Study the Importance of Insulated Combustion Chamber with & Without Catalyst Inside the Combustion Chamber on the Performance of Four Stroke C. I. Engine

Devendra Kumar Gupta [1], Pawan Mishra [2] and Dr.Tasmeem Ahmad Khan[3]

1. Assoct.Prof.,Mech.Engg. Deptt., Indraprastha Engg, College, Gzb
2. Asst.Prof., Mechanical Engg. Deptt., Krishna Engg. College, Gzb
3.Prof., Mechanical Engg. Deptt, A.F.S.E.T., Faridabad

Abstract

Actual requirements in the automotive industry are the reduction of fuel consumption, pollution emission, and improvement of engine efficiency. Many researches take place to improve performance and reduce exhaust emission from Diesel and Petrol engine. The four stroke C I Engine is widely used in heavy vehicles because of simplicity and large power out put. However this engine has a poor fuel economy & high exhaust emission .One of the best way to improve combustion is to insulate the combustion chamber areas. Coating the combustion chamber of a cylinder head can increase performance significantly. In addition, more compression can be run as the proper coating will provide resistance to detonation. Tuning changes can also increase the level of power generated. Coating of the intake and exhaust runners can also improve performance. Coating the exterior and the area under the valve cover can improve heat management. By coating the combustion chamber, we reduce the amount of heat that escapes during the power stroke which means more of the heat generated is utilized in "pushing" the piston down. The coating also insulates the surfaces so that they absorb less heat, reducing the load on the cooling system and reducing the amount of dimensional change.
In present work in order to improve the fuel economy & reduces exhaust emission in four stroke C. I. Engine, the following methods were attempted.

- *Insulation of combustion chamber wall*
- *Catalyst coating on piston head*

Keywords: *Four stroke C.I. engines , Catalyst coating , Thermal efficiency , exhaust emission*

INTRODUCTION

In our country, about fifty per cent of the diesel sold is consumed by mainly four stroke compression ignition engine. Hence a small improvement in fuel economy will results in considerable amount of foreign exchange. The four stroke C I Engine is generally regards as a simple, compact & low cost power plant for heavy vehicles. It is found in millions on the roads in developing countries like India.

However this engine has a poor fuel economy & high exhaust emission of smoke, unburned hydrocarbon HC, carbon monoxide CO and nitrogen oxides . Four stoke C I Engine has poor thermal efficiency and high exhaust emission. Even though in developing country like India, this type of engines is widely used because of its simplicity in all respect.

Why Coating is Required?

The coating functions in several ways:

- To keep heat (Thermal Barrier) inside the cylinder and make better combustion. Catalyst reacts with hydrocarbon during combustion and produces minimum exhaust. Combining these features increases power level, reduces part operating temperature, aids in reducing detonation and can increase fuel efficiency and reduce emissions.
- By transferring less heat to the incoming fuel charge detonation is reduced, as pre ignition which causes detonation, is generally the result of excessive heat absorption by the fuel as it enters the combustion chamber.
- By allowing the heat of combustion to be more efficiently used, the fuel charge is better combusted, allowing more compression while reducing the fuel quantity need (in most cases) and increasing power.
- By accelerating the burn rate of the fuel, through better heat management, less timing is needed to have the optimum burn occur at top dead centre.
- Coating the ports helps with flow and provides additional thermal benefits. Coating the intake runner with a Dry Film Coating can reduce fuel drop out while insulating the incoming fuel from the heat of the head.
- Coating the exhaust can improve flow by creating a very slick surface, while reducing the amount of heat that can pass from the hot exhaust flow into the head.
- Coating the exterior of the head allows for faster transfer of the heat that is absorbed from combustion, into the air flow around the head, thus allowing the head to run cooler.

  This will impact the amount of heat transferred to the intake manifold as well as reduce the heat that accessories will be exposed to, that are mounted on or near the head. When coating is applied to the area under the valve cover, better oil drain back is achieved as well as better thermal transfer to the oil, which is cooling the head and valve springs. As thermal efficiency of four stroke C. I. engine is about 25% to 35%, there is vide scope for improvement.

Literature Survey

- Insulation of Combustion Chamber Walls

Due to the insulation of the combustion chamber in-cylinder temperature increases which leads to better combustion, high brake thermal efficiency, less smoke and lower hydrocarbon (HC) and carbon monoxide (CO) emissions. By insulating the combustion chamber, higher combustion temperatures are achieved by which it is possible for better vaporization of fuel and it is also possible to burn leaner mixtures in the diesel engines. These facilitate more complete and fast burning of air-fuel mixtures. Significant saving in fuel consumption and reduction in exhaust emissions of HC/CO can be obtained by moderate thermal insulation of piston and cylinder head.

According to Gerhard woschni et al [1] from the thermodynamic point of view it would be much better to decrease the temperature level of the components not by more intensive cooling but by insulating the combustion chamber walls. In this way the heat flux and thus the heat losses, temperature gradients, and the temperature level decrease. Insulating the

combustion chamber, a direct improvement of the thermal efficiency of the cycle is obtained by decreasing the heat losses. Higher exhaust gas energy associated with insulated combustion chamber engine can additionally be used such as in bottoming cycle. Assanis et al [2] reported that insulated combustion chamber in compression ignition engine could realize several benefits including, lower exhaust emissions, improved combustion, higher brake thermal efficiency and higher exhaust temperatures. So far, numbers of experimental and analytical studies related to the use of ceramic materials in engines have focused on diesel engines but relatively very few on spark-ignition engines.

In general, high in-cylinder temperatures are compatible with diesel combustion but not with spark ignition. This is because the premixed fuel-air in gasoline engines could pre ignite from hot component surfaces, resulting in undesirable combustion.

Today all production diesel engines are in a sense ‘adiabatic’ due to the accumulation of carbon deposits on the combustion chamber surfaces [2], typically carbon deposits posses thermal properties comparable to ceramic materials. Application of a thin ceramic coating to the combustion chamber of a diesel engine would consistently provide the same level of insulation. According to Kamo, R. and Bryzik, W., [3] ceramic coating prevent uncontrolled build up and subsequent growth of deposits. Hence it would minimize knock problem associated with deposits. Unburned hydrocarbon emission decreases due to higher temperature. However, nitric oxide (NOx) emission increases in an engine due to high in cylinder temperature.

According to Ramesh Babu et al [4] significant saving in fuel consumption and reduction in exhaust emission of HC and CO can be obtained. Among the different catalysts investigated, copper is very effective in reducing both HC and co emissions together with an improvement in the brake thermal efficiency about 11.0 % for the normal engine operating conditions.

Several criteria for successful catalytic charge activation have been identified. They are listed below.

- Activation should take place in a well defined volume. In this regard, a catalytic pre chamber is an attractive concept. Reasonably adiabatic conditions during the later stages of compression will promote the activation mechanism.
- The catalytic surface should possess as little thermal inertia as possible. This aids in both the heating and cooling processes. By adding sufficient thermal mass to the catalytic surface, it is possible to quench rather than intensify near by gas phase reaction.
- Catalytic surface should be designed to minimize contact between the catalyst and the surrounding gas. This will ensure better mixing between hot products coming off the catalytic surface and surrounding reactant molecules. It is through such preheating that gas phase ignition delay is reduced by thermal insulation of the piston top and cylinder head in CI engines. Since these methods lead to higher combustion temperature, it is possible to use leaner mixtures which results fuel economy and reduced exhaust emissions.
- Research on advanced heat engine concepts, such as the low heat rejection engine, has shown the potential for increased thermal efficiency, reduced emissions, lighter weight, simpler design, and longer life compared to current diesel engine designs (ref. 1).

These improvements are achieved through the reduction or removal of the cooling system, insulation of the combustion chamber components with ceramics, and converting increased exhaust energy to shaft output power with a recovery turbine.

Analysis & Identification of Problem

In this research work author have tried to increase the thermal efficiency first attempt is made by providing the thermal insulation to the combustion chamber so increase in cylinder temperature by which it leads to better combustion, high brake thermal efficiency and low exhaust emission. Second attempt to decrease the emission from four stroke engine is to insert catalyst inside the combustion chamber. The usual practice to reduce the exhaust emission is to attach catalytic converter and/or thermal reactor at the muffler/silencer, means product of combustion is treated when it come out from the engine. My research is to study the effect of catalyst inside the cylinder where product of combustion generates.

Detail experimental investigation will be carried out using different fuels to study the effect of insulated combustion chamber with & without catalyst inside the combustion chamber on the performance of four stroke C. I. Engine.

Catalytically Activated Combustion

The chemical activation of the fuel-air mixture prior to ignition in the presence of a catalyst increases the flame velocity and reduces minimum ignition energy and hence, combustion efficiency is improved over a broad range of equivalence ratios [5]. Catalysts such as copper, Nickel and chromium coated on the combustion chamber accelerates the prelate reactions which results in improved combustion.

The concept of an internal combustion engine where the oxidation of the fuel is brought about with the aid a catalyst offers the advantage of a stratified charge engine without any disadvantages. Introducing a catalytic surface into a combustible environment can lead to species activation due to desorption of active radicals as well as partially oxidized intermediate from the catalyst surface [3]. As a result of catalytic pre-reaction lower ignition energy required and higher flame velocities are achieved and hence better combustion. This concept deserves series consideration because it does not rely on extensive modifications which complicate fuel delivery, ignition or exhaust systems.

Conclusions

Based on the experimental investigation on the performance of four stroke CI engine, insulating the combustion chambers beneficial effects with regards to break thermal efficiency and excessive emission.

The coating also insulates the surfaces so that they absorb less heat, reducing the load on the cooling system and reducing the amount of dimensional change. In present work in order to improve the fuel economy & reduces exhaust emission in four stroke C. I. Engine, the following methods were attempted.

- Insulation of combustion chamber wall
- Catalyst coating on piston head

REFERENCES

[1] Gerhard Woschni, Walter Spindler, and Konrad Kolesa, Heat Insulation of Combustion Chamber Walls – A measure to decrease the fuel consumption of I.C. Engines? SAE Transactions 870339.

[2] Dennis N. Assanis and Tans Mathur, 'The effect of thin ceramic coating on S.I. engine performance, SAE Paper 900903

[3] Kamo, R. and Bryzik, W., Thin thermal barrier coating for engines, ASME Paper 99, ICE-14, 1999.

[4] Ramesh Babu, P., Nagalingam, B. and Gopalakrishnan, K.V., The effect of combustion chamber insulation on the performance of a small S.I. engine, Paper accepted for the IV int. Conf. On Small engines and Their fuels, Thailand, Sept., 93.

[5] Ramesh Babum, P., Nagalingam, B. and Gopalakrishnan, K.V., A comparative study of catalytic combustion in a S.I. engine with gasoline and Methanol as fuels, JI. Of the Institute of Automobile Engineers (India), Vol.4, No.1, pp.5– 11, 1994.

[6] Ramesh Babu, P., Cherian, N.K., Nagalingam, B. and Gopalkrishna, K.V., Exhaust Emission control through Catalytic Activation of the combustion in S.I. engine, Proc. Of the int. conf., on Environmental Pollution, Liston, (Portugal), Vol.2, pp. 195-203, April 1991
.
[7] Brenner A and Riddell G E, "Nickel plating by chemical reduction", US Patent US2532282, 1950.

[8] Riedel W, "Electro less Nickel Plating", UK: Finishing Publications Ltd, 1991.

[9] Apachitei I, Tichelaar F D, Duszczyk J and Katgerman L, " The effect of heat treatment on the structure and abrasive wear resistance of autocatalytic NiP and NiPSiC coatings", Surf. Coat. Technol., Vol 149, p 263, 2002.

[10] Balaraju J N and Seshadri S K, "Preparation and characterization of electro less Ni-P and Ni-P-SiC composite coatings", Trans. IMF, Vol 77, p 84, 1999.