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Experimental Study The Effect Of Octane Number On Performance Of The Spark Ignition Engine

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Abstract- This research aimed to an experimental study the effect of octane number of the fuel on the performance of the spark ignition engine. The study included the preparation of fuel with octane number (70,75,80,85,90) by using a standard engine (CFR).The experiments had been carried out using four stroke, single cylinder type (TD110), with compression ratio(6:1), coupled to hydraulic dynamometer type (TD115).The study showed that, using fuel with octane number (70 and 75) had problems at the beginning of starting and acceleration. The difficulty are knock and delay in warming up of the engine. The results show that the engine performance are increased step by step according to the increases of the octane number of fuel, and this appeared clearly in the obtained results of samples (70 and 90) as follows: At the speed 2800 r.p.m. the torque and the brake thermal efficiency are increased by 9.75% and 12.48% respectively. While at the speed 3400 r.p.m the brake power and exhaust temperature are increased by 8.97% and 3.7% respectively. also the brake specific fuel consumption decreased by 15% at 2800 r.p.m. .

Key words- Octane number, Performance, Spark ignition engine

I. INTRODUCTION

The process of evaluating internal combustion engines rely on performance-based transactions, which include: the power and Torque and specific fuel consumption and others. The performance parameters of this depends on the design factors (size of the engine and the compression ratio and the number of input and output valves and site candle mug and the system of ignition, etc.) and operational factors of the engine include Load and speed, air temperature, air-fuel ratio and the quality of fuel used that mixing fuel with air process, especially in spark ignition engines and therefore the impact on the combustion process and flame spread and speed of combustion and resist knock and self-ignition. Large number of studies has performance of engine, for instance:

Xiaolei Gu et al.[1], investigated experimentally the spark ignition engine, port fuel-injection, fuelled with of n-butanol and gasoline blends at different EGR rates and spark timings. The obtained result revealed that the blends of n-butanol and gasoline reduce engine specific NOx, CO and HC emissions in comparison with that of gasoline. There is decreases in particle concentration and NOx and increases in engine specific CO and HC emissions when a n-butanol is used. EGR can decrease the particle concentration and NOx emissions simultaneously in SI engine fueled with blends of n-butanol and gasoline.

Mustafa Kemal Balki et al.[2], experimentally investigated the effect of a combined Methanol and ethanol on the compression-ignition (CI), emission and performance of a single cylinder low power engine. The results revealed that the combustion efficiency, thermal efficiency, brake specific fuel consumption (BSFC) and the torque of the engine increase when Methanol and ethanol is used as a fuel.

T. Korakianitis et al. [3], study the performance and emissions of CI and SI engines fueled with natural gas. 17.2% higher (F/A) and the 2.2% lower LHV_f of natural gas compared to gasoline affects the engine power. Natural gas induction in the intake manifold seriously affects volumetric efficiency η_v. All the three factors affect power output which leads to about 10-15% reduction in power in comparison with gasoline-fueled engines.

Mustafa Koç et al.[4], studied the effects of unleaded gasoline (E0) and unleaded gasoline–ethanol experimentally on engine emissions and performance. The engine test result indicated that ethanol addition to unleaded gasoline will without occurrence of knock increases the compression ratio and also increase the engine fuel consumption, power and engine torque and decreases the emission of NOx, HC and CO.

Erjiang Hu et al.[5], experimentally investigate the influence of different EGR rates and hydrogen fractions on the performance and emissions of a SI engine. The results shows that the introduction of large EGR decreases the engine output power. However, hydrogen addition increases the output power at huge EGR. At low EGR rate, the thermal efficiency decreases with decreases in hydrogen fraction. Whereas at high EGR rate, there is a decreasing trend in both thermal efficiency with increment in hydrogen fraction.

M. Bahattin Celik,[6], studied the effect of ethanol on small gasoline engine. Ethanol fuel at high CR was used to decrease the emission and increase the performance of the engine which has low efficiency. It was found that E50 is the best in terms of emission and performance. The result also showed that the engine power will be increased by 29% when running on E50 compared to that of E0.

I˙smet Sezer et al.[7], conducted an experimental study on the effects of blends of gasoline with MTBE on the CO emissions and performance of a SI engine. It was found that MTBE-gasoline blends give higher bmep values compared to those of base, leaded, and unleaded gasoline, especially at lower engine speeds. The maximum improvement in bmep is obtained with addition of 10% MTBE to base gasoline for a CR of 8 and an ST of 10° BTDC at a 1400 rpm engine speed. MTBE addition to base gasoline improves bte up to a 15% blending ratio, but further addition of MTBE results in slight decreases in bte. Thus, in the present study, the maximum bte is obtained with a 15% addition of MTBE for all tested conditions among the blended fuels. The best performer among the pure fuels and blends is unleaded gasoline.

L. Shenghua [8], did the study of spark ignition engine fuelled with methanol gasoline blends. The engine was three cylinders with a bore of 68.5 mm. The methanol was blended with gasoline containing 10, 15, 20, 25, and 30% in volume. The engine power, torque and brake thermal efficiency are measured with the change in speed at WOT condition with the increased fraction of methanol. Engine power and torque decreases while the brake thermal efficiency is improved. The maximum pressure is higher than that of pure gasoline operation under the same engine speed and throttle opening (50% WOT) when engine fuelled with M20.

H. S. Yucesu [9], comparative study of mathematical and experimental analysis of spark ignition engine performance used ethanol – gasoline blend fuel. In this study, ethanol- unleaded gasoline blends (E10, E20, E40, and E60) were tested in a single cylinder, four stroke spark ignition and fuel injection engine by varying the ignition timing, relative air fuel ratio and compression ratio at a constant speed of 2000 rpm and wide open throttle. It was concluded that torque with blended fuels was higher than that of base gasoline in all the speed range and a significant reduction in HC emissions was observed as a result of the leaning effect and additional fuel oxygen caused by the ethanol addition.

It was suggested that higher compression ratios can be used with ethanol gasoline blends without knock.

Wei-Dong Hsieh et al. [10], investigate experimentally using gasoline-ethanol blended fuels at different blending ratio the pollution emission and the engine performance of a spark ignition engine. Results revealed that the heating value of blended fuel decreases as the ethanol content increases. They also showed that as the ethanol contents increases, the octane number of the blended fuels increases. However, there was slight increment in fuel consumption and output torque of the engine when ethanogasoline blended fuel was used.

II. THE THEORETICAL SIDE

Gasoline Fuel is one of the most common type of fuel used in spark ignition engines, which is a mixture of different types of hydrocarbons such as Paraffin, Alleviant, Invthiat and aromatics. The ingredients vary depending on the source of crude oil, according to the liquidation operations and chemical additives [11]. Fuel oil is classified depending on the number of standard specifications including, Rate of evaporation at different temperatures and the amount of Athlete added sulfur content and octane number, which is considered the most influential of the level of performance and fuel spark ignition engines than those who preceded or classified based on vapor pressure and volatility, and these have to do to use season Winter or summer.

The measure, which was developed by (Graham Edgar) the year (1926) expresses the Octane number is done by taking a single high-resistance hydrocarbon compounds bang and specifically Iso_Octane (C8H18) and given its number hundred. Then chosen Hbtane normal n-Hptane (C7H16) and outstanding high crackle and give it's a number zero. Located octane number for any mixture of the two compounds between zero and hundred.

The identification octane number for the rest of hydrocarbon compounds, or any combination thereof when comparing features burned in a standard engine with characteristics of combustion with different proportions of models of Iso_Octane and n-Hbtane usual in a standard engine (Cooperative Fuel Research-engine) ASTM-CFR (consisting of one cylinder with ratios compression variable) [12,13].

Differed ways to calculate octane number for a fuel oil depending on the circumstances and on this basis was adopted three ways to calculate [14,15].

1- Research Octane Number (RON), Measurement tests conducted in the laboratory and then run the engine speeds (600 r.p.m.) and under simple conditions to determine the properties of oil fuel in a knock at low velocities.
2- Motor Octane Number (MON), measurement tests conducted in the laboratory on special machines and under harsher conditions and speeds (900 r.p.m.) to see the properties of oil fuel in a knock when those conditions.
3- Mean: either in this way depends on the arithmetic mean, namely: ((RON + MON) / 2) and called (Anti-knock index)

Since the examination octane number engine combustion chamber has been designed in the thirties of the twentieth century, because the test is being accelerated under the low-lying octane number that we get it in this way is not appropriate on a permanent basis to work on the high velocities engines. Since it is possible to find the same compression ratio engines, but differ in the geometry of the combustion chamber, one works without knock while the other is happening with knock using the same fuel [16].

Octane number calculated way research is the highest compared with the calculated way Motor and Called on the difference between the two, fuel sensitivity (f_s), which represents the following equation:

$$f_s = RON - MON \qquad \text{..............................} \ (1)$$

The sensitivity of fuel represents the best measure of the sensitivity of the knock which are affected by the combustion chamber in the engine combustion and usually (f_s) up to (0-10). When the (fs) is low (ie less than 5) means that the recipe or the viability of knock fuel is sensitive to the geometric shape of the combustion chamber. Because of the conditions of the experiment (examination) we can notice a difference between both MON and RON for the same fuel on the one hand and on the other hand, we note that the fuel may have the same RON and MON.

At the beginning of the twentieth century has been the use of fuel with a octane number and the fact that sessile ratios a low-compression. At the beginning of the second half of the last century, the need to use fuel with octane number of high-emerged (as a result of the evolution in the science of metals and the possibility of obtaining engines ratios high compression), prompting researchers in research centers and companies tireless efforts for the efforts to obtain it through the use of additives fuel oil.

It was reached several types of additives, which contribute to raising the octane number and increase resistance to pop them increase the proportion of hydrocarbons with a number of higher octane number or add amines aromatic as used with oil fuels for aircraft as well as (TEL) (C2H5) Pb (Tetra-ethyl-lead) [16,17].

III. THE PRACTICAL SIDE

The study was conducted on various combinations of oil fuel, which have been prepared in research laboratories and quality control manager of North and using the engine (CFR). To find the number of models octane number of fuel was recycled using a single standard engine models were changing the compression ratio to get on Standard knock intensity [14,15]. At the same compression ratio found two types of Blends of fuel for comparison (Reference fuel) generated the intensity of knock a little bit of the intensity and the highest lower tapping of the model was then a degree octane of the model in a manner interpolation and repeated the process for the rest of the models were obtained on models octane number of fuel (90,85,80,75,70). Table {1} shows the types of structures and models of fuel used in the work.

Table {1}: Installation and fuels models used in research

Sample number		1	2	3	4	5
Research octane number (*RON*)		70	75	80	85	90
Ingredients	Light Naphtha (%)	90	50	15	0	0
	Riformat (%)	10	50	85	0	0
	Coloring (%)	0	0	0	74	74
	Alaizooctan (%)	0	0	0	10	22
	The usual Alhbtan (%)	0	0	0	16	4
	Additives (TEL) (ml)	0.208	0.24	0.416	0.24	0.469
	Lead (gm)	0.13	0.15	0.26	0.15	0.31

Has been conducting all the tests on Italian engine single-cylinder type (TD110) four-stroke with the ignition spark the length of half a (5.7) cm and a cylinder diameter of (6.7) cm and a compression ratio (6:1). the cooling system depends on the air fan which tied by crank shaft. Was used testing device performance parameters of Hydraulic Dynamometer type (TD115) and shown in fig.(1). Readings were recorded for each of the speed and torque, fuel consumption and the degree of exhaust gas temperature by unit standards TD114 type (Instrumentation unit) and described in fig.(2).
Angle was changed to provide the spark and the delay of the engine based on the octane number wildly without being bound by values, taking into consideration secure the stability of the engine without loading less time.

Data were recorded (torque and engine speed and the degree of the exhaust temperature and volumetric flow of fuel pressure difference across the slot damping Air Fund) for each type of fuels after the arrival of the engine to the state of stability.

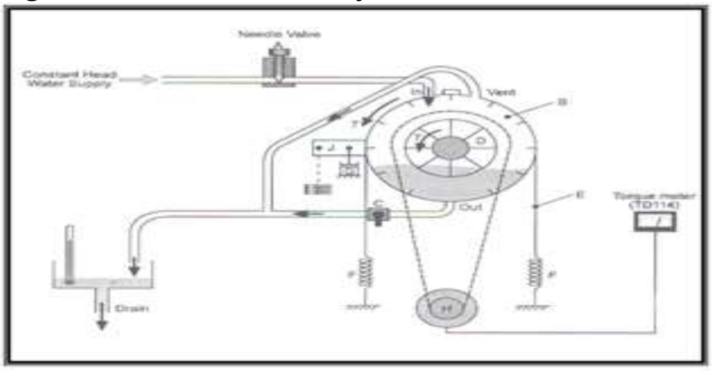

Fig.(1): Testing the hydraulic performance transaction device type (TD115)

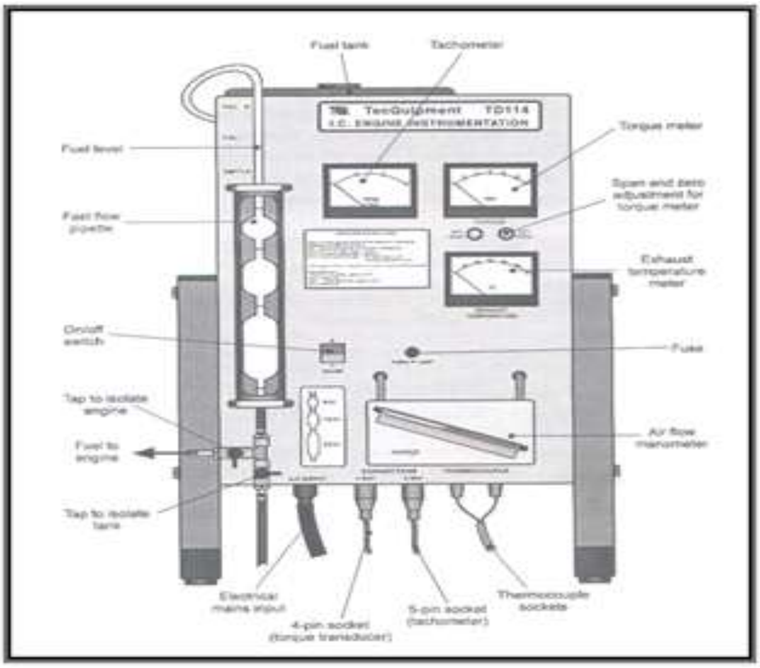

Fig. (2): Instrumentation unit, Type (TD114)

Brake Power calculation by the following relationship[17]:

$P_B = 2\pi \times N \times T$ ………………………(2)

Brake specific fuel consumption, It has been calculated from the following relationship[7]:

$B.s.f.c = \frac{m_f}{P_B}$ ………………………..(3)

$m_f = \rho_f \times \vartheta_f$ ..………………………(4)

Determine Brake thermal efficiency, It has been calculated from the following relationship[17]:

$\zeta_{Bth} = \frac{P_B}{m_f \times Q_{HV}} \times \zeta_c$ ………………………(5)

It equations (2,3,4,5) The performance and transactions relations calculations after it has been assuming combustion efficiency (ζ_b=95%).

IV. RESULTS AND DISCUSSION

It expressed some models of fuel irregularity in the engine rotation at the beginning of operation and accelerate as it led to the occurrence of knock phenomenon (as a result of pre-primers) even with the change of angle of incidence spark such as octane number fuel (70 and 75), but shortly after gradually stabilized the engine because of the warm-up.

Fig.(3) shows the relationship between the rotational speed of the engine with the torque and shows increasing engine torque with an increased number of octane for the same velocities due to the occurrence of complete combustion and not get any advance ignite the fuel in addition to the maximum of the calorific value of the fuel benefit. As it can be noted that the determination of the value of torque of the engine when using fuel with octane number 70 and 75 are close but the difference is clear when using fuel with octane number 90, as is increased by 9.75% at a speed of 2800 rpm.

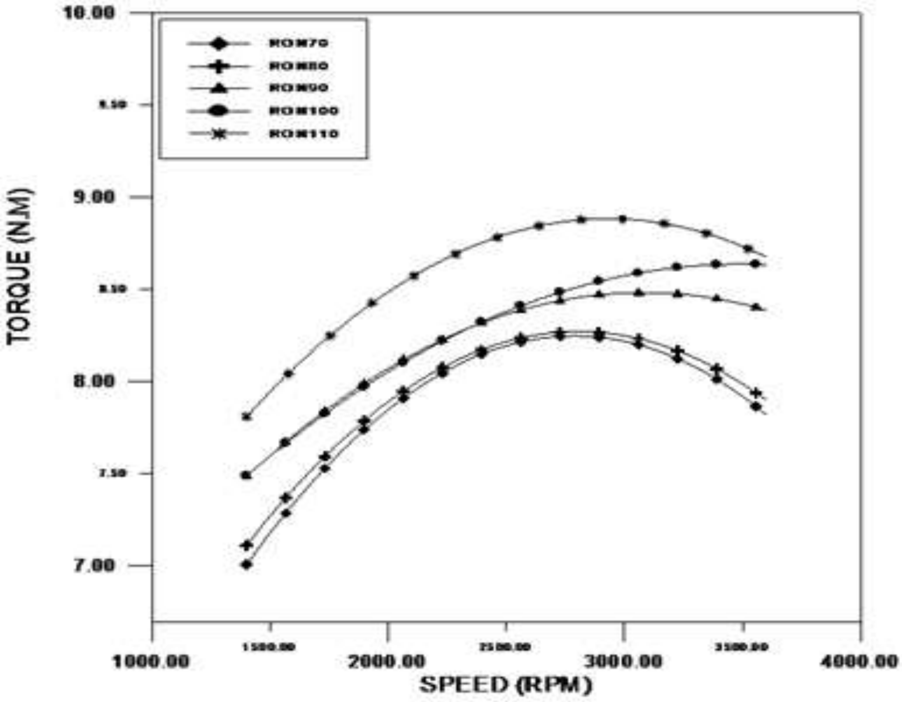

Fig.(3): Relation between speed and torque

Increases Break Power of the engine to increase octane number, this increase is simple when velocities low-lying but be clear at high velocities, where up to 8.97% increase the octane number of 70 to 90 when the speed of 3400 rpm and remains close values at 70 and 75 (where the increase in octane number continues is not sufficient) as well as between 85 and 90 (where it was found that the increase in octane number of more does not give the desired improvement in the performance of transactions, including an increase equal to the cost required) and can be seen in Fig.(4).

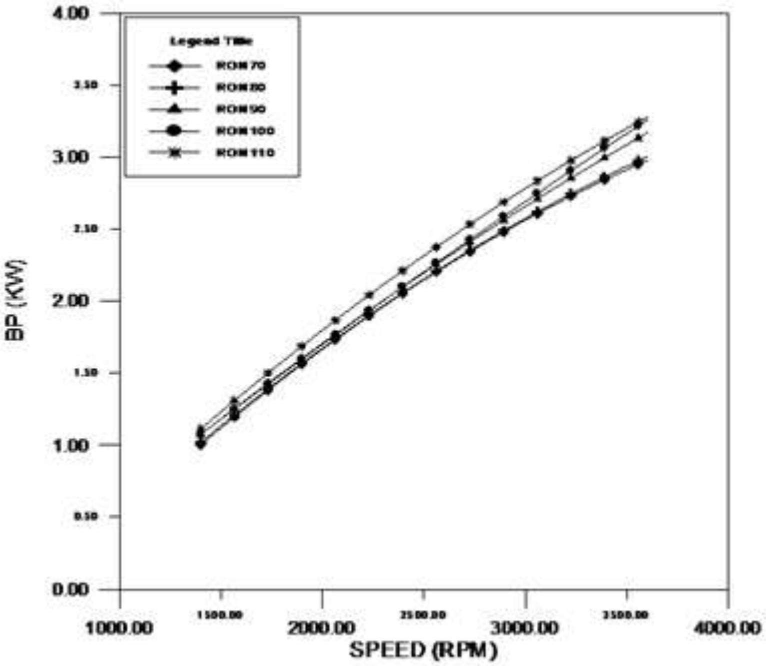

Fig.(4): Relationship between speed and Brake Power

Fig.(5) shows the relationship between each of the rotational speed of the engine Break thermal efficiency where we note that the thermal efficiency of the engine increases with the number octane fuel and be close increase when using fuels with a number 85 and 90, where the percentage of the increase to 12.48% at a speed of 2800 rpm, up octane number from 70 to 90.

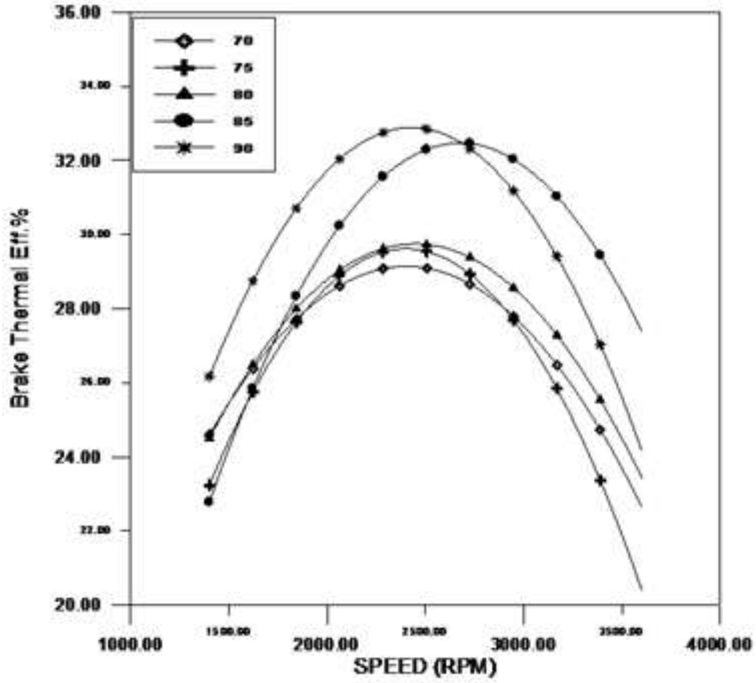

Fig.(5): Relationship between speed and Brake thermal efficiency

The relationship between the rotational speed of the engine and Exhaust Temperature illustrated in Fig.(6), which shows accompanied by an increase in temperature of exhaust with the increasing octane number of fuel, this is a result of the improvement of the combustion process, with increasing temperature from 540°C to 560°C when the speed of 3400 r.p.m. by 3.7 % when increasing the octane number of 70 to 90.

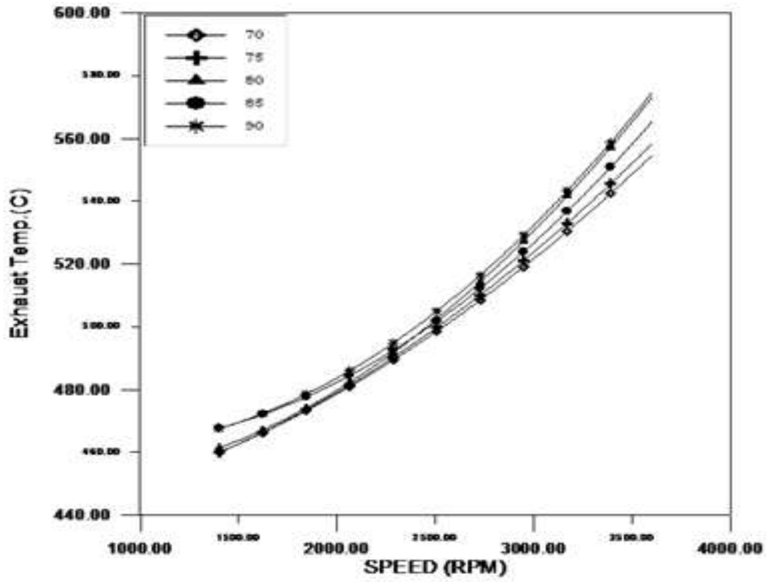

Fig.(6): Relationship between speed and Exhaust Temperature

can be seen the effect of octane number qualitative Brake specific fuel consumption evident in Fig.(7) and is embodied reduction in specific fuel consumption increased octane number, where at least qualitative Brake specific fuel consumption increased by 15% when increasing the octane number of 70 to 90 and at the speed of 2800 r.p.m.

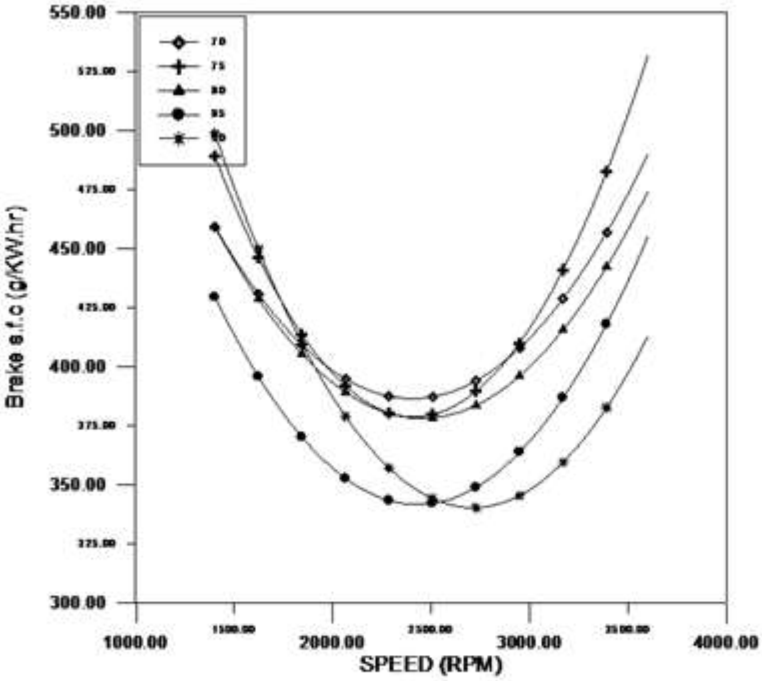

Fig.(7): Relationship between speed and Brake specific fuel consumption

V. CONCLUSIONS

Find the results of the operation showed a set of facts about the impact of octane number on the performance of internal combustion engine are consistent with those brought by others [16,17] and are the following:

1. The low fuel octane number is a cause difficulty in the beginning of the operation and the delay in accelerating the result of self-primers for fuel and the occurrence of knock.
2. Increase in the performance of the internal combustion engine increase octane number gradually due to improved combustion process and without the occurrence of self primers transactions.
3. The increase in octane number of more than does not give the desired improvement in the performance of transactions in parallel with the increase in the cost required.

VI. NOMENCLATURES

N : The number of engine revolutions per minute (r.p.m.)
T : Engine torque (N.m)
m_f : Mass rate of fuel consumption (gm/hr)
ρ_f : Fuel density (Kg/ℓ)
υ_f : Volumetric rate of fuel consumption (ℓ/hr)
P_B : Brake Power (kw)
ζ_{Bth} : Brake thermal efficiency (%)
Q_{HV} : Calorific value of the fuel (Kj/kg)
ζc : Combustion efficiency (%)

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