Improved Combustion Technique with porous structure in Internal Combustion engines

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ABSTRACT

The currently employed heterogeneous combustion results in incomplete combustion and an uneven temperature distribution in the engine cylinder. The major effect of this improper combustion is on the efficiency of the engine. This yields high NOx, CO and UHC, etc., emissions, resulting also in extensive soot formation. The emissions can only be improved by catalytic treatments, but such treatments, however, result in high costs and relatively low conversion efficiency. This paper suggests development of a new combustion technique to yield improved primary combustion processes inside the engine for the improving the efficiency with drastically reduced exhaust gas emissions. Dr. Franz Drust has proposed a new combustion concept to perform homogenous combustion in I.C. engines, in which application of porous medium (PM) combustion technique, called "PM-engine", is used. Practical results show an overall improvement in efficiency along with the drastic reduction in exhaust emissions sand soot formation.

Keywords - **porous medium combustion, internal combustion engine, Improved combustion technique.**

I. INTRODUCTION

Nearly all engine manufacturers have been successful in the field of development of reduction in fuel consumption, considerably, for both diesel and gasoline engines, and further progress can be expected in the years ahead. In particular, the ongoing development of the direct injection (DI) concept still shows good potential to yield further reductions in fuel consumption. This concept also offers potential for the reduction of NO_x emission by applying exhaust gas recirculation (EGR) in the combustion region, both for stoichiometric and for lean-burn engine operating conditions. However, inevitable trade-offs limit the possibilities for reducing emissions substantially if the conventional mixture preparation and combustion techniques are maintained, because this results in a non-homogenous fuel-air ratio distribution in the combustion chamber and causes a regionally slow, incomplete and diffusionally controlled combustion. From this, non-homogenous temperature fields emerge and high level, engine-load-dependent emissions result that not only is difficult to control but can barely be reduced much further. This is outlined in the present paper and it is stressed that a new approach is needed to provide a better mixture preparation and / or improved combustion conditions. It has a claim that, without such a new approach, drastic reductions of emissions from internal combustion engines cannot be obtained, i.e. the emission levels obtainable these days can only be reduced through improved and very costly catalytic treatments of the exhaust gases[1-2]. The new concept of controlled combustion in porous media, suggested in this paper for DI-IC engines, offers the potential to increase the engine efficiency and a nearly zero emissions in IC engines [3].

II. POROUS MEDIUM (P.M) TECHNOLOGY

The porous medium technology for IC engine means the utilization of specific features of a highly porous medium for supporting and controlling the mixture formation and combustion processes in I.C. engines. The specific features of PM employed are directly related to a very effective heat transfer and very fast flame propagation within the PM.

Most important features of PM are high heat capacity, large specific surface area, excellent heat transport property (radiation conductivity), transparency for fluid flow, flame propagation, variable pores size, pores density, pores structure, high thermal resistance, mechanical resistance and thermal shock resistance [4-5].

III. DESIGN MODIFICATION BY INCORPORATION OF POROUS STRUCTURE USING PLASMA ARC SPRAY

A plasma arc spray torch consists of a tubular copper anode in the rear of which is a tungsten cathode, both electrodes are water cooled and are surrounded by an insulating body which them in correct relation to each other and serves as an arc chamber. A high current arc is generated within the gas injected into the arc chamber where it is heated and, on passing through a constriction in the anode bore, is converted into a high temperature plasma powdered surfacing material is injected in to this plasma jet and thus heated and accelerated on to the substrate.

The advantages of this method are the high temperature enables almost all material to be sprayed; deposits are of high density and strongly bonded to the substrate, very low heat input to the substrate.

This method is very much costlier and rarely available in the industry, used mostly for refractory, high melting point materials, ceramics etc. [6]

Figure below shows:

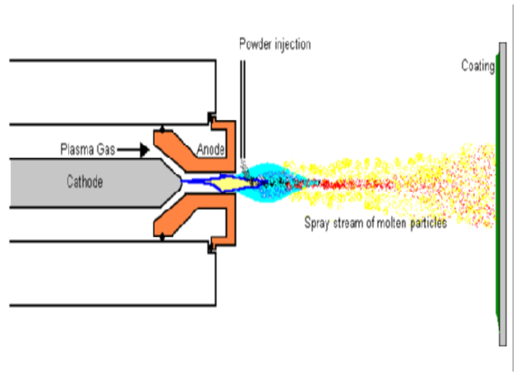

Figure 1 Schematic Diagram of the Plasma Spray Process

Figure 2 Piston with Sic coating using Plasma Spray Process

IV. PRINCIPLE OF THE PM ENGINE

The PM engine is defined as an internal combustion engine with the following processes realized in a porous medium: internal heat recuperation, fuel injection, fuel vaporization, mixing with air, homogenization of charge, 3D thermal self ignition followed by a homogeneous combustion.

PM engine may be classified with respect to the heat recuperation as:

- Engine with periodic contact between PM and working gas in a cylinder (closed chamber)
- Engine with permanent contact between PM and working gas in cylinder (open chamber)

On the other hand, positioning of the PM combustion chamber in engine can be used to design different engines:

- Cylinder heads (PM is stationary).
- Cylinder (PM is stationary).
- Piston (PM moves with piston).

One of the most interesting features of PM engine is its multi-fuel performance. Independently of the fuel used, this engine is a self –ignition engine characterized by its 3D thermal ignition in porous medium. Finally, the PM engine concept may be applied to both two and four –stroke cycles. Owing to the differences in the thermodynamic conditions, the PM engine cycle has to be separately analyzed for closed and open chambers [7-8].

V. . POTENTIAL OF PM TECHNOLOGY IN CREATING OF ADAPTIVE COMBUSTION SYSTEM

In the PM-engine the liquid fuel is injected directly in to PM-volume and fuel atomization and spray geometry are not critical. A self-homogenization process in PM-volume is observed permitting spatial distribution of the liquid fuel throughout the PM-volume. A strong heat transfer from hot PM-surface and gas to liquid fuel permits fast and complete fuel vaporization. No liquid or gaseous form of the fuel is present in a free volume of the cylinder. Injection timing, spray atomization or spray geometry are not critical in this system.[9,10,12]

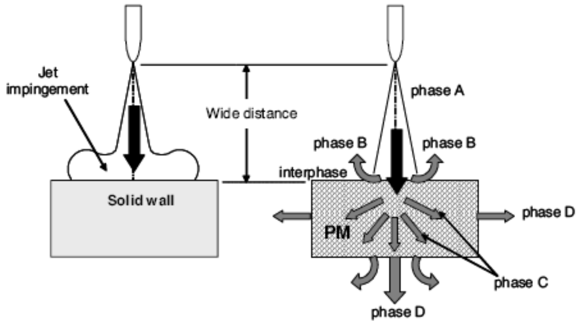

Figure 3 Model Describing Basic Phases Of Diesel Jet Interaction With Porous Medium

- Phase A: represents outlet from the nozzle and free jet formation.
- Phase B: represents jet interaction with PM interface.
- Phase C: represents liquid distribution throughout the PM-volume.
- Phase D: represents liquid leaving the PM-volume.

VI. STEADY STATE POROUS MEDIUM COMBUSTION

Generally, Main feature of the stationary combustion process taking place in a porous medium for a pre-mixed gaseous charge are the following:

- Very low NO_x emission level due to homogeneous combustion and controlled temperature in the PM combustion zone.
- It is possible to (almost) eliminate the soot formation.
- Theoretically higher than conventional engine cycle efficiency due to similarity to the Carnot cycle.
- Very low combustion noise due to significantly reduced pressure peaks.
- Nearly constant and homogeneous combustion temperature field.
- Very fast combustion.
- Multi –fuel systems
- May operate with homogeneous charge from stoichiometric to very lean mixture compositions
- Mixture formation and combustion processes are almost independent of in- cylinder flow structure, of turbulence or of spray atomization.

Owing to the ability of the PM engine of operating with a homogeneous combustion at all required optional conditions, the system may be called "intelligent" (adaptive) mono-mode combustion system". [9]

VII. RESULT

The results of the experiment carried out on the engine with porous medium is compared with the normal engine and also with 1mm and 2mm layers of SiC and it is found that the efficiency of the engine is improved. Exhaust emissions like NOx, CO, UHCs are reduced drastically, and also it has been recorded that the soot formation is almost negligible.

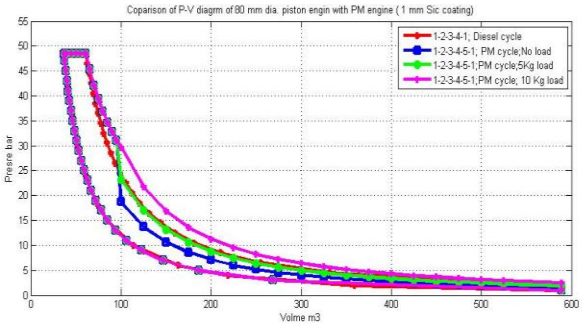

Figure 4 Comparative P-V diagrams for 80 mm dia. Piston engine

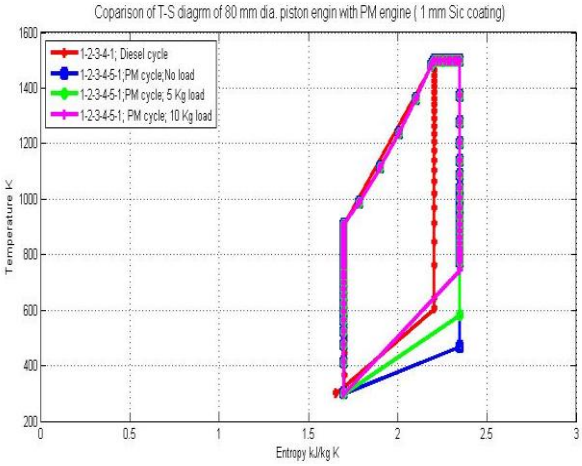

Figure 5 Comparative T-S diagrams for 80 mm dia. Piston engine

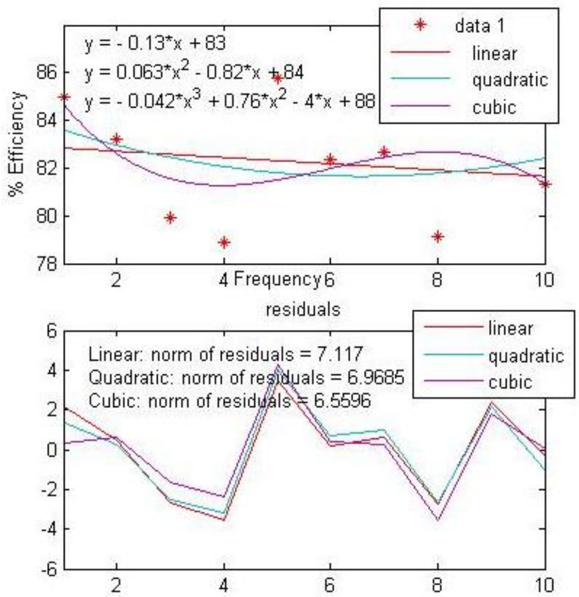

Figure 6 Efficiency plot for 80 mm diameter piston engine with no load condition

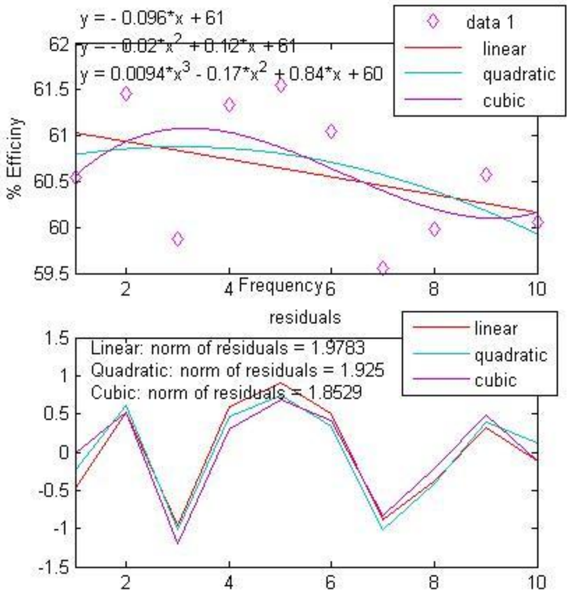

Figure 7 Efficiency plot for 80 mm diameter piston engine with 10 kg load condition.

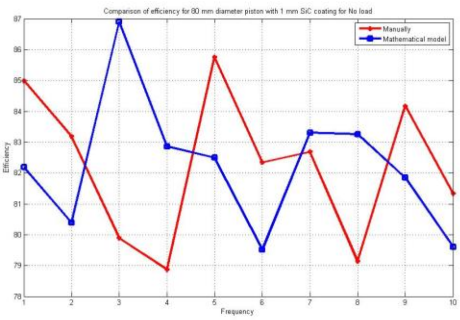

Figure 8 Comparison of efficiency for 80 diameter piston with 1mm SiC coating for no load

The P-V diagrams and T-S diagrams, individual and comparison of all at different load condition are shown above. Analysis of the results obtained from the trials conducted on the engine with the design changes of the piston, indicate the clear difference in work done with design changes, which is directly enhances the overall efficiency and performance of the engine giving improvement in exhaust emissions. The graph plotted shows the comparative improved efficiency with respect to change in design of the piston.

VIII. CONCLUSIONS

A Porous Medium technology has been defined as a utilization of large specific surface area, large heat capacity, high porosity etc. of open cell structures for supporting different processes realized in engine. Especially important is the application of this material for homogenous mixture formation and complete combustion in engines. In this paper novel concepts for combustion engines based on the application of Porous Medium technology is presented and discussed. The main attention is focused on the engine concepts having potential for homogeneous combustion process under variable engine operational conditions. All these processes (e.g. gas flow, fuel injection and its spatial distribution, vaporization, homogenization, ignition and combustion) can be controlled or positively influenced with the help of porous media/ceramic foams or other structures

All the above findings are claimed after conducting iterative experimentation and analyzing the experimental data. It is unique research work being conducted and an excellent approach towards the overall development of the engine efficiency which is the need of the current scenario in the field of Automobile.

NOMENCLATURE

PM	Porous medium
CO	Carbon monoxide
DI	Direct injection
EGR	Exhaust gas recirculation
GDI	Gas direct injection
MDI	Mixed direct injection
NOx	Oxides of nitrogen
SiC	Silicon carbide
UHCs	Unburned hydrocarbons

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