Analysis Of The Technological Scheme And Compounding Process Of Motor Gasolines At An Oil Refinery In Uzbekistan

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Abstract

The gasoline blending station is a key unit at an oil refinery, ensuring the production of finished products compliant with modern technical specifications. The purpose of this study is a comprehensive analysis of the technological process and layout of a gasoline blending station operating at an oil refinery in Uzbekistan. The investigation covers the feedstock base, equipment, sequence of operations, automated process control system, and features of enhanced fuel production. The process is based on the compounding of three components-light naphtha, reformate, and butane fraction-followed by the addition of specialized detergent additives to produce QuWatt-branded fuel. A critical factor ensuring consistent product quality is the adjustment of the blending recipe based on real-time laboratory data on the properties of the feedstock components. The analysis confirms a high level of reliability and safety of the unit, achieved through a multi-level system of alarms, interlocks, and automatic regulation, enabling effective control of the complex technological process and the production of gasoline grades strictly in accordance with national standards.

Keywords: Compounding, light naphtha, reformate, butane, multifunctional additive.

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1. Introduction

The production of high-quality motor fuel is one of the priority objectives of Uzbekistan's oil refining industry, aimed at ensuring the country's energy security and meeting the growing demands of the domestic market. Under tightening environmental regulations and the increasing performance requirements of modern internal combustion engines, the final stage of fuel production—gasoline compounding (blending)—has assumed critical importance [1]. This stage is decisive in guaranteeing the required fuel quality parameters, as it combines components with diverse physicochemical properties into a finished gasoline product that meets operational specifications and quality standards [2].

The gasoline blending station represents a complex technological unit whose operation demands a high degree of precision, reliability, and automation due to the necessity of strict quality control over both feed components and the final product, as well as the management of multi-component flow streams. Contemporary automation strategies involve the integration of control systems, real-time quality monitoring, and optimization of production parameters [3]. The efficiency of this process directly impacts the refinery's economic performance, as product stability and consistent compliance with quality specifications determine the enterprise's market competitiveness. A key function of the blending station is not only to achieve target values for octane number, distillation characteristics, and Reid vapor pressure, but also to maintain the stability of these parameters despite variability in feedstock properties and external factors [4].

In recent years, Uzbekistan has actively pursued a strategy to upgrade fuel quality, including the introduction of enhanced gasoline grades formulated with modern detergent additives [5]. The launch of branded products such as QuWatt gasoline necessitates the adaptation of existing process schemes and control methodologies, underscoring the need for a thorough analysis of current production practices [6].

This study is aimed at the systematic and detailed examination of the technological process and layout of a gasoline blending station operating at an oil refinery in Uzbekistan. The research objectives include identifying the structural features of the equipment, elucidating the operating principles of automated control systems, and evaluating the role of laboratory quality control in ensuring the stable production of a wide range of commercial gasoline grades—from AI-80 to high-octane AI-98—and their enhanced QuWatt variants. The findings are expected to serve as a foundation for further optimization of production processes and improved efficiency in the utilization of feedstock resources at domestic refineries.

2. Methods

This study is based on a systematic analysis of the industrial gasoline compounding technology implemented at the blending station of an oil refinery in Uzbekistan. The research methodology employed a structured review of operational documentation, followed by the classification of data according to key aspects: feedstock composition, equipment configuration, process flow scheme, operational parameters, and quality control methods.

Feedstock and Products. The production process is based on the blending of three primary components:

- Light naphtha—a fraction with an end-point boiling temperature not exceeding 85 °C and a Reid vapor pressure up to 100 kPa;

- Reformate—a high-octane component with a boiling range of 35–215 °C, characterized by a high concentration of aromatic hydrocarbons;

- Butane fraction—a liquefied petroleum gas containing no more than 5 % propane, ≤0.003 % hydrogen sulfide, and a vapor pressure of up to 1.6 MPa at 45 °C.

Equipment and Infrastructure. The blending station comprises four functional units:

- a storage park for light naphtha,

- a storage park for reformate and finished products,

- a battery of isothermal vessels for butane,

- a blending pump station.

Feed components are stored in vertical steel tanks (1,000–2,000 m^3) equipped with floating roofs to minimize evaporative losses. Butane is stored in horizontal isothermal tanks (100 m^3 each) maintained at 7–12 °C. The total tank farm capacity is designed to support 36 hours of uninterrupted plant operation. Transfer of components is performed using centrifugal pumps: vertical pumps for reformate and gasoline, horizontal pumps for light naphtha, and hermetic (sealed) pumps for butane.

Technological Process. Blending is carried out inline via two separate manifolds: one dedicated to AI-80 gasoline and the other to high-octane grades (AI-91 to AI-98). Component ratios are adjusted by operators based on real-time laboratory analysis. The finished product is routed to finished-product storage tanks, where final quality verification is performed. If specifications are not met, a corrective procedure is initiated—additional components are dosed, followed by circulation to ensure homogeneity.

Production of QuWatt-branded fuel takes place in a dedicated storage tank. Prior to injection into the main stream, a 50 % solution of detergent additive in gasoline is prepared and then metered using a specialized dosing pump. Additive concentration ranges from 200 to 2,000 g per metric ton of fuel, depending on the target gasoline grade.

Laboratory Quality Control Methodology. Quality control of both feedstocks and finished products complies with the national standard for motor gasoline in Uzbekistan. Sampling from storage tanks follows established industry protocols. Key monitored parameters include:

- Octane number (by both Research Octane Number [RON] and Motor Octane Number [MON] methods),
- Distillation characteristics and boiling curve,
- Reid vapor pressure (seasonal limits: 35–80 kPa in summer, 35–100 kPa in winter),
- Induction period (minimum 450 minutes),
- Sulfur, benzene, and aromatic hydrocarbon content.

The analytical results serve as the basis for blending recipe adjustments and constitute a critical element of the closed-loop quality management system at the blending station.

3. Results

Analysis of the technological regulations enabled the identification of specific numerical parameters governing the gasoline compounding process. The obtained data demonstrate a high degree of standardization and control throughout all stages of production:

1. Reformate proportion: In the production of high-octane gasoline grades (AI-95/AI-98), reformate constitutes 81.1% of the blend, whereas for low-octane fuel (AI-80), its share decreases to 44.5%. This confirms the critical role of reformate as the primary octane-enhancing component. Corresponding pump flow rates for these operational modes are 140–155 m³/h for high-octane blends and 40–51 m³/h for AI-80.

2. Automated control system: The automated process control system ensures precise management of safety-critical parameters. Specifically, the maximum allowable level in finished-product storage tanks is maintained at 10,000 mm; exceeding this triggers an automatic interlock that closes the electric valve on the feed line. Similarly, to prevent pump “dry running,” a minimum tank level is set at 6–10% of the total tank height, below which pumps are automatically shut down.

3. QuWatt fuel production: The manufacture of the enhanced QuWatt gasoline involves the addition of a specialized detergent additive at concentrations ranging from 200 to 2,000 g per metric ton of fuel—an order of magnitude higher than in conventional formulations—specifically to deliver the claimed superior performance characteristics, including improved engine cleanliness and efficiency.

These quantitative findings are systematically summarized in Table 1 and Table 2.

Table 1

Approximate component ratios and equipment throughput for different gasoline grades

Gasoline Grade	*Reformate Share, %*	*Reformate Flow Rate, m³/h*	*Butane Share, %*	*Butane Temperature, °C*
AI-95, AI-98	81.1	140–155	3.9	7–12
AI-91, AI-92	77.0	140–155	5.2	7–12

AI-80	44.5	40–51	6.4	7–12

Table 2

Key setpoints of automatic control and safety systems

Monitored Parameter	*Equipment / Location*	*Trip Setpoint*	*Consequence*
Liquid level	Finished-product tanks RVSp-47–50	10,000 mm	Automatic closure of feed line valve
Liquid level	Finished-product tanks RVSp-47–50	6–10% of tank height	Automatic pump shutdown
Bearing temperature	Pumps N-1–N-4	80 °C	Emergency pump shutdown
Hydrocarbon gas concentration	Entire blending station area	20% LEL (Lower Explosive Limit)	Alarm signal to operator control room

4. Discussion

The obtained results enable several important conclusions regarding the organization of the technological process at the gasoline blending station.

First, the production process is characterized by an adaptive rather than static nature. Although the technological documentation specifies approximate component ratios, in practice these are routinely adjusted based on real-time laboratory analysis of incoming stream properties. This indicates that consistent product quality is ensured not by rigid adherence to a fixed blending recipe, but by a flexible feedback loop linking laboratory monitoring with operational process control.

Second, the industrial safety system is implemented as a four-tier hierarchical protection structure:

1. Prevention—achieving target blending parameters through precise dosing of components using pneumatically actuated control valves;

2. Monitoring—continuous surveillance of critical parameters (temperature, pressure, liquid level, and hydrocarbon gas concentration);

3. Signaling—prompt notification of operators when parameters deviate beyond allowable limits;

4. Interlocking—automatic activation of protective measures (e.g., pump shutdown, closure of isolation valves) in emergency scenarios such as pump “dry running” or tank overfill.

This multi-layered approach aligns with modern principles of functional safety and significantly mitigates risks associated with human error.

Nevertheless, certain limitations in the current process implementation have been identified. The most significant is the reliance on periodic offline laboratory analysis. The entire cycle—including sample collection, transportation to the laboratory, testing, and communication of results to operators—requires considerable time. Consequently, a real-time closed-loop control system cannot be established, creating a potential risk of temporarily producing fuel that does not fully comply with regulatory specifications, particularly during transitional periods between recipe adjustments.

An additional constraint is the inflexible strategy for detergent additive dosing in QuWatt fuel production. While additive concentration is varied within a fixed range (200–2,000 g per metric ton) depending on the gasoline grade, it does not account for the actual condition of the base blend or evolving operational performance requirements. This precludes adaptive optimization of the additive dosage—an expensive component—and thereby reduces the economic efficiency of the process.

In summary, the current technology ensures reliable, safe, and standardized production of motor gasoline fully compliant with national standards. At the same time, it holds significant potential for improvement in both efficiency and product quality through the integration of intelligent control systems based on online monitoring of component properties and real-time adaptive recipe correction.

5. Conclusion

The analysis of the technological process and layout of the gasoline blending station at an oil refinery in Uzbekistan has revealed key features that ensure the stable production of high-quality fuel across a broad product range—from AI-80 to AI-98—and their enhanced QuWatt variants.

It has been established that the foundation of the unit's efficient operation lies in a flexible, adaptive control system, wherein precise dosing of the three base components (reformate, light naphtha, and butane) is continuously adjusted based on real-time laboratory data. This confirms that consistent product quality is achieved not through rigid adherence to a fixed recipe, but through a closed-loop cycle of "analysis → correction → verification."

Particular attention is warranted for the multi-level industrial safety system, which integrates automated alarms, interlocks, and emergency equipment shutdowns. By continuously monitoring parameters such as liquid level, temperature, pressure, and hydrocarbon gas concentration, this system ensures robust protection of personnel, equipment, and the environment—even in the event of process deviations.

The findings underscore a high degree of technological maturity in the compounding process at the facility. The data demonstrate that the modern blending station functions as an integrated complex, where storage, precise dosing, automated control, and laboratory analysis are tightly coordinated. This integration not only guarantees full compliance with national fuel standards but also establishes a solid foundation for further quality improvements through the adoption of advanced intelligent control systems, such as real-time online optimization and adaptive blending strategies.

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