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Performance and Exhaust Gas Analysis Of A Single Cylinder Diesel Engine Using HHO Gas (Brown's Gas)

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Abstract— **In the present scenario the growing concern of the people living in every part of society is the ever increasing price of fuel and the harmful effects caused due to higher level of pollutants in the atmosphere. One of the closest solution to control the above two concern is the evolution of the hybrid vehicle. Any vehicle that combines one or more sources of on board power that can directly or indirectly provide propulsion power is a hybrid vehicle. The hybrid vehicle attempts to significantly increasing the mileage and reduce the emission levels of a gasoline powered engine and Diesel Engines. The water hybrid vehicle uses an HHO (Oxy Hydrogen) generator to supply hydrogen on demand by Electrolysis. The Electrolysis process is carried out in HHO Dry Cell, when the current starts flowing through the stainless steel plates electrolysis process is carried out between the 2 terminals of the plate by which water molecules get separated as HHO gas. The integration of this produces great results. The IC Engine of hybrid vehicle during operations simultaneously charges the battery using alternator which run through generator. The water hybrid system is an attempt to provide an affordable low emission fuel efficient vehicle with performance standards better than most of the conventional Engines.**

Key words: Browns gas, performance, HHO Dry cell, Electrolysis

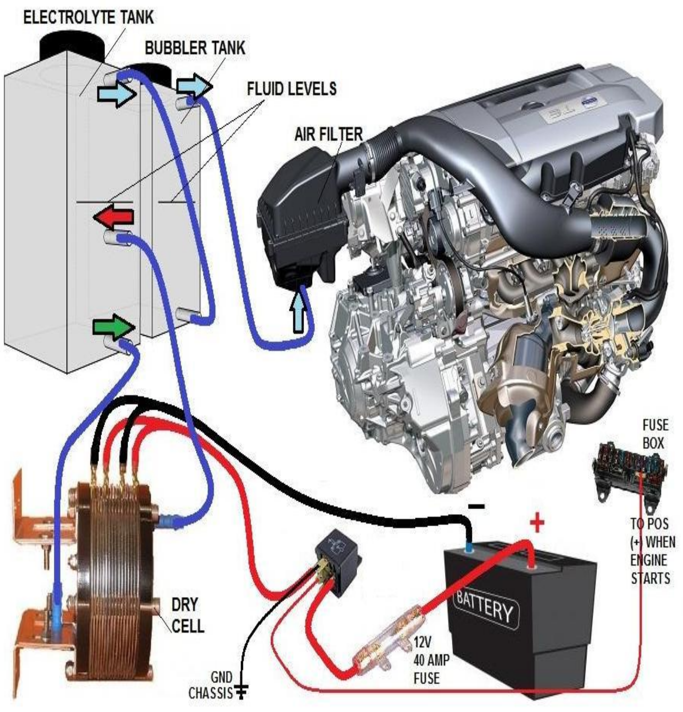
I. Introduction

The water hybrid system plans essentially to convert a vehicle to use water as a source of supplemental or even (theoretically) primary fuel. The engine derives fuel from Hydrogen gas generated by the electrolysis of water and petrol (primary fuel). Although petroleum derived fuel and an external electrical generating system is not theoretically required, in most circumstances it is a practical necessity. The only by-product resulting from the combustion of Hydrogen gas within the engine is water vapour. Therefore, emissions are usually cleaner, emitting fewer polluting particles. In short, the Water hybrid system is a "cleaner" system; one that derives supplemental fuel from a free and inexhaustible resource water. It has the unique advantage of being able to remove pollutants from the air during combustion, and even reduces the carbon residue within the engine (similar to the effect of higher octane fuels). Water electrolysis is simply the breaking down of water into its basic hydrogen and oxygen atoms by passing an electronic current through it. HHO referred to as Hydrogen gas, water gas, and brown gas (in automotive applications) is a weekly bonded water molecule which exists in gaseous state. It is 2:1 molar mixtures of hydrogen and oxygen. Ali Can Yilmaz, Erinclu, U dumar, Kadir Aydin.[1] has give information about HHO production and it was produced by electrolysis process of different electrolytes (KOH),Naoh,Nacl,with various electrode designs in a leak proof reactor(Hydrogen generator). Bauer C and Forest T[2] has investigate the effects of hydrogen fundamental characteristics of propagating spherical methane/airflame conditions. The emphasis is placed on laminarflame, speed, and mark stein length of hydrogen and fuel. It is found that as the laminar flame speed increases monotonically with hydrogen blends. Wang J, et al[3]explains the combustion behaves of a direct injection engine operations on various fractions of natural gas ,hydrogen blends. The results should be observed by the author that as brake thermal efficiency increases hydrogen fraction also increases at low &medium engine loads. Hung-Kuk, O [4] proposes to test the effect of adding Brown's Gas, from an electrolysis unit, to the air intake of a combustion process. Combustion parameters such as fuel consumption exhaust emissions and system efficiency will be measured. Tests will be conducted on a hydrocarbon burner to determine the effect of Brown's Gas addition on heating efficiency. Eckman C [5] explains the Brown's Gas boasts a plethora of unusual characteristics that defy current chemistry. It has a cool flame of about 130 degrees, yet melts steel, brick and many other materials. Confusingly research both confirms and rebuffs many claims about it, leading to a smorgasbord of theories today seeking to explain its unusual properties. One possible theory, currently gaining support even from establishment science, depicts "plasma orbital expansion of the electron in a water molecule". In this process, unlike electrolysis, the water molecule "bends" into a linear, dipole-free geometry. Cassidy J[6]has done An experimental program using a multicylinder reciprocating engine was performed to extend the efficient lean operating range of gasoline by adding hydrogen. Both bottled hydrogen and hydrogen produced by a research methanol steam reformer were used. These results were compared with results for all gasoline. Also he explains the results were used to explain the advantages of adding hydrogen to gasoline as a method of extending the lean operating range. As per Park, et al[7] for the first time, using Brown's gas. Vitrification of pelletized fly ash (fly ash + water glass) results in a decrease of the leaching of toxic heavy metals to much below the Korean regulatory limit values, although melted fly ash was a poorly vitrified product that had a dark gray appearance. The addition of glass cullet to the fly ash increased the silica content and decreased the basicity. It was determined that a decrease in basicity from 2.94 to 0.28 leads to good vitrified products that have an amorphous glassy structure that is dark brown in colour. Leaching all of the potentially hazardous heavy metals present in fly ash also decreased as the basicity decreased. It was determined that all the heavy metals (zinc, lead, chromium, arsenic, copper, manganese, and cadmium) were efficient in regard to substituting for parent Al and Ca ions in the silicate structure.

II. Material and Methods

In metallurgy, stainless steel, also known as inox steel or inox from French "inoxydable", is defined as a steel alloy with a minimum of 10.5 or 11% chromium content by mass. Stainless steel does not corrode, rust or stain with water as ordinary steel does, but despite the name it is not fully stain-proof. It is also called corrosion-resistant steel or CRES when the alloy type and grade are not detailed, particularly in the aviation industry. There are different grades and surface finishes of stainless steel to suit the environment the alloy must endure. Stainless steel is used where both the properties of steel and resistance to corrosion are required. Since stainless steel resists corrosion, maintains its strength at high temperatures, and is easily maintained, it is widely used in items such as automotive and food processing products, as well as medical and health equipment. The most common US grades of stainless steel are: Type 304, the most commonly specified austenitic (chromium-nickel stainless class) stainless steel, accounting for more than half of the stainless steel produced in the world. This grade withstands ordinary corrosion in architecture, is durable in typical food processing environments, and resists most chemicals. Type 304 is available in virtually all product forms and finishes. Austenitic (chromium-nickel stainless class) stainless steel containing 2%-3% molybdenum (whereas 304 has none). The inclusion of molybdenum gives 316 greater resistances to various forms of deterioration. Ferrite (plain chromium stainless category) stainless steel suitable for high temperatures. This grade has the lowest chromium content of all stainless steels and thus is the least expensive. The most widely used martensitic (plain chromium stainless class with exceptional strength) stainless steel, featuring the high level of strength conferred by the martensitics. It is a low-cost, heat-treatable grade suitable for non-severe corrosion applications. The most widely used ferrite (plain chromium stainless category) stainless steel, offering general-purpose corrosion resistance, often in decorative applications. Stainless steels are available in the form of plate, sheet, strip, foil, bar, wire, pipes and tubes. There are many advantages and benefits to using an acrylic sheet over something like plastic or glass. The Cast manufacturing process leads to slight variations in the thickness of sheets whereas the thickness of Extruded sheet varies very little, if at all. Cast has an isotropic response to temperature with a maximum shrinkage of 2% in all directions. However, the extrusion process applied to Extruded sheet leads to differences in shrinkage depending on the thickness and direction of extrusion. Rubber rings are used to separate the stainless steel plates and prevent the distilled water from being drowned between the plates.The stainless steel bolts and nuts are used to prevent the corrosion caused due to the reaction in between the stainless steel plates and distilled water. These nuts and bolts are corrosion resistant and prevent any further reaction. The inlet outlet valves are used in the set to pass the distilled water in the stainless steel setup and also the hho gas gets out from the valves through the pipes. The non return valve in the hho set up is used to prevent the back fire of the hydrogen gas from the combustion chamber to the hho dry cell set up.

BLOCK DIAGRAM OF HHO DRYCELL



The block diagram of the HHO dry cell consist a battery of 12 volts connected to the fuse of 20 amps. The fuse is then connected to a switch. An ammeter is kept to measure the readings of the current flowing from the battery to the HHO dry cell. The positive wire from the ammeter is connected to the HHO dry cell and the negative is connected to the car grounding. When the process starts HHO is produced and the gas from the outlet is sent directly to the carburetor with the help of a silicon pipe.

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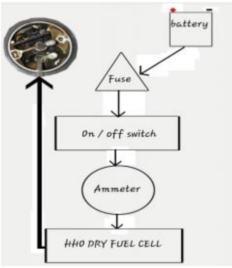
CIRCUIT DIAGRAM



CIRCUIT DIAGRAM

The above circuit diagram shows fuse is connected to battery and then on/off switch is in series with fuse which in turn connected to ammeter then to HHO Dry Fuel cell. And then the gas enters into the Engine as shown in circuit.

ARRARGEMENT OF HHO CELL

The HHO kit is arranged behind the car as shown in fig. or it can also be placed or arranged at the Engine. It is properly and safely clamped in the trunk near the stepnie. Leakages should be checked properly while arranging the kit in the car.

WORKING OF HHO DRY CELL

When the current starts flowing through the stainless steel plate's electrolysis process is carried out between the two terminals of the plates by which the water molecules get separated as HHO gas. The gas flows through the bubbler tank provided with a non-return valve to prevent the backpressure of gas. From bubbler the HHO gas flows through the P.V.C pipe provided at the outlet valve using the silicon pipe the gas flows to the air intake of the carburetor. Water The most abundant resource on our planet and you can use it as a fuel. That's Right, a supplementary Fuel from Water Hydrogen Generators have become an essential fuel assistant for internal combustion engine applications. By converting water into its primary elements of Hydrogen and Oxygen (HHO) and introducing the hydrogen/oxygen gas in conjunction with your regular fuel, our Hydrogen Generator can improve the fuel economy of your engine from 15 - 45%+ as well as drastically lower emissions to exceptionally clean standards .

ON ELETROLYSIS:

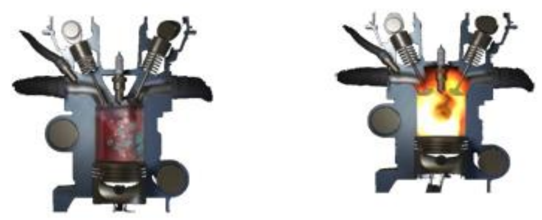
$2\ H_2O\ (l) \rightarrow 2\ H_2\ (g) + O_2\ (g);\ E_0 = -1.229\ V$

INJECTING DISTILLED WATER

They can be used in any type vehicle, bike, car, truck, diesel truck, boat or stationary engine such as power generators and irrigation pumps. Fuel from Water systems work with any type of fuel, Gasoline, Diesel, Biodiesel, Vegetable Oil, Ethanol, E85, E10, and CNG. By converting your vehicle to a Hydrogen Hybrid, this alternative renewable energy will not only improve fuel economy but it will also drastically reduce emission exhaust levels. Fuel from Water Hydrogen Generators is an on demand supplemental fuel system. Here is a simplified explanation on how the systems work in changing water into Hydrogen and Oxygen. We call it an HHO generator because it produces both Hydrogen and Oxygen simultaneously through the process of electrolysis. When water is introduced with electrical current/voltage. It has a tendency to become excited and divides into its primary elements of Hydrogen and Oxygen. The produced Hydrogen and Oxygen are now in a gaseous state from the liquid water. It's been said by others that the two elements have been split apart from one another into their sub-diatomic molecular state. A fallacy out there is that it takes more energy to produce the HHO than the energy it releases. Not at all true, that's why there are HHO generators available out there. You can produce HHO with as little as 1.5 volts DC and an amp of current. It's not only how it's done but the way in which the HHO generator is configured to permit a useful output with minimal power input. You can put 2 bare ended wires into a bucket of water with an electrolyte and produce a small quantity of HHO by putting a DC current through the wires. The principle is to produce as much HHO as possible with the least amount of electrical energy and generated exothermic heat. In reality, once the HHO generator has been charged up it actually acts like a wet cell battery. It holds a charge of 1.5 - 2.0 volts DC and can operate when charged with the power switch turned off, until the remaining suspended HHO gas is pulled off and the cell ultimately discharges. The power switch is primarily used to maintain the HHO generators charge. What we do here is draw off that produced gaseous material by vacuum created by the vehicles engine and feed the gasses directly into the combustion purposes. The system is an on demand system, "NOT" a pressurized storage system the HHO generator only produces what the vehicles engine may call for, nothing more.Can we idle an engine on pure HHO, the answer is absolutely, but to actually operate the vehicle under normal driving conditions the current technology is not quite there yet. Currently most of our users see from 25 - 45% on average concerning fuel savings. But don't think it stops there; the new Magnum Series HHO generators are pushing the fuel savings into the upper 50% range. If we keep on working on the problems that hold us from using just HHO long enough we will reach that point where the vehicles fuel tank will become a water reservoir tank for holding just water. The process is as follows, you start with water and an electrolyte, and there are many different types. You add DC current, the H_2O breaks down into H_2 & O [we just call it HHO]. We introduce it into the engine by use of the engines vacuum. The HHO combines with the gasoline and air in the combustion chamber and is burnt. Once burnt, it converts back to H_2O [water]. It's now going to absorb the inner heat from the engine normally at 350 - 450F CHT and turn into super heated dry steam. Then its pushed out during the exhaust stroke and out the tail pipe. There it condenses back into to water vapour and eventually collects back into water so what are our results, first and foremost a really odourless clean exhaust. Lowering HC, Co, Co2 and No_2 emissions to almost to 0, In short the exhaust emissions drop off the scale as you know them and you produce water vapour from your vehicles tail pipe. Why vapour instead of water? Because the hydrocarbon fuel [gasoline] produces enough heat during combustion to keep the burnt HHO in a water vapour state, so it will totally condense into water outside of the exhaust system against their business model, if I can sell you an automobile that runs on inefficient fuel loaded with all sorts of emission devices and promise you better mileage next time, and you haven't any other choices, what are you really going to do? Why is it that the auto builders have to be mandated to improve vehicle mileage? Because they are in bed with the oil producers and the lot of them are in bed with lobbyists and big banking. Here is a little bit of knowledge for you... This technology has been around since the middle 1800's. yes that's right over 100 years. Back before the take off of the industrial revolution and the real use of oil and coal to power our factories and vehicles. But oil and coal was easier technology and easily found and so if you could gain performance, better fuel efficiency, smaller bills at the gas pump and be green too .Just as long as you the consumer realize that you have been methodically led into a money pit concerning energy and fuel.

WORKING OF HHO GAS IN ENGINE

In the combustion chamber the Diesel which comes from the fuel injector gets mixed up with the mixture of air and hydrogen gas coming from the hydrogen dry cell. The hydrogen gas mixed with air enriches the fuel. As the hydrogen gas is highly flammable it helps in efficient burning of the fuel and removes the carbon deposits inside the cylinder and helps in running a cleaner engine.



WITHOUT HHO **WITH HHO**

COMBUSTION IN ENGINE

The process is as follows, you start with water and an electrolyte, and there are many different types. You add dc current, the H_2O breaks down into H_2 & O [we just call it HHO]. We introduce it into the engine by use of the engines vacuum. The HHO combines with air and is burnt together in the combustion chamber. Once burnt, it converts back to H_20 [water]. It's now going to absorb the inner heat from the engine normally at 350 - 450°F CHT and turn into super heated dry steam. Then it's pushed out during the exhaust stroke and out the tail pipe. There it condenses back into to water vapour and eventually collects back into water. The most amazing part of the process is that the emissions are reduced to exceptionally clean low levels.

HYDROGEN ASSISTED COMBUSTION

This review covers tank hydrogen-diesel experiments that have several similarities to the experimental setup in this research project. Conditions for commonality include naturally aspirated diesel engine, constant engine speeds at or near 1500rev/min replicating a generator, small rates of either hydrogen or HHO injection into the air intake, with fuel consumption and NOx emissions analysis. Throughout this paper, all gas mass flow rates are converted to volumetric flow rate at standard temperature and pressure – 298.15K and 101.325kPa. Firstly it takes 7.79kJ to produce 1L of HHO, and secondly the net efficiency of converting the equivalent diesel energy to

HHO energy was between 11.4% and 16%. Thirdly 4.4Wh of electrical energy was required make 1L of HHO with the experimental setup; this includes losses from the switch mode power supply. Taking an arbitrary net HHO conversion efficiency of 15%, it would require 51.9kJ or 14.426Wh of diesel energy to produce 1L of HHO.

HYDROGEN GENERATORS-MAKING OUT OF WATER

Although the technology has been around for over a century, progress has been slow to develop an Alternative fuel from this planet's most abundant commodity known as water. With the increased dependence on fossil fuels from oil, the costs of this vital resource are escalating along with damage caused by air pollution. Global warming is a very important and real threat issue that can reduce our chances for survival in the future. Water may just save us, if we use it wisely and keep it from becoming polluted also. The most abundant element in the known universe is hydrogen. Water is composed of two atoms of hydrogen (H) and one atom of oxygen (O).Thus H_2O= Water. There is a device called a Hydrogen generator that uses a process known as electrolysis to separate and extract both hydrogen and oxygen out of water. Earlier developments for hydrogen generators were designed to extract HHO or sometimes referred to as Browns Gas. They were originally designed for welding and cutting purposes, but HHO can be used as a supplemental fuel for internal combustion engines, even diesel motors. One company has developed a patented pending design that is compact and can fit into almost any vehicles motor compartment.

BENEFITS OF HHO TECHNOLOGY

HHO is composed of two separate elements of Water, consisting of two atoms 1of Hydrogen (H) and one atom of Oxygen (O), thus H_2O becomes HHO gas. The most abundant element in the known Universe is Hydrogen, which is the volatile part of this amazing fuel. Oxygen does not burn, but it does support combustion. The technology that is used to extract the two elements from water is known as Electrolysis. Electrolysis of water has been used for experimentation and other industrial processes for over a hundred years. The HHO fuel systems used today are used primarily as a supplemental fuel rather than a replacement for gasoline. The electrolyser, a device for producing HHO, is connected to the engine's air intake plenum or duct by a hose and HHO is mixed with the air and gasoline as it is drawn into the combustion chamber. The design is considered an on demand system, meaning that HHO fuel is produced only as is needed, having no storage tank, and stopping when the ignition key is turned off. Fuel mileage is increased because the gasoline burns more completely, producing cleaner exhaust emissions, and you can save money on fuel costs and help the environment by reducing air pollution.

III. Results and Tables

1. Brake power developed by the engine (B.P)

B.P = (πDNW) K.W
D = 0.3+0.015= 0.315 m
d_1 = 0.3---m
d_2 =0.015-----m

N =1484 rpm=1484/60=24.7 rps

W_1 = 8 kg

W_2 =0.8 kg

W= net load on the dynamometer = (w_1-w_2) = (8-0.8)

=7.2 kg=70.6 KN

B.P= (π*0.315*24.7*70.6)/1000=1.726 KW

2. Total fuel consumed T.F.C (M_f)

T.F.C (M_f) = (Q*SP GRAVITY)/1000 ---Kg/sec
Where Q=10/t
t=time of collecting n cc fuel consumption in "sec" t =48 Sec
T.F.C (M_f) = (Q*sp)/1000
= (10*0.8275)/(1000*48)
= $1.72*10^{-4}$ Kg/Sec

3. Heat input to the engine ($Q_{i/p}$)

$Q_{i/p}$ =T.F.C (M_f)*C.V ---K.W

C.V = calorific value of the fuel=10833 kcal/kg=45368 kj/kg

$Q_{i/p}$ =T.F.C (M_f)*C.V =$1.72*10^{-4}$*10833*4.188= 7.764 K.W

4. Indicated power (IP)

I.P = B.P+F.P ---K.W

Where B.P = brake power =1.726 K.W

F.P = frictional power graph = 0.2 K.W

I.P=B.P+F.P =1.726+0.2= 1.926 KW

5. Brake thermal efficiency ($\eta_{b.th}$)

$\eta_{b.th}$ = (B.P/ heat input)*100
= (1.726/7.764)*100= 22%

6. Indicated thermal efficiency ($\eta_{i.th}$)

$\eta_{i.th}$ = (I.P/heat input)*100
= (1.926/7.764)*100 =24.7%

7. Mechanical efficiency (η_{mech})

η_{mech} = (B.P/I.P)*100

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= (1.726/1.926)*100 =89.5%

8. Brake specific fuel consumption (B.S.F.C)

B.S.F.C = $(m_f/B.P)$------kg/K.W h

= $(1.72*10^{-4}/1.726)*3600$ = 0.99 kg/K.W h

9. Indicated specific fuel consumption (I. S.F. C)

I.S.F.C = $(M_f/I.P)$ -------kg/K.W h

= $(1.72*10^{-4}/1.926)*3600$

= 0.895 kg/K.W h

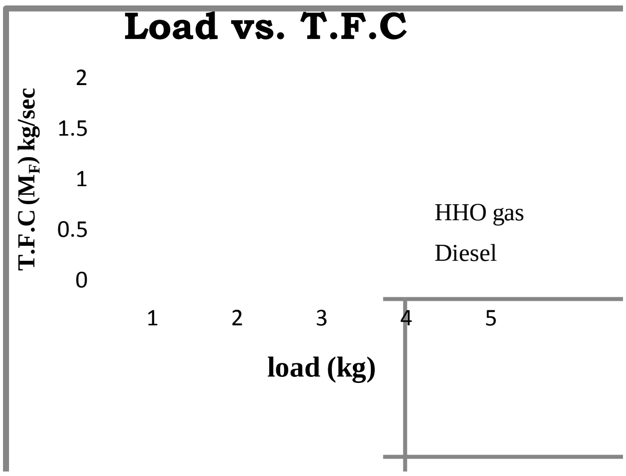

Fig 1:LOAD vs. T.F.C

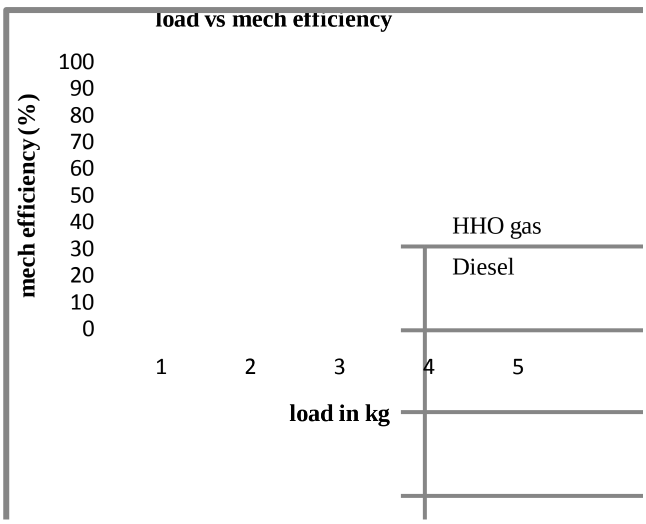

Fig 2: LOAD vs. MECHANICAL EFFICIENCY

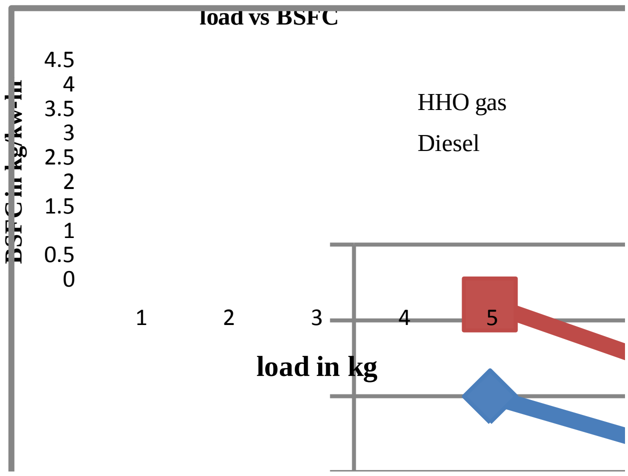

Fig 3: LOAD vs. BSFC

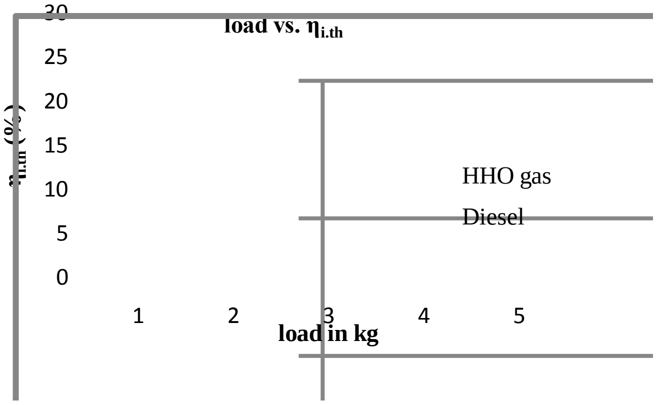

Fig 4: **LOAD vs. INDICATED THERMAL EFFICIENCY ($\eta_{i.th}$)**

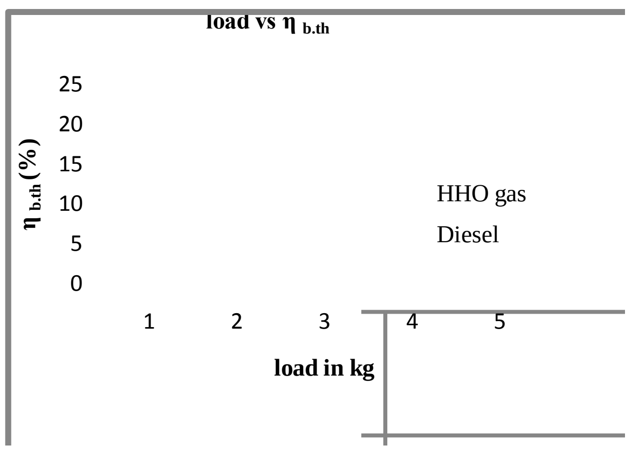

Fig 5: LOAD vs. BRAKE THERMAL EFFICIENCY($\eta_{b.th}$)

DIESEL-HHO GAS EMISSIONS

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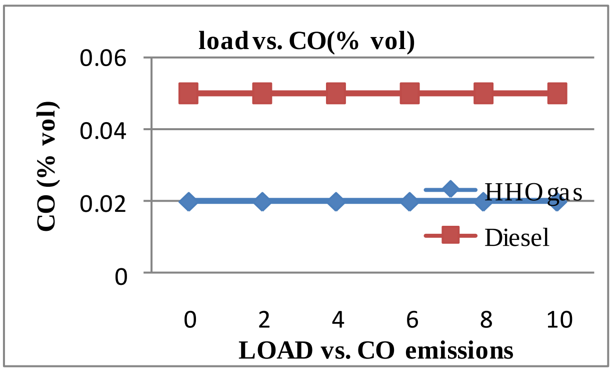

Fig 6:LOAD vs. CO (%vol) EMISSIONS

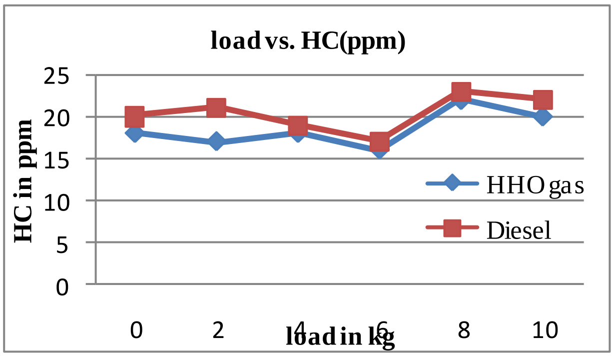

Fig 7:**LOAD vs. HC (ppm)**

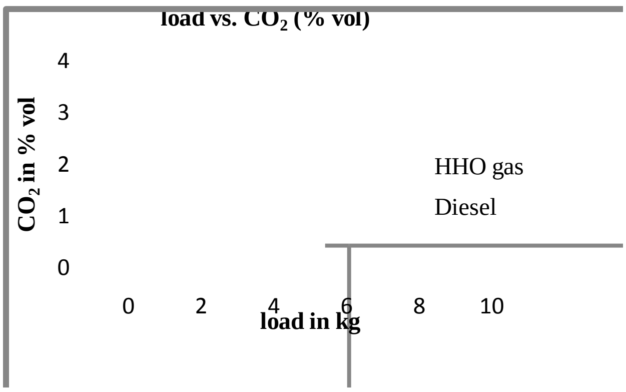

Fig 8:LOAD vs. CO_2 (%vol) EMISSIONS

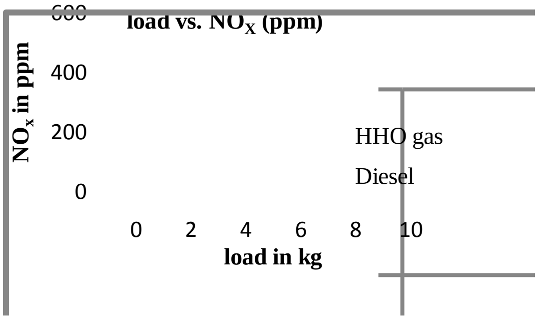

Fig 9: **LOAD vs. NO_x (ppm)**

Without the hho gas combustion of fuel in the combustion chamber was low and as a result carbon deposits occurred in the cylinder. On sending the hho gas with the fuel air mixture combustion of fuel increase 15-40%. Brake power, indicated power, mechanical efficiency, brake specific fuel consumption, indicated specific fuel consumption, brake thermal efficiency and indicated thermal efficiency of the engine at various loads for diesel are measured and compared with HHO gas .Performance curves are drawn at various loads and a comparisons is made between pure diesel and HHO gas. Engine exhaust emissions are measured for different pollutants against rated loads. a comparison of exhaust gas emissions with pure diesel and selected HHO gas is done. Exhaust emission characteristics measured for pure diesel and HHO gas are compared with existing Emission Norms.

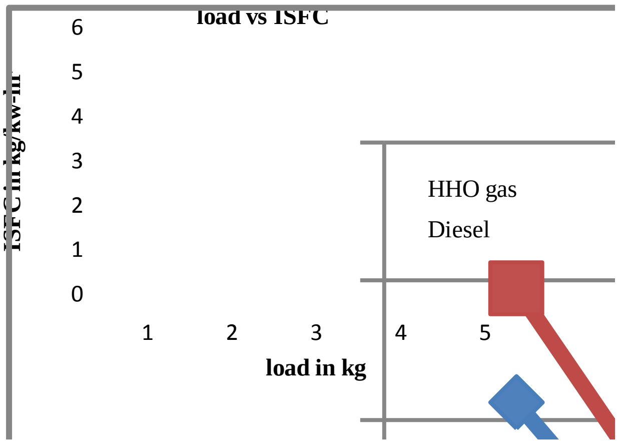

Fig 10:LOAD vs. ISFC

IV CONCLUSION

As the load increases Brake power increases. The brake power developed by the engine operated on HHO gas is more as compared with pure Diesel. Mechanical Efficiency of the engine increases, for engine operated with HHO gas is more as compared with pure diesel. Brake thermal efficiency, indicated thermal efficiency of the engine increases, for engine operated with HHO gas is more as compared with pure diesel. Total fuel consumption of the engine increases, for engine operated with HHO gas is more as compared with pure diesel. Emissions like carbon monoxide (CO), hydro carbons (HC), carbon dioxide (CO_2) , NO_x are greatly reduced for the engine operated with HHO gas compared to pure diesel engine.

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M.D Mr. Sivaramfor providing us the necessities for completing the journal paper.

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