Periodicals of Engineering and Natural Sciences ISSN 2303-4521
Vol. 9, No. 1, February 2021, pp.139-146

Increasing the efficiency of the internal combustion engine using chemical additives

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ABSTRACT

Increasing the octane number of combustion machines by adding some chemicals and studying the effect of these additives on the internal combustion efficiency of the machines taking the consideration of surrounding conditions are present in this research. Laboratory's conditions have directly affected to the physical properties of the fuel. After adding the chemical additives, gasoline have been inflow to the distillation unit to increase the efficiency and to identify the suitability of the additives with gasoline and their impact on internal combustion, as the difference between the two cases was observed. Different ratios were selected with a variety of chemicals such as methanol ethanol and AHA (belonging to the researchers and an unknown chemical formula) for the analysis of experimental data. The results showed the effect of additives the octane number and alteration in the physical properties of the fuel and at the same time on the properties of the engine. The results could be utilized to determine the chemical additives that increase the octane number and the efficiency of internal combustion of the machines as well as to determine the emissions of some gases. It is exposed that adding 2% of AHA to fuel have raised the octane number by 2.7 (3.09%) in warm areas, this ratio can be increased in cold areas. The analysis results data have done within the limits of global and environmental safety determinants.

Keywords: Octane number, Fuel optimizers, Internal combustion engine, Gasoline distillation.

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1. Introduction

Cars fuel is a derivative mixture of crude oil and consists mainly of hydrocarbon components [1][2]. Gasoline is easily produced by the distillation process and is called ordinary gasoline, but does not have the required specifications for new car engines, especially the octane number and other physical characteristics and for this reason some chemicals are added with different ratios to improve the efficiency of gasoline [3]. The majority of ordinary gasoline has a low octane number and consists of a mixture of hydrocarbon components such as alkanes, annular alkanes, aromatic compounds, and alkenes. The presence of these hydrocarbon components depends on the type of refinery used to produce gasoline, as the number of units in each refinery is different from the other, as well as on the type of crude oil used in refining operations [4].

Gasoline volatilizes more than diesel and kerosene, not the ordinal cause of distillation processes, but because of the additives applied to it. The volatility depends on the ambient temperature[5], at high temperature the volatility will increase and for this reason there are limits to volatilization of gasoline according to the summer and winter and another intermediate between them, the limits of gasoline volatilization has been reduced in most countries at present time to reduce toxic and polluting emissions that occur during filling the car tanks with gasoline [6].

The problems of ordinary gasoline increase especially in the summer or high temperatures due to the increase in the proportion of hydrocarbon component normal heptane because these compounds are not resistant to early combustion which occurs inside the internal combustion cylinders due to high temperature [7]. This problem increases directly in the hot areas, which at the same time decreases air density with the proportion of oxygen,

which that the main reason for the lack of complete and sufficient combustion in the internal combustion machines and access to insufficient engine power and the pollution of the air with poisonous or non-completely burned gases like (CO) [8].
In this research, these problems were discussed and addressed using some additives which are added to gasoline at certain rates. Many laboratory experiments were conducted to increase the efficiency of combustion of gasoline in internal combustion engines by means of chemical additives, taking in to account the reduction of toxic emissions, in these experiments, researchers added ethyl tert-butyl ether (ETBE) to standard gasoline and studied the effect of these compounds on the physical properties of gasoline[9], While other researchers used ethyl acetate and methyl acetate to improve the physical properties of standard gasoline, these properties were compared with gasoline to which methanol and ethanol were added as chemical additives[10]. Others have studied the combination of ethanol and ethyl tert-butyl ether (ETBE) with gasoline to improve the quality of standard gasoline [11]

2. Material and methods

Six standard forms of gasoline were prepared by adding the chemical compounds mentioned in the research at a certain percentage, table 1. shows some physical properties of these compounds which were measured in a laboratory. After that, we inserted the six models in to the distillation unit at a temperature of ($200C^0$), in order to evaporate the gasoline and condense it again, to get rid of the light volatile compounds that could affect the results of the practical experiments and to ensure a good mixing between gasoline and the compounds added to it. The results of the practical experiments were the same before and after the introduction of the six models in to the distillation unit, meaning that the chemical compounds which added to gasoline did not volatilize. At the same time, a sample of commercial gasoline with good physical properties and the octane number required for internal combustion process was taken for the purpose of comparing this commercial model with other models, we finally had eight samples of gasoline as shown in the table 2.

Table 1. The physical properties of chemical materials

Fuel	Methanol	Ethanol	AHA
Structure	CH_3OH	CH_3CH_2OH	---------
Molecular weight	32	46	---------
O_2 wt%	50	33	---------
Boiling point (C^o)	66	76	60
RON	110	117	130
MON	90	92	96
H_{vapor} (KJ/Kg)	1168	1220	1400
Solubility in water25C^o	Miscible	Miscible	Non- Miscible
Sp.gr 20C^o	0.792	0.801	0.815
Purity %	99.9	99.7	99.8

Table 2. Samples of gasoline

Sample (1)	Normal gasoline + 2% methanol
Sample (2)	Normal gasoline + 4% methanol
Sample (3)	Normal gasoline + 2% ethanol
Sample (4)	Normal gasoline + 4% ethanol
Sample (5)	Normal gasoline + 2% AHA
Sample (6)	Normal gasoline + 4% AHA
Sample (7)	Normal gasoline
Sample (8)	Commercial gasoline

Two experiments were conducted for the eight samples. The first experiment was some practical experiments in a laboratory before putting fuel sample in the internal combustion machines where we measured the physical properties of the samples such as Vapor pressure, doctor examination, density, octane number and smoke point. Second Experiment, some practical experiments were carried out after the fuel samples were placed inside the two-stroke engine, some readings are taken after the engine start working such as the sound intensity of the engine, engine temperature, exhaust and smoke. Exhaust smoke samples are then taken by a gas pump for each of the eight samples and placed in large balloons and sent to the laboratory for the purpose of chemical analysis of the exhaust gas components by the device(Gas chromatography)[12], then we get the type and amount of gas compounds coming from the exhaust for each of the gasoline samples. After conducting the two experiments, the physical properties and readings of these samples obtained from the two experiments are compared with each other and with the global determinants of gasoline.

3. Results and discussion

3.1. Effect chemical additives on the octane number

In first experiment, it is noted that the octane number of gasolines increases between (0.5-4.4) in all chemical additives except sample (1), which remains constant as shown in table 3 and Fig.1. The main reason for making this experiment is to know which chemical additives increase or decrease the octane number of gasolines.

Table 3. Effect of chemical additives no the octane number

Type of gasoline	Normal gasoline	Commercial Gasoline	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Octane number (After the distillation process)	87.2	87.9	87.2	87,8	87.7	88.0	89.9	91.6
Octane number (Before the distillation process)	87.2	87.9	87.2	87.9	87.7	88.1	89.9	91.6

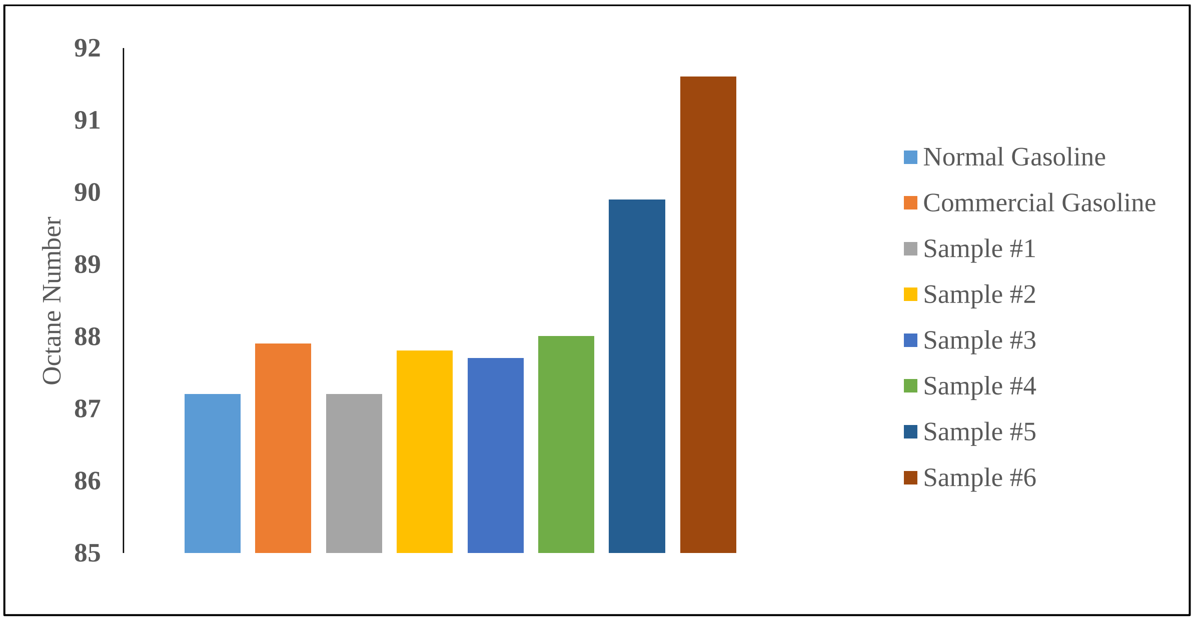

Figure 1. Effect of chemical additives on octane number

3.2. Effect of chemical addition to the vapor pressure

The addition of the chemical substances mentioned in the experiment is working to raise the vapor pressure of gasoline between ratio (0.7- 3) psi. The increase of vapor pressure leads to an explosion, especially when the temperature rises, and leads to incomplete combustion in the engine and increase the sound of the engine [13],[14]. The increase in vapor pressure depends on volatility increasing due to the presence of light compounds which volatilize by increasing the temperature as shown in table 4. and Fig. 2. The increase in vapor pressure after the addition of chemicals is acceptable because the results of the experiment with in the range, and recommended by the US Safety Commission [15], which are between (6-9) psi.

Table 4. Effect of chemical additives on vapor pressure

Type of gasoline	Normal gasoline	Commercial Gasoline	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Vapor pressure (PSI) (After the distillation process)	6	6	7	9	6.70	7.20	7.25	9
Vapor pressure (PSI) (Before the distillation process)	6	6	7.02	9.04	6.72	7.24	7.27	9.03

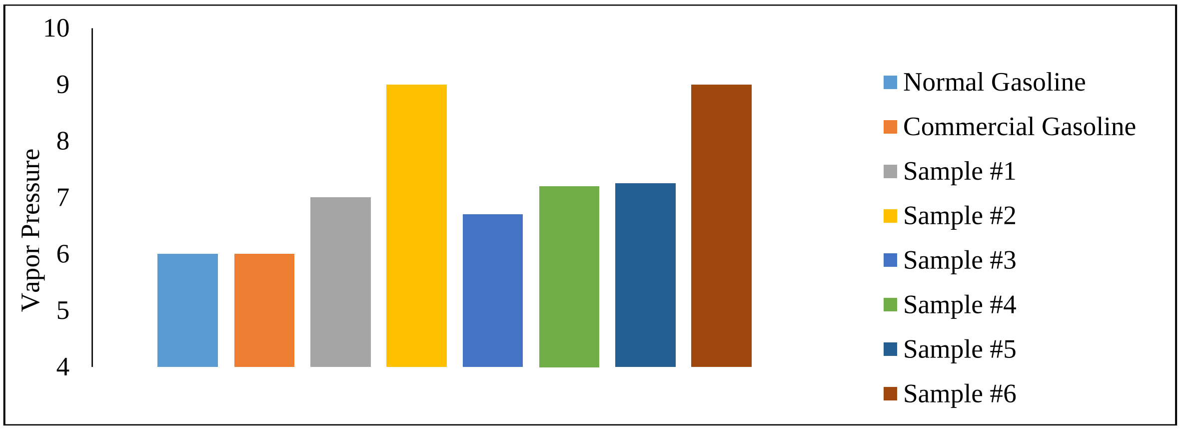

Figure 2. Effect of chemical additives on vapor pressure

3.3. Effect chemical additives to the smoke point

The smoke point for gasoline increases and decreases according to the amount and the type of chemicals added in the experiment [16], The increase in the length of a flame indicates an increase in the proportion of kerosene and light compounds in gasoline that affect to the efficiency of engine internal combustion [17]. It has been shown that some chemical additives have increased or decreased in ratio of kerosene as shown in table 5. and Fig.3.

Table 5. Effect of chemical additives on smoking point

Type of gasoline	Normal gasoline	Commercial Gasoline	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Smoke point(mm) (After the distillation process)	16	19	16	14	20	20	14	15.5
Smoke point(mm) (Before the distillation process)	16	19	16.06	14.11	20.03	20.05	14.02	15.55

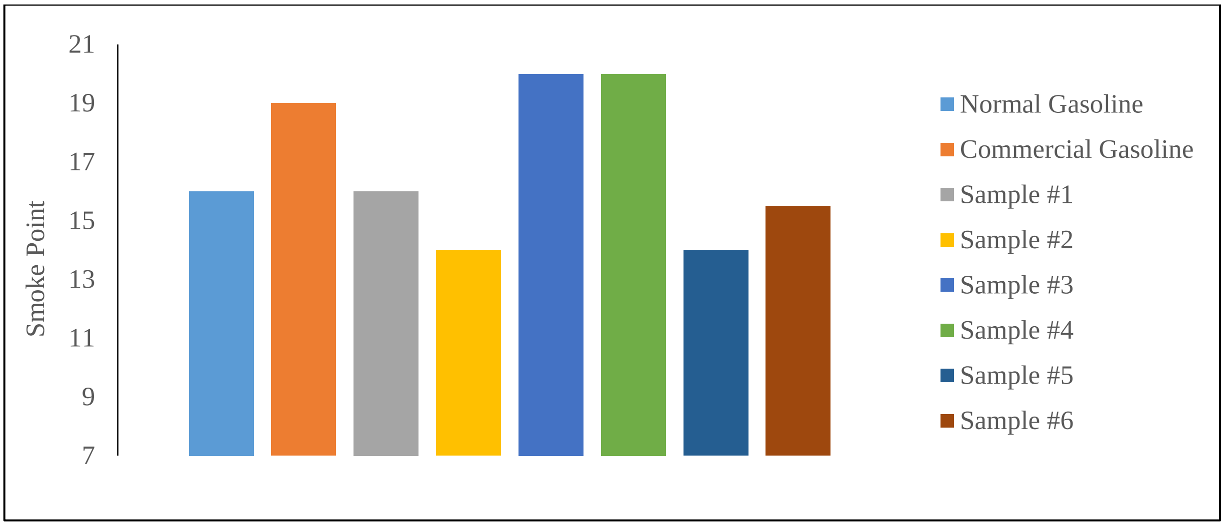

Figure 3. Effect of chemical additives on smoking point

3.4. Effect chemical addition to the density

It can be notifed that all the chemical additives which added to the normal gasoline have increased the density of gasoline. The increase in gasoline density after the addition is a good indicator of practice especially in hot areas [18][19], because the main purpose for making this experiment is to know the quality of the product after adding chemicals is it light or heavy. The effect of chemical additives on gasoline density can be observed from table 6. and Fig.4.

Table 6. Effect of chemical additives on density

Type of gasoline	Normal gasoline	Commercial Gasoline	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Density(g/cm^3) (After the distillation process)	0.7126	0.7299	0.7315	0.7351	0.7294	0.7307	0.7308	0.7310
Density(g/cm^3) (Before the distillation process)	0.7126	0.7299	0.7312	0.7348	0.7293	0.7303	0.7305	0.7306

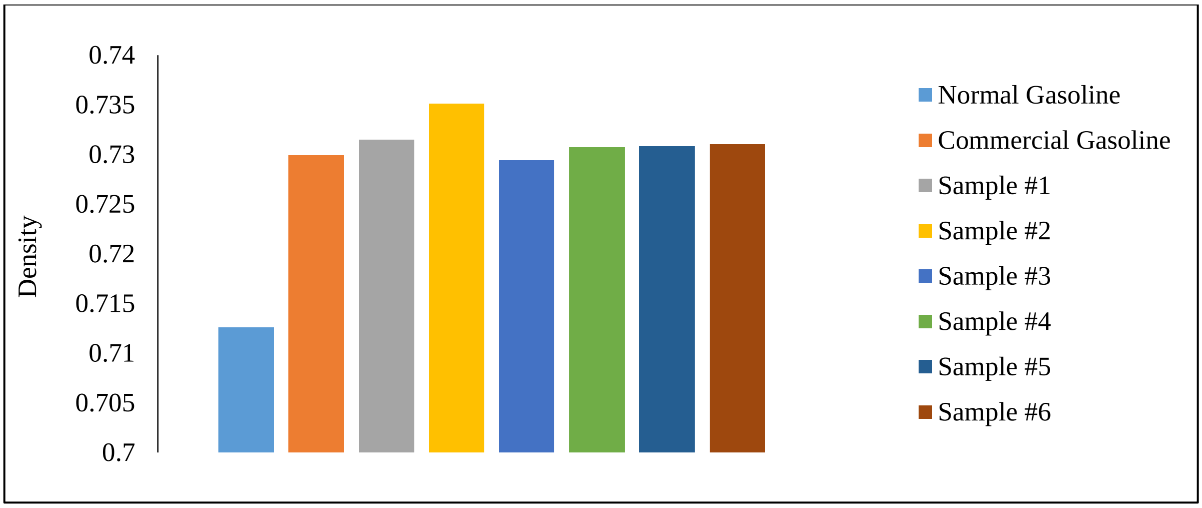

Figure 4. effect of chemical additives on density

3.5. Effect of chemical additives on the internal combustion products

The temperature of the engine, engine intensity, smoke temperature and air temperature will calculate for each sample of gasoline after being placed in to a dual-stroke internal combustion engine. It has been taken a sample of product smoke to estimate the components of exhaust gases before and after adding chemical additives, table 7. shows the components of exhaust gases and thermal properties of the engine before and after chemical additions.

Table 7. Concentrations of exhaust gases

Components		Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Normal gasoline(7)	Commercial Gasoline(8)
CH_4 ppm		2.18	11.69	21.79	18.63	34.03	24.90	11.17	35.16
NMHC ppm		0.94	20.22	25.46	20.76	20.63	16.65	24.04	21.04
THC ppm		3.16	31.91	47.25	39.39	54.66	41.55	35.21	56.20
SO_2 ppm		115	68	137	84	89	82	28	102
CO ppm		2224	2320	2352	2280	2060	2256	1820	2068
CO_2 %		1.50	2.08	1.85	1.97	1.34	2.13	2.36	1.53
O_2 %		9.39	8.25	7.27	8.19	10.88	7.33	9.07	9.65
Engine Temp. (C^o)		206.1	177.1	169.1	158.7	182.7	178	206	183.4
Exhaust Smoke Temp. (C^o)		59.3	59.7	60	63.3	61.4	61.9	61	61.6
Atmosphere Temp. (C^o)		24.7	26.9	26	31.1	30.2	33.2	22.5	30.1
Engine Noise(dB)	max	86.9	92	91.9	87.7	91	91	91.1	91
	min	79.3	80.3	71.5	84.8	79.9	81.3	80.3	80.7

When comparing the results of analyzing of gases components before and after the addition of chemicals, it is found that there is a minor variance and a small increase or decrease in the amount of gases emitted and in the physical characteristics of the engine. The most important result to be verified is the emissions of harmful gases (SO2, CO, CH4, NMHC and THC) because these gases are toxic gases to all organisms and harmful to the ozone layer.

The results have shown that adding an AHA by (2%) to the fuel increases the octane number by (3.09%) in hot areas. This percentage also can be increased in cold regions and at the same time the rate of sound intensity and engine temperature decreases. Furthermore, the results of the analysis of this data are within the range of global and environmental safety determination. Thus, the amount of oxygen will increase by 1.81% in gas emissions and reduces the ratio of harmful gas for the environment as well as improving the quality of fuel.

4. Conclusions

The best chemical compound to raise the octane number of gasoline as well as making the percentage of toxic gas emissions and the results of vapor pressure of gasoline within the range of the US Environmental Agency (6-9psi) is the compound of (AHA). This within 2% of AHA and gives the largest proportion of oxygen gas with exhaust gases. When measuring engine temperature and exhaust smoke for all gasoline samples except sample

(4), it is found that the temperature is lower after adding chemicals if it compared with the results of normal and commercial gasoline. The temperature of sample (4) increases by 0.1 C^o by comparing with the temperature of ordinary gasoline engine. While, the temperature of exhaust smoke for models (4) and (6) increas by 1.7 C^o and 0.3 C^o respectively, over the temperature of commercial gasoline. The sound intensity of the engine after the addition of chemicals becomes less. The quantity of oxygen increases by 1.81% as it is noted in the sample (5), which mean it is possible to use this addition with gasoline of the high mountain areas to compensate the lack of oxygen ratio as we rise from the surface of land.
THC calculations for samples (3, 4, 5, 6) are larger than THC calculations of normal gasoline and less than of commercial gasoline, while in the samples (1, 2) THC calculation are lower than normal and commercial gasoline, which means it is possible to use methanol at small percentage to reduce hydrocarbon gases emissions. During calculation the percentage of toxic gases (CH_4, SO_2, NMHC), it is notified that the sample (1) has the lowest emission rate of gas (CH_4), while the emission of SO_2 for samples (2, 4, 5, 6) are higher than in sample (7) and less than in sample (8), samples (1, 3) have higher than all samples mentioned above. The (NMHC) for all samples are similar to samples (7, 8), except samples (1, 6) that presented tiny percentage by compared with others model.
A commercial price per liter for the chemicals range (10-15$), however, if these materials are manufactured locally, the price will drop to (1-2.5$). This due to the availability of raw materials for these chemicals locally in large quantities, each sample has a specific benefit. In addition, sample number (6) with high octane number can be used in low temperature land, then the risk of high vapor pressure will eliminate. Methanol and ethanol dissolve when water exist in gasoline under certain conditions, while (AHA) does not dissolve in water under the same conditions. Sulfur compounds, when exist with fuel in large quantities, affect the physical properties of the fuel, exhaust gas outputs, and power generated by the engine. It is notified a slight change in the results of the practical experiments obtained before and after inflowing the gasoline in to the distillation unit, and this is evidence of the non-evaporation of additives at high temperatures and their compatibility with gasoline and their non-impact on the internal combustion of machines.

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