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DEVELOPMENT OF AN AIR PREHEATER FOR HCCI IN SPARK IGNITION ENGINES

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ABSTRACT

Although the title self defines its aim, the main purpose of an air preheater would be to heat addition to the inflowing air into the cylinder of an S.I. Engine so than we an achive a sucessful combustion ignition it.
Now focusing on the objective for this research the aim is to sucessfully achive HCCI in a petrol engine , petrol has the higher kindling temprature than diesel this requires spark to ignite. I through this study wish to achieve autoignition of petrol bye provding a higher compression ratio and in addition to that heated charge of air , heated throug the pre-heater. It should have capabilities to transmit sufficient power.

I. INTRODUCTION

The principle of HCCI combustion is already known for decades. It was first introduced by in 1979. HCCI can be seen as a combination of SI (Spark Ignition) and CI (Compression Ignition) engine principles. As in SI engines, a homogeneous mixture of air and fuel is brought into the combustion chamber. As in CI engines, the mixture is exposed to high enough temperatures and pressures for auto-ignition to occur. The combination of both types of combustion methods makes it possible to combine the benefits of both. Diesel-like efficiencies and low to zero emissions of soot and NOX are the result. On the other hand, relatively high CO and HC emissions but also a controlled operating range and ardousness of start of combustion . Research over the last three decades has shown the great potential of HCCI for achieving high efficiencies and low emissions.

II. CHALLENGES OF HCCI

Researchers have been mainly focusing on the effect of different kinds of parameters like compression ratio, inlet temperature, air-to-fuel ratio and use of EGR(exhausht gas recirculation). Their experimental results give a better understanding of the combustion process of HCCI and their influence on the start of combustion, but still there is no consensus on how to control the start of combustion in the right way. The variety of parameters that can be changed, make it hard to design and optimize a control strategy. Simulation software could offer a breakthrough in this regard. Today, simulation software is used that is designed for classical SI and CI engines. In these models fluid dynamics play an important role because of the flame propagation and in-cylinder injection phenomena that needs to be taken into account.

III. ABOUT HCCI

HCCI can be seen as a combination of SI and CI engine principles. As in SI engines, a homogeneous mixture of air and fuel (and exhaust gases if EGR is applied) is brought into the combustion chamber. Several fuel introduction strategies can be distinguished. There is port injection (PFI), early in-cylinder injection, late in-cylinder injection and a combination of PFI and in-cylinder injection, called dual fuel injection. As in CI engines, the mixture is exposed to high enough temperatures and pressures for auto-ignition to occur. The combination of both types of engines makes 5 Chapter 2. HCCI 6 it possible to combine the benefits of both. The auto-igniting homogeneous charge results in a uniform combustion. This is different from SI engines, whose combustion depends on the propagation of a turbulent flame front. It is also different from CI engines, whose combustion depends on diffusive combustion.

Now we must compare the start of combustion in different engines from the following figure

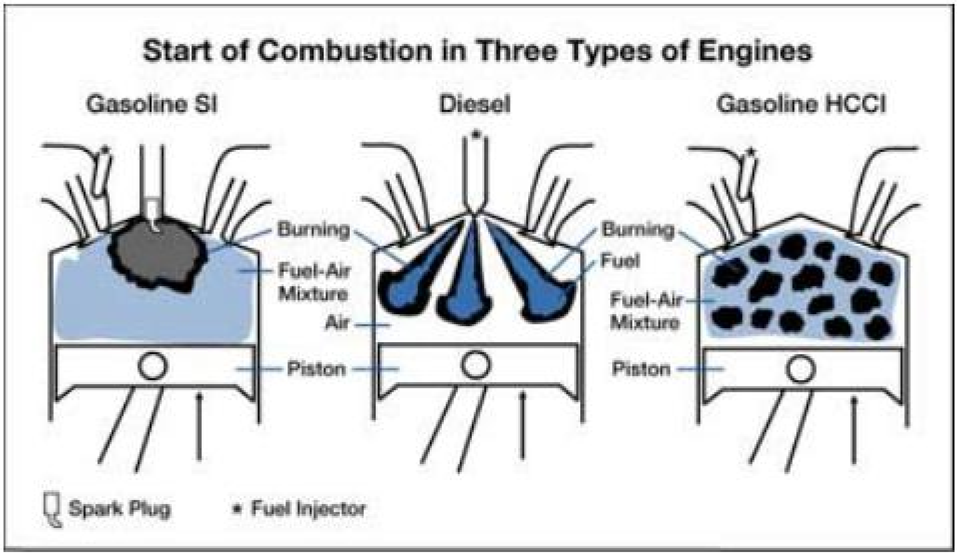

Figure 1: Comparision of combustion in SI, CI and HCCI.

The left part is the SI combustion process. We can see the presence of the spark plug, the port fuel injector and the moving flame front. The middle part is the CI combustion process. You can see the fuel injector and the injected spray. The right part is the HCCI combustion process. You can see a port fuel injector but no spark plug or in-cylinder injector. The mixture is ignited by compressing the mixture enough in order to get auto-ignition, so there is no direct control of the start of combustion. You can also notice multiple burning hot spots. This is the mixture burning at several points at the same time because the state of the homogeneous mixture is roughly the same in the whole combustion chamber. It can be said that there is a uniform combustion.

The eficiency in petrol engines is one major why diesel engines are chosen with far more intent, petrol engines produce more NO*x* and CO emissions The eficiency of gasoline engines is rather low. At part load, the throttle valve induces pressure losses which lead to low efficiency. The risk of auto-ignition due to high temperatures limits the CR, thus reducing the theoretical efficiency. These low eficiencies imply relatively high fuel consumption and consequently high CO2 emissions.

Diesel engines (CI engines) produce a lot of particulate matter (**PM**) and have NO*x* emissions comparable to gasoline engines. Moreover, the rather low exaust temperatures and the oxygen-rich environment make it difficult to achieve an effective after-treatment. This causes relatively high tailpipe emissions. The part load efficiency however is higher than for gasoline engines, this is mainly due to the lack of a throttle valve. The power control strategy of diesel engines relies on the amount of fuel injected into the combustion chamber. There is no need for a throttle valve so there are no pressure losses. Although a Diesel cycle has a lower theoretical efficiency at the same CR than an Otto cycle, the theoretical efficiency is higher due to the high CR which is needed for high in-cylinder temperatures to allow auto-ignition. These relative high efficiencies imply a lower fuel consumption and consequently lower CO2 emissions than with gasoline engines. It can be concluded that gasoline engines have relatively low emissions but a low efficiency (high CO2 emissions) and diesel engines have relatively high emissions but a high eficiency (low CO2 emissions).

"Efficiency" in HCCI engines can be high as a result of the high CR (Compression Ratio), the CR is high as is the case with diesel engines. This CR is needed for homogeneous charge to reach temperatures as high as combustion temperature. This high CR leads to higher theoretical efficiency. With CR the compression ratio and γ the ratio of specific heats.

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$$\eta_{otto} = 1 - \frac{1}{CR^{\gamma-1}}$$

Equation 1.

IV. AUTO IGNITION TEMPRATURES OF SUBSTANCES

The temprature at which a substance self ignites without an external flame or spark , it is also known as kindling point of a substance ,one must not confuse flash point to kindling point as flash ponit is when an external source if flame is present. Diesel has alower kindling point so it is used in CI engines we need to heat the mixture of air that is getting into the engine so that kindling point of petrol can be achieved. I plan to achieve auto ignition of petrol by increasing the temprature of the incoming air.

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Substance	Autoignition[D]	Note
Barium	550 °C (1,022 °F)	550±90[5][C]
Bismuth	735 °C (1,355 °F)	735±20[5][C]
Butane	405 °C (761 °F)	[6]
Calcium	790 °C (1,450 °F)	790±10[5][C]
Carbon disulfide	90 °C (194 °F)	[7]
Diesel or Jet A-1	210 °C (410 °F)	[8]
Diethyl ether	160 °C (320 °F)	[9]
Ethanol	365 °C (689 °F)	[7]
Gasoline (Petrol)	247–280 °C (477–536 °F)	[7]
Hydrogen	536 °C (997 °F)	[10]
Iron	1,315 °C (2,399 °F)	1315±20[5][C]
Lead	850 °C (1,560 °F)	850±5[5][C]
Leather / parchment	200–212 °C (392–414 °F)	[8][11]
Magnesium	635 °C (1,175 °F)	635±5[5][B][C]
Magnesium	473 °C (883 °F)	[7][B]
Molybdenum	780 °C (1,440 °F)	780±5[5][C]
Paper	218–246 °C (424–475 °F)	[8][12]
Phosphorus,white	34 °C (93 °F)	[7][A][B]
Silane	21 °C (70 °F)	[7] or below
Strontium	1,075 °C (1,967 °F)	1075±120[5][C]
Tin	940 °C (1,720 °F)	940±25[5][C]
Triethylborane	−20 °C (−4 °F)	[7]

Figure 2 (Src. :wikipedia)

V. COMPRESSION RATIO

The **compression ratio** of an internal combustion engine, is a value that represents the ratio of the volume of its combustion chamber from its largest capacity to its smallest capacity. It is a fundamental specification for many common combustion engines.

In a piston engine, it is the ratio between the volume of the cylinder and combustion chamber when the piston is at the bottom of its stroke, and the volume of the combustion chamber when the piston is at the top of its stroke.

VI. CHALLENGES OF HCCI COMBUSTION

Before implementing the benefits of the HCCI combustion engines, it has to overcome some of the barriers for mass production. The challenges of the HCCI combustion are reviewed below. Among these challenges, the homogeneous mixture preparation and combustion phase control play vital role in determining the efficiency and emissions.

A. Combustion phase control

The main challenge of the HCCI engine is to control ignition timing, which influences the power and efficiency. The conventional engines have a direct mechanism to control the start of combustion. Unlike, spark timing in SI engines and fuel injection timing in CI engines, the HCCI engine lacks start of combustion controlled by auto-ignition. The fuel–air mixture is premixed homogeneously, before the start of combustion initiated by the auto-ignition of time temperature history. This phenomenon of auto-ignition leads to the main combustion control which is affected by the few factors [93- 9 fuel auto-ignition chemistry and thermodynamic properties, combustion duration, wall temperatures, concentration of reacting species, residual rate, degree of mixture homogeneity, intake temperature, compression ratio, amount of EGR, engine speed, engine temperature, convective heat transfer to the engine, and other engine parameters. Hence, the HCCI combustion control over a wide range of speeds and loads is the most difficult task. Controlling combustion is the most important parameter, because it affects the power output and the engine efficiency. If combustion occurs too early, power drop in terms of efficiency and serious damage to the engine occurs, and if combustion occurs too late, the chance of misfire increases. Most of the researchers believe on the fact that HCCI combustion is governed by chemical kinetics

B. Abnormal pressure rise with noisee

The instananeous heat relese which is causd by autoignition of the whole homogeneous charge simultaneously during compression stroke. The instantaneous heat relese results in abrupt rise in temperature followed by abrupt pressure rise, and then high levels of noise. Controlling this sudden heat release is extremely important, because it is the main source of pressure rise, which may cause a severe damage to the engine.

C. Homogeneous charge preparation

The mixture preparation is the key to achieve high fuel economy and low exhaust emissions from the engine. The thermodynamic cycle time of internal combustion engine takes a very short span and within that, the homogeneous mixture preparation time for combustion is much lower. The degree of homogeneity of the fuel–air mixture is greatly improved only by increasing the time for mixture preparation

VII. PROPOSED IDEA AND WORK

I plan to construct an air preheater so as to increase the temprature of air that is getting into the engine so that the air is charged before it enters the engine block, this way the air when mixed with petrol can achieve the kindling temprature.

Now the major question is how?
First of all we need to adjust the compression ratio so that we can achieve ratios in order of those of CI engines.a higher compression ratio means a lean fuel mixture is burnt .

After solving the compression ratio problem we must note that normal petrol cannot directly be used for HCCI. HCCI engine are likely to knock since they are controled by chemical kinetics and there is no fixed mechanism to check knock in them. Knocking phenomena restricts the load range of an HCCI engine: upper load operations can easily initiate knock, so high load limits have to be applied. In all engines, knocking occurs when the combustion starts before the piston reaches TDC, while misfire is when combuustion commences after TDC. Knocking and misfire are two different behaviours which must be avoided in engine operation as both of them can contribute to deterioratin of engine performance . If HCCI engines operate on hydrogen–diesel fuels, knocking is expected to occur when high amount of hydrogen is added. Knocing will take place if the hydrogen content is more than 16% of the energy ratio it was necessary to use hydrogen with mass fraction less than 15% to achieve stable combustion.

VIII. CONSTRUCTION OF AIR PRE HEATER

The device that we are about to construct would be a rather simple heater mechanism fixed ahead of the carbureator of the engine that will heat the air before mixing and charge formation in the carbureator. The device is expected to harness rejected heat of the engine t warm the air fuel mixture, also the problem of cold start is to be checked by an additional heater inbuilt , the heater shall derive its power from the battery to cold start the engine.

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