is studied by mathematical correlations to calculate thermal loads produced during combustion. Fuels considered are Diesel and Blended fuels. Blended fuels are usually Ethanol fuels blended in different percentages. Percentages vary from 10%, 15% and 25%. Material used for Valve is Steel is Cast Iron.

Theoretical calculations are done to calculate the temperature produced for combustion when fuel is changed. Thermal analysis is done on the valve applying temperature by changing the fuels used for combustion. The cases considered are Diesel, Diesel + 10% Ethanol, Diesel + 15% Ethanol, Diesel + 25% Ethanol.

By observing the analysis results, by using only diesel as fuel the heat transfer rate is more than by taking blended fuels. When the blended fuels are considered, by increasing the percentage of ethanol, the heat transfer rate is reducing. So it can be concluded that, for blending fuels, less percentage of ethanol is better.

FUTURE SCOPE

More experiments have to be done for using higher percentages of ethanol so that the use of conventional fuels is reduced with minimizing disadvantages of using ethanol.

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