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A Comparative Study of Specifications Products among Different Refineries at North Refineries Company NRC Baiji

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ABSTRACT

This research aims to study the results of laboratory tests conducted on petroleum products produced by the Northern Refineries Company (NRC) Baiji at multiple refineries, including the Sumoud, Kirkuk, Sinya, Haditha, and Kasik refineries. Subsequently, the most significant governing tests will be compared to determine the reasons for the increase in the production of certain products and the decrease in others by the seasons of the year and local needs. The required experiments, including density, flash point, sulfur content, and distillation, were conducted on premises within the laboratories of each refinery. The results showed that the specifications were linked to each other depending on the nature of the products and operation conditions. Hence, the data included in this research is expected to enable researchers to conduct a systematic comparison between the products of NRC Baiji.

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دراسة مقارنة لمواصفات منتجات النفط في مختلف مصافي شركة مصافي الشمال بيجي (NRC)

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الملخص

يهدف هذا البحث إلى تجميع نتائج الفحوصات المختبرية التي أجريت على المنتجات النفطية المنتجة في شركة مصافي الشمال (NRC) في عدة مصافي مختلفة، بما في ذلك مصفى الصمود وكركوك والصينية وحديثة والكسك. بعد ذلك، سيتم مقارنة أهم الاختبارات الحاكمة لتحديد أسباب زيادة إنتاج بعض المنتجات وانخفاض إنتاج أخرى حسب فصول السنة والاحتياجات المحلية. أجريت التجارب اللازمة، بما في ذلك الكثافة ونقطة الوميض ومحتوى الكبريت والتقطير، في مواقع داخل مختبرات كل مصفى. أظهرت النتائج أن المواصفات كانت مرتبطة ببعضها البعض اعتمادًا على طبيعة المنتجات وظروف التشغيل. وبالتالي، ستساعد البيانات الواردة في هذا البحث القارئين على مقارنة منتجات شركة مصافي الشمال.

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Introduction

Petroleum is an organic substance containing hydrocarbon compounds, oxygen, nitrogen, and some sulfur, and metal-containing organic species with varying compositions, structures, and molecular weights. Although it is not considered a renewable source, its depletion was previously thought to be complete. However, the continued discovery of new oil fields throughout the years has pushed the predicted period in the future when petroleum crude as a mineral supply will be depleted (Shishkova et al., 2022). Fuel oil (FO) is a fuel that can be utilized in compression ignition engines since it is inexpensive and has minimal operating costs (Tariq & Saleh, 2023). The world is currently heavily reliant on fossil fuels for electricity generation, as well as for domestic vehicle and machinery operations in agriculture, mining, and transportation, among other industries. On the other hand, in today's world, the use of fuel in everyday life has increased tremendously due to its heating value, cost-effectiveness, versatility, and their energy produced (Jahirul et al., 2022).

Oil contains organic hydrocarbon compounds that make it a flammable substance; various petroleum derivatives can be produced from it (Abdulqader et al., 2022). Its depletion was once believed to be total, although it is not regarded as a renewable source. However, the continued discovery of new oil fields throughout the years has pushed the predicted period in the future when petroleum crude as a mineral supply will be depleted (Humadi et al., 2024). To rationalize the use of petroleum crude, one must first understand its chemical makeup. That is a difficult task because crude oil is composed of several organic compounds with varying composition, structure, and molecular weight (Mohammed, Gheni, et al., 2024). The distribution of petroleum specifications, such as density, temperature, and others, can be characterized using probability functions. The procedures used to produce various petroleum-derived products, such as gasoline, kerosene, monomers, feeds for organic synthesis, and polymers, are found to be highly dependent on the properties of the petroleum raw material (Fathi et al., 2023). That is why the classification of petroleum crudes is so important in many investigations. Many different methodologies have been used to analyze the chemical properties of various crude oils discovered around the world (Saleh et al., 2023). Although huge advances in sophisticated analytical methods have been made to characterize the most difficult work of the crude distillation the which called (bottom of the barrel) also is most difficult to analyze and understand part, the asphaltenes or heptane insoluble, the mutual relations of the various materials that make up the petroleum are still not well understood (abdulqader et al., 2021).

This study focused on the characteristics which are specific gravity (Sp. gr), American petroleum institute (API), read vapor pressure (R.V.P), pressure measured in unite pound per square inch (psi), A "doctor test" Dr. test for sulfur, like ASTM D4952, is a chemistry procedure to find corrosive mercaptans and hydrogen sulfide in fuel products (kerosene and gasoline), research octane number (RON), flash point (F.P), viscosity at 40 °C (Vis @ 40 °C), and viscosity at 40 °C Vis @ 50 °C". The biggest challenge in this research is the multiplicity of fuel sources used in different refineries. What is even bigger is that these different products produce the same white petroleum products that we use in our daily lives, which are (gasoline, kerosene, and then gas oil) (Abdulqader et al., 2023). In this study, the focus was on two basic tests (density and distillation). The focus in the distillation test was on the initial boiling point and the final boiling point, which determine the quality of the petroleum product. This research aims to prepare the results of laboratory tests for petroleum products produced in the Northern Refineries Company for more than one refinery, which are (Sumoud, Kirkuk, Sinya, Haditha and Kasik refineries), and then an inter-comparison of the most important governing tests and the reason for the increase in the production of some products and the decrease in other products according to the seasons of the year and local need. In this study, the necessary tests were conducted on site in the laboratories of each refinery mentioned, like: (density@15.0 °C, API, R.V.P. (psi), Dr. Test, RON, F.P °C, Vis @ 40 °C, Vis @ 50 °C, pour point °C, Sulphur wt%, Oxygenate ppm, Color, Cetane index, and distillation).

Materials and Methods

Oil samples

In this research, six different samples of oil, which are (crude oil, naphtha, gasoline, kerosene, gasoil, and fuel oil), were used, brought from several refineries owned by North Refineries Company (NRC), Baiji (i.e., Kirkuk, Sinya, Haditha, Kasik, and the main refinery in Baiji Al-Sumoud refinery).

Specification analysis methods

The summary of this work is presented in Figure 1. The specific gravity test (Sp.gr) of samples was calculated according to the standard method (ASTM D 1298) (Novandy, 2019). The American Petroleum Institute (API) gravities were calculated according to (ASTM D-4052) (Banurea et al., 2024). The Reid vapor pressure (RVP) test was carried out according to ASTM D323-56 (Kongkiatpaiboon, 2024). Test of research octane number (RON) according to the ASTM D2699 (Zhao et al., 2024). The doctor test (Dr. test) was done depending on (ASTM D4952) (Abdurrojaq et al., 2021). The flash point (F.P.) was tested according to the ASTM D93 (Kaisan et al., 2020). The viscosity of samples was calculated depending on (ASTM D2896 and ASTM D445-06) (Sentanuhady et al., 2020). Pour point was done via (ASTM D79). The color was carried out according to the (ASTM D3699) (Elehinafe et al., 2024). Oxygenation was done via (ASTM D5599) (Aslam et al., 2023). Cetane index was done via (ASTM D4737) (Mekonnen et al., 2024). Distillation was done via (ASTM D86) (Al-Rubaye et al., 2024).

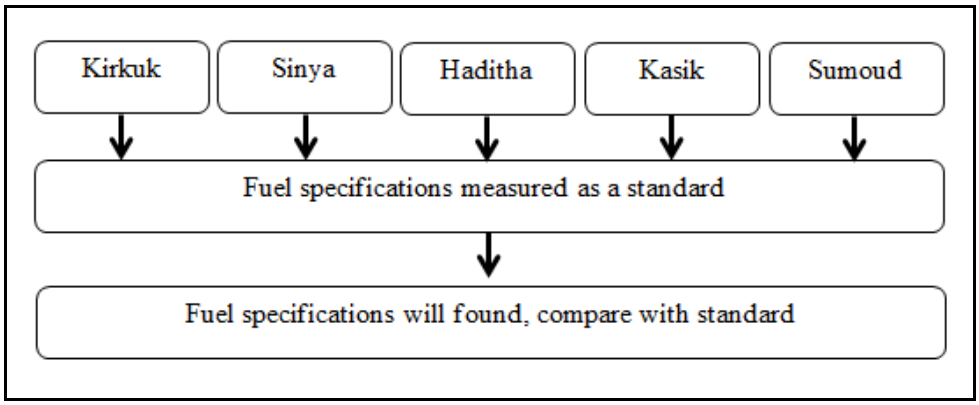


Fig. 1. Diagram illustrating the summary of this research

Results and Discussions

Physical properties of Al- Sumoud refinery

Table 1 shows the physical properties of Al-Sumoud fuel samples at NRC Baiji. As a result of petroleum products, which are (gasoline, naphtha, gas oil, and fuel oil), it was found that there is a closeness between them, due to their proximity to each other. Additionally, it was determined that the Reid Vapor Pressure (RVP) test differs significantly between the identical products. As for the sulfur test, it was found that naphtha was slightly content. On the other hand, it was noted that the sulfur percentage in the gasoline product was 18 ppm, which was also acceptable for the results of the other products (Mohammed, Humadi, et al., 2024).

Physical properties of Kirkuk products

As a result, the petroleum product tests, which are (naphtha, kerosene, gas oil, fuel oil, and crude oil) it showed that there is a closeness between the products of kerosene and gasoline, due to the proximity of the cuts to each other. It was also found that there is a noticeable difference in the steam pressure test between the same products. As for the sulfur test, it was found that naphtha was free of it, which indicates the effectiveness of the distillation tower. On the other hand, it was noted that the sulfur percentage in the gasoline product was 0.846 wt% %. It was also acceptable for the results of the other products (Humadi et al., 2024).

Physical properties of Syniah products

Table 3 shows the physical properties of Al-Syniah fuel samples at NRC Baiji. Table 3 shows that there were no kerosene test results due to the high demand for the gas oil product. The results also showed the production of heavy gas oil fuel, as its density reached 0.9530, which indicates the accuracy of the distillation tower.

Table 1. Al-Sumoud refinery specification of light products, and fuel oil

Test	Gasoline	Naphtha	Kerosene	Gas oil	Fuel oil
Density@15.0 °C	731.5	737.3	787.5	816.1	958.7
API	61.9	60.4	48.1	41.8	16.1
R. V. P (psi)	8.6	1.7	--	--	--
Dr. Test	Neg	--	Neg	--	--
RON	82	--	--	--	--
Flash point °C	--	--	56	65	133
Vis @ 40 °C	--	--	--	2.1	--
Vis @ 50 °C	--	--	--	--	221
Pour point °C	--	--	--	-18	+15
Sulphur wt%	18	--	3.5	0.78	3.7
Oxygenate ppm	--	34	--	--	--
Color	Yellow	+30	+28	0.5	--
Cetane index	--	--	--	52	--
Distillation					
I. B. P °C	36	83	167	171	
5 %	45	94	173	185	
50 %	87	120	187	238	
85 %	--	--	--	295	
90 %	144	151	207	300	
E. P °C	177	174	231	329	
TD vol%	98%	98%	98%	98%	
Res vol%	0.0	0.0	2.0	2.0	
Loss vol%	2.0	2.0	0.0	0.0	

Table 2. Kirkuk refinery specification of light products, and fuel oil

Test	Naphtha	Kerosene	Gasoil	Fuel oil	Crude oil
Density@15.0 °C	0.7156	0.7886	0.8238	0.9427	0.8515
A. P. I	66.2	48.3	40.2	18.6	34.6
Flash point °C	---	42	73	77	---
Color	+30	+ 29	0.5	---	---
Cetane index	---	---	53	---	---
Total sulfur wt %	0.0808	0.1799	0.846	3.7	2.3
Oxygenate ppm	31	---	---	---	---
Vis @ 50 °C	---	---	---	175.8	---
Vis @ 40 °C	---	---	3.12	---	4.15
Pour point °C	---	---	15 +	+9	---
Distillation					
I. B. P °C	28	145	178	---	---
5 %	48	158	186	---	---
10 %	58	168	202	---	---
50 %	105	182	243	---	---
85 %	--	---	292	---	---
90 %	148	194	305	---	---
E. P °C	178	223	332	---	---

Table 3. Al-Syniah refinery specification of light products, fuel oil, and crude oil

Test	Crude oil	Naphtha	Kerosene	Gas oil	Fuel oil
Density@15.0 °C	0.8641	0.7328	---	0.8269	0.9530
A. P. I	32.3	61.5	---	39.6	16.9
Flash point °C	---	---	---	70	81
Pour point °C	---	---		-12	+12
Sulphur wt%	2.3	0.084	---	0.85	2.6
Oxygenate ppm	---	31.0	---	---	---
Color	---	+26	---	1.0	---
R. V. P (psi)	5.1	6.1		---	---
Vis @ 40 °C	---	---	---	202	---
Vis @ 50 °C	---	---	---	---	173
Distillation					
I. B. P °C	---	54	---	160	---
5 %	---	71	---	188	---
10 %	---	86	---	214	---
50 %	---	102	---	242	---
85 %	---	---	---	304	---
90 %	---	132	---	318	---
E. P °C	---	191	---	350	---

Physical properties of Haditha products

Table 4 shows the physical properties of Haditha fuel samples at NRC Baiji. From the table below, we notice the absence of kerosene test results due to the conversion of the production of the modern refinery to gas oil. We also notice the existence of a relationship between the density of crude oil and gasoline.

Table 4. Haditha refinery specification of light products and fuel oil

Test	Naphtha	Kerosene	Diesel	Fuel oil	Crude oil
Density@15.0 °C	0.7113	---	0.8235	0.9749	0.8819
A. P. I	67.4	---	40.3	13.6	28.9
Flash point °C	---	---	68	86	---
Color	28 +	---	1.0	---	---
Sulphur wt%	0.098	---	0.83	3.7	2.3
Oxygen at ppm	30	---	---	---	---
Vis @ 50 °C	---	---	---	240	---
Vis @ 40 °C	---	---	2.5	---	---
Distillation					
I. B. P °C	36	---	166	---	---
5 %	53	---	187	---	---
10 %	61	---	194	---	---
50 %	107	---	244	---	---
85 %	--	---	316	---	---
90 %	147	---	332	---	---
E. P °C	174	---	360	---	---

Physical properties of Kasik products

Table 5 shows the physical properties of Kasik product samples at NRC Baiji. The results were somewhat different, which indicates that the refinery's feed was received from different sources. As a result, the Sp.gr light naphtha and kerosene were close to each other. This finding means the efficiency of the distillation column (Humadi et al., 2025).

Table 5. Kasik refinery specification of light products and fuel oil

Test	Light naphtha	Kerosene	Gasoil	Fuel oil Ain Zala	Fuel oil Kirkuk	Fuel oil
Density@15.0 °C	0.7232	0.7886	0.8240	0.8787	---	0.9567
A. P. I	64.1	47.9	40.2	29.5	---	16.4
Flash point °C	---	44	62	---	---	65
Color	+28	+ 21	1.0	---	---	---
R.V.P (psi)	3.8	---	---	4.3	---	
Cetane index	---	---	53	---	---	---
Total sulfur wt%	0.070	0.290	0846	2.481	---	3.954
Oxygenate ppm	20	---	---	---	---	---
Vis @ 50 °C	---	---	---	---	---	163
Vis @ 40 °C	---	---	2.8	---	---	---
Pour point °C	---	---	12 +	---	---	+15
Distillation						
I.B.P °C	28	145	168			
5 %	40	149	174			
10 %	52	153	188			
50 %	108	182	246			
85 %	--	---	295			
90 %	144	210	306			
E. P °C	174	238	340			

Conclusion

The Al-Sumoud, Kirkuk, Al-Syniah, Haditha, and Kasik refineries at North Refineries Company (NRC) Baiji specification results were detailed in this work. These results presented in this research are considered quarterly results on the properties of petroleum products of the aforementioned refineries, giving a real and clear impression of the fluctuation of the results, which indicates the nature of the feed material (crude oil) and the final products mentioned, such as (crude oil, naphtha, gasoline, kerosene, gasoil, and fuel oil). Laboratory test results were found to be correlated with each other, particularly for light products such as naphtha. It was also shown that the feed crude oil has a direct effect on the light white products.

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References

Abdulqader, Mahmod, Syed Hassan, S., Jawad, A., & HABEEB, O. (2021). Characterization Study of Petroleum Oily Sludge Produced from North Refineries Company Baiji to Determine the Suitability for Conversion into Solid Fuel. *Egyptian Journal of Chemistry*, *0*(0), 0–0. https://doi.org/10.21608/ejchem.2021.54222.3126

Abdulqader, M. A., Habeeb, O. A., Dheab, M. S., Saber, S. E. M., Rabet, A. O., Mohammed, G. J., & Saleh, A. H. (2022). Solid Fuel Char Production via Pyrolysis Process of Oily Sludge Produced as a Resulted in Storage Tanks at North Refineries Company Baiji. *Journal of Petroleum Research and Studies*, *12*(1 (Suppl.)), 199–210.

Abdulqader, M. A., Salih, H. Y., Habeeb, O. A., Saber, S. E. M., & Jasem, A. A. (2023). Clean char solid carbon fuel production via microwave processes of oily sludge produced at North Refineries Company Baiji. *AIP Conference Proceedings*, *2862*(1).

Abdurrojaq, N., Devitasari, R. D., Aisyah, L., Faturrahman, N. A., Bahtiar, S., Sujarwati, W., Wibowo, C. S., Anggarani, R., & Maymuchar, M. (2021). Perbandingan Uji Densitas Menggunakan Metode ASTM D1298 dengan ASTM D4052 pada Biodiesel Berbasis Kelapa Sawit. *Lembaran Publikasi Minyak Dan Gas Bumi*, *55*(1), 49–57.

Al-Rubaye, A. H., Al-Robai, H. A., Jasim, D. J., Al-Khafaj, H. A. M., Ameen, H. F. M., & Al-Turaihi, A. S. (2024). Environmental Method of Distilling Gasoline Based on ASTM D86: A Comparative Study. *IOP Conference Series: Earth and Environmental Science*, *1371*(2), 22021.

Aslam, M., Maktedar, S., & Sarma, A. K. (2023). *Green Gasoline: A Green Spark Transportation Fuel* (Vol. 77). Royal Society of Chemistry.

Banurea, R., Frida, E., Rahwanto, A., Nasution, D. L. S., & Simbolon, T. R. (2024). Design a machine with technology to convert plastic waste into fuel renewable energy. *Journal of Physics: Conference Series*, *2733*(1), 12004.

Elehinafe, F. B., Ogunleye, C. O., Adesina, A., & Sonibare, J. A. (2024). Experimental development of predictive models for quantification of total volatile organic compounds (TVOCs) from the points of sales of petroleum products in fueling stations. *Case Studies in Chemical and Environmental Engineering*, *9*, 100641.

Fathi, M. I., Abdulqader, M. A., & Habeeb, O. A. (2023). Microwave process of oily sludge produced at NRC Baiji to micro-char solid carbon production. *DESALINATION AND WATER TREATMENT*, *310*, 142–149.

Humadi, J. I., Aabid, A. A., Mohammed, A. E., Ahmed, G. S., & Abdulqader, M. A. (2024). New Design of Eco-Friendly Catalytic Electro-Photo Desulfurization process for Real Diesel Fuel. *Chemical Engineering Research and Design*.

Humadi, J. I., Mohammed, A. E., Khamees, L. A., Jafar, S. A., & Abdulqader, M. A. (2025). Oil upgrading via desulfurization process using a new composite nano-alkaline-iron oxide over titanium oxide catalysts. *Energy & Environment*, 0958305X251344235.

Jahirul, M. I., Faisal, F., Rasul, M. G., Schaller, D., Khan, M. M. K., & Dexter, R. B. (2022). Automobile fuels (diesel and petrol) from plastic pyrolysis oil—Production and characterisation. *Energy Reports*, *8*, 730–735.

Kaisan, M. U., Anafi, F. O., Nuszkowski, J., Kulla, D. M., & Umaru, S. (2020). Calorific value, flash point and cetane number of biodiesel from cotton, jatropha and neem binary and multi-blends with diesel. *Biofuels*.

Kongkiatpaiboon, S. (2024). Improving Offshore Condensate Production Optimization Processes with Prediction of Reid Vapor Pressure Using Machine Learning. *Offshore Technology Conference Asia*, D031S030R003.

Mekonnen, K. D., Endris, Y. A., & Abdu, K. Y. (2024). Alternative Methods for Biodiesel Cetane Number Valuation: A Technical Note. *ACS Omega*, *9*(6), 6296–6304.

Mohammed, A. E., Gheni, S. A., Mohammed, W. T., & Abdulqader, M. A. (2024). *Converting Iraqi Hazardous Crude Oily Sludge into Value-Added Activated Carbon using KOH Activation Technique* 175–154 ,(1)*14* .

Mohammed, A. E., Humadi, J., Issa, Y. S., Ahmed, M. A., Aqar, D. Y., Aabid, A. A., Abdulqade, M. A., & Ahmed, G. S. (2024). Process Model Development and Optimal Kinetics for Fuel Desulfurization via a Novel Nano-Catalyst. *Iranian Journal of Chemistry and Chemical Engineering*.

Novandy, A. (2019). EVALUASI UJI DENSITY METODE ASTM D 1298 dan D 6822. *Swara Patra*, *9*(1), 1–6.

Saleh, A. M., Alias, A. B., Saleh, N. M., Yassin, K. F., Ahmed, O. K., Abdulqader, M. A., &

Mahdi, H. H. (2023). Production of first and second-generation biodiesel for diesel engine operation: A review. *NTU Journal of Renewable Energy*, *5*(1), 8–23.

Sentanuhady, J., Majid, A. I., Prashida, W., Saputro, W., Gunawan, N. P., Raditya, T. Y., & Muflikhun, M. A. (2020). Analysis of the Effect of Biodiesel B20 and B100 on the Degradation of Viscosity and Total Base Number of Lubricating Oil in Diesel Engines with Long-Term Operation Using ASTM D2896 and ASTM D445-06 Methods. *Teknik*, *41*(3), 269–274.

Shishkova, I., Stratiev, D., Kolev, I. V., Nenov, S., Nedanovski, D., Atanassov, K., Ivanov, V., & Ribagin, S. (2022). Challenges in petroleum characterization—A review. *Energies*, *15*(20), 7765.

Tariq, A. I., & Saleh, A. M. (2023). An experimental investigation into the combustion properties, performance, emissions, and cost reduction of using heavy and light fuel oils. *Case Studies in Thermal Engineering*, *44*, 102832.

Zhao, Y., Guo, X., & Fang, Y. (2024). Coprocessing of cashew nut shell liquid and phenol model compounds with VGO in a pilot-scale FCC riser. *Energy*, *307*, 132764.