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Study of Performance, Exhaust analysis & Future scope of Petrol Engine Using Methanol Blends

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Abstract - *This paper represents the present scenario of the petrol engines used as well as it focuses on the use of methanol in pure or blended form in the petrol engine. The paper has a comparative as well as experimental studies of the engine using pure methanol as well as methanol blends. The work shows all the recent activity went away in these areas as well as it proposes certain improvements to be done for proper utilization of the methanol in the petrol engines. Today we are facing a serious issue of pollution as well as increased global consumption of the energy sources, use of alternative sources like methanol has become very important in the modern scenario. There are many alternatives for petrol including biodiesel, among them we find methanol to be most useful and on a short note M15 blend of methanol proves to be the best alternative for petrol in the present used engines in the world. The octane value of Methanol is maximum, having high heat of vaporization. In addition to this HC, CO content from the exhaust also decreases when we replace the petrol with methanol. The graphical comparison is also shown for various parameters of the engine with different methanol gasoline blends.*

Key Words: *Methanol; Methanol-Gasoline blends; Exhaust emissions; Octane value; M15.*

1. INTRODUCTION

Before we begin, we all know that the crude oil is not used directly as a fuel but as a feedstuff to petrochemical industry to produce commercial fuels, synthetic rubbers, plastics, and additional products. Oil refineries were originally situated near the oil rigs but in recent years due to economic and strategic reasons the crude oil started been transported to local refineries.

In recent years there has been an urgent need to develop a good, sustainable, low polluting and easy transportable fuel.

Methanol has been proposed to have most of these characteristics and is showing an upper hand over most of the fuels to be used in internal combustion engine. Historically, the methanol was first produced from pyrolysis of wood, however modern day methanol is being produced from the coal (as in china), but the most important method of producing it, is from biomass i.e. waste products, which can be the best way to recycle solid waste and also goes with the line "waste to fuel". There has been a lot of discussion over the usage of methanol in the current operating internal combustion engines with or without optimization, but this discussion comes to end by the fact that the methanol blend of M15 is ideal for the current operating carburetors. Methanol is a less polluting fuel in comparison to the traditionally used fuels. M85 is already in use in China.

1.1 LITERATURE REVIEW

Before we begin let us go back to the history of methanol which was first used by ancient Egyptians in their embalming process. However, first isolation of methanol was done by Robert Boyle in 1661, when he produced it via. Distillation of buxus. It has been used in vehicles produced by major car manufacturing companies in US. The usage still continues in fast racing cars as well as the sprint cars.

However, the use of methanol today as a gasoline blend or directly as a fuel is minimal .After many studies conclusions were given that the as the percentage of alcohol was increased, the performance of the engine was decreased, but from this paper we would like to conclude that many of the problems can be overcome by applying certain changes in the engine.

1.2 METHODOLOGY

In petrol engine, petrol is used as the fuel. Petrol engine can be of two type, two stroke and four stroke. Most of the heavy duty vehicles uses four stroke engines. The engine is provided with suitable loading arrangements to apple and measure the load. The provision are also available to measure the fuel consumption and speed. The paper is intended to study engine performance, emission when it utilizes low fraction of methanol gasoline fuel blends. In this study, a 3 - cylinder with bore of 68.5mm, total displacement about 0.8 litre PFI engine was adopted and fuelled with the prepared fuel blends. Engine performance, emissions including regulated and non-regulated pollutants were studied.

2. METHANOL AS AUTOMOTIVE FUEL

Physical and chemical properties of methanol is given in table 1. From table 1 we can draw the following conclusion:

1) Using as a fuel in SI engines can offer an increased thermal efficiency and increased power output due to its high octane rating 114 and high heat of vaporization.

2) It can be obtained from many natural sources and can be manufactured.

3) It can be used to help control internal engine temperatures and heat flows so as to reduce heat losses and thus raising fuel efficiency.

4) It is a high octane fuel with antiknock index numbers over 100.Engines using high octane fuel can run more efficiently by using high compression ratios.

5) It has higher laminar burning velocity which is good for high efficiency and emissions.

6) It has low sulphur content in the fuel.

7) Higher heat of vaporization resulting in a higher temperature drop and therefore higher volumetric efficiency.

8) Studies shows that there is substantial reduction in HC, NOx due to lower combustion temperature and CO emissions were also reported to be lowered.

9) It can be a great fuel for developing nation as it can be obtained from cheap biomass and coal.

10) There is also a proposal of fuel reformation using exhaust heat (MIT proposal).

DRAWBACKS

1) Methanol molecule contains oxygen, methanol contains only 53% as much energy per liter as gasoline .Therefore vehicles running on methanol would be requiring a tank larger than the gasoline tanks to carry more fuel.

2) It has a high specific heat and high heat of vaporization which can cause starting and warm up problems.

3) Methanol is found to be corrosive for certain materials.

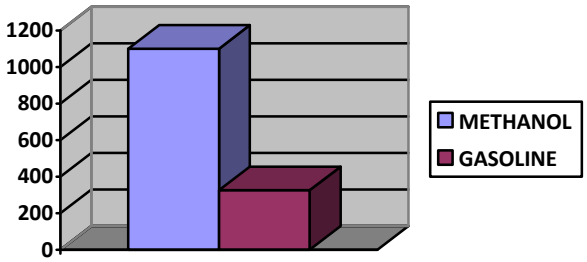
4) Methanol vehicles require special engine oil for proper working of engine in long run.

5) Though the CO, HC and NOx emissions decreased, but there is significant increase in aldehyde emissions, which can be overcome by the use of catalytic converter

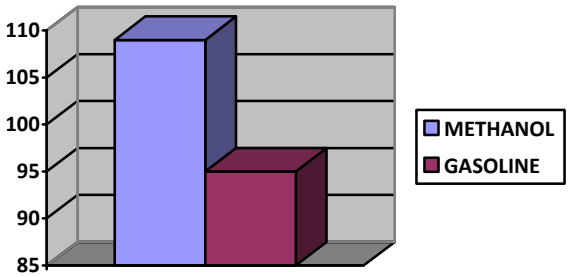
Table -1: Comparison of properties between Methanol and Gasoline

Property	Methanol	Gasoline
Density (20° C) kg/m³	791	740
Lower Calorific value(MJ/kg)	19.5	44
Viscosity(20° C)(cP)	0.6	0.42
Heat of vaporization(kJ/kg)	1104	330
Boiling temperature(°C)	65	30-225
Octane number	110	92
Stoichiometric air- fuel ratio	6.5	14.6
Boiling point(°C)	64.7	149-270
Auto ignition temperature(°C)	464	257
Specific Heat	2.6	2.009
Laminar Burning Velocity(cm/s)	45	30

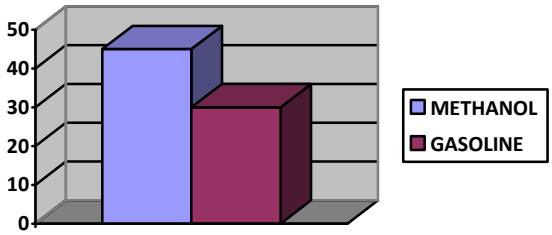
(a) Heat of vaporization(KJ/kg)



(b) OCTANE NUMBER(RON)



(c) LAMINAR BURNING VELOCITY(cm/s)



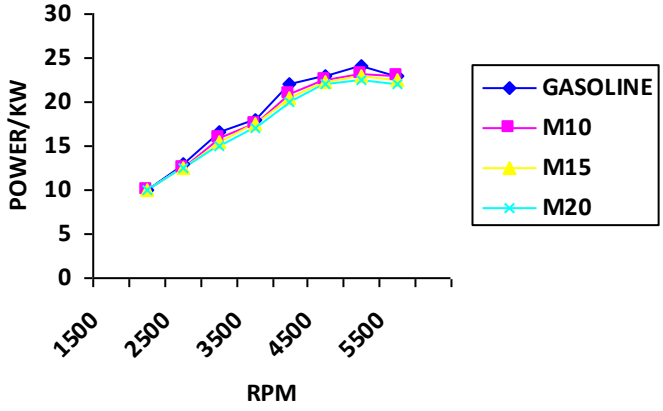
3. EFFECT OF METHANOL ON ENGINE PERFORMANCE

3.1) EFFECT ON POWER AND FUEL ECONOMY

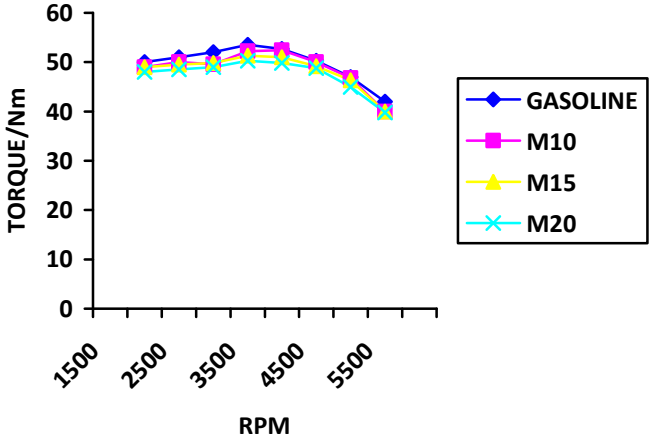
Several kinds of fuel blends were prepared for the different purpose of engine test, containing 10%, 15%, 20%, 25%, and even 30% of methanol in volume, respectively. The test engine remains its original set of parameters, especially the 7 degree CA (crank angle) spark ignition timing. When it ran on above specified blends and based gasoline as showed in the fig 1, the WOT (wide open throttle) operation performance of engine power

FIG - 1

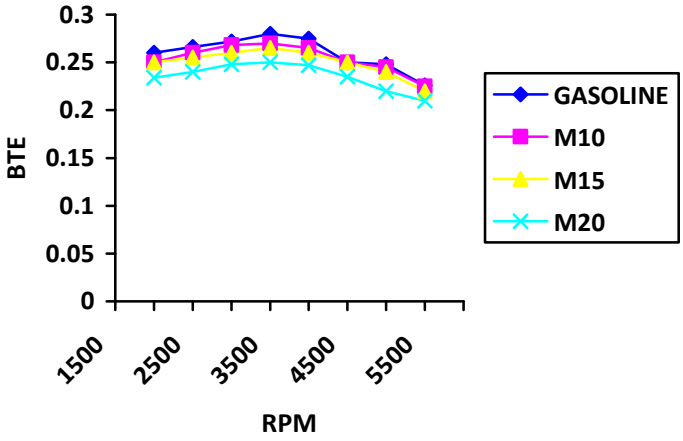
(a) POWER



(b) TORQUE



(c) Brake thermal efficiency



Torque and brake thermal efficiency are measured. With the increase fraction of methanol, engine power and torque decrease, while the brake thermal efficiency is improved. Considering that motors are seldom run on WOT conditions, even when fuel is changed to be M15, it has little effect on power performance.

However, if the spark ignition time is advanced 2 degrees Without any further optimizations, under WOT (wide open throttle) full load conditions, the engine power loss is negligible.

3.2) EFFECT ON FUEL CONSUMPTION

The effect of methanol-gasoline blends on the fuel consumption is shown in fig 2 .However, its low energy content of 19.7MJ/Kg and Stoichiometric air fuel ratio of 6.42:1 mean that fuel consumption will be higher than gasoline. The fuel consumption increases as the brake power increases at constant engine speed 2000 RPM because methanol has calorific value less than the gasoline .Fuel consumption increased about 2.9 times as the engine brake power increased from 0.15 KW to 3.807 KW. The brake specific fuel consumption (BSFC) decreased. This behavior is attributed to LHV per unit mass of methanol fuel, which is distinctly lower than that of gasoline.

FIG-2

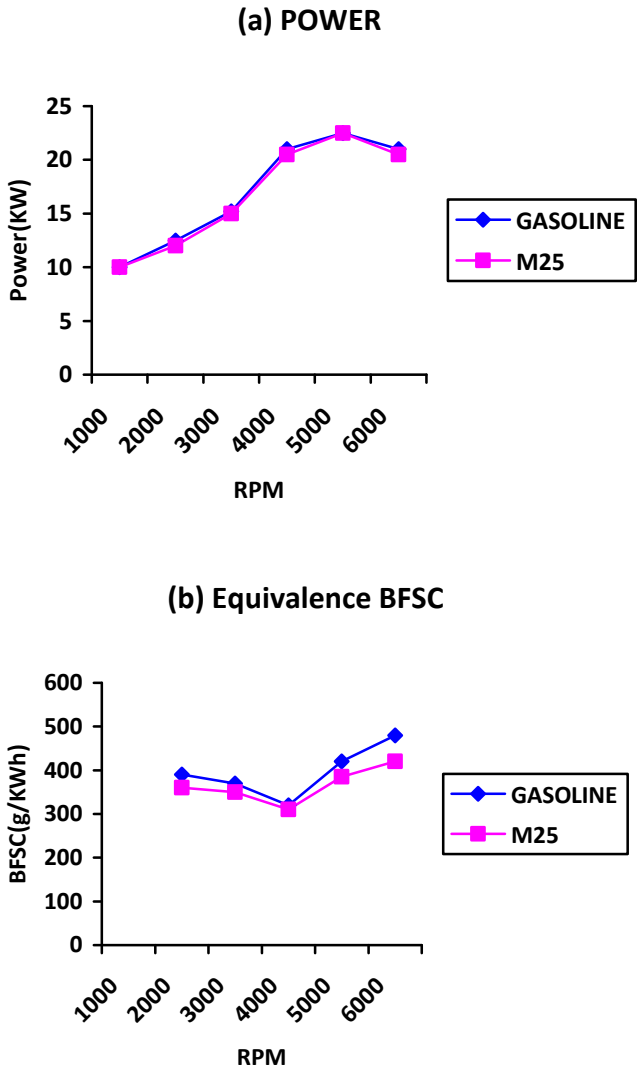
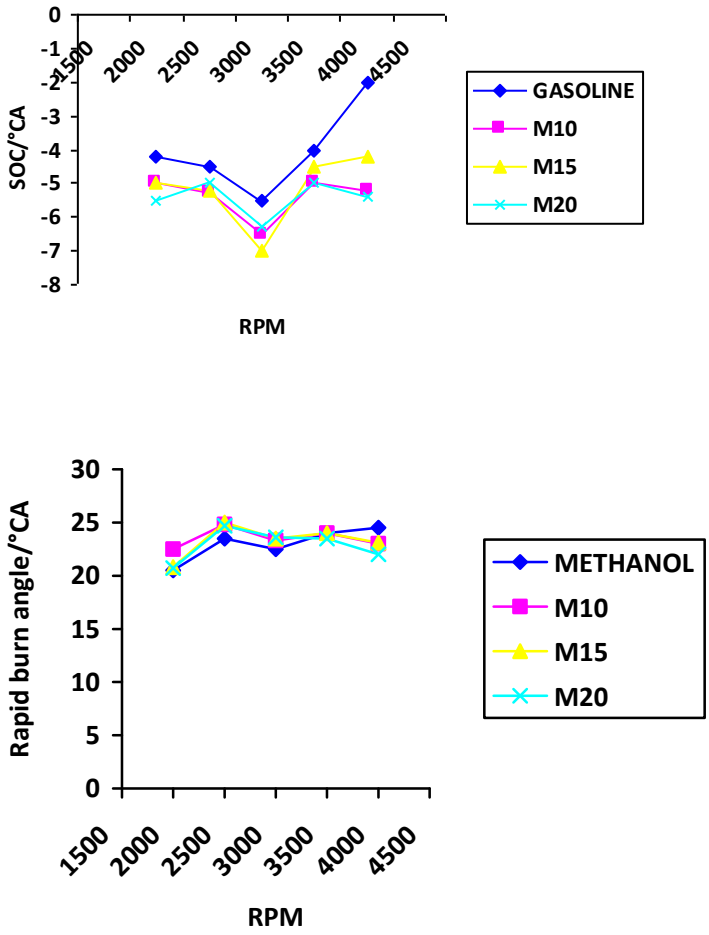


FIG -3



4. EFFECT ON ENGINE COMBUSTION CHARACTERISTICS

Cylinder pressure shows that, under the same engine speed and throttle opening, when the engine fueled with M15, the maximum pressure is higher than that of pure gasoline operation. The IMEP are 0.91MPa for M15 and 0.88 for gasoline. Engine thermal efficiencies are 0.284 and 0.262 respectively.

In most of the cases, the start of combustion is delayed due to addition of methanol, while the rapid burning phase becomes shorter at high speed operating conditions. Fig 3 shows the changes of SOC and RBP under the constant torque of 30Nm operating conditions. Therefore, if the spark ignition time is advanced 2 to 3 degree CA (crank angle), the engine combustion will be centralized near TDC, so engine power and efficiency can be improved.

EFFECT ON EXHAUST GAS TEMPERATURE

Exhaust gas temperature increases as the percentage of the methanol increases. Because the heating value of the methanol is lower than that of gasoline therefore on adding of methanol it increases the octane number but decreases the heating value. Moreover, auto ignition temperature of the methanol is higher than that of pure gasoline so the temperature required for the ignition would be high, which consequently increases the exhaust temperature.

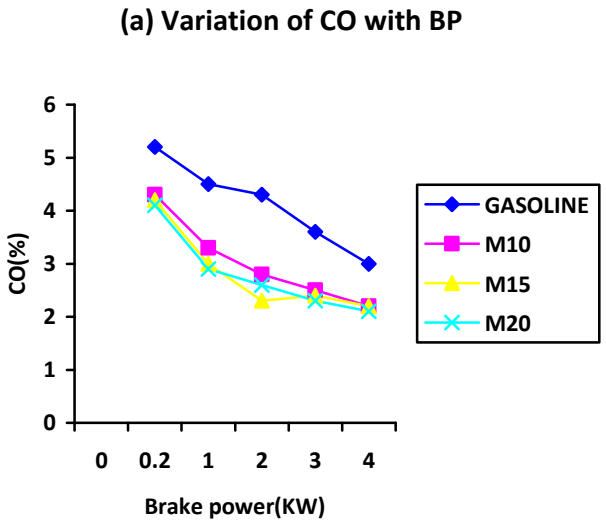
5. EFFECT ON EXAUST EMISSION

The effect of the methanol percentage in the fuel blend on the CO, HC, CO_2, etc., emissions are divided into two categories

5.1) EFFECTS ON REGULATED EMISSION AND CONVERSION

The regulated gaseous emissions include CO, HC and NO_X. Fig 4 shows a group experimental data of engine under 2500 rpm constant engine speed operating conditions. When methanol is added into gasoline, the fuel blend contains more oxygen, which reduces CO and HC emissions. Also, when the engine utilizes fuel blends, after TWC (Three Way Catalysts), CO and HC emissions are better than that of pure gasoline operation. The effect on NO_X emission is ignorable, neither prior to nor post the TWC. Therefore, methanol used in SI engine can reduce emissions of HC and CO in this study.

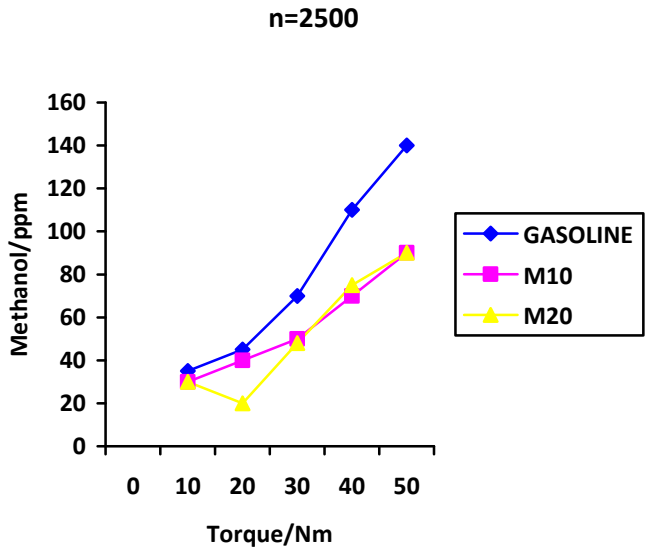
FIG - 4

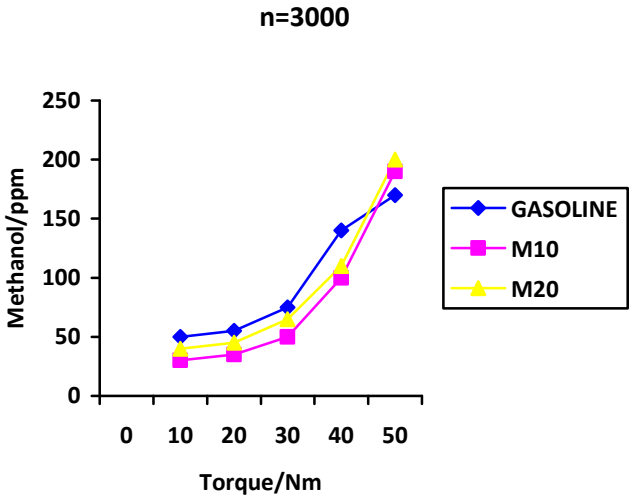


5.2) EFFECT ON NON-REGULATED EMISSIONS AND CONVERSION

In the study, the unburned methanol and formaldehyde were measured and they are generally called to be non-regulated emissions. Both formaldehyde and methanol are measured. Fig 5 indicates that methanol emission increases with the increase of engine speed and load, however, methanol contents in fuel blends have no significant direct effects on its emission in the experimental range

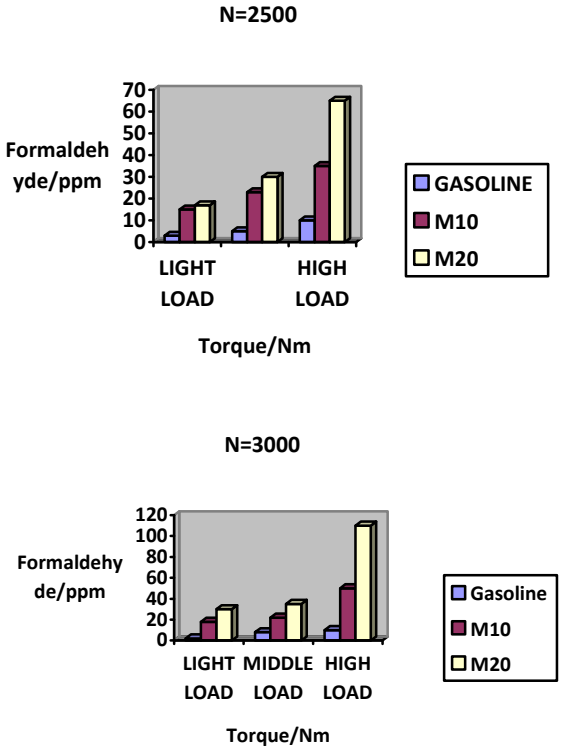
FIG - 5





Actually, because of cyclic combustion variation of SI engine combustion and the small sampling volume (500 micron liters), the results are not so repeatable. On average, formaldehyde emissions are increased with methanol content, engine speed and load as showed in Fig 6. Formaldehyde emission of M20 is about 10 times as high as gasoline, however, the total concentration is still within.

FIG - 6



200ppm. With TWC, the methanol and formaldehyde can be oxidized effectively. Within the calibration range, formaldehyde cannot be measured. Comparing the data, it is safe to say that commercial TWC can convert formaldehyde sufficiently.

6. EFFECTS ON COLD START AND WARMING UP PROCESS

FTP (Federal Test Procedure) tests show that about 80% HC and CO emissions are cold start and warm up periods, so cold start investigations becomes an important branch in control of engine emissions. And also, there is no report concerned on the combustion and emission characteristics of methanol/gasoline blend fueled engine. The characteristics are of CO and HC during cold start and warming up (at 5°C) .When engine is fueled with M30, HC and CO are much better than that of gasoline operation. HC emission is reduced to more than 50% in the first few seconds (cold start period) and nearly 30% in the following period (warming period). CO is reduced to nearly 25%. The engine speed is quite similar, while the exhaust temperature is higher, which is good to light off TWC earlier.

7. CONCLUSIONS

From this study, it can be concluded that low fraction methanol/gasoline blend can be used in SI engine without any modifications. The fuel blend has slightly lowered the engine power and torque, while increases engine brake thermal efficiency. For better operation, spark timing is optimum. Methanol gasoline blended fuel may lower HC and CO emissions, but there is no obvious effect on TWC conversion efficiency. However, the increase of methanol increases the unburnt methanol and formaldehyde emissions. Both regulated and non-regulated emissions can be converted effectively by conventional TWC.
The most interesting thing is that methanol addition to gasoline improves the SI engine cold start and lower CO and HC emissions significantly.

8. FUTURE SCOPE

There are many problems demanding further research and development works are as follows:
1) Changing the engine operating parameters such as increase compression ratio, high energy spark plugs, and changed carburetor system by larger cross-section area of fuel nozzle.
2) Injection timing and atomization ratio, has been carried out in many studies on IC engines, aiming to reduce emissions and performance better.
3) For proper working of methanol in vehicles, it is required to build corrosion resistant tank both for vehicles and for distribution.
4) The concept of using methanol should not be taken as a thing of future as Chinese economy is soon going to be a

methanol economy. Many of the provinces have made M15 as standard for usage. Major Chinese automakers like FAW Group, Shanghai Huapu, Geely Group, SAIC, etc. have already been successful in making methanol capable vehicles.

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BIOGRAPHIES

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