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CFD Analysis of Emission Characteristics of 4-Stroke Single Cylinder SI Engine by Using Eucalyptus Oil and Gasoline Blend

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ABSTRACT:

Majority of the automobiles run with internal combustion engines such as spark ignition (SI) and compression ignition (CI) engines which use conventional fuels such as Petrol, Diesel etc. The use of automobiles increasing day by day in the human life .As the use of the automobiles increases, the consumption of the fuels like petrol, diesel also increases and due to the increased consumption of the fuels depletion of fuel resources occur. Along with the depletion the emissions from the automobile engines increases and there by affect human health, and environment. The main emissions like hydrocarbons(HC) , carbon monoxide (CO) ,nitrogen oxides(NOx) and oxides of sulphur (SOx) emitted from automobile engines affect human lungs and also affects the environment which causes global warming and acid rains. From the above reasons in order to reduce the emissions various researches going on petrol and diesel engines. The petrol engines are very popular from the time of their invention; most of the automobiles are run by these engines mainly because of its simplicity and ease of operations, they are the choice for number of researches. As crude oil reserves are decreasing and increasing price of petrol alternative fuels are coming in to picture.

Now a day's most of the alternative fuels like ethanol, methanol, orange oil, eucalyptus oil are biomass derived and easily available. Alternative fuels which are eco friendly, reduce the dependency on fossil fuels and they help to preserve the atmosphere by reducing the emission levels. Alternate fuels can be in the form of solid, liquid, and gaseous form. The solid fuels are not used in ic engines due to their physical properties, the liquid fuels are alcohols (ethanol, methanol) and vegetable oils (edible and non edible), and the gaseous fuels are LPG, CNG, H2 and producer gas. Liquid fuels are easy to handle and calorific value of these types of fuels is more...

Many alternative fuels blends has been introduced in past and they gave satisfying results. Therefore, in this project the eucalyptus oil which is high octane biomass derived fuel is blended with petrol 15% by volume that is Eu15 and used as fuel in four stroke single cylinder petrol engine and pollution characteristics were studied and analyzed using ANSYS-FLUENT software.

KEY WORDS: ***CFD Analysis, Gasoline, Eucalyptus oil, Petrol engine.***

1 INTRODUCTION:

The first chapter of the thesis devotes to the general view of a Petrol engine, in relation to the combustion and emissions. The chapter presents the operation of the Petrol engine with alternate fuels, especially bio fuels which are to be blended with petrol and also

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discusses intake system of air fuel mixture into the engine. At the end of the chapter, the types of fuels are presented.

1.1Background of the petrol engines:

A petrol engine (known as a gasoline engine) is an internal combustion spark ignition engine, designed to run on petrol (gasoline) and similar volatile fuels.

The first practical petrol engines was built in Germany by Nikolas August Otto, although there had been earlier attempts by Etienne Lenoir ,Siegfried Marcus , Julius hock and George brayton.

The first petrol combustion engine (one cylinder 121.6 cm3 displacement) was prototyped in 1882 in Italy by Enrico bernardi.

In most petrol engines, the fuel and air are usually premixed before compression (although some modern petrol engines now use cylinder – direct petrol engine) the pre-mixing was formally done in a carburettor . But now it is done by electronically controlled fuel injection except in small engines where the cost/ complication of electronics do not justify the added engine efficiency.

The process different from a diesel engine in the method of mixing the fuel and air, and in spark plugs to initiate the combustion process. In diesel engine only air is compressed (and therefore heated) and the fuel is injected into hot air at the end of the compression stroke and self ignites.

1.2Alternate fuels for the petrol engine:

As the time passes it is believed that the petroleum products and crude oil will not be enough and will be costly .various researches are going on for the improvement of fuel economy of engines. However as the demand and availability for petrol and diesel is somewhat un balanced and there is a need to balance since that is mainly happened due to enormous increase in number of vehicles, if the same situation continuous then the scenario will be more disastrous and petrol and diesel will be more costly and limited .with increase use and the depletion of fossil fuels today more emphasis is given on the alternate fuels.

There is an essential need of alternate fuels in a way or other .Today intensive search for the alternative fuels for both spark ignition (SI) and compression ignition (CI) engines and it has been found out that the biomass derived fuels are suited for the alternate fuels .in spark ignition engines fuels like eucalyptus oil and orange oil are the suitable substituents for the petrol. They can be blended with petrol over a wide range of percentage according to the requirement. Another reason for the need of alternate fuel for ic engines is the emission problems. Combine with other air polluting factors, the large no of automobiles is a major contributor to the air. The main problems with the altenate fuels cannot be run directly in the engines .therefore these are blended with gasoline at various percentages . One of the main reason for neglecting these fuels is the similarity in the properties of these with gasoline and they are miscible with gasoline without any phase separation .The engines used for these blending with alternate fuels are modified engines which were originally designed for gasoline fuelling .the eucalyptus oil can be used in spark –ignition engines with very little engine modification has a blend with gasoline .since the octane number of eucalyptus oil is more than gasoline, so it enhances the octane value of the fuel when it is blended with low octane gasoline .at the same time the compression ratio (CR) which is dependent on knock can be increased when these fuels are blended with gasoline.

1.3Types of alternative fuels:

Basically there are three types of fuels liquid, gaseous and solid fuel.

SOLID FUELS have very less practical applications mainly because of handling problems and disposing off the left over components .But they played a vital role during the initial stage of engine development .solid fuels such as the pulverized coal, slurry and charcoal which are not used in IC engines due to their physical properties.

LIQUID FUELS are the derivatives of liquid petroleum and they are used in most of the modern internal combustion engines. The three principal

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commercial types of fuels are benzyl, alcohol and petroleum products. Today the petroleum products form the main fuels for internal combustion engines. the liquid fuels are alcohols (ethanol, methanol) and vegetable oil (edible and non edible)

GASEOUS FUELS are considered ideal fuel and display very few problem when they are used in internal combustion engines because they mix with the air very easily and give a significantly homogeneous mixture. They also suffer with the problem of handling and storage .their principle application can be seen in stationery power plants. Some of the gaseous fuels can be liquefied under pressure resulting in less storage volume but this type of arrangement is very expensive as well as risky. The gaseous fuels are LPG, CNG, H2 and producer gas.

2 EUCALYPTUS OIL:

Eucalyptus oil is the generic name for the distilled oil from the leaf of Eucalyptus, a genus of the Plant family mytraceae, native to Australia and cultivated worldwide. the leaves of selected Eucalyptus species are steam distilled to extract eucalyptus oil. the main chemical component of eucalyptus is 1,8 –cineole.

Eucalyptus is a tall ever green tree .it attains the height more than 100 meter. The adult leaves are 15 to 30 cm long and 2 to 5 cm broad .Eucalyptus oil has a history of wide application , as a pharmaceutical ,antiseptic, repellent, flouring, fragrance and industrial uses. The cineole (eucalyptol) based oils can also be used as an insect repellent and bio pesticide .Eucalyptus oil has been used as an effective way of killing dust mites.

Fig. 1 eucalyptus oil

2.1PHYSICAL AND CHEMICAL PROPERTIES OF EUCALYPTUS OIL(HIGH OCTANE FUEL):

Eucalyptus oil is mainly from the leaves of the eucalyptus tree. a very eucalyptus species like mallees species produces the leaf oil . this is composed of mixture of volatile organic compounds hydro carbons, alchols, aldehydes, key tones, acids , ether,esters.1-8 cineole is the active components of eucalyptus oil. cineole is cyclic ether with empherical formula $C_{10}H_{18}O$. and its systematic name is 1,3,3trimethyl1-2-oxabicloоctane.

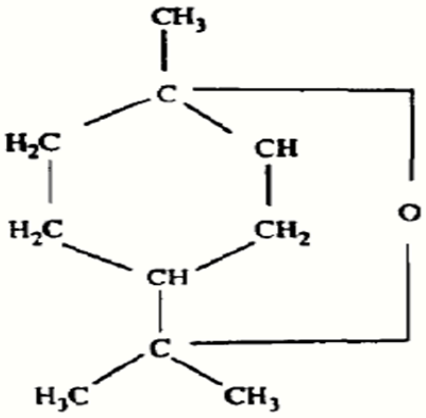

Fig 2.Chemical structure of the 1-8 cineole

2.2PROPERTIES OF THE EUCALYPTUS OIL AND GASOLINE BLEND

Table -1 properties of the eucalyptus oil and gasoline blend

S. No	PROPERTIES	EUCALYPTUS OIL(Eu15)	GASOLINE	BLEND
1	%Mass	15	85	
2	Density at 40^0 Centigrade	913	780	797
3	Viscosity at 40^0 centigrade	2.0	0.40	0.47
4	Specific heat(kj/kgk)	3.2	1.8	2.1

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3 OVERVIEW OF FLUENT PACKAGE

FLUENT is a state-of-the-art computer program for modeling fluid flow and heat transfer in complex geometries. FLUENT provides complete mesh flexibility, solving your flow problems with unstructured meshes that can be generated about complex geometries with relative ease. Supported mesh types include 2D triangular/quadrilateral, 3D FLUENT also allows user to refine or coarsen Mesh based on the flow solution.

FLUENT is written in the C computer language and makes full use of the flexibility and power offered by the language. Consequently, true dynamic memory allocation, efficient data structures, and flexible solver control are all made possible. In addition, FLUENT uses a client/server architecture, which allows it to run as separate simultaneous processes on client desktop workstations and powerful computer servers, for efficient execution, interactive control, and complete flexibility of machine or operating system type.

All functions required to compute a solution and display the results are accessible in FLUENT through an interactive, menu-driven interface. The user interface is written in a language called Scheme, a dialect of LISP. The advanced user can customize and enhance the interface by writing menu macros and functions.

3.1MODELING THE GEOMETRY:

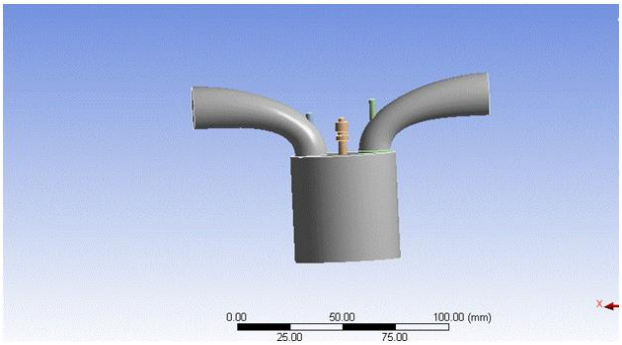
Engine specifications for modeling geometry

Fuel type: Eucalyptus oil and gasoline
Engine type :V6
Displacement :2721cm^3
Induction system : Twin-turbo(VGT)
Valves/cylinder:1
Bore x Stroke : 81 mm X 88mm
Connecting rod length :160mm
Compression ratio(CR) : 17.3
Intake valve max lift:8.00mm
Exhaust valve max lift :8.1mm
Intake valve diameter : 25.9mm
Exhaust valve diameter :23mm
Intake duration : 252CAD
Exhaust duration:291 CAD

ANSYS WORKBENCH:

Importing the geometry

Ansys mainly supports the cad interactive interface with any software or the most common file formats like STEP IGES and Para solid. STEP file is a CAD file format, usually used to share 3D models between users with different CAD systems. CAD file interchangeability is a huge, huge headache in the field, so it has to be make uniform. Standard ISO 10303 is trying to solve this problem. Initial Graphics Exchange Specification (IGES) is a neutral file format designed to transfer 2D and 3D drawing data between dissimilar CAD systems. The IGES standard defines two file formats: fixed-length ASCII, which stores information in 80-character records, and compressed ASCII.



The above Fig 3 represents the volume imported to do the fluent analysis in ansys (step)

BOUNDARY CONDITIONS

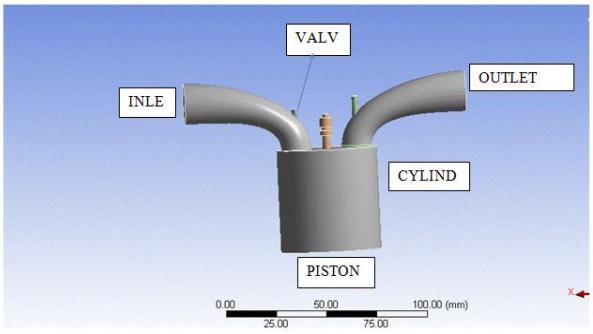


Fig 4 shows the Boundary conditions for imported 3D volume

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4 -IMPLEMENTATION METHODOLOGY

ANSYS Fluent Solver set up:

Set up:

-models

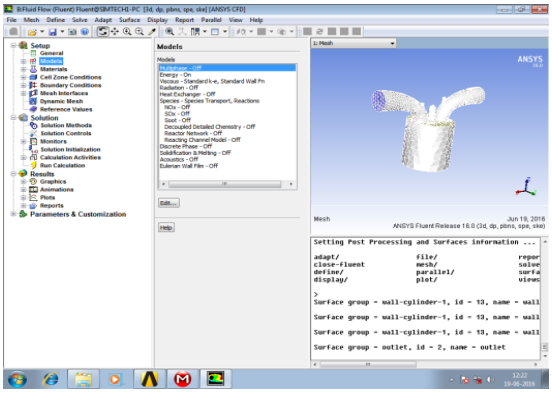

Fig:5 cfd models –multiphase off

Materials:

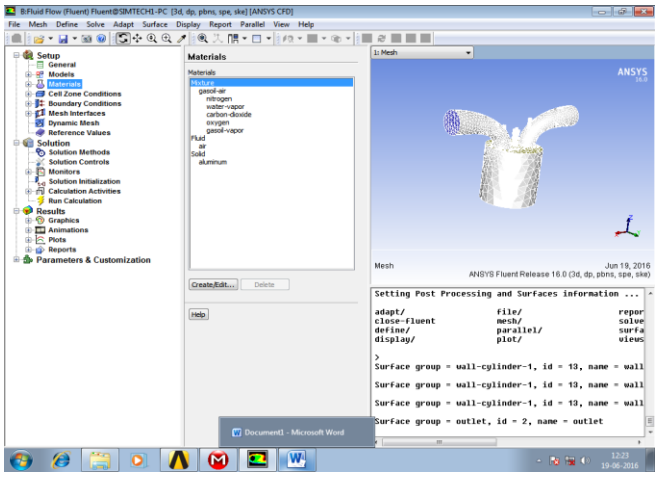

Fig 6 shows about the materials mixture of the gasoline and eucalyptus blends

Cell Zone conditions:

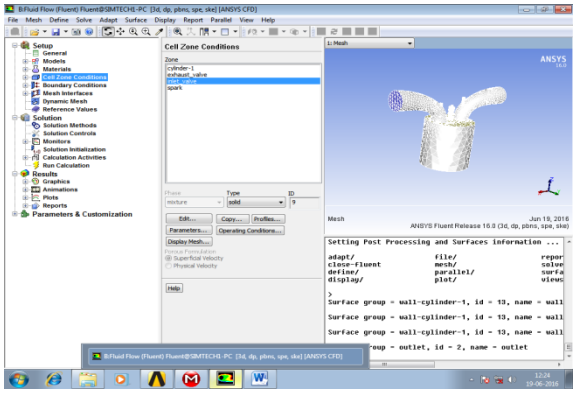

Figure 7 about the Cell zone conditions to inlet valve

Boundary Conditions:

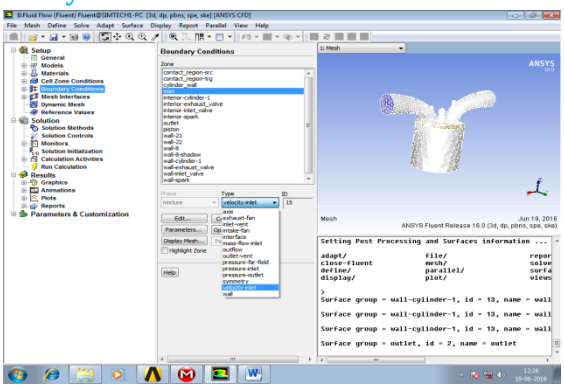

Figure 8 shows the Boundary conditions - inlet – velocity inlet

Solution:

Solution Methods:

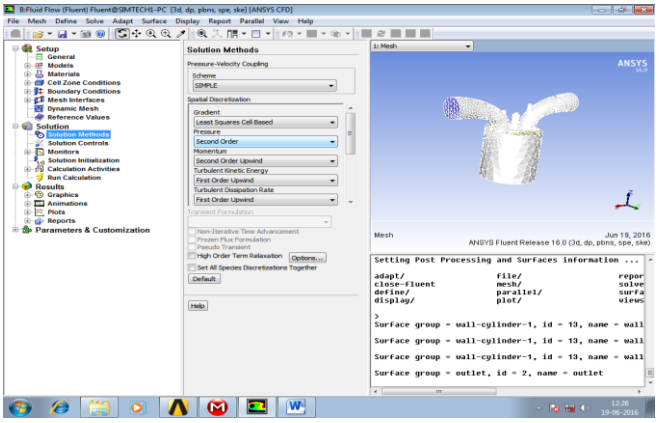

Fig 9 shows the solution methods – second order.

Solution Control:

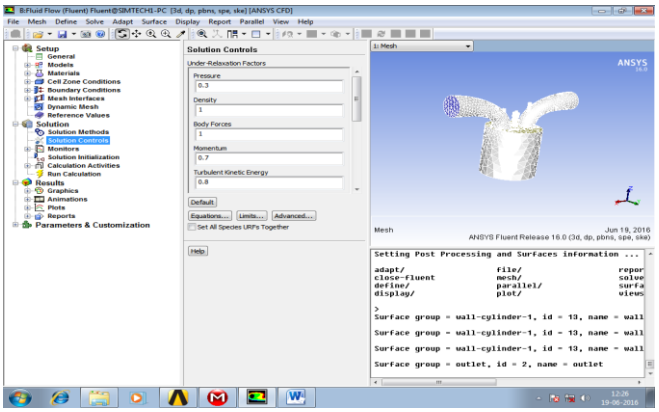

Figure 10 shows the Solution Controls

Pressure= 0.3pa

Density= 1kg/m^3

Momentum =0.7m/s

Turbulent kinetic energy= 0.8m^2/s^2

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Solution Initialization:

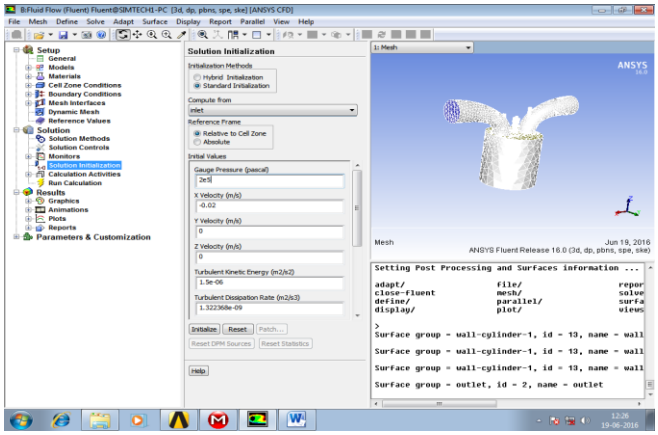

Figure 11 shows the Solution Initialization

Run Calculation:

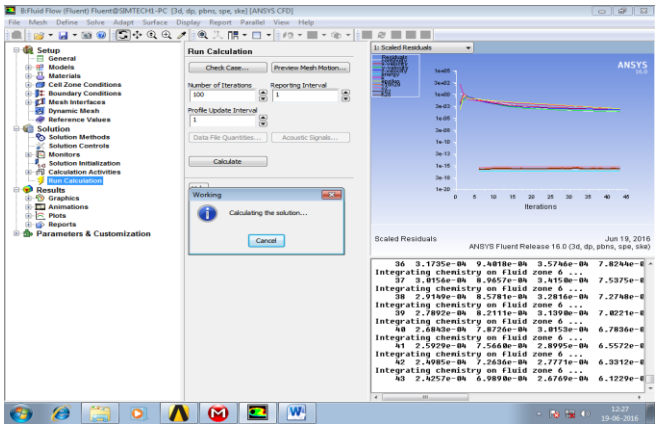

Fig 12 shows the Running the Calculations

RESULTS:

Graphics

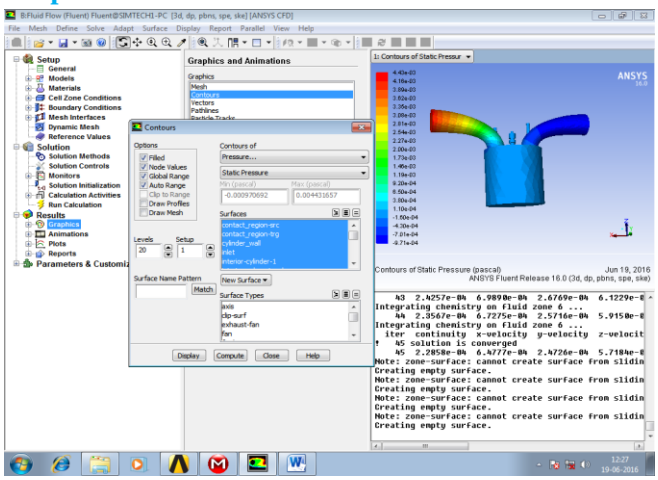

Fig 13 shows the Graphics of the contours of pressure

5 RESULTS AND DISCUSSIONS

The results show the contour plots of the different pollutants of the IC engine like as HC, NH3, and NO etc.

THE CONTOUR PLOT OF THE HYDROCARBONS:

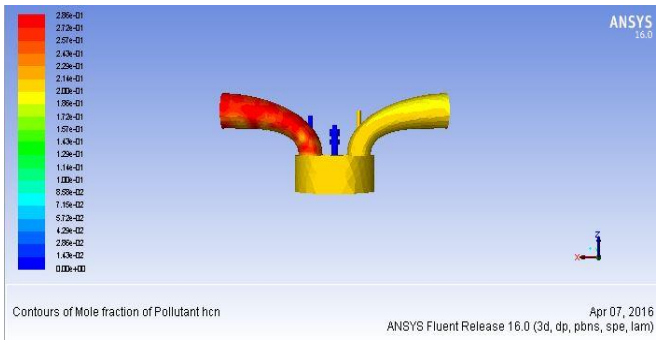

Figure 14 shows the contours of Mole fraction of HC.

CONTOURS OF MOLE FRACTION OF NITROGEN MONOXIDE

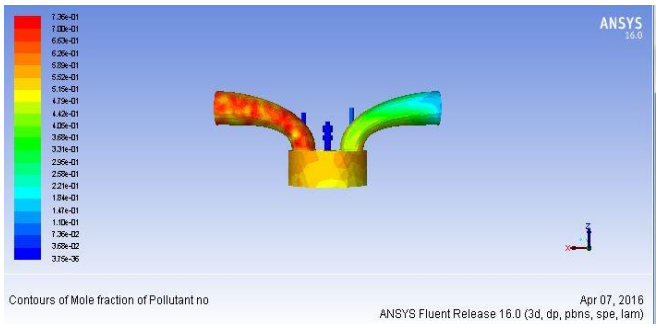

Fig 15 shows the mole fraction of pollutant NO

CONTOURS OF THE MOLE FRACTION OF POLLUTANT NH3:

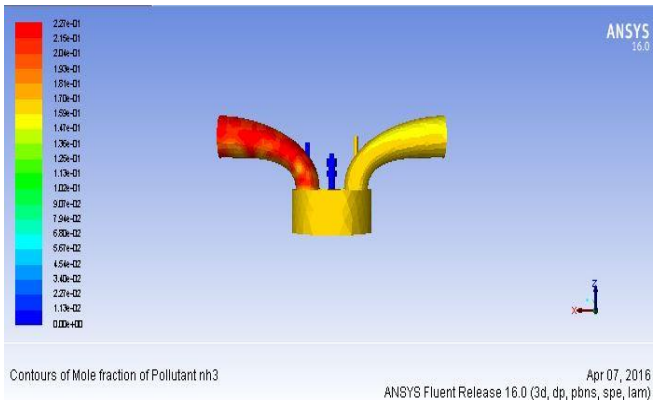

Fig 16 shows the mole fraction of pollutant NH3

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5.1 EMISSION ANALYSIS:

The emissions coming out from the internal combustion engine undesirable. These emissions are exhausted into the surroundings,pollute the atmosphere and causes the various problems like global warming, acid rain, smog ,odours and hazard to the respiratory system.

The engine running with the petrol as the fuel emission parameters are not specifically ideal that results in more emission of unburnt hydrocarbons (HC), carbon monoxide (CO) and oxides of nitrogen (NOx)

Engine emissions are classified into two types

1 Exhaust emissions
2 Non exhaust emissions

Exhaust emissions:

The exhaust emissions as the mentioned above are

- Unburnt hydro carbon (HC)
- Oxides of carbon

1. Carbon monoxide (CO)
2. Carbon dioxide (CO)

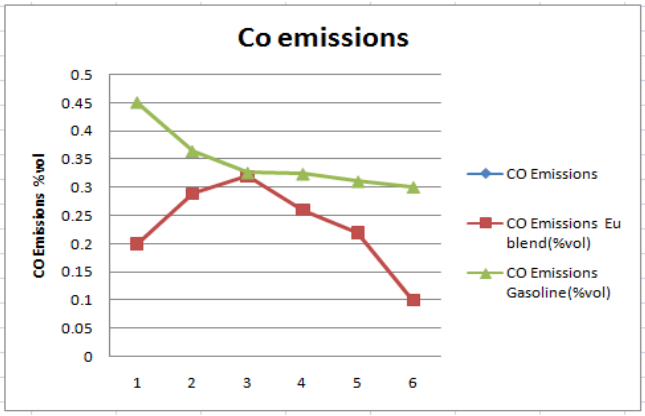
- Oxides of nitrogen (NOx)

These emissions common to both SI and CI engines

Non exhaust emissions:

Non exhaust emissions are the un burnt hydrocarbons from the fuel tank and crank case emissions

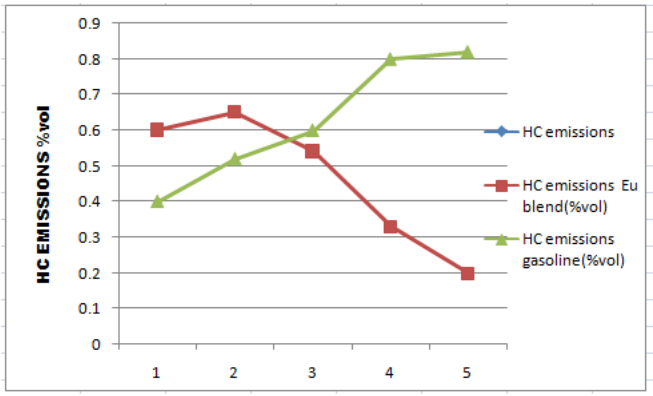
5.1.1CARBON MONOXIDE EMISSION:



Graph 1 shows the variation of CO emission with average iterations

The graph-1shows at initial iteration CO emissions are significantly reduced but higher as the iterations increases CO emissions decreases due to the reason for the low CO emission is due to the enrichment of O2 in the eucalyptus oil principle component of cineole which increases the production of oxygen and promotes for the oxidation of CO during the engine exhaust process.

5.1.2 HYDROCARBON EMISSION:



Graph 2 shows the variation of HC emission with the average iterations

SI engine exhaust gases leaving the combustion chamber consists of 600ppm of HC components about 1-1.5% of fuel. HC emission different for gasoline blends and different engine geometry and operating conditions.

One of the main reason for the HC emission is absence of Oxygen to react with all the carbon present in a rich fuel mixture resulting in high level of HC and CO in the exhaust products.

This mainly occurs during the starting conditions where air fuel mixture is very rich and if the air fuel mixture is kept lean then there will be poor combustion again resulting in HC emission.

CAUSES OF HC EMISSION:

- In complete combustion due to improper mixing and flame quenching
- Leakage of exhaust valve

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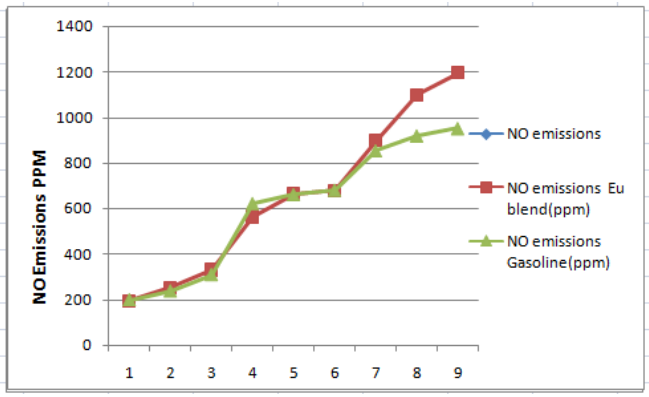
- Flow of fuel between the piston, piston rings, and cylinder walls
- Deposition of fuel on walls
- Oil on combustion walls

The graph- 2 shows the HC emissions with iterations. HC emissions low as compared to normal gasoline. the HC emission decreases when the gasoline blends with eucalyptus oil and operated entire conditions due to the reason for the less HC emission is equivalent ratio and easily decomposition of eucalyptus oil which gives more intermediate compounds and presence of oxygen in cineole which is main component of eucalyptus oil results in availability of more oxygen for carbon to react causing less HC emission.

5.1.3 OXIDES OF NITROGEN (NO) EMISSION:



Graph 3 shows the variation of NOx emissions with average iterations

The graph- 3 shows the NOx emission with variation of iterations. NOx emissions increases with continuously increasing with iterations increases because of the oxygen present in the eucalyptus oil and oxygenated fuel blends causes an increase in NOx emission and also complete combustion of fuel high combustion temp is achieved which results in formation of NOx

Another major reason for raise in NOx emission is due to longer ignition delay caused by eucalyptus oil and releases more heat during premixed phase of combustion

6 CONCLUSIONS:

After detailed cfd analysis of the 4-stroke single cylinder SI engine HC emissions are low as compared normal gasoline engine.The reason due to equivalent mixture ratio and easily decomposition of eucalyptus oil gives more intermediate compounds and presence of oxygen n in cineole which is the main component of eucalyptus oil results in availability of more oxygen for carbon to react causing less HC emission

CO emissions are low due to the reason that the enrichment of O_2 in eucalyptus oil principal component of cineole which increases the production of oxygen and promotes for the oxidation of CO during the engine exhaust process.

NOx emission increases with continuously increasing the iterations because the presence of the oxygen in eucalyptus oil and oxygenated fuel blends causes an increase in NOx emission

7 FUTURE SCOPES:

More experiments can be performed
-By using different kinds of eucalyptus oil and gasoline blends.
-By changing the engine parameters like compression ratio, design of combustion chamber etc.
-By using different types of alternate fuels and fuel blends.

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