Improved Combustion Technique with porous structure in Internal Combustion Engine

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ABSTRACT
The currently employed heterogeneous combustion result 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 HC, etc., emissions, resulting also extensive soot formation. The emission can only be improved by catalytic treatments, but such treatments, however, result in high cost and relatively low conversion efficiency. This paper suggests development of new combustion techniques to yield improved primary combustion process inside the engine for improving the efficiency with drastically reduced exhaust gas emission. The porous medium combustion technology for energy efficient and environmentally safe operations in IC engine. The main attention is focused on the engine concept having potential for homogeneous [nearly emission free] combustion process under variable engine operating conditions. The porus media can be used to great variety of improvement in combustion process. The key role of NOx reduction and soot emission elimination in homogeneous combustion engine. A brief identification and survey of porous material (PM) used in this area is also presented with their operating and limiting parameters. Homogeneous 3D thermal self ignition, wide and dynamic power regulation, extremely low pollutant emissions, incorporation of porous medium in the cylinder head, open type-and closed type- PM – engines.for in this technique may implemented from IC engines for improving the efficiency drastically and reduced exhaust gas emission.

Keyword - Porus medium combustion, internal combustion engine, Improve 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 year 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 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-homogeneous fuel-air ratio distribution in the combustion chamber and cause regionally slow, incomplete and diffsionally 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. 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.

(a) 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 I 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.

(b) 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 are 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 high temperature I enables almost all material to be sprayed; deposits are of high density and strongly Figure below shows:

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.

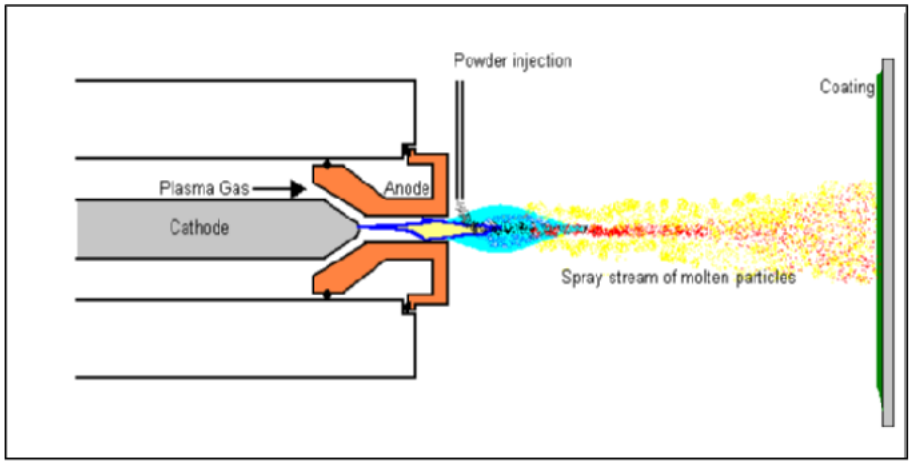

Fig 1 Schematic Diagram of the Plasma Spray Process

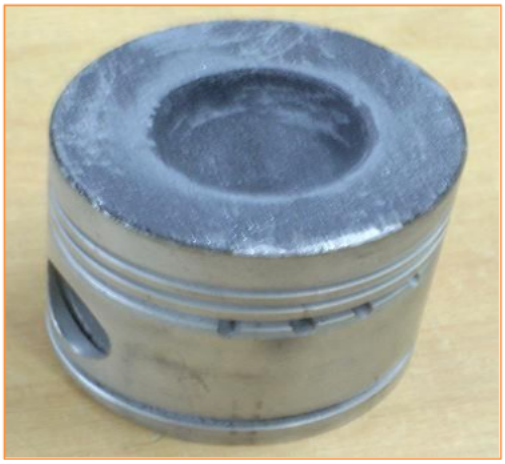

Fig 2 Piston with Sic coating using Plasma Spray process

(c) Principle of The PM Engine- The PM engine is defined as an internal combustion engine with the following processes realized in a porus medium: internal heat recuperation, fuel injection, fuel vabourization, 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 porus 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.

(d) 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.

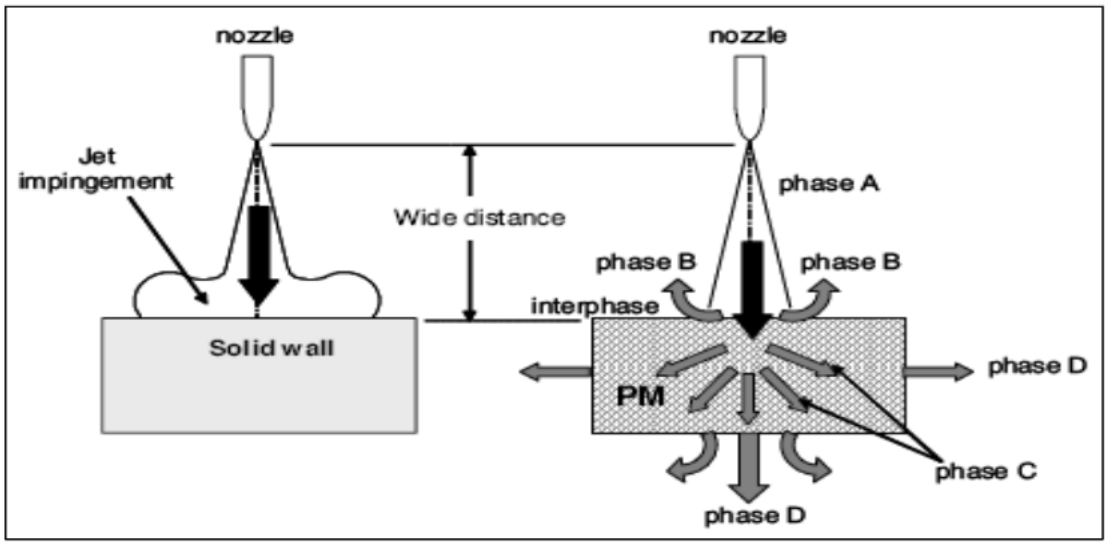

Fig 3 Model Describing Basic Phases of Diesel Jet Interaction with Porous Medium

- 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

(e) 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 NOx emission level due to homogeneous combustion.
- 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.
- Mearly constant and homogeneous combustion temperature field.
- Very fast combustion.
- Multi + or – fuel systems.
- May operate with homogeneous charge from stoichiometric to very lean mixture compositions.
- Mixture formation and combustion processes are almost independent of the cylinder flow structure, of turbulence or of spray atomization.

Owing to the ability of PM engine of operating with a homogeneous combustion at all required optional conditions, the system may be called combustion.

II SIMULATION AND 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 has improved. Exhaust emissions like NOx, CO, UHCs are reduced drastically, and also it has been recorded that the soot formation is almost neligible.

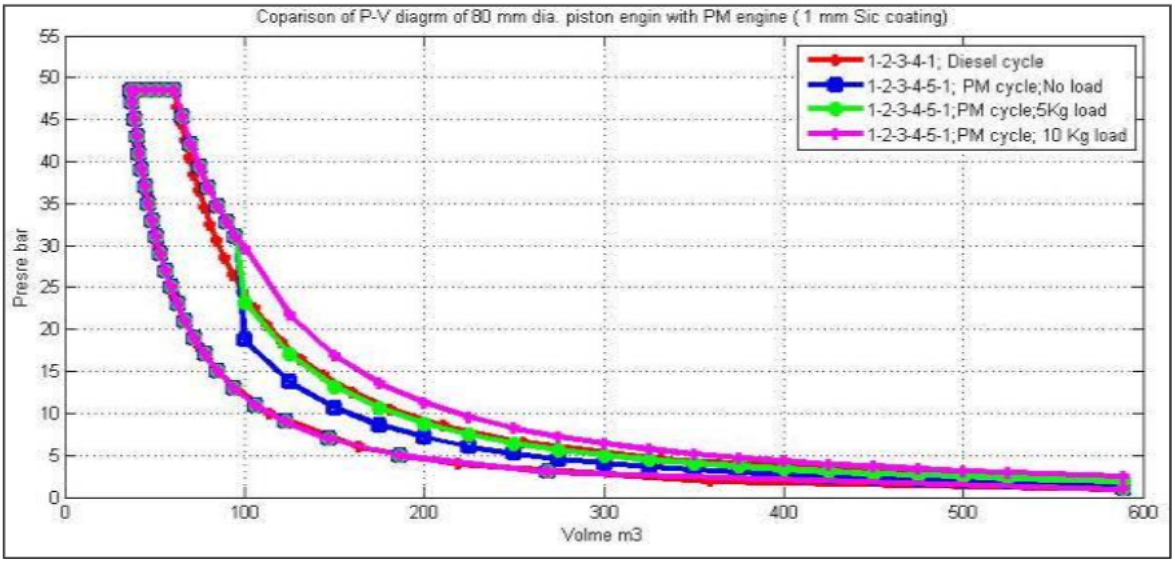

Fig 4 Comparative P-V diagrams for 80 mm dia.piston engine

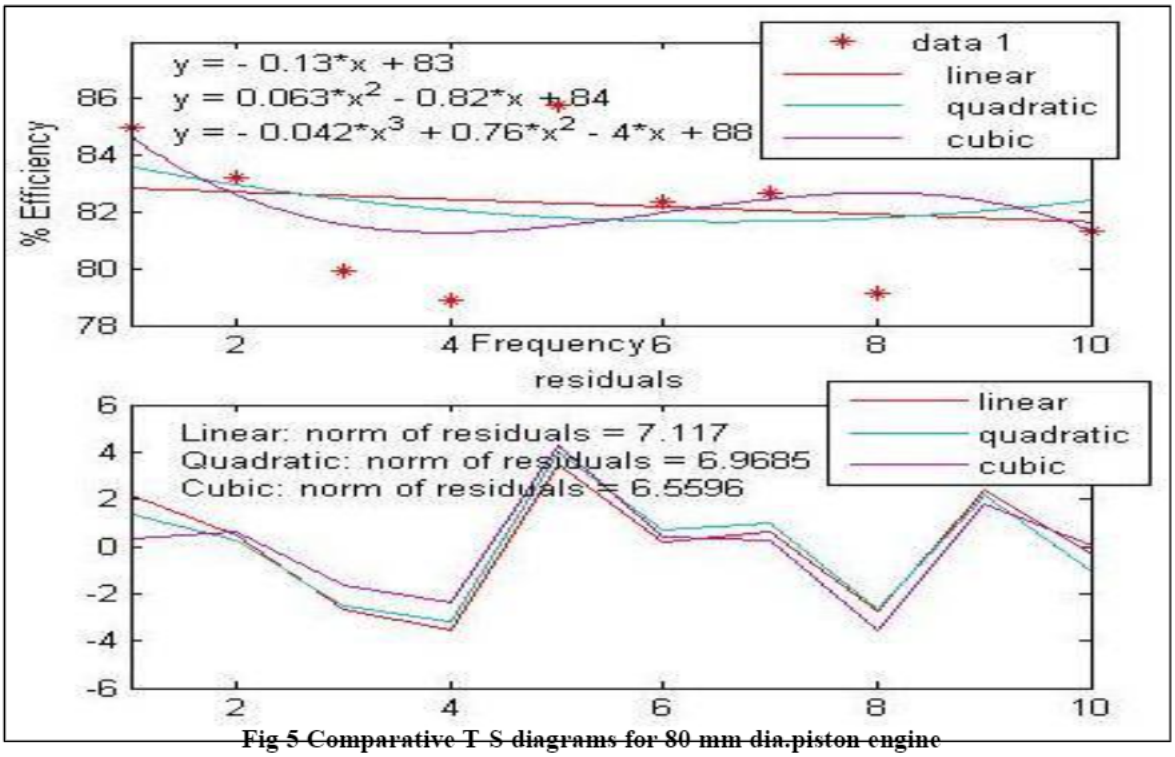

Fig 5 Comparative T-S diagrams for 80 mm dia.piston engine

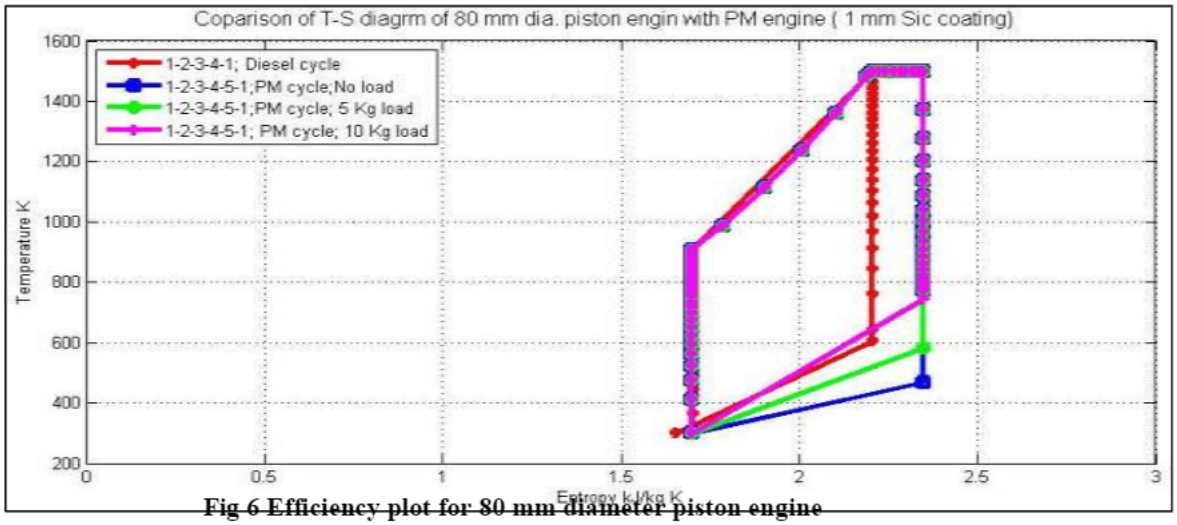

Fig 6 Efficiency plot for 80 mm diameter piston engine

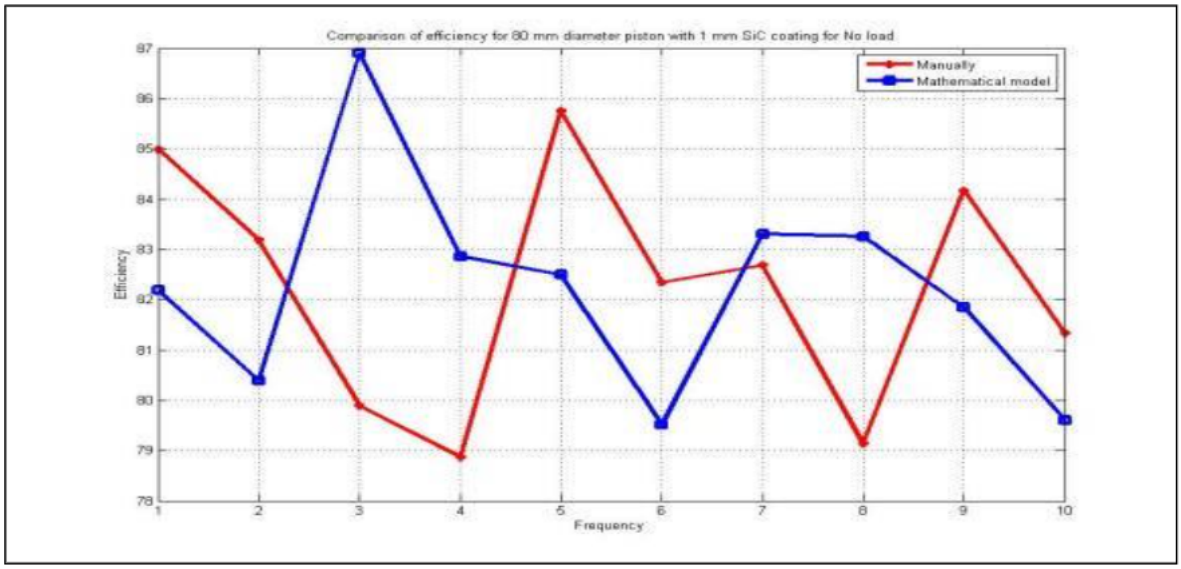

Fig 7 Piston with 1 mm silicon coating for no load condition

The PV diagrams and TS diagrams, individual and comparison of all at different load conditions are shown above. Analysis of the result obtained from the trails concluded that the engine with the engine changes of a piston, indicate the clear enhance meal 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 piston.

III CONCLUSION

A porous medium technology has been defined as 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 homogeneous mixture formation and compete combustion engines. In this paper novel concepts for combustion engines based on the applications of porous medium technology is presented and discussed. The main attention is focused on the engine concepts having potential for homogeneous combustion process to be controlled or positively influenced with the help of porous media ceramics foams or other structures.

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

ABBREVIATIONS

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

REFERENCES

[1] Dhale Ashok A., Dr.Awari G.K., Dr.Singh M.P., Analysis of IC engine with a new concept of porous Medium combustion for the future clean engine. Thermal Science International Scientific Journal , Volume 14, Number 4, Year 2010 , pp. 943-956.

[2] Dhale Ashok A., Dr.Awari G.K., Dr.Singh M.P., New strategy for intelligent engine combustion International Journal of Advancements in Technical Research and Development. Volume 1, Number 4, January 2012 , pp. 29-42.

[3] Weclas, M., Diesel soot (PM) emissions and technologies: state of the art, Internal Report, 2004, institute of vehicle technology, university of nursing applied science in numbers.

[4] Weclas, M., Porous media in internal combustion engines [in] cellular ceramic structure, manufacturing, properties and application scheffler M. Colombo, P. (Eds), Willey-VCH-Publ.2005

[5] Weclas, M., New strategies for homogeneous combustion in I.C. engines based on the porous medium (PM)-technology, ILASS Europe, June2001.

[6] Dhale Ashok A., Dr.Awari G.K., Dr.Singh M.P., Application of porous medium technology to I.C.engines.national conference on nascent Technologies, NCNTE-2012.