Review on Engine Decarbonisation Process

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Abstract

The combustion of fuel inside the internal combustion engine lead to form many by-products like CO2, CO, Exhaust hydrocarbons, various oxides of nitrogen and compound like soot basically known as carboneous deposits. To sustain the engine performance and emission control, this soot must be clean out. This literature contains various mechanical and chemical methods for carbon deposits cleaning, also the formation and adverse effect of soot formation on internal combustion engine. The conventional methods show their performance appreciably on various parameters, but still there is need of a cleaning system that can vanish out all the battle-necks of conventional methods. This literature will also give review about the automated system which will overcome all the drawbacks of conventional methods.

Keywords: Carbonisation, Emission, Engine, Particulate Matter, Soot

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I. Introduction

Over past few years, there is a great evolution in the automobile industry. The various technologies are coming forward enhancing the performance and efficiencies of internal combustion engine. The demand for such power generating engines has raised remarkably, all an all the demand and proportion of automotive vehicles introduced in market.

The new technology faded vehicles still have some emission and performance related drawbacks. The vehicle engine require optimum and scheduled maintenance for its smooth breathing and performance. The combustion products from engine contain various harmful constituents which are environmentally hazardous; these are nothing but CO, NOX, CXHX, etc. The various methods are invented for reduction of prescribed emissions and there hazards. Among all those combustion products 'soot' is one of the reason affecting on engine performance. Soot is microscopic carbonaceous particle, product of incomplete combustion of hydrocarbon in case of gasoline and diesel fuel. It consists of carbon, ash and unsaturated (unburnt) hydrocarbon. The unsaturated hydrocarbons are essentially acetylene and polycyclic aromatic hydrocarbons. The components have particularly high levels of acidity and volatility [1]. The various methods for removal of carbon deposits are as follows;

One of method employed is to provide chemical additives to dissolve carbon deposits on the combustion surface. These chemical are applied in several ways, one being by simply adding selective chemicals to the fuel tank that supplies diesel to engine where by chemical is mixed and carried through the engine system [2]. New inventions in carbon cleaning methods are made but they have some drawbacks if the factors like effectiveness, required time, cost, safety are concerned.

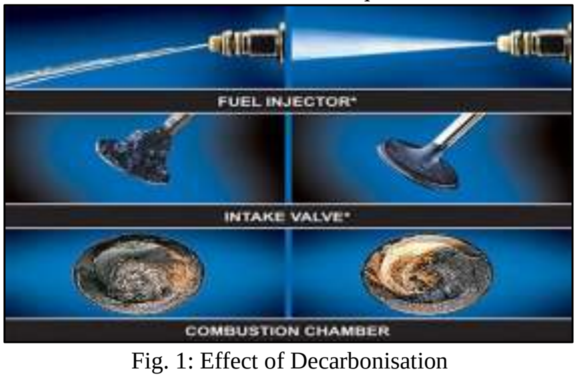

Fig. 1: Effect of Decarbonisation

The system which can stand against those all drawbacks of previous inventions can be made, by making the carbon deposit cleaning automatic. This literature will give the review of such system. By studying the effect of soot formation on exhaust gas constituents, the numerous data collected can help to determine the amount of soot formed in the internal combustion engine. From the constituents of exhaust gases, hydrocarbons do not have constants molecular weight. The general survey has shown that the percentage of hydrocarbon is varying in various cases like idling, cruising, de-acceleration and acceleration where the carbon monoxide percentage can be seen maximum during the idling and acceleration in engine. So the determination of CO is depends on the presence of fresh oxygen for the combustion of fuel. If there is an adequate amount of O2 in intake air there will lesser formation of CO, where some times the excess air also lead to form more percentage of CO. From general it is come to know that, soot formation results in increased proportion of hydrocarbons and carbon monoxide due to incomplete combustion. By processing the data with regarding HC% in exhaust the particular action can be taken for the removal of soot.

The numerical data shows the percentage of HC and as per the condition, if the proportion is not belongs to tolerance limit, the control unit will take action and clean out the soot formed inside the internal combustion engine with help of suitable additives. The engine requires well schedule maintenance rather; formed soot can degrade the performance of engine. The mentioned system is providing timely service with respect to the formation of soot.

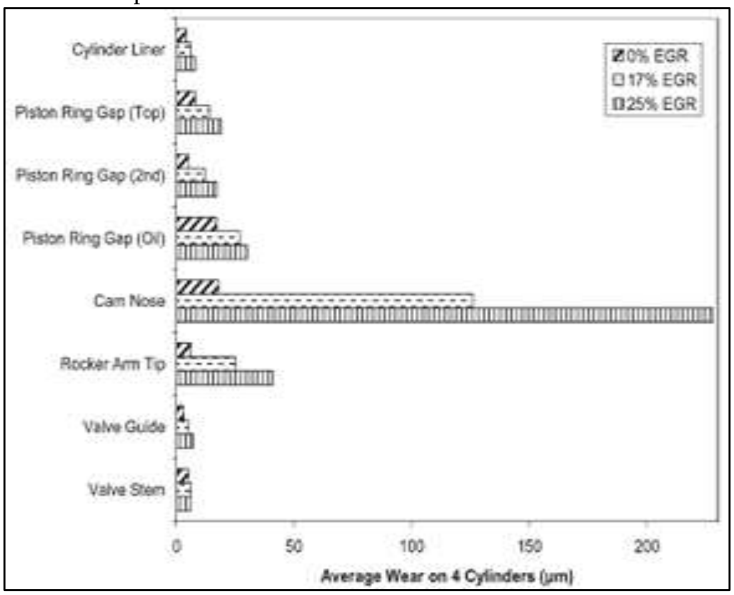

Fig. 2(a): Reproduction of 4D55T/C engine wear data showing relative component wear levels [15].

II. NEED OF ENGINE DECARBONISATION

It is well known that reciprocating internal combustion engines tend to form carbonaceous deposits on the surface of engine components such as, fuel injectors, cylinder liners, piston head, etc. It is believed that some of the unbunt hydrocarbons in the fuel undergoes complex cracking, polymerization and oxidation reactions, leading to reactive moieties which can interact With

The fuel, recirculated gases and lubricating oils; thus forming insoluble. These deposits, even when present in relatively minor amounts, often cause noticeable operational performance issues such as loss of engine performance, increased fuel consumption and increased production of exhaust pollutants. It also results in deformation of injector spray patterns, poor atomization, fuel impingement on the cylinder liner and lubricating oil contamination [4].

In the operation of internal-combination engines, deposits, composed chiefly of carbon, form on the cylinder Walls, cylinder heads, pistons and valves. The carbon in these deposits may come from either the fuel or lubricating oil being employed, and, inasmuch as the deposits result in a loss of power, they are extremely objectionable. With the advent of internal-combustion Engines, particularly automotive engines, having high compression ratios, it has become more imperative than ever to reduce carbon deposits to a minimum in order to maintain high output performance in such engines. Even the use of currently marketed high octane fuels does not permit knock-free operation of engines without the formation of substantial amounts of deposits in the combustion chambers [5].

The use of exhaust gas recirculation (EGR) is increasing; this is where a portion of the exhaust gases are recirculated into the inlet manifold. This acts to reduce the peak combustion temperature and therefore to reduce the nitrogen oxide (NOx) emissions. EGR also causes combustion products to be recirculated, rather than to pass out of the engine in the exhaust gases, which leads to further oil contamination. Figure 2 shows component wear data from engine test with increasing degrees of EGR (and hence soot). Clearly, wear rises in the in-cylinder and valve train components, but is worse in the valve train [15].

The soot particles are contained within the lubricant by dispersant additives. Current lubricant technology, however, has reached a limit on the amount of dispersants that can be added, as too much will result in a corrosion problem in the engine due to the free amines associated with the dispersant [15].

Soot particles tend to be more prevalent in diesel engines than in gasoline engines owing to the differences in the combustion mechanisms. Diesel engines are operated at higher air-to-fuel ratios, which tend to produce greater levels of engine soot. The majority of modern diesel engines operate using direct fuel injection and swirl within the combustion chamber to assist fuel–air mixing. Combustion initiates close to the injection point and occurs very rapidly as a diffusion flame. At this point, the air and fuel mix well, but the mixture is very fuel rich, causing very high levels of soot to be produced. After diffusion burning, the combustion process progresses through the rest of the combustion chamber by pyrolysis burning, which slowly burns the majority of the remaining fuel. This slow burning produces more particulates (soot) and unburned hydrocarbons at the end of the combustion process [15].

Through cylinder-on-disc reciprocating testing, Liu et al. [59] measured the variation in friction coefficient of different diesel lubricants with various soot contamination levels (using soot produced in a fired engine). While there was some scatter, results showed that the friction coefficient decreased with soot present in the lubricant. It is suggested that the soot particles acted as friction modifiers [15].

The study showed that soot contamination of oil increases the viscosity and therefore reduces its ability to perform its function, particularly at lower operating temperatures [15].

Once the particulate is collected, it is necessary to burn it off. Diesel particulate spontaneously burns in air at about 600–625 1C. This temperature range is not regularly achieved in the typical diesel vehicle operations for sufficient periods of time to enable self-regeneration. If an excess of soot is collected on the filter, the exhaust gas temperature raises due to the increased back-pressure, and leads to a sudden burn off, which might occasionally cause the filter temperature to raise above the melting point of the filter itself [16].

The existence of fuel-rich high temperature zones lead to fuel pyrolysis, hence a diesel engine also produces soot particle emissions. Given the intensive use of diesel engines and the detrimental effects of soot particles on environment and health (USEPA, 2002), more stringent emissions standards have been imposed (OECD, 2001) [17].

Deposits in the combustion chamber formed as an effect of fuel combustion cause problems with auto ignition- as a result engines octane demand increases. Besides problems with engine starts appear, engine power decrease and fuel consumption and emission of toxic components of exhaust fumes increase [5-12, 14, 15] [12].

III. Mechanical decarbonisation

A more positive but expensive means of removing carbon from a fuel diesel engine is to physically take the engine apart in order to clean the individual parts. This requires the costly and time-consuming dismantling of the engine, and often the fuel pump and injectors as well [6].

An another method is by using unbalanced tool, which may be provided or not with a cutting edge, is mounted on the free end of the flexible shaft, so that when the shaft is rotated at a suitable speed a vibratory action is setup, and when the tool is bought into contact with the surface to be treated the said surface is subjected to a very rapid succession of blows or hammering action. Provision may also be made for adjusting the points of support of the shaft in relation to the too or free end of the shaft, so that the nature of the vibration may be varied [3]. It will be understood that the described method is applicable for cleaning certain parts of cylindrical structures, the pointed edge of tool may damage the said surface to be cleaned. Figure 3 and 4 are diagrams illustrating vibrations which are set up when tool is in use.

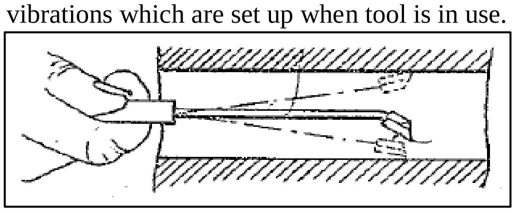

Fig. 3: General application of scrapping system [3].

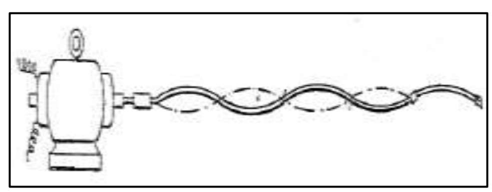

Fig. 4: Setup of vibrating shaft scrapper [3].

One suggested method is incineration in place, brought about by increasing the engine exhaust gas temperature to the combustion temperature of the collected particulates. In some engine applications, particularly those for use in lighter automotive vehicles, operation under heavy load may rarely occur. In this case, the engine exhaust temperatures may not be sufficient to burn off collected particulates at the time such action is desirable. For example, in a currently produced automotive diesel engine operated in simulated city driving conditions at 25 miles per hour road load, the exhaust manifold temperature was measured at only 360° E, which is far below the temperature of approximately 900° F [8].

Laser cleaning has been used to remove the contaminants on the surface of crowns, but slight melting and oxidation in micron scale on the irradiated surface is inevitable [19]. Thermal cleaning can effectively remove the carbonaceous deposits on the machine parts, but some thermos sensitive materials such as aluminium parts with low melting points are limited to this cleaning method [19].

Common practice in removing carbon deposits has been either to scrape such deposits from the parts affected or to burn the deposits with a blowtorch. The scraping process is slow and consequently expensive, while the use of a blowtorch requires considerable skill in order to avoid damage to the engine [2].

IV. CHEMICAL DECARBONISATION

Compositions and methods have been devised that push engines with cleaning fluid or other types of chemical solvent solutions in an attempt to clean these surfaces. In one such system, a separate canister containing a liquid mixture of engine fuel and injector cleaning solvent is connected to the fuel line, and the engine is operated using the fuel solvent mixture. Additionally, typical conventional solvent and detergent cleaning fluids are mixed with gasoline and the automobile engine is run during cleaning. When these cleaning fluids are successful in dislodging or removing carbon deposits they essentially only move the deposits downstream to the combustion chamber and/or exhaust system. Emissions during such a 'cleaning treatment processes are dramatically increased as the carbon and sludge moves further into the engine. We have surprisingly found that switching a heterogeneous charge compression ignition engine for a short period to McNeil Cycle® and running it on polyol or a mixture of polyols removes carbon deposits from injection equipment and internal surfaces of the engine. As the polyol's the following compounds and their blends could be used: propane-1, 2, 3-triol, ethylene glycol, propylene glycol [4].

It has discovered that the accumulations within the engine may be removed by pumping a suitable fluid into the engine and circulating this fluid under pressure by the 'action of the engine pistons. The particular fluid that is used is immaterial so long as it has the property of loosening .the deposits and there are many such preparations on the market. The disadvantage of this method is, various components like carburettor, spark plug has to remove and special plugs or connectors need to attach, resulting more costly and time consuming method with requirement of skilled operator [2].

Another method that has been utilized to remove carbon deposits is to introduce a solvent oil into the spark plug opening of each cylinder, one at a time. This method has proved unsatisfactory since the oil introduced may be completely ignited during one ignition stroke and the products of combustion expelled during the next subsequent exhaust cycle. Since this ignition occurs while the exhaust valves are closed, the solvent oil thus introduced cannot dissolve or burn off the carbon on the exhaust valves and seats [7].

Another object of the invention is to devise a method for decarbonizing internal combustion engines wherein solvent oil introduced during an intake cycle is deposited on the cylinder walls and pistons and on the piston rings during the subsequent compression stroke, is burned by the subsequent ignition stroke, and in which additional solvent oil introduced during the exhaust stroke is ignited by the products of combustion of the solvent oil introduced during the intake stroke so that carbon on the exhaust valves and seats may be effectively removed [7].

Oxazines which are varnish removers are particularly useful in removing carbon deposits. The best method of using these is to apply them to carbon coated parts which have been heated preferably to a temperature above 150° F., the optimum conditions for water cooled engines being at approximately the boiling point of water. Mixture comprising by volume 40 parts morphs line, 30 parts benzol, and 30 parts of ethyl alcohol. The engine is operated until the temperature of the metal parts of the combustion chamber is at least 158degree F. When the mixture is injected or otherwise introduced into the cylinders and the engine stopped. The mixture is permitted to remain in the cylinders for about 2 hours, more or less, depending upon the nature of the carbon deposits, during which time the gummy binder is softened and dissolved. Then the engine is started and loosen deposits is gradually blown out of the exhaust [1].

Fig. 5: Chemical Decarbonisation system

V. IN COMPARISON WITH CONVENTIONAL CLEANING METHODS

As discussed early, the soot formed is main reason for various performances reducing parameter. The emission of hazardous gases may cause various environment problem also health related too, as the soot is carcinogenic. Methods described early are can be done only in special condition and inspection. They even require special tools is and costly equipment's for cleaning operations our cleaning system is based on one time investment which is quite affordable.

The operator is not aware of soot formation during operation into the internal combustion engine. The cleaning methods are applied when the engine start showing the reduced efficiency, jerk in acceleration, black smoke, etc. that means when engine starts showing symptoms related to it. This is not a good practice. this will be better that at the time when soot formed goes further the particulate limit the decarbonisation will done automatically, which can be done by our system.

The soot may increase the emission of NOX. So the vehicle in which soot is formed in greater extended will lead to exhaust more % of NOx. So the timely carbonisation provided by the new system can reduce the NOX proportion even. This is hazardous to environment.

In our system there is no need of any special operation, tools and costly equipment's. As the setup is mounted to the engine there is no need of dismantling of engine or even no need to remove the fuel input. So it is not rusty job for operator. The system provided self –maintainability to engine.

The cleaning of internal combustion engine increases the internal parts service life of engine. The operator will be aware about the emission performance and carbonaceous content vehicle have through this system which is quite not possible conventional one.

VI. Future Scopes

The given system is button operated, i.e. when the percentage of HC is get increased in exhaust gases with respect to soot formed, the operator has to press a button when the particular indication on screen is blinked, so this can be made fully automated by considering the condition of engine motion and used for cleaning should able to run the engine even in loading condition. The provided system can be used in various industries like marines, automobiles, aircraft, etc.

To make operator aware about the emission one can provide a display showing constituents of exhaust gases, in a way he can diagnose any problem at his own.

VII. Conclusion

To keep internal combustion clean it is necessary to provide timely service to engine. The mechanical and chemical showing there effect in carbon cleaning but there not providing self-maintainability to engine, external operations are required to perform the decarbonisation by conventional methods.

The soot formed may provide real damage to the engine such as exhaust valve, cylinder lines, piston head, and piston rings and even to the catalytic convertor which can explode even. So the proper treatment is necessary. To make vehicle environment friendly by reducing the hazardous emission can achieved only by timely disposal of carbonaceous deposits.

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