

A Improved normal gasoline specifications by adding high-octane number gasoline at (NRC) Baiji

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Abstract

The aim of this work was to the improvement of regular gasoline specifications by adding high-octane gasoline, then found the mixing ratio to ensure accuracy in the desired octane number. Three samples of gasoline were used (regular gasoline, premium gasoline, super gasoline). The tests were conducted of them by finding its octane number, density, and distillation after and before the addition processes. Moreover, laboratory test results showed that the octane number results before addition were reached 79, 97 and 82 normal gasoline, super gasoline, and premium gasoline, respectively. The results also showed that adding 7500 m³ of super to 30000 m³ of regular resulted in a mixture with an octane number of 82 and an amount of 37000 m³, which indicates the effectiveness of the mixing process. The results recommend the NRC Baiji to adding these amounts to make sure gasoline quality

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Introduction

The fuel octane number influences the fuel consumption and emission characteristics of vehicles equipped with spark-ignition engines. An assessment of the

impact of commercial types of gasoline with varied research octane numbers (RON) on a vehicle's performance can provide significant insights and guidance for future

engine and fuel design [1]. The octane rating is the most often used metric for determining the autoignition quality of a fuel. The octane rating is a standard assessment of fuel's autoignition resistance that has been used for decades to assess the fuel's appropriateness for avoiding knocking in SI engines. Traditionally, two separate octane ratings have been employed to assess the anti-knock property of a fuel: the Research Octane Number (RON) and the Motor Octane Number (MON) [2]. Gasoline is a volatile, flammable liquid hydrocarbon mixture derived mostly from the refining of petroleum. The majority of gasoline is used as fuel in spark-ignition engines, which primarily power automobiles and certain airplanes. Gasoline qualities that affect engine performance include volatility (Reid vapor pressure), octane number, and heat content. Reid vapor pressure (RVP) is one of the gasoline specifications that affect engine performance. Reformulated gasoline rules now protect the environment by minimizing smog precursors and prohibiting tetraethyl lead (TEL) [3].

Liquid hydrocarbons are commonly utilized as fuel in internal combustion engines because of their high volumetric energy density and simplicity of handling, storage, and transport. Gasoline is the most popular fuel for light-duty vehicles and passenger cars. The research octane number (RON), among other vehicle ignition-related qualities, is a key indicator of the quality of light-duty automobile fuels. Because measuring RON is expensive and time-consuming, an alternative cost-effective engine grading approach, such as machine learning, is sought. However, there is a notable nonlinear relationship between the physicochemical qualities of gasoline ingredients and the fuel's RON. The fuel octane number has long been used to indicate the anti-knock performance of gasoline [4]. However, whether octane numbers could capture the real knocking combustion process in practical engines remains unknown [5]. Historically, gasoline knock resistance (or conversely, auto-ignition propensity) has been described by the research octane number (RON) and the motor octane number (MON) [6]. It has since been shown that octane number does not adequately describe knock resistance in modern SI engines [7]. However, the octane index has been implemented as a practical means to utilize RON and MON as well as engine operating parameters to define a more accurate definition of the in the modern SI. The determination of the octane number plays a major role in quantifying the quality of gasoline. The standard method, the international standard ASTM-CFR internal combustion engine, used for this purpose suffers from its high cost and time. Many algorithms have been developed to address the limitations of this method, taking advantage of infrared

spectroscopy, which provides easily measurable parameters that can be used to predict the octane number [8]. In recent years, gasoline fuel is considered one of the most important fuels in the world, so its specifications have been improved by raising the octane number by adding improvers. However, some of these improvements have been banned internationally and have not been implemented for nearly a decade. However, the alternatives are still few and useless, and the only solution remains to produce high-octane fuel by hardening the operating conditions in the distillation towers and monitoring the efficiency of their work to ensure the production of high-quality fuel. Internal combustion engines need high-quality fuel in order to operate and provide services. Gasoline fuel burns, releasing carbon dioxide gas, which in turn will contribute to environmental pollution [9]. The Northern Biggie Refineries Company produces low-quality gasoline (low octane number gasoline) and it cannot be sold in local markets because it causes environmental pollution, which prompted researchers to find an alternative fuel that included mixing imported gasoline (high-octane number gasoline) with local gasoline in order to improve its quality, which will ignite by leaving a smaller percentage of carbon dioxide gas. Thus, we have contributed to reducing carbon dioxide emissions, contributing to preserving the environment and creating a green environment. To achieve the aim of this study the scope and limitation of this study it was focused on the limitations of this study required improving the specifications of regular gasoline and premium gasoline based on the octane number only, not studying other specifications such as density and distillation points, because the octane number is the ruling test at North Refineries Company (NRC) Baiji. This study will be of great importance in terms of the accuracy of the results, specifically in the warehouse department and the laboratory and quality control department in the North Refineries Company (NRC) Baiji. Therefore, this study will avoid random mixing ratios and the resulting negative consequences such as a decrease in the mass number or vice versa [10]. It will also save time and increase the profits of North Refineries Company (NRC) Baiji. The main objectives of this research are to rid the mixing of light naphtha produced from Baiji refineries with imported high-octane gasoline according to pre-studied proportions to production of normal gasoline fuel. Moreover, this study focused on the improvement of regular gasoline specifications by adding high-octane gasoline, then investigation the mixing ratio to ensure accuracy in the desired octane number.

2. Materials and methods

2.1 Gasoline samples preparation

The gasoline samples were brought from north refineries company NRC Baiji as a material

employed in this work. Table 1 shown the materials were subjected in this research, such as regular gasoline sample (local product), super gasoline (imported product).

2.2 Materials and methods

In this research were found the physical properties of gasoline products (regular and super). This study included taking samples from products (kerosene and gas oil), and specifications were calculated. Moreover, the specifications and octane number calculating after and before addition processes at Baiji refinery, the (Alsumod refinery). The instruments were used in this experiment to improve the local gasoline sample has low octane at NRC Baiji via mixing high and low octane number gasoline fuel as listed in Table 2, tanks of gasoline and CFR machine. Laboratory tests were conducted on petroleum products at the laboratory of the Oil Products Distribution Company, Western Authority, Salahuddin branch (OPDC). The physical properties of gasoline samples (regular and super) were investigated. These

laboratory tests included specific gravity (sp.gr) was carried out according to ASTM D 4052 [11] and distillation according to ASTM D86 [12]. However, the distillation test included (initial boiling point (I.B.P), end boiling point (E.B.P) total distillation (T.D), residue volume ml, and loss volume ml).

2.3 Calculations processes

The addition processes were calculated to verify the octane number to be reached. The octane number of regular gasoline fuel (lower than 82) was increased by adding a super gasoline fuel (more than 82) to raise the octane number during the Equation 1.

$$\text{Trated gasoline} = \frac{82 - \text{RON lower}}{\text{RON higer} - 82} \times Q \quad (1)$$

When:

82 is a constant number.

RON Lower is a lower octane number fuel (regular).

RON Higher is a higher-octane number fuel (premium).

Q is a quantity of fuel before addition process (regular).

Table 1: Materials were use in this study

Products	Octane number	Source
Regular gasoline	79	Local product
Super gasoline	97	Imported product

Table 2: Instrumens were use in this study

Instruments	Function	Source
Cylinder	Sp.gr test	NRC Baiji
Thermometer	Sp.gr test	NRC Baiji
Hydrometer	Sp.gr test	NRC Baiji
Zeltex	Octane number tester	NRC Baiji



Figure 1 : The CFR machine was used in this study



Figure 2: Spiscific gravity test of

Results and discussions

Improvement of specific gravity

Table 3 shows the specific gravity of regular gasoline was (0.7400) before the addition process for regular to premium gasoline, the specific gravity of regular gasoline was (0.7100) [13]. Conversely, the new product gasoline has a specific gravity (0.7200). This means the Sp.gr has been improved, it will be use as a better fuel. Gasoline consists of various hydrocarbon components such as alkanes, olefins, aromatics, paraffins, and naphthalene, with boiling points ranging from 60 to 200 °C [14]. The specialty of gasoline lies in its various constituent components so that its physicochemical properties vary widely [15]. Gasoline is a type of fossil fuel used for an internal combustion engine (ICE) as well as a spark-ignition engine [16].

3.2 Improvement of octane number

The octane number of gasoline fuel was investigated as in Table 4. The quantity (30000 m³) of the regular low octane number local gasoline product reached (79) was Developed ro to the

high-octane number according to the equation (1) by adding the (7500 m³) of the regular gasoline reached with octane number of (94) then total amount be (37500 m³) as shown in Table 4 [17]. The octane number has been enhancing from 79 to 82 during adding processes which clearly that the fuel will be borne with release small amount of CO₂ imitation [10].

3.3 Improvement of distillation tests

Table 5 shows the results of the distillation test for the gasoline product before addition, as well as the high-octane gasoline product. Table 5 shown the improvement in the specifications, especially in the initial boiling point and final boiling point, which shows a noticeable improvement in the quality of the product [18]. The results showed the initial boiling point (I.B.P) was improves from 58 to 62 and 64 °C regular gasoline, premium gasoline and super gasoline respectively [19]. The end boiling point (E.B.P) was also improved this finding means the gasoline fuel was enhanced via adding processes [20]

Table 4: Gasoline quantities, specific gravity and octane number

Gasoline fuel	Quantity m ³	Sp.gr	Octane number

Regular gasoline	30000	0.7400	79
Super gasoline	7500	0.7100	97
Premium gasoline	37500	0.7200	82

Table 5: Distillation tests of regular, premium, and super gasoline

Distillation	Regular gasoline	Premium gasoline	Super gasoline
I.B.P °C	58	62	64
5%	77	79	77
10%	85	88	85
20%	93	100	99
30%	100	125	115
40%	120	130	125
50%	125	140	135
60%	130	155	150
70%	150	170	165
80%	170	185	180
90%	174	190	188
95%	188	200	198
E.B.P °C	201	210	205
T.D%	98 ml	98	98
Res %	1.8 ml	0.7	0.5
Loss%	0.2 ml	0.3	0.5

Figures 3, 4, and 5 show the current results of regular not affected by a visible effect, which indicates the effectiveness of the mixing and addition processes. Therefore, mixing gasoline and improving its specifications was a successful mixing [22].

gasoline premium, gasoline, and super gasoline products and the differences among them. These results showed the specification of gasoline products and distillation results [21]. The results of the distillation test showed that they were

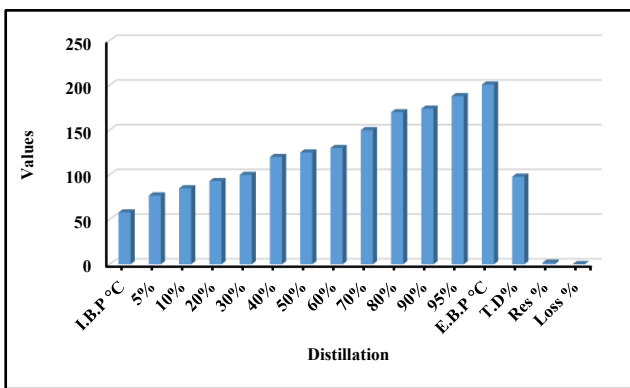


Figure 3: Distillation test of regular gasoline fuel gasoline

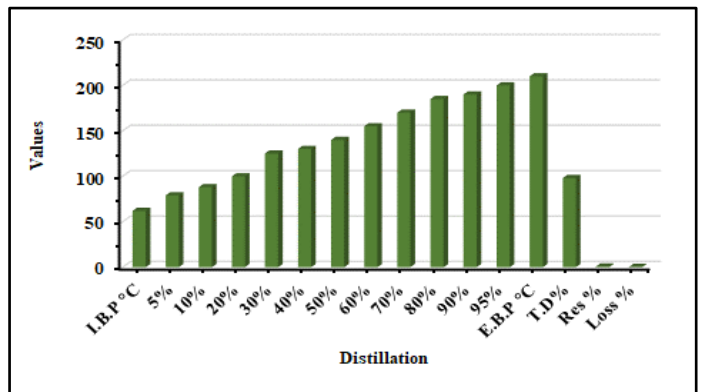


Figure 4: Distillation test of premium gasoline

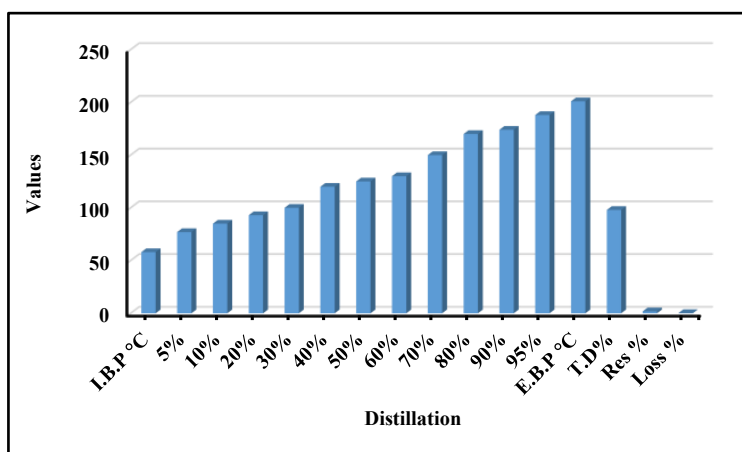


Figure 5: Distillation test of super gasoline fuel results of this research

4. Conclusion

In this study have been discussed the effect of the addition of high-octane number fuel to low octane number fuel at (NRC) baiji was successful. This research will reduce carbon dioxide emissions by improving fuel quality and reducing knocking, thus maintaining a green environment. Through the results and laboratory tests dealt with in this study, we recommend were verifying the specifications of locally produced gasoline and imported gasoline. It is necessary to follow the

References

- 1.Wen M, Zhang C, Yue Z, Liu X, Yang Y, Dong F, Li H., Effects of gasoline octane number on fuel consumption and emissions in two vehicles equipped. with GDI and PFI spark-ignition engine. J Energy Eng. 2020; 146 (6): 4020-069.
- 2.Lopez-Pintor D, Dec J and Cho S. Performance of octane index in LTGC engines from beyond MON to beyond RON, Fuel. 2023; 341:127625. <https://doi.org/10.1016/j.fuel.2023.127625>
- 3.Hsu CS and Robinson PR. Gasoline production and blending. Springer Handb Pet Technol. In: Handbook Petroleum Technology, Springer nature. USA, 2017; pp: 551–587.
- 4.Sun X, Zhang F, Liu JL, Duan X. Prediction of gasoline research octane number using multiple feature machine learning models Fuel. 2023; 333: 126510. <https://doi.org/10.1016/j.fuel.2022.126510>.
- 5.Han D, Lyu D, Sun Z, Liang X, Huang Z. On knocking combustion development of oxygenated gasoline fuels in a cooperative fuel research engine. Int J Engine Res. 2023; 24(6): 2410–2421. <https://doi.org/10.1177/1468087422>
6. Mohammed AE, Humadi J, Y, Aqar DY, Aabida A, Abdulqader MA,Ahmed GS. Process Model Development and Optimal Kinetic for Fuel Desulfurization via a Novel Nano Catalyst Iran J Chem Chem Eng. 2024; 43(145): 3904- 3907. DOI:10.30492/IJCCE. 2024. 2027346
- 7.Durrett RP, and Najt PM, “RON and MON chemical kinetic modeling derived correlations with ignition delay time for gasoline and octane boosting additives. Combust Flame.2020;219:359–372.<https://doi.org/10.1016/j.combustflame>
- 8.Ghoggali N, Douak F, and Ghoggali W. Towards a NIR Spectroscopy ensemble learning technique competing with the standard ASTM-CFR: An optimal boosting and bagging extreme learning machine algorithms for gasoline octane number prediction. Optik Stuttgart. 2022; 257:168813. <https://doi.org/10.1016/j.ijleo.2022.168813>
- 9.Alwaise AM, Alrashedi MA, Mohammed AE, Hussein OA. The effect of physical properties of lost petroleum quantities in vertical tanks at (NRC) Baiji, Energy Explor Exploit.2023;24(2):685-691. DOI:10.1177/01445987231220961.
- 10.Saleh et al AM.Production of First and Second-Generation Biodiesel

mixing method used in this research. Checking the octane number of the fuel produced after mixing and comparing it.

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- for Diesel Engine Operation :A Review. 2023; 5:8–23.DOI: <https://doi.org/10.56286/ntujre.v5i1.512>
- 11.Barbosa LL, Kock FVC, Almeida VMD, Menezes LS, and Castro EVR. Low-field nuclear magnetic resonance for petroleum distillate characterization, Fuel Process. Technol.2015;138:202–209. DOI:<https://doi.org/10.1016/j.fuproc.2015.05.027>.
- 12.Jati JF and Bhikuning A. Fuel Parameter Analysis from Kerosene Blended with Biodiesel and Diesel Fuel. IOP Conf Ser Earth Environ Sci. 2022;1104(1)DOI: 10.1088/1755-1315/1104/1/ 012036.
- 13.Hamed H, Mohammed A, HABEEB O, Ali O, Aljaf O, and Abdulqader M. Biodiesel Production From Waste Cooking Oil using Homogeneous Catalyst. Egypt J Chem. 2021; 0(0):0–0. DOI: 0.21608/ejchem.2021
- 14.Abdulqader MA, Habeeb OA, Dheab MS, Saber SE, Rabet AO, Mohammed GJ, Saleh AH. Solid Fuel Char Production via Pyrolysis Process of Oily Sludge Produced as a Resulted in Storage Tanks at North Refineries Company Baiji. J Petrol Res Stud.2022; 12(1):199–210. OI: <https://doi.org/10.52716/jprs.v12i1>.
- 15.CalvinY L, Y , Hariyanto PT, Usman AI, Masuku M, Wibowo CS, Fathurrahman N A, and Sugiarto. Volatility and physicochemical properties of gasoline- ethanol blends with gasoline RON-based 88, 90, and 92 Fuel. 2022; 307: vol. 307:121850. <https://doi.org/10.1016/j.fuel.2021.121850>
16. Ali BM, Salih MI, Abdulqader MA, Bakthavatchalam B, and Hussein OA. Dehydration and decarboxylation via

- pyrolysis process of waste oily sludge accumulated at North Refineries Company Baiji for use as a pyro-fuel. *Desalin Water Treat.* 2024;318:100330, DOI: <https://doi.org/10.1016/j.dwt.2024.100330>
17. Pirouzfard V, Hakami M and Su CH. Improving the performance of gasoline fuels by adding methanol and methyl tertiary-butyl ether along with metal oxides titanium oxide and magnesium oxide,” *Energy*.2024; 294: 130687
- 18.Hamed H, Mohammed A R, Khalefa O, Habeeb and Abdulqader M. The Effect of using Compound Techniques (Passive and Active) on the Double Pipe Heat Exchanger Performance. *Egypt J Chem.* 2021; 0 (0): 0–0, DOI: 10.21608/ejchem.2021.54450.3134.
- 19.Hameed EA, Salih RA, Saleh AM, Issa HM and Abdulqader MA. The Effect of Chemical Coagulant Dosages on the Removal of Turbidity from Wastewater. *AUIQ Complement Biol Syst* 2024;1(1):6. 10.70176/3007-973X.1006
- 20.Abdellatif TMM, Ershov MA, Mustafa A . A unifying methodology for gasoline-grade biofuel from several renewable and sustainable gasoline additives. *Process Saf Environ Prot.* 2024;190:1386–1402. DOI: 10.1016/j.psep.2024.07.112.
- 21.Humadi JI, Aabid AA, Mohammed AE, Ahmed GS and Abdulqader MA, New Design of Eco- Friendly Catalytic Electro- Photo Desulfurization process for Real Diesel Fuel. *Chem Eng Res Des:* 2024;6:DOI: <https://doi.org/10.1016/j.cherd.2024.05.001>
- 22.Qin Z, Li Z., Luo W, and Ling X. Gasoline Engine Misfire Fault Diagnosis Method Based on Improved YOLO V8 Electronics. 2024;13(14): 2688. <https://doi.org/10.3390/electronics13142688>.

الخلاصة

هدف هذا العمل إلى تحسين مواصفات البنزين العادي بإضافة بنزين عالي الأوكتان، ثم إيجاد نسبة الخلط لضمان الدقة في رقم الأوكتان المطلوب. تم استخدام ثلاث عينات من البنزين (بنزين عادي، بنزين ممتاز، بنزين سوپر). أجريت الاختبارات عليها من خلال إيجاد رقم الأوكتان والكثافة والتقطير بعد عمليات الإضافة وقبلها. علاوة على ذلك، أظهرت نتائج الاختبارات العملية أن نتائج رقم الأوكتان قبل الإضافة بلغت 79 و 97 و 82 للبنزين العادي والسوبر والبنزين الممتاز على التوالي. كما أظهرت النتائج أن إضافة 7500 متر مكعب من السوبر إلى 30000 متر مكعب من العادي أدى إلى خليط برقم أوكتان 82 وكمية 37000 متر مكعب، مما يدل على فعالية عملية الخلط. توصي النتائج NRC Baiji بإضافة هذه الكميات للتأكد من جودة البنزين.

