International Journal of Advanced Research in Science, Engineering and Technology

ISSN: 2350-0328

Vol. 12, Issue 9, September 2025

Integrated Pathways from Extraction to Upgrading of Extra-Heavy Oil the YANGI UZBEKISTAN FIELD

Yaxshiyeva Kibriyo Oybekovna, Tajimova Gulistan Raman kizi, Nurullayeva Zarina Valiyevna , Adizov Bobirjon Zamirovich

Doctoral student of the Tashkent State Technical University named after Islam Karimov, Republic of Uzbekistan, Tashkent.

Doctoral student of the Institute of General and Inorganic Chemistry of the Academy of Sciences of the Republic of Uzbekistan, Tashkent, Uzbekistan.

Doctoral student of the Institute of General and Inorganic Chemistry of the Academy of Sciences of the Republic of Uzbekistan, Tashkent, Uzbekistan.

Doctor of Technical Sciences, Professor, Head of the Laboratory of Petrochemistry, Institute of General and Inorganic Chemistry of the Academy of Sciences of the Republic of Uzbekistan, Tashkent.

ABSTRACT: The Yangi Uzbekistan field, discovered in 2022 in the Zarafshan depression, represents the largest deposit of extra-heavy oil and natural bitumen in Uzbekistan. This oil exhibits extreme viscosity (up to millions of mPa·s at reservoir conditions), density near 1.0 g/cm³, and high sulfur and asphaltene content. Direct refining is not feasible; therefore, integrated pathways from extraction to deep upgrading are required. This article analyzes extraction methods (thermal stimulation, steam injection, catalytic aquathermolysis), primary preparation (electro-dehydration and desalting), and upgrading processes (visbreaking, coking, and hydroconversion). International experiences from Canada and Venezuela are compared with Uzbekistan's conditions.

KEYWORDS: extra-heavy oil, natural bitumen, hydroconversion, visbreaking, aquathermolysis, hydrogenation conversion, hydrocracking, synthetic oil.

I. INTRODUCTION

Global oil reserves are increasingly shifting toward unconventional sources such as extra-heavy oils and natural bitumens. Countries like Canada (Athabasca oil sands) and Venezuela (Orinoco Belt) have pioneered integrated extraction-upgrading complexes, producing synthetic crude oil compatible with conventional refineries [1].

Uzbekistan, traditionally reliant on light crude, entered this field with the discovery of the Yangi Uzbekistan deposit in 2022, with estimated resources of around 100 million tonnes. The oil is nearly immobile at reservoir conditions, with density 0.98–1.0 g/cm³, viscosity exceeding 138,000 mPa·s at 50 °C, and sulfur content up to 8–8.5%. Its composition is dominated by resins and asphaltenes (~67%), making it closer to natural bitumen than conventional crude [2].

These characteristics necessitate a comprehensive strategy that integrates extraction technologies, feed preparation, and deep upgrading processes to produce marketable synthetic crude. Beyond technical complexity, the project is strategically important for Uzbekistan's energy security, as it reduces reliance on imported petroleum and creates opportunities for the development of hydrogen infrastructure, sulfur management facilities, and environmentally sustainable closed water cycles.

Thus, the Yangi Uzbekistan field represents not only a technological challenge but also a unique opportunity to implement innovative, internationally benchmarked solutions tailored to regional conditions. Moreover, it opens avenues for cooperation with global technology providers and research institutions, enabling knowledge transfer, pilot testing of advanced upgrading methods, and the establishment of integrated refining complexes within Uzbekistan. This positions the field as a cornerstone of the country's long-term industrial modernization and energy diversification strategy.

II. SIGNIFICANCE OF THE SYSTEM

The development of an integrated system for processing extra-heavy oil from the Yangi Uzbekistan field carries profound significance at both national and international levels.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 12, Issue 9, September 2025

Strategic importance. As Uzbekistan has historically relied on lighter crude and petroleum imports, the utilization of this large extra-heavy oil resource provides an opportunity to strengthen national energy security. The project aligns with long-term goals of reducing import dependency, diversifying the energy portfolio, and creating new value chains in petrochemicals and refining [3].
Technological relevance. The field presents a unique testing ground for implementing advanced upgrading technologies such as hydroconversion, catalytic aquathermolysis, and closed-loop water management. Successfully applying these methods will not only enable the production of refinery-ready synthetic crude but also allow Uzbekistan to join the group of countries pioneering heavy oil innovation.
Economic benefits. Beyond fuel supply, integrated upgrading can generate additional revenue streams through by-products such as sulfur, light olefins, and petrochemical feedstocks. The establishment of upgraders and associated infrastructure will stimulate local industries, create employment opportunities, and attract foreign investment in energy and technology sectors.
Environmental and sustainability aspects. By applying electro-dehydration, desulfurization, and catalytic processes, the system reduces harmful emissions, lowers coke formation, and facilitates responsible water usage through closed cycles. This aligns with Uzbekistan's broader agenda for sustainable industrial development and environmental responsibility.
In this context, the system for processing extra-heavy oil from the Yangi Uzbekistan field is not merely a technological pathway, but a cornerstone for advancing energy independence, industrial modernization, and ecological sustainability in the region [4].

III. METHODOLOGY AND DISCUSSION

The methodology for assessing processing pathways of extra-heavy oil from the Yangi Uzbekistan field combined laboratory analysis, field data, and international benchmarking.
Laboratory and field characterization. Crude samples were analyzed to determine viscosity–temperature behavior, density, SARA composition (saturates, aromatics, resins, asphaltenes), and heteroatom content. Water cut in produced fluids exceeded 98%, highlighting the necessity of efficient dehydration and desalting systems. Autoclave experiments with catalytic aquathermolysis demonstrated viscosity reduction by approximately 1.5 times and increased liquid yields by 12–15% [5].
Evaluation of extraction technologies. Thermal recovery methods such as Cyclic Steam Stimulation (CSS) and Steam-Assisted Gravity Drainage (SAGD) were considered as the most feasible approaches under Uzbekistan's geological conditions. Catalytic additives further enhanced oil mobility and improved recovery efficiency [6].
Feed preparation and upgrading assessment. Electro-dehydration reduced water content from 98–99% to 0.5–1.0%, while electro-desalting decreased salts from 350 mg/L to less than 10 mg/L. These steps are essential to avoid corrosion and fouling in downstream processes. Upgrading routes analyzed included visbreaking, delayed coking, hydrocracking, and hydroconversion (slurry and ebullated-bed reactors). Hydroconversion achieved residue conversion of 85–90%, producing synthetic crude with 28–32°API and sulfur content below 0.5%.
The technological sequence for handling extra-heavy oil from the Yangi Uzbekistan field is illustrated in Figure 1. The process begins with extraction, where thermal recovery techniques such as Cyclic Steam Stimulation (CSS), Steam-Assisted Gravity Drainage (SAGD), or in-situ catalytic processes are employed to mobilize highly viscous oil.
The mobilized oil is then directed into the production well, where it is lifted to the surface along with significant amounts of water and dissolved salts. From here, the crude moves to the transportation stage, which represents a critical step due to the extreme viscosity of the oil. To ensure stable pipeline flow, diluent addition (such as lighter hydrocarbons or solvents) is often required.
Once transported, the oil enters the *processing stage,* where deep upgrading methods are applied. These include:

- *Hydrocracking,* which breaks down heavy hydrocarbon molecules into lighter fractions,
- *Hydrotreating,* which removes sulfur, nitrogen, and other heteroatoms, improving fuel quality,
- *Hydroconversion,* a catalytic process in slurry or ebullated-bed reactors that achieves high conversion of residue (85–90%) and produces synthetic crude with 28–32°API.

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 12, Issue 9, September 2025

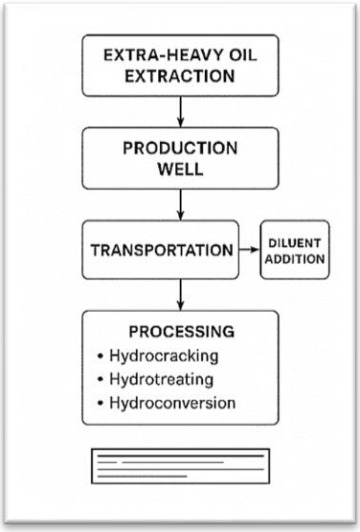

Fig1. Integrated Pathway of Extra-Heavy Oil from Extraction to Processing

The scheme emphasizes a fully integrated approach: from extraction through stabilization and transportation to advanced refining processes, ensuring that extra-heavy oil can be converted into refinery-ready synthetic crude compatible with modern refineries.

IV. EXPERIMENTAL RESULTS

The results of experimental and literature-based evaluations indicate that while visbreaking and coking remain economically less capital-intensive, they yield lower-value products and are associated with higher coke formation (8–20%). In contrast, hydroconversion achieves deeper residue conversion (85–90%), producing synthetic crude of 28–32°API with sulfur content below 0.5%. These outcomes confirm the superior efficiency of hydroconversion in terms of product quality and yield, though its deployment requires extensive hydrogen infrastructure, advanced catalysts, and efficient sulfur recovery systems.

Autoclave experiments demonstrated that the use of alumina-based and mixed-metal catalysts in aquathermolysis reduced viscosity by 1.5 times and increased liquid yields by 12–15% compared to non-catalytic thermal treatments. Furthermore, coke formation decreased nearly twofold, highlighting the role of catalysts in improving both economic and environmental performance.

Electrostatic dehydration reduced water content from 98–99% to 0.5–1.0%, while electro-desalting decreased salts from ~350 mg/L to less than 10 mg/L. These parameters meet the requirements for stable pipeline transportation and minimize corrosion risks in upgrading units.

Analysis of upgraded fractions showed that polycyclic aromatic hydrocarbons (PAHs) were reduced by 35–40% compared to thermal processes, while implementation of closed water cycles decreased wastewater discharge by up to 90%. Such results emphasize that environmentally conscious process integration can complement technological efficiency.

The international experience of Canada and Venezuela demonstrates that these challenges can be addressed through integrated upstream–downstream complexes, which serve as a model for Uzbekistan. However, local adaptation is necessary, particularly in hydrogen production capacity, sulfur recovery plants, and the optimization of water usage.

The methodology and experimental findings confirm that stepwise integration of extraction, feed preparation, and advanced upgrading—especially hydroconversion—represents the most viable path for transforming the Yangi Uzbekistan extra-heavy oil into refinery-ready synthetic crude.

The comparative performance of upgrading processes is summarized in Figure 2, highlighting differences in liquid yield and sulfur content across coking, visbreaking, hydrocracking, and hydroconversion.

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 12, Issue 9, September 2025

ISSN: 2350-0328

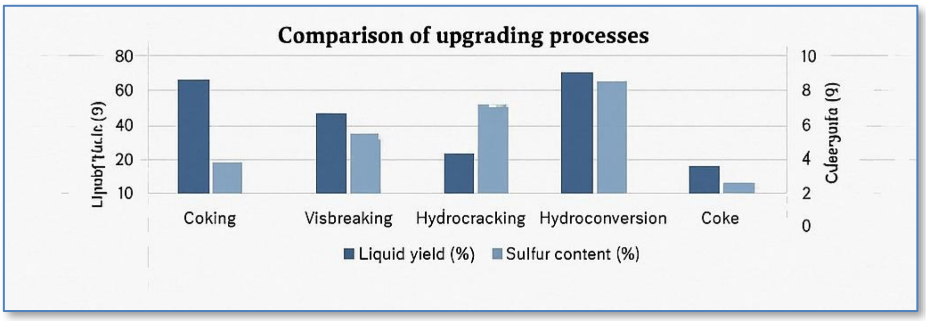

Figure 2. Comparison of upgrading processes for extra-heavy oil from the Yangi Uzbekistan field.

V. CONCLUSION AND FUTURE WORK

The analysis of extra-heavy oil from the Yangi Uzbekistan field demonstrates that its unique characteristics—extremely high viscosity, elevated sulfur and asphaltene content, and high water cut—pose significant challenges for conventional refining. Experimental and comparative evaluations confirm that while visbreaking and coking can be implemented with lower capital investments, they produce lower-value products and higher coke yields. Hydroconversion, supported by advanced catalysts, has emerged as the most effective pathway, delivering high liquid yields (85–90%), synthetic crude of 28–32°API, and sulfur content below 0.5%.

The integration of extraction technologies, electrostatic feed preparation, and advanced upgrading methods offers a viable strategy to transform immobile bitumen-like crude into refinery-ready synthetic oil. Furthermore, environmental benefits such as reduced PAHs, minimized coke formation, and implementation of closed water cycles strengthen the sustainability of the approach.

Future work should focus on pilot-scale implementation of catalytic hydroconversion under Uzbekistan's specific operating conditions, expansion of hydrogen generation infrastructure, and development of efficient sulfur recovery units. Research collaboration with international partners, particularly those with established expertise in Canada and Venezuela, will be crucial for adapting global best practices to regional needs. In addition, advanced modeling and techno-economic assessments should be conducted to optimize process integration and evaluate long-term commercial viability.

In this way, the Yangi Uzbekistan field can evolve from a technological challenge into a strategic asset, contributing to Uzbekistan's energy independence, industrial modernization, and sustainable development goals.

REFERENCES

[1] Canada Energy Regulator, "Market Snapshot: Trends in In-Situ Bitumen Production," CER Report, Apr. 5, 2023. Available: https://www.cer-rec.gc.ca/

[2] Sanoat Energetika Guruhi and Kontiki-Exploration, "Discovered the largest oil and bitumen field in Uzbekistan," UzDaily, June 29, 2022. Available: https://www.uzdaily.uz/ru/

[3] R.F. Meyer, E.D. Attanasi, and P.A. Freeman, "Heavy Oil and Natural Bitumen Resources in Geological Basins of the World," USGS Open-File Report 2013–1286, 2013. Available: https://pubs.usgs.gov/of/2007/1084/OF2007-1084v1.pdf

[4] J.G. Speight, Introduction to Enhanced Recovery Methods for Heavy Oil and Tar Sands. Gulf Professional Publishing, 2016. Available: https://www.sciencedirect.com/book/9780128499061/introduction-to-enhanced-recovery-methods-for-heavy-oil-and-tar-sands

[5] A.A. Akhunov, F. Aliev, N. Mukhamadiev, et al., "Aquathermolytic Upgrading of Zarafshanian Extra Heavy Oil Using Ammonium Alum," Molecules, vol. 30, no. 14, article 3013, 2025. doi: 10.3390/molecules30143013

[6] E.A. Galiullin and R.Z. Fakhrutdinov, "New Technologies for Processing Heavy Oils and Natural Bitumens," Vestnik of Kazan Technological University, no. 23(4), pp. 30–36, 2016. Available: https://cyberleninka.ru/article/n/novye-tehnologii-pererabotki-tyazhelyh-neftey-i-prirodnyh-bitumov

AUTHOR'S BIOGRAPHY

Full name	Yaxshiyeva Kibriyo Oybekovna
Academic rank	doctoral student
Institution	Tashkent State Technical University named after Islam Karimov