

ANALYSIS OF ECONOMISER FOR TWO WHEELERS

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ABSTRACT

In this modern world the major problem looming in front of us is the air pollution and a fuel scarcity. A remedial measure is necessary to reduce the pollution and to overcome the fuel scarcity. Lean conversion is one such solution where in fuel economy is increased and the exhaust emissions are reduced to a considerable extent. lean combustion there by reference to the combustion of a homogenous mixture of Air and fuel higher than stoichiometric ratio .we therefore fabricating an equipment namely “economizer” and fitted it to two Wheeler the economizer works on the principle of lean fuel -air mixture and thereby ensures fuel consumption and emission controls .

1.Introduction

In this age of rapid industrialization one of the biggest problems looming in front of us is the fuel economic and clean air .Among various sources contributing to the air-pollution the automobile industry has emerged as the largest source of urban air pollution in the

developing countries. because of versatility, flexibility and low initial cost of auto mobiles there has been boom in their usage in the developing countries .this has resulted in that Rapid deterioration in the air quality .

There has been a continuous effort in the field of IC engines to reduce the fuel consumption and reduced exhausted mission. Lean combustion is one such a solution where in fuel economy is increased and the exhaust emission are reduced to considerable extent .this is because of low concentration in the exhaust gas. Lean combustion refers to the combustion of a homogenous mixture of air & fuel higher than stoichiometric ratio.

As the mixture is weakened to a considerable extent over the stoichiometric ratio many trouble are induced including degrading specific fuel consumption, rough engine operation and increased hydrocarbon emissions due to

1. Misfiring
2. Partial or unstable conditioned
3. Reduced flame speed etc

Therefore in order to put extremely low mixtures to actual use for the reduced exhaust mission much improvement is required in problem prone areas

Only SI engines contribute for more exhaust emission. In case of a CI engine power is varied by varying the quality of the mixture and because of the provision to control the quality of the mixture, exhaust gas emissions are controlled.

In SI engines provisions are there to control the quality of the mixture along with the quantity for varying the power as well as altering the desired emission level. Nowadays all leading manufacturers use microprocessor based fuel injection system along with catalytic convector. Our country has got maximum number of two wheelers and such sophisticated devices can not be fitted and may not be economical.

Any attempt to lean the mixture reduces the Pick up and this is not desired by the user and manufacturer. This project aims to solve the above problem by considering the following points.

1. No variation in acceleration or pick up at low speed.
2. Reducing the rich mixture at high throttle opening.
3. To introduce the method in any vehicle either new or already presents vehicles in the road.

4. Cost must be economical.

5. Easy to set without disturbing the engine configuration

6. Complicated controlling system is to be avoided and the device must achieve a promising level of performance on its own.

By taking into account the above mentioned points the performance of 4 stroke engine is analysed by using lean mixture to save fuel and reduced emission.

The major concerns that were thrown light rally around the following points.

1. Fabrication of a lucid economizer for enhanced combustion
2. Variation of Jet size and spark gap.

2.Literature review:

Ather A. Quad et al. conducted preliminary studies on lean operation. Low nitric oxide emissions and good fuel economy were obtainable at very lean mixtures. However unstable operation caused by misfire and erratic combustion prevents present spark ignition engines from being operated very lean. His studies focused on effects of mixture preparation, intake airflow, exhaust gas recirculation (simulated by N₂ dilution), compression ratio, intake mixture temperature, engine number of spark plugs and spark plug locations at minimum

advance for best torque(MBT) spark timing in single cylinder engines. Propane and isooctane were the fuels used. The lean limit with reference to equivalence ratio and efficiency is clearly explained.

1.The lean misfire limit was extended by increasing mixture homogeneity, decrease in charge dilution, increasing mixture temperature and decreasing engine speed. More central spark location and mullet spark plugs also permitted leaner operation.

2. The crank angle Intervals flame initiation and as well as the combustion duration, apparently reached limiting values at the lean limit. This crank angle interval found to be independent of all variables tested except spark location and number of spark plugs

3. Hydrocarbon emissions at the lean limit increased when the lean limit was extended. Specific fuel consumption decreased for engine variable changes that permitted leaner operations.

Based on these results, it is concluded that the lean misfire limit in the engines is governed by the same fundamental variables (Mixture homogeneity, dilution inert gases, mixture temperature,

and fuel type) that governed lean flammability limit in the non engine experiments. The added restrictions of the intervals available during the engine cycle for flame initiation and flame propagation under MBT conditions is intriguing.

The lack of clearly identified constraints for ignition and flame propagation had hindered understanding the process which limit lean operation in spark ignition .His further studies explored flame initiation, and flame ignition engines. Propagation as limits of lean operation in engines.

In separate tests conducted in single cylinder CFR(Cooperative fuel research) engine, the spark timing was either advanced or retarded from MBT to determine ignition-limit or partial-burn-limit spark timing,respectively.

These two limiting spark timings, respectively. These two limiting spark lean misfire limit, the ignition-limit and the partial-burn-limit spark timing lines converged. Apparently flame initiation as well as flame propagation considerations constrain lean operation could be concluded.

IGNITION SYSTEM:

Spark plug parameters and lean limit:

Tamuma et al has conducted a wide range of studies on the effects of parameters of ignition system in extending the lean limit and reducing exhaust gas concentrations. The parameters of the ignition system which are generally used to extend the lean limit are spark gap width, Center electrode diameter, and gap projection of a spark plug and spark energy.

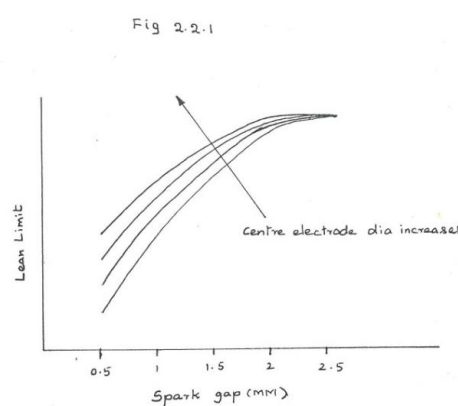
A) Effect of spark gap width and center electrode diameter:

When a gap is widened the following two changes to be expected include

1. Reduction of the quenching effect of electrodes on the flame kernel.
2. Increase in the energy of the capacitive component and decrease in the energy of the inductance component of the spark and shortening of spark duration.

But it has been substantially deduced that the effect of widening gap of the lean limit is mainly based on the reduction of quenching effect on the flame kernel. This effect can be clearly studied from the fig(2.2. 1)

It has also been observed that the more advanced the spark timing, the



greater the effect of widening the gap on the lean limit becomes. On the other hand, when the spark timing is retarded considerable there is tendency towards lower lean limited particularly in wider gaps. This is due to misfiring because of the following two factors.

1. Temperature drops of the electrode tip of the spark plug caused by a shortened period of its exposure to high temperature gas in the cylinder.
2. Increase in cyclic variation of mixture temperature, proportion of residual gas fraction in the mix and the mixing state of residual gas and fresh mixture. This is caused by the increased cyclic variation of the exhaust gas pressure and temperature

due to the increased cycle to cycle combustion variation.

B) Effect of Spark gap projection:

The effect of gap projection on the lean limit is due to

1. Decrease in the quenching effect on a flame kernel as the result of the temperature rise of electrodes.
2. Increase of the mixture temperature adjacent tip the gap as the result of the temperature rise of electrodes.

However it will be necessary to take into account the difference in mixture velocity at the gap, which is caused by the difference of spark gap locations in the combustion chamber.

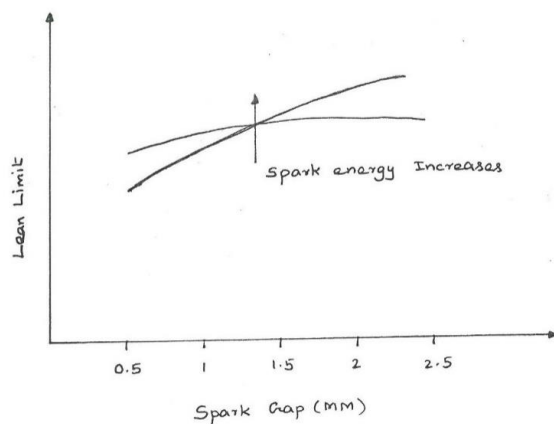
C) Effect of spark energy:

While comparing the discharge characteristics between the high energy ignition systems and the normal one with each other, it has been elucidated that the energy of the inductance component of the spark increased and the spark duration was prolonged. Increase in spark energy has an effect on the lean limit, particularly when the gap width is so narrow that the quenching effect by the electrodes is great,

or when the spark timing is so advanced that the mixture pressure and temperature at the time of spark discharge are low.

Increase in spark energy in case of very large gap widths somewhat improves the lean limit. Evidently, this is due to improvements of the discharge characteristics by the high ignition system. This effect can be clearly studied from the fig(2.2.3)

Fig 2.2.3



EFFECT OF SPARK ENERGY ON LEAN LIMIT

The effect of the increased spark energy becomes small as the spark timing is reduced. This is caused by the influence of the cyclic variation of the mixture condition due to cycle to cycle combustion variation.

D) Effect of mixture turbulence:

The lean limit is greatly extended by this due to

1. Sufficient mixing of fuel, air and residual

gas to produce good uniformity of the mixture.

2. Decrease in Cyclic variation of the mixture condition including proportion of residual gas fraction in the mixture condition can be obtained by the reduced cycle to cycle combustion variation which is expected to be caused by the increased flame velocity due to the increased mixture turbulence.

E) Engine performance and spark timing in lean mixtures:

The spark timing which was adjusted to best specific fuel consumption at each air fuel ratio, advanced gradually according to the weakening of the mixture but did not advance and kept a constant value when, the mixture was made leaner beyond a certain air-fuel ratio. The spark timing that gives best specific fuel consumption in the mixture that is than the lean limit is a compromise between the following two contradictory requirements.

1. For best thermal efficiency of ignited cycles, advance spark timing.
2. For decreasing misfires retard spark timing

In order to prevent misfire and to get good engine performance with the leanest mixture possible, the following two methods are used.

- i. Extend the lean limit by modifying the ignition system and improving the mixture condition such as uniformity or temperature of mixture.
- ii. Design the combustion chamber and the other components which affect the spark timing for best specific fuel consumption such as the location of spark gap in the combustion chamber, so that the spark advance for the best specific fuel consumption may be small

2.2.2. Comparison between Plasma - Jet and conventional ignition system.

Kupe et al carried out extensive research work and analysis on the operational behavior of a 4 stroke SI - engine with newly developed plasma - jet ignition and a conventional transistorized ignition system, respectively.

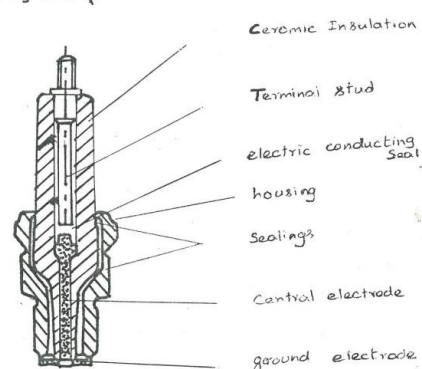
Investigations on the engines were completed by tests in a combustion chamber with methane air mixture.

With plasma jet ignition the combustion delay and the combustion duration are clearly shorter. The engine tests also

revealed a clearly extended lean misfire limit and reduction of cyclic variations. The No_x emissions were only slightly higher than the transistorized ignition. In the case of plasma jet ignition the analysis of the combustion process shows an essential reduction of losses due to real combustion, while heat losses increases less distinctly. Compared to the standard ignition system, burn delay and combustion duration of an SI engine are noticeably reduced. Plasma jet provides a larger initially ignited mixture volume as well as a faster and more complete combustion. The energy requirement of about 500 ml of the present PJI -system is lowest than that of other concepts presented so far.

Also life of plasma plug was found to be more than 40 hours, at present operating

Fig 2.2.4



conditions. A typical plasma spark plug is represented in fig (2.2.4).

2.2.3. Rail Plug - A new type of Ignitor

In the wake of extensive research work on indifferent ignition systems the plasma jet proved to be working with 4-stroke SI engines. With plasma jet ignition the combustion delay and the combustion duration are clearly shorter, and so the lean limit had also extended and cyclic variations were reduced. Brake thermal efficiency improved considerably but nitrogen oxide emissions slightly increased. A new type of high energy ignition called as RAIL PLUG have been introduced 16,71 it is a miniaturized rail gun which produces a high velocity plume of plasma jet ignitions, electromagnetic forces enhance the schematic outlook.

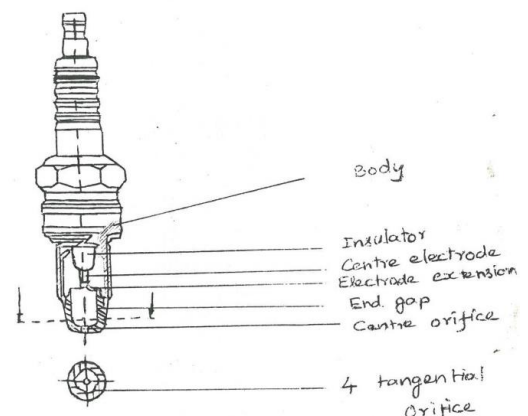
Thus, for a railplug, the combustion chamber. Several engines operating condition on configuration can be identified that traditionally present ignition problems, and might benefit from enhanced ignition system. One of these is ultraclean combustion in spark ignition engine; this has the potential for lowering nitrogen oxides which simultaneously improves thermal efficiency. The current lean burn engines cannot be operated sufficiently lean before

ignition related problems are encountered to offer any benefits. High EGR engines have similar potentials for emissions improvement, but also experience similar ignition problems, particularly at idling. Other potential application includes diesel cold start, alcohol and dual fuel engines, and high altitude flight of gas turbines. The rail plug may find application in any of the above.

2.2.4.

Swirl

Fig 2.2.7



Chamber

sparkplug:

Reinhard latsch (8) has carried out investigations on the swirl chamber spark plugs as a means of faster and more uniform

energy conversion process to achieve further reduction of fuel consumption and exhaust emission from present day engines. The spark plug, shown in fig (2.2.7) has a small chamber with five orifices (one central, four tangential). On the compression stroke the four tangential orifices generate a marked swirl in the chamber. The ignition spark jumps from a small lateral pin on the customary center electrode across to the cylindrical wall of the swirl chamber. As a result of the swirl, a very rapid combustion takes place in the chamber and generated five torch jets which ensure rapid and uniform energy conversion in the main combustion chamber.

The tests conducted brought out the following facts:

1. Compared with conventional plugs the swirl chamber spark plugs achieve more uniform and (particularly at the beginning of the combustion) faster energy conversion, that is, improved engine smoothness regarding lean combustion, EGR and low idle speed.
2. In the lower part - load range and during warm-up, thermal efficiency is improved.
3. With appropriate adjustment of normalized air -fuel ratio, spark advance and engine speed, improvements in fuel consumption and exhaust emission

particularly Nox-can be achieved.

4. Within the dimensions of the conventional spark plugs, the swirl chamber plugs can be used to greater or lesser advantage in engines with widely varying combustion chamber shapes, compression ratios, ignitions systems and mixture preparation systems and especially in newly developed engines.

5. Maximum torque and power are reduced by 1-2% In most cases, however, the knock tendency is reduced so that design can made to offset these disadvantages.

6. Demands on the ignition system are reduced. The spark -advance adjustment range is narrower, the voltage requirement is less, and the influence of the electrode gap on the engine characteristics is reduced.

2.2.5. Multigap spark plugs:

Rado et al⁹¹ reported improvements in the initiation of combustion by the use of multigap spark plugs and current production ignition systems. The multiplicity of gaps is a way to produce the enlarged flame kernel. This facilitates better performance compared to that wide gap spark plugs, especially under light load or exhaust gas recirculating conditions. These plugs, however,

would require no additional available ignition voltage to initiate combustion reliably under heavy load, high cylinder pressure operation. An actual 3 gap spark plug using a resistor-spark-gap network with its equivalent electrical circuit is outlined in fig (2.2.8).

2.2.6. Multipoint spark ignition:

Nakamura et al(10) studied effects of multipoint spark ignition on combustion duration, fuel consumption and lean misfire limit. A plate which consists of 12 spark gaps in each cylinder, and a new CD ignition system had been developed for accomplishing the multipoint spark ignition. This plate was installed between cylinder block and head in a 4 cylinder engine.

Compared with the single gap plugs, the results of 12 pages showed a reduced combustion duration by about 50%, a 5% decrease in fuel consumption and an extended lean misfire limit by 3 air - fuel ratio numbers. Further more the multipoint spark ignition on both sides of the combustion chamber was more effective than on one side. With this system HC emissions was reduced as well. The results of this study showed that, compared

to those obtained with swirl this multi point spark ignition was more effective in improving fuel consumption. Similar investigations were carried by Harrington et al by using a carbureted single cylinder engine to have similar extension in lean misfire limits and EGR tolerance.

2.2.7. Heat losses to spark plug electrodes and flame kernel development:

John B. Heywood et.al worked on a conventional spark plug and a spark plug with smaller electrodes in M.I.T's transparent square piston engine. The purpose was to learn more about how the electrode geometry affects the heat losses to the electrodes and electrical performance of the ignition system, and how this

affects the flame development process in an engine. A schlieren system which provides two orthogonal views of the developing flames was used to define the initial flame growth process, for as many as 100 consecutive cycles. Voltage and current waveforms were recorded to characterize this spark discharge, and cylinder pressure were used to characterize the engine performance.

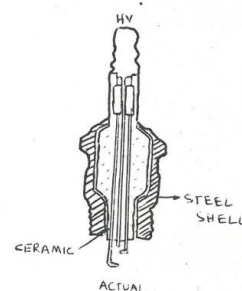


Fig 2.2.5 An actual 3 gap spark plug

The spark plug with the smaller electrodes were shown to reduce the heat losses to the electrodes, and thereby extend the stable operating condition of the engine. At conditions close to the stable operating limits. Cycle - to cycle variations and heat losses cause significant cyclic variations in flame development.

The cyclic variations in heat loss are due to cyclic variations in contact area between flame and electrodes. The contact area is largely controlled by local flow field in the spark plug vicinity cycles in which flame is convected away from the electrodes have a smaller contact area than cycles in which flame remains centered in the spark gap.

The thin electrode spark plugs was more likely to operate in the are discharge mode. Since are and glow discharge modes differ primarily in the electrode fall regions. They deliver same energy to the gas initially. However a longer discharge duration with the are discharge mode as well as higher release rate of usual energy towards the end of the discharge. This also contributed to the ended lean limit with thin electrode spark plug.

Under conditions where heat losses and electrical energy have an important impact on the initial flame kernel growth, the local flow velocity was identified as the dominant parameter affecting the initial kernel growth, the local flow velocity affects the heat loss to the electrodes as it determines the contact area, and it affects the electrical energy release during the low current discharge as it stretches the discharge channel.

The correlation coefficient found between individual cycle flow velocity and initial flame growth was 0.8 for a condition close the ignition limit.

3.1 PROBLEMS PERTAINING IN PRESENT CARBURETTOR :

The carburettor is a device for atomizing and vapourizing the fuel and mixing it with air in required proportions to suit the changing operating conditions of motor vehicle engine. The process of breaking up and mixing gasoline with air is called carburation.

The carburetors are metered on the basis of their volume whereas the air- fuel ratio is defined on the mass. When the discharge through venture is increased at higher throttles the velocity head is increased, since the area of cross section at throttle is

constant, this leads to decrease in pressure head, since the total energy is constant. Thus the reduced compared to the supposed one or the density of air decreases as the throttle opening increases. This leads to rich mixtures inside the combustion chamber than expected at high throttle openings. As the mixture becomes rich, sufficient air is not present for complete combustion. As a result this leads to increase in exhaust emission and increased fuel consumption i.e., acceleration leads to increase in carbon monoxide, oxides of nitrogen and hydrocarbons. Nox will be high during cruising and HC will increase during deceleration. Because of incomplete combustion due to inadequate presence of air it also leads to increased pick up time.

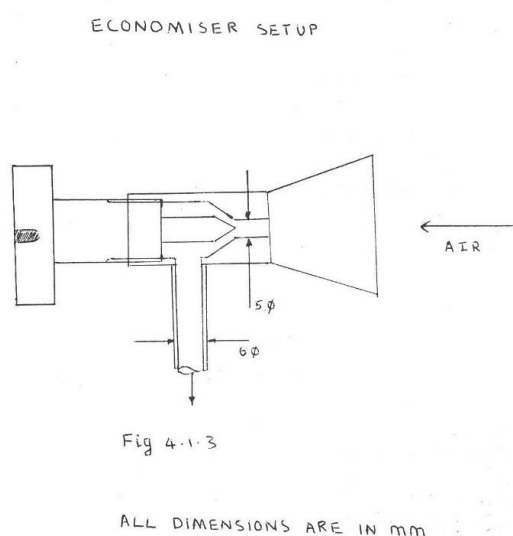
3.2 AIR FUEL RATIO:

The air in the mixture furnishes the oxygen necessary for combustion. Where there is little air, insufficient oxygen is supplied to burn all the fuel and some the fuel wasted or partly burnt. When there is too much air in the mixture it will burn slowly and erratically and power will a result power developed by the engine will reduce, CO will increase and acceleration will reduce.

4.1 Design of Economiser:

An economizer is fitted to the carburetor flange in a L -bend arrangement with a divergent opening is designed for smooth flow of air. At the divergent section an air filter is fixed for entry of free air. The L bend lengths are fixed by taking factors such as case of fitting and reduced turbulence effect. The L -bend is attached to the flange by drilling hole (1/4") in the flange at the section where the air fuel mixture and the additional air mixed causes a swirl in portion (flange) before the stream enters into the engine cylinder. This cause uniform mixing of air & fuel.

The diameter of L bend tube is 1/4" with inner diameter of 5mm. An adjustable air screw is fitted near the carburettor portion of the opening for metering the amount of air to be supplied.



The economiser is very much self explained in fig (4.3) Road tests were conducted in the vehicle with the actual (standard) size jet (85) and gap (0.7), for this best setting is recognized.

The L -bend tube is made up of copper so as

- i. The easy flow air with negligible resistance
- ii. To withstand temperature produced surrounding the engine.
- iii. For its flexibility i.e., can be bend to U - shape
- iv. Less weight per unit volume.

4.1.2. FIELD TEST DESCRIPTION:

- i. The vehicle carburettor is first completely dried.
- ii. A standard reference 100 ml is taken for conducting all road test uniformly.
- iii. The measuring jar is fitted of the same head as that like petrol tank,
- iv. The vehicle is started and made to run at the uniform speed (40 KMPH) through out the test.**
- v. The readings obtained are converted into mileage in terms of kilometers per litre.
- vi. The adjustable screw is varied to obtain best fuel economy & reduced emission.
- vii. The load is maintained uniform (i.e., 130 Kg)through out the test.

4.1.3. VARIATION IN SPARK GAP

The jet size which is originally 85 was varied in the lean range (below 85) for optimality.

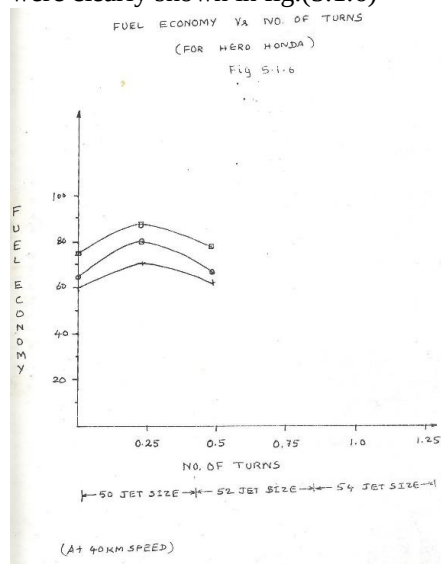
The spark plug gap is adjusted to the recommended specification (0.6 - 0.7mm) by bending the ground electrode. It is measured with the help of feeler gauge.

For the above jet size and gap width road tests were performed for best fuel economy.

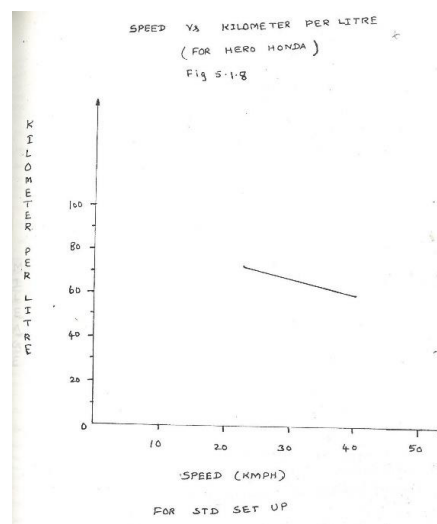
The lean jet, air screw opening and the equivalent gap width were optimized from the above said test for the subsistent condition,

5. RESULTS AND DISCUSSION:

The test conducted for existing intensity and keeping the standard jet size and spark gap shows an increase in mileage of 28KMPL (ie., from 61 KMPL to 89 KMPL at desired screw opening condition). The graph relating number of turns of air screw to optimum fuel economy were clearly shown in fig.(5.1.6)



From the graph it is evident that as the amount of air entering the economizer is varied by varying the air screw the mileage increases to an optimum (peak) value and then slowly decreases. The point where the curve reaches the peak for a particular number of turns(i.e., at 1/4 turn) is the leanest best fuel economy condition. After more than half turn of air screw the mileage shows a drop. This is due to the reason that the mixture got over diluted and the required spark intensity is not sufficient for causing combustion.



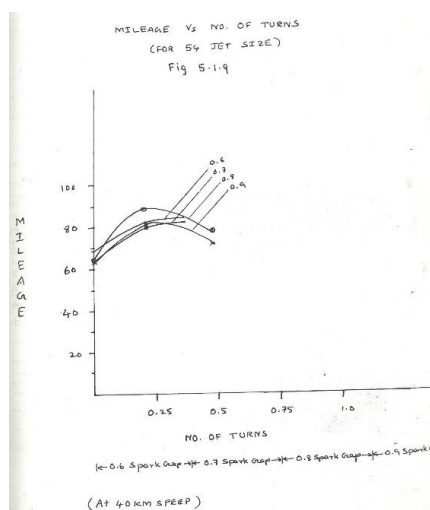


Fig (5.1.8) Shows the fuel economy in standard setup whereas the fig (5.1.9) shows the fuel economy with the economizer setup. This graph clearly shows that the economizer increases in mileage of 28KMPL (ie., from 61 KMPL to 89 KMPL at desired screw opening condition).

6.1 CONCLUSION:

The necessity of saving fuel has become a must in these days. With the objective of better fuel economy and reduced emission the real world test were carried out and following conclusion were made.

1. The net increase in mileage was 28% for four stroke vehicle when operated in leaner

limit for existing engine condition. The lower efficiency may be due to low compression ratio and retarded spark during certain modes of operation.

2. The emission control is the foremost part which should be concentrated has been controlled to a very good extend for leaner operation; CO emission got reduced to 37% and in case of four stroke vehicle.

Although this project produced relatively consistent data set much more search work must be conducted by using vehicles, including those which have undergone significant mileage accumulation, different conversion technologies etc., before broad conclusion can be reached.

6.2 SCOPE FOR FUTURE WORK:

When the engine is operated in leaner condition complete combustion is taking place and hence much amount of heat is produced. This may result in melting of spark plug tip after a prolonged use of time. Hence suitable material to withstand high temperature such as platinum tipped electrode can be used.

The engine when operated in leaner jet size and increased spark gap (beyond 0.9mm) there occurs a drop in mileage which may be due to insufficient spark intensity which is not able to burn the mixture. This can be overcome by suitably adjusting the voltage intensity of the spark plug for leaner operation.

The temperature distribution, turbulence nature inside the engine cylinder and flame spread in latter stage of combustion process can be analyzed using ANSYSpackage.

All the test was conducted only for a single four stroke vehicle it is not possible to over generalize the result. Hence more real world test must be conducted in various vehicles so as to make more general conclusion Related to fuel economy and reduced emission for the designed economizer.

Similar achievement in the initiation of combustion is expected to be achieved by the use of multigap spark plugs and current production ignition systems. The multiplicity of gaps is a way to produce an enlarged flame kernel. This is expected to facilitate achievement comparable to that of wide gap plugs, especially under light load or EGR conditions. Such plugs, however, would require no additional ignition voltage to initiate combustion reliably under heavy

load, high cylinder pressure operation.

Multipoint spark ignition with several spark plugs in combustion chamber is one of the most effective techniques for reducing combustion duration and extended lean mixture limit better result could be achieved as flame kernel's size is very much increased improving the reliability of ignition. This system could be incorporated to have economy and lowered cycle to cycle variation.

Though the work has consolidated on different simple method of implementing lean combustion results in decreased fuel consumption through road tests, other parameters as lean limit, brake power, thermal efficiency could be worked out by loading the engine on a test bed.

Further works can be done on finding out AJF rate at different values. This helps to set the correct intensity for causing complete combustion.

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