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A COMPARATIVE STUDY FOR THE PERFORMANCE OF S.I.E USING ETHANOL AND GASOLINE FUELS

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ABSTRACT:

Ethanol offers a near - term alternative to replace petrolium based fuels for spark ingition engines. It can contribute a considerable part of energy resources using domestic renewable resources.

This work comprises a comparative study for the performance and emission characterestics of spark ignition engines using gasoline and ethanol. The experiments were carried out on a four stroke four cylinders petrol engine modified to use ethanol as fuel.

The results show that ethanol can provide a smooth and clean burning fuel for convensional spark ignition engines if some little carburettor modifications are made and the problem of cold starting is solved. The results also showed that ethanol has better detonation resistance which allows the use of higher compression ratios. Use of ethanol as a fuel for S.I.E resulted in increase of the engine power , lower emissions of unburned hydrocarbons and carbon monoxide.

1. INTRODUCTION

Since the invension of internal combustion engines , it is well known that alcohols are potentially capable of being used as engine fuels. In the past , the excessive cost of alcohols as compared with gasoline made the investigators to give less attention to alcohol as motor fuel. In the last ten years , the picture has been changed due to the large increase in oil prices and the expected decrease of petroleum resources in the near future. Therefore alcohol has received lately much attention as an alternative to replace petroleum based fuels. Alcohol has the advantage that it can be produced synthetically from coal , wood , sugar cane charcool and the fermentation of muicipal wastes. It has the advantages of having high Ootane number without lead additives allowing the use of high compression ratio without knock [1] , wider flammability limits higher burning velocity than gasoline under lean mixture conditions [2] and lower unburned hydrocarbons, carbon monoxide and nitric oxide emissions in the exhaust [3] .

Bernhardt and lee [4] found that the use of methanol results in increase of 10% of engine power and efficiency and lower exhaust emissions of NO., CO. and unburned hydrocarbons. Annand et al [5] studied the use of methanal as a fuel for S.I.E and found that it has a number of attractions to be considered as a substitute or extender for petroleum based fuels.

Exhaust emissions and engine characterestics of S.I.E burning methanals were also studied recently by a number of investigators [6] and [7] confirm the early observations and indicate that only minor modifications would be necessary to allow current design engines use methanol as fuel.

Branch et al [8] studied exhaust emissions and the fuel economy of a large volume prechamber, fuel injected , stratified charge engine with gasoline and gasoline 20% methanol blend. Keller[6] discussed the use of methanol and ethanol as fuels for the two cases of straight and blended. He also studied the cold starting, phase separation , water tolerance and vapor lock problems. Yand et al [9] discussed Brasil's Gasohol program as practical application for using alcohol as motor fuel on a large scale and its profound implementation for the country's economy in the long run. It should be recalled that Brasilian engines fueld by gasohol containing up to 20% alcohol did not lose performance with no engine modifications.

As shown in the fore going discussion that most of these investigations were concerned with methanol. In Egypt, ethanol is considered as a bi-product for the national sugar industry. Therefore, it is more important to study the use of ethanol as a fuel in internal combustion engines and one of the future fuels to share the efforts searching for alternatine energy sources.

2. EXPERIMENTAL SET UP

The experimental work has been carried out at one of the workshops of the ministry of defence at Mansoura. A four stroke, four cylinders, water cooled petrol engine type GAZ 69 M is used through out the investigation. The engine has a cylinder diameter of 88 mm , 100 mm diameter and 6.5 compression ratio. The engine is mounted on a research test bed type HPA [10] equiped with water brake engine dynamometer to measure the torque of the engine . Engine speed is measured using an electronic tachometer . The temperature of the fuel - air mixture in the induction manifold is also measured using a thermometer. The fuel and air consumption are also measured.

In order to use this engine with ethanol as fuel some minor modifications have been made. The carburettor main idling and accelerating pump jet diameteres are increased to 1.2 those for use with gasoline. Due to the fact that ethanol has a very high latent heat of vaporization (about 2.5 times that for gasoline) , cold starting is sometimes impossible. Therefore , an electric heater is fixed in the induction manifold to supply the heat necessary for enough vaporization. The heater is connected with the starting circuit such that it is switched off as the engine starts. The intake manifold of the engine is equiped with three cross-flow stainless steel tubes of 8 mm diameter. Exhaust gas is drawn through these tubes to raise the temperature of air - ethanol mixture which allows rapid vaporization of ethanol droplets. This is necessary to ensure homogeneous mixture in the manifold and uniform distribution to the engine cylinders.

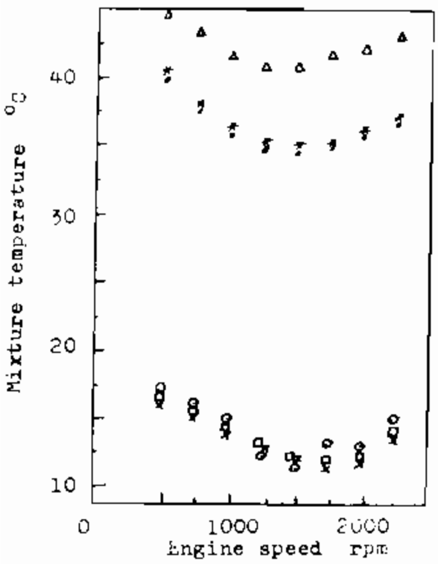
The effect of increasing the compression ratio of the engine upon its performance characteristics for both gasoline and ethanol is also studied. The engine compression ratio is increased by grinding the cylinder head to decrease the clearance volume. Three compression ratios ; 6.5 , 7.36 and 8.7 are used throughout this work. The details of the experimental set up and technique is shown in ref. [10] .

3. RESULTS AND DISCUSSION

As a fuel for spark ignition engines , ethanol has a number of attractions to be the best alternative for autombile fuels . Its known advantages include high Octane number without lead additives, reduction of the exhaust pollutant emissions and easy storage compared with hydrogen. In addition to the fact that it can be produced by the fermentation of molasses, sugar cane juce and starch containing feedstokes.

Ethanol differs markedly from gasoline in several characteristics. Compared with gasoline ethanol requires 61% as much air for combustion, produces 66% as much energy and requires 2.6 times as heat of vaporization. For a given engine output, ethanol requires 4 times as much as heat of vaporization. This is shown in figure (1) as a large drop in the temperature(about 25°C) of ethanol - air mixture compared with gasoline - air. In contrast to gasoline , ethanol has a single boiling point at the lower end of gasoline range. The flammability limit for ethanol is such that its saturated vapor with air is flammable at common ambient temperatures but too lean to ignite at temperatures below 15°C. These characterestics lead to difficulty in starting the engine in cool wether with pure ethanol. Hence , some modifications should be made to the induction system to supply the necessary amount of heat to permit satisfactory driveability. Ethanol used as an additive to gasoline or substitution can immediately help to solve both energy and pollution problems. Better performance and economy are also expected in an engine designed specifically for ethanol. Such design should encompass higher compression ratios and a fuel injection system.

Both the peak pressure and temperature of the engine are calculated from the fuel - air constant volume combustion cycle. The effect of variable specific heats and chemical equilibrium conditions are considered for both ethanol and gasoline fuels. Figure (2) shows the peak pressure results for different equivalance ratio. It shows that ethanol has lower peak pressures than these for gasoline. Figure (3) shows the results for peak



Figure(1)

Mixture temperature at induction manifold; Gasoline(• CR=6.5, * CR=7.36, Δ CR=8.7) and Ethanol(x CR=6.5, □ CR=7.46, o CR=8.7)

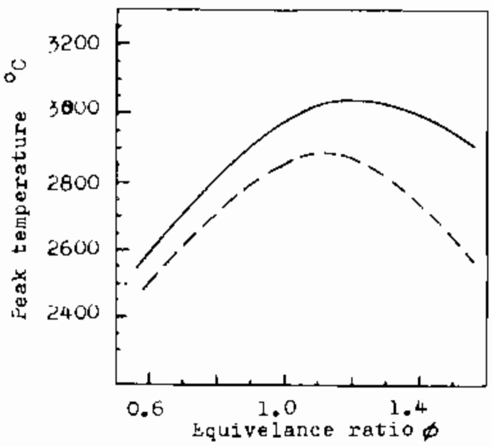


Figure (2)

Comparison between the peak temperature of gasoline and ethanol fuels; ——— Gasoline, - - - - Ethanol

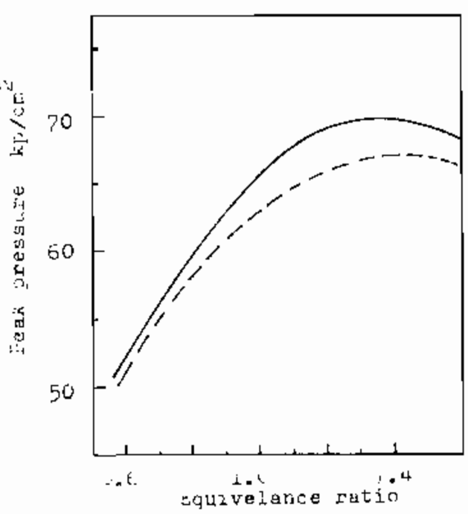


Figure (3)

Comparison between the theoretical peak pressures of gasoline and ethanol fuels; ——— Gasoline, - - - - Ethanol.

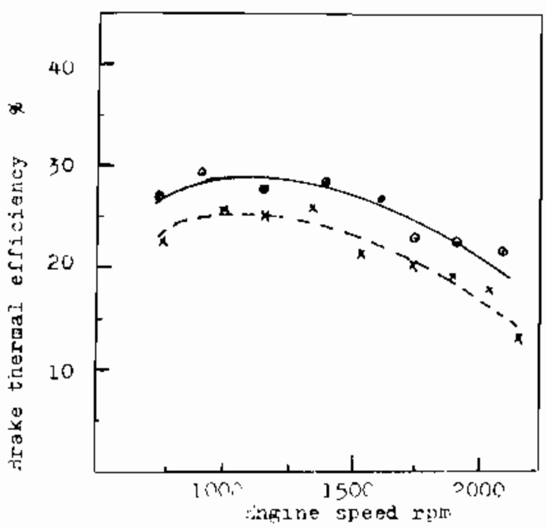


Figure (4)

Comparison between the thermal efficiency of gasoline and ethanol as function of engine speed at constant power of 30 b.hp; x- - - - - - Gasoline, o ——— Ethanol.

temperature as function of the equivelance ratio. It is clearly shown that ethanol has lower peak temperatures compared with gasoline. The difference increases with the equivalence ratio. From these results one can expect an increase in detonation resistance of ethanol due to its lower peak pressure and a reduction of heat losses due to lower combustion temperatures.

The experimental results of the performance of the S.I.E. using ethanol as a fuel are discussed compared with these of gasoline as follows.

3.1. Brake Thermal Efficiency:

Figure (4) shows the thermal efficiency of the engine at constant power of 30 hp as function of the engine speed. It is cleare that the thermal efficiency decreases with the speed. The figure shows that the brake thermal efficiency is almost 10 % higher than that for gasoline at all speeds for 6.5 compression ratio. Figure (5) shows the brake thermal efficiency as function of the power output for two different compression ratios of 6.5 and 8.7 respectively. Fig. (6 and 7) presents the brake thermal efficiency using ethanol relative to that of gasoline as function of engine speed and power output respectively for three different compression ratios 6.5 , 7.36 and 8.7 respectively. These results clearly demonstrate that ethanol as a S.I.E fuel gives higher thermal efficiency than that of gasoline at all speeds , power outputs and engine compression ratios. The increase in thermal efficiency is independent on engine speed or power output but increases with the engine compression ratio. At CR = 6.5 the brake thermal efficiency increases about 10% but for CR = 8.7 it increases by 30% of the values of gasoline fuel.

This most noticeable increase in the thermal efficiency of the engine operating with pure ethanol is attributed to the reduced heat losses due to lower combustion temperatures reduced combustion time losses due to high flame speeds. The lower peak pressures and temperatures of ethanol compared with gasoline result in lower values of unburned hydrocarbons and better combustion efficiency. Ethanol has the advantage of wider flammability limits and higher buring velocity under very lean conditions. This directly results in more efficient combustion process and better brake thermal efficiency.

3.2. Brake Specific Fuel Consumption (bsfc)

Figures (8 and 9) present the brake specific fuel consumption of the SIE using ethanol in comparison with gasoline as function of engine power and equivelance ratio respectively. Figure (10) also show the b.s.f.c of ethanol relative to gasoline as function of the engine speed. The results show that ethanol has higher b.s.f.c than gasoline. This is due to its lower calorific value (about 60% that of gasoline).

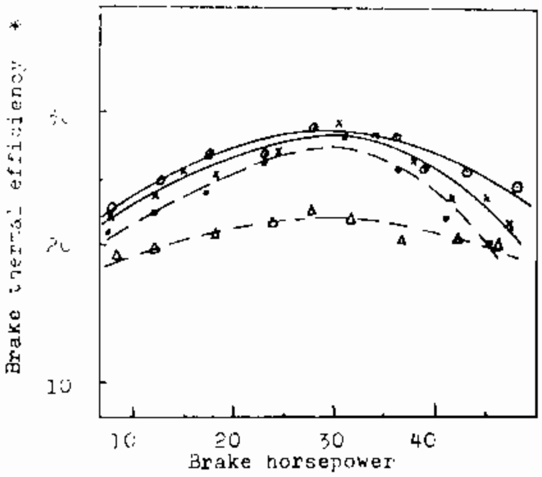


Figure (5)

Brake thermal efficiency as function of the brake horsepower of Gasoline ---- (• CR=6.5, Δ CR=8.7) and Ethanol ——— (x CR=6.5, ⊙ CR=8.7)

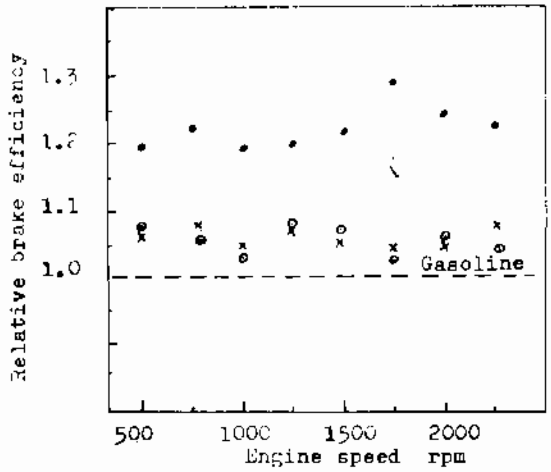


Figure (6)

Brake themal efficiency of ethanol relative to gasoline as function of engine speed; x CR=6.5, ⊙ CR=7.36, • CR=8.7

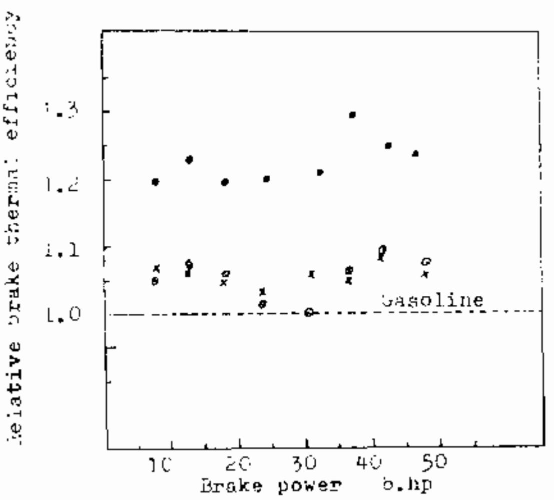


Figure (7)

Brake thermal efficiency of ethanol relative to gasoline as function of brake power; x CR=6.5, ⊙ CR=7.36, • CR=8.7

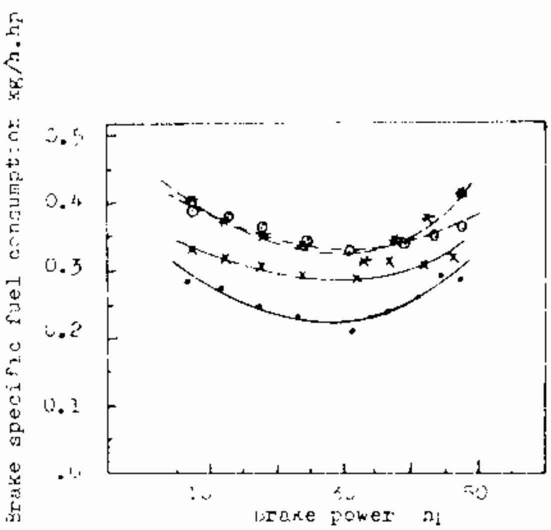


Figure (8)

Brake specific fuel consumption of ethanol compared with gasoline as function of brake power; ——— Gasoline(• CR= 6.5, x CR=8.7) and ---- Ethanol(✱ CR= 6.5, ⊙ CR=8.7)

The bsfc of both gasoline and ethanol have a minimum value at 1500 r.p.m. 30 bhp and 0.8 equivalence ratio. The results also show that the bsfc of ethanol decreases with the compression ratio due to the increase in thermal efficiency.

Defining the fuel consumption on energy bases, ethanol results exhibit lower values than gasoline due to its higher thermal efficiency.

3.3. Power Output:

Figure (9) shows the brake mean effictive pressure of ethanol compared with gasoline as function of equivelance ratio, at full throttle and 1500 r.p.m. The results shows that ethanol has higher bmep at all values of the equivalence ratio and consequently higher engine output. Figure (11) presents the bmep as function of the engine speed at full throttle for both ethanol and gasoline. The values relative to gasoline are also shown in figure (12) for different compression ratios. These figures show that ethanol has higher bmep that those of gasoline at any compression ratio. This is more noticeable at high compression ratios . This remarkable increase in engine output with ethanol attributed to the increase in thermal efficiency and the increase in engine volumetric efficiency resulting from the high latent heat of vaporization of ethanol.

3.4. Exhaust Emissions:

Figure (13) presents the results of Orsate analysis for the exhaust gases of ethanol in comparison with those of gasoline at different equivalence ratio. It shows that the concentration of CO in the exhaust gases is lower for ethanol than that for gasoline. However O_2 and CO_2 are higher in concentration for ethanol than those for gasoline.

4. Conclusions

This work shows the importance of ethanol as a fuel for spark ignition engine and its compitability with gasoline. In addition to the advantages of higher detonation resistane and lower undesired exhaust emissions, ethanol can be produced from agriculral products.

This work also that very minor modifications can be carried out to the ourrent design engines to use straight ethanol as engine fuel. Ethanol provides improved engine output , specific energy consumption and thermal efficiency relative to gasoline . It also reduces undesireable exhaust emissions such as CO and NO.

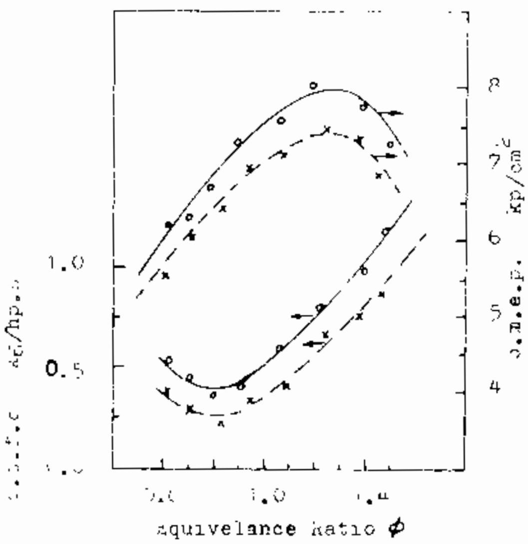


Figure (9)

Brake specific fuel consumption b.s.f.c. and brake mean effective pressure b.m.e.p. as function of equivelance ratio. x — — Gasoline, o —— Ethanol

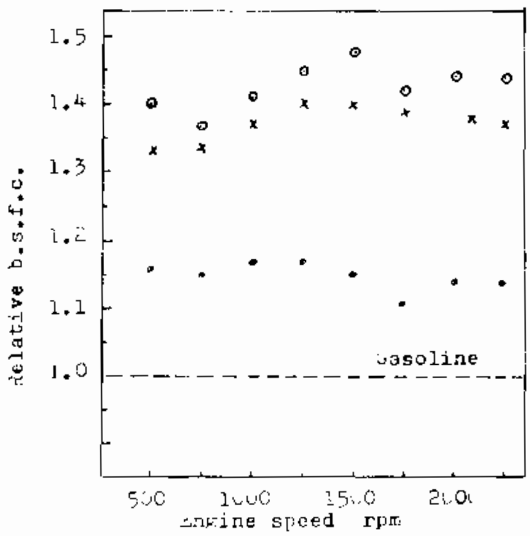


Figure (10)

Brake specific fuel consumption of ethanol relative to gasoline as function of engine speed; o CR=6.5, x CR=7.36, • CR=8.[illegible]

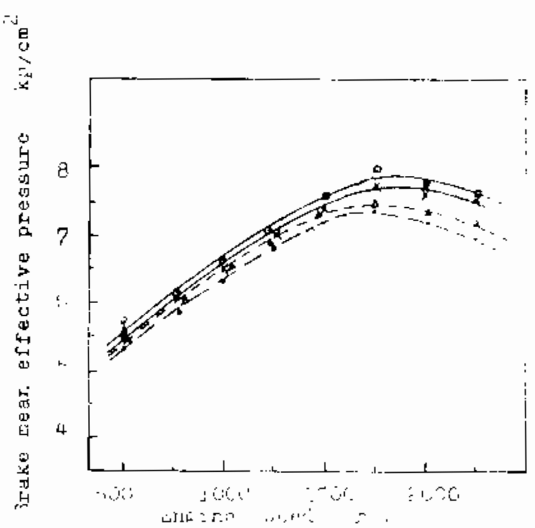


Figure (11)

Brake mean effective pressure as function of engine speed; ----- Gasoline (• CR=6.5, Δ CR=[illegible]) ——— Ethanol(x CR=[illegible], o CR=8.[illegible])

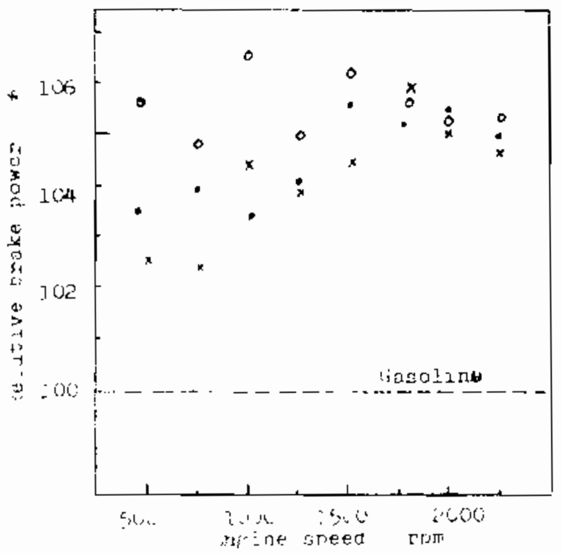


Figure (12)

Brake horsepower of ethanol relative to gasoline as function of engine speed; x CR=6.5, • CR=7.[illegible], o CR=8.[illegible]

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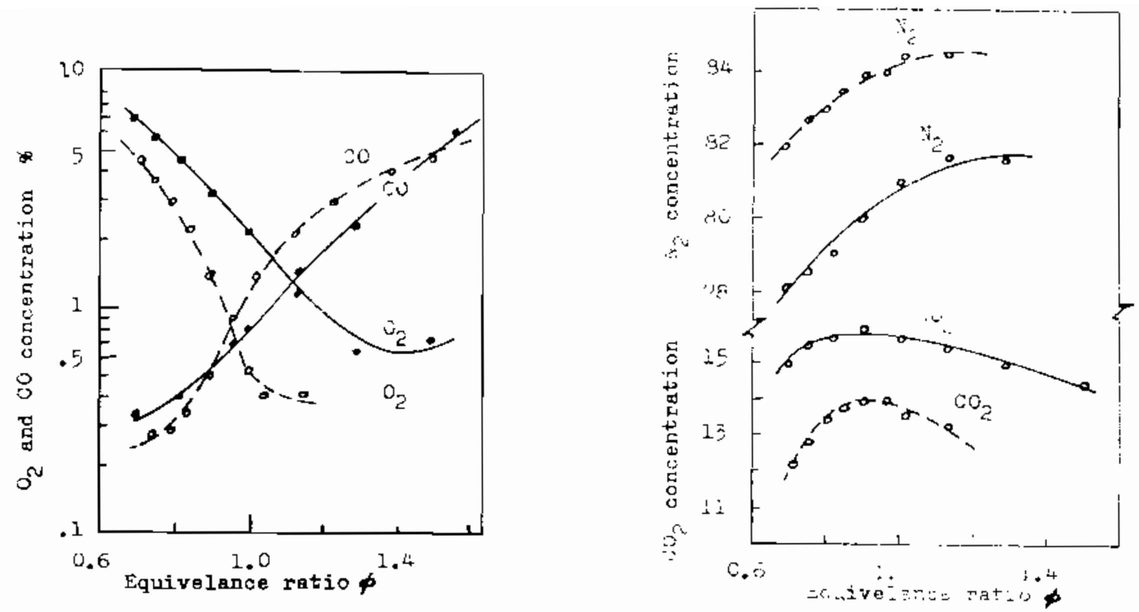

Figure (13)

Orsat analysis for the exhaust gas of gasoline and ethanol fuels as function of the equivelance ratio; -------Gasoline, ——— Ethanol