Amine Gas Treatment Process Application

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Abstract: *This study evaluates amine gas treatment processes at A Plant and B Plant, identifying bottlenecks and proposing optimizations. The single-loop system at A Plant enables efficient gas processing and additional oil production, while the two-loop system at B Plant limits production. Transitioning to a single-loop system at B Plant could increase oil output by 25 kbopd. Economic analysis confirms a payback period within one year, highlighting operational and financial viability. This report provides a framework for optimizing oil and gas processing facilities sustainably and efficiently.*

Keywords: *Amine Gas Sweetening, Single-Loop System, Dual-Loop System, Gas Processing Optimization, Economic Analysis*

1. INTRODUCTION

This foundational overview sets the stage for understanding the challenges and solutions provided by amine-based gas treatment technologies. Following this introduction, the existing amine treatment technology analysis explores how these systems are implemented across diverse plants.

The energy industry is increasingly focused on efficiency and environmental compliance as production scales up. Challenges associated with treating high-sulfur feedstocks and associated gases necessitate advanced technologies. This work emphasizes the critical role of amine-based gas treatment in meeting these demands. By evaluating single-loop and dual-loop systems through case studies of A Plant and B Plant, this research provides actionable insights into their respective strengths, operational designs, and improvements.

The increasing demand for energy resources has led to a significant rise in oil and gas production. However, this growth is coupled with challenges related to the treatment of associated gases and processing high-sulfur feedstocks. Amine gas sweetening plays a pivotal role in addressing these challenges by removing acid gases such as hydrogen sulfide (H_2S) and carbon dioxide (CO_2), thereby ensuring environmental compliance and operational efficiency. This study focuses on evaluating and optimizing amine-based gas treatment systems to meet the requirements of modern oil and gas facilities. By leveraging case studies from A Plant and B Plant, this work provides insights into the practical implementation and technological advancements in single-loop and dual-loop amine systems.

2. METHODOLOGY

The study employs a combination of computational simulation, comparative analysis, and economic evaluation to optimize amine gas treatment processes at two distinct facilities (A Plant and B Plant). The following steps were undertaken:

2.1. Data Collection

Operational Parameters: Data from A Plant (single-loop system) and B Plant (dual-loop system) were collected, including:

- o Gas throughput rates.
- o Amine solution concentrations.
- o Energy consumption metrics.
- o Process configurations and equipment specifications.

Historical Performance: Historical data on production outputs and energy efficiency were analyzed to establish baseline performance metrics.

2.2. Simulation Tools

HYSYS Software:

- o Used to simulate the amine gas treatment process at both plants.

- o Key parameters modeled included gas flow rates, amine solution dynamics, and system pressure/temperature profiles.

- o Sensitivity analysis was conducted to evaluate the impact of varying operational parameters on performance.

Questor Program:

- o Applied for economic analysis, including CAPEX and OPEX evaluations for system modifications.

- o Detailed cost estimations were generated for transitioning from a dual-loop to a single-loop system at B Plant.

2.3. Process Analysis

Comparative Study: The performance of single-loop and dual-loop configurations was assessed based on:

- o Gas processing capacity.

- o Energy efficiency.

- o Operational flexibility.

Bottleneck Identification:

- o Key bottlenecks in B Plant's dual-loop system were identified, focusing on throughput limitations and solution losses.

2.4. Economic Evaluation

A cost-benefit analysis was performed to evaluate the financial viability of transitioning B Plant to a single-loop system. This included:

- o Estimating payback periods.

- o Calculating annual revenue increases based on additional oil production (25 kbopd at $70 per barrel).

- o Identifying cost-saving opportunities from reduced energy consumption.

2.5. Validation

Verification of Results:

- o Simulated results were cross-checked with existing plant data and industry benchmarks to ensure accuracy.

Peer-Reviewed Literature: Findings were validated against published studies, including works by Akurpekova et al. (2021) and Malik et al. (2005), to confirm the reliability of recommendations.

3. EXISTING AMINE TREATMENT TECHNOLOGY ANALYSIS

Building upon the background provided in the introduction, this section delves into a comparative analysis of two distinct plants, A Plant and B Plant, showcasing their unique design philosophies.

The analysis of amine treatment plants highlights the diversity of design strategies adopted to meet specific operational requirements. A Plant utilizes a single-loop amine configuration prioritizing simplicity and low costs, while B Plant employs a dual-loop system tailored for flexibility and high-efficiency gas processing. These approaches exemplify the adaptability of amine treatment technologies

to address diverse challenges in the oil and gas industry, particularly concerning energy efficiency, environmental compliance, and economic viability.

The review of amine gas treatment plants at A Plant and B Plant reveals distinct design philosophies tailored to their operational needs. The A plant employs a single-loop amine system characterized by simplicity and cost-effectiveness. In contrast, the B plant has adopted a dual-loop configuration, which offers enhanced efficiency and flexibility for processing sour gas with variable compositions. These facilities highlight the adaptability of amine treatment technologies to diverse industrial requirements, setting benchmarks for efficiency, energy consumption, and environmental performance.

1. A Plant - The Single-loop amine unit has one saturated amine loop, and the current throughput is gas 14 MMSCMD at an amine solution concentration of 33%. The Single-loop system has one amine unit. (Akurpekova et al., 2021). This system description has been verified for accuracy.

2. B Plant - The Dual-loop amine unit has two amine units. One line has two loops: saturated and semi-saturated amine. At an amine solution concentration of 40%, the current throughput of one line is gas 9 MMSCMD. (Malik et al., 2005). This system description has been verified for accuracy.

3. Design units at other plants include permanent amine filtration systems, while the facility under study uses a temporary filtration system, which leads to loss of solution and a decrease in process efficiency.

4. In absorbers of other complexes, IMTP packings are used, providing a reduction in pressure drops and preventing foaming, while at the current facility, tray columns are used Akurpekova A.K., Nefedov A.N., et al. (2021).

Description of Single-Loop Amine Gas Sweetening System Diagram (Akurpekova et al., 2021). This system description has been verified for accuracy.

3.1 A Plant - the single-loop amine

With an understanding of the existing amine treatment technologies, the single-loop amine system employed by A Plant is analyzed in detail, highlighting its simplicity and effectiveness in handling consistent gas compositions.

The single-loop amine gas sweetening system, as implemented in the plant A, represents an efficient approach for removing H2S and CO2 from sour gas streams. This configuration utilizes a single saturated amine loop for absorption and regeneration, providing a straightforward and cost-effective solution. Key features include:

- A simplified process flow with reduced equipment and maintenance requirements.

- Optimized amine concentration for effective gas treatment with minimal energy consumption.

- Proven performance in handling consistent feedstock quality.

This system is particularly suitable for facilities prioritizing operational simplicity and economic feasibility.

This system's simplicity makes it easy to operate and maintain, but it may have limitations in handling varying gas compositions or high processing volumes. (Akurpekova et al., 2021).

Below (Fig.1) is the schematic diagram of a single-loop amine gas sweetening system. This diagram illustrates the basic flow of operations with components including an absorber, a regenerator, and pumps. The amine solution circulates in a single loop, providing a straightforward and efficient process for gas sweetening. (Akurpekova et al., 2021). This system description has been verified for accuracy.
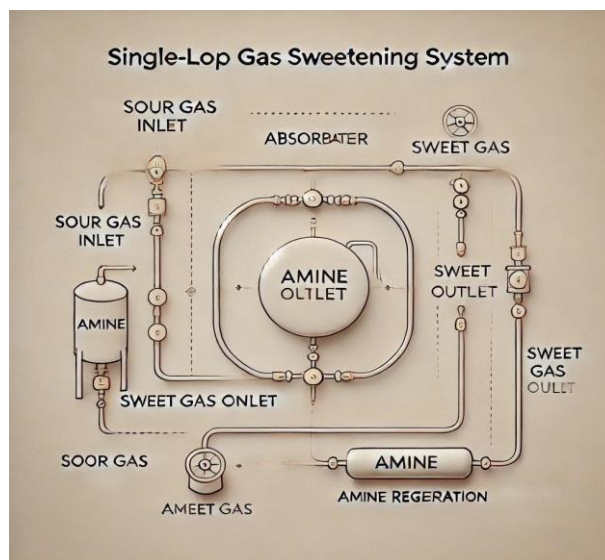
Figure 1. *Single-Loop Schematic diagram*

Practical implementation of a single-loop amine gas cleaning system was carried out in Kazakhstan. The main equipment and piping are shown in Figure 2 using the HYSYS program.
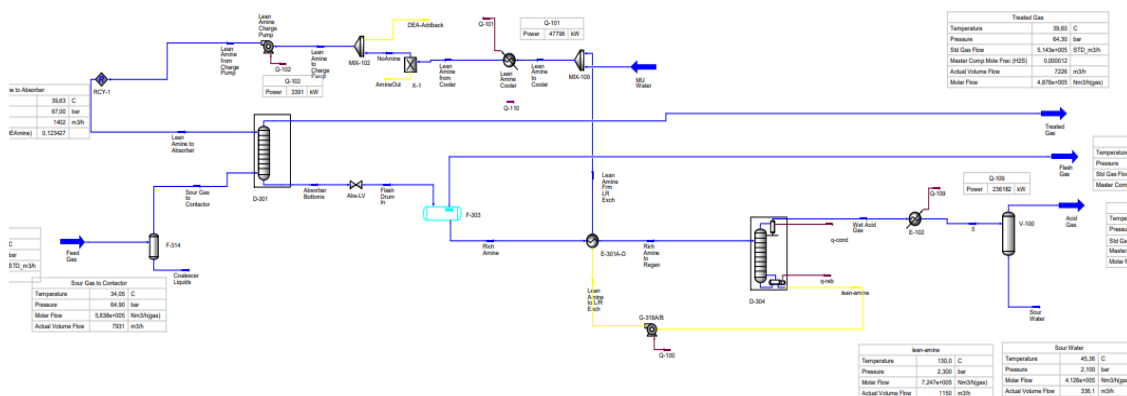

Figure 2. *Existing A Plant Single-Circuit Diagram*

A Plant - Single-Loop System

Design: A single saturated amine loop for absorption and regeneration.

Key Features:

- o Simplified flow with fewer components, reducing maintenance needs.
- o Optimized for consistent gas compositions.
- o Current throughput: 14 MMSCMD at 33% amine concentration.

Performance: Effective for stable operations with limited flexibility for variable gas qualities.

3.2 B Plant - The dual-loop amine

In contrast to the single-loop system, the dual-loop amine system at B Plant is explored, emphasizing its adaptability and advanced capabilities for processing variable sour gas compositions.

The dual-loop system at B Plant represents an evolution in amine treatment technology, designed to manage diverse and variable sour gas streams. Its configuration includes:

- A semi-saturated loop for initial gas treatment to lighten the load on the saturated loop.

- A saturated loop for final cleaning, ensuring high-purity gas output.

- Integrated regenerators and absorbers that enhance system efficiency.

This system offers increased operational flexibility, reduced energy consumption, and the capability to manage high sulfur loads effectively.

This setup reduces energy consumption, improves gas treatment capacity, and handles higher volumes of sour gas effectively. It is particularly beneficial in environments with variable sour gas quality or high production demands. (Malik et al., 2005). This system description has been verified for accuracy.

Below (Fig.3) is the schematic diagram of a dual-loop amine gas sweetening system. This system incorporates two loops: a saturated loop and a semi-saturated loop, allowing for more efficient capture of sour gas components. Key components include absorbers, regenerators, pumps, and pipelines, optimized for industrial gas sweetening processes. (Malik et al., 2005).
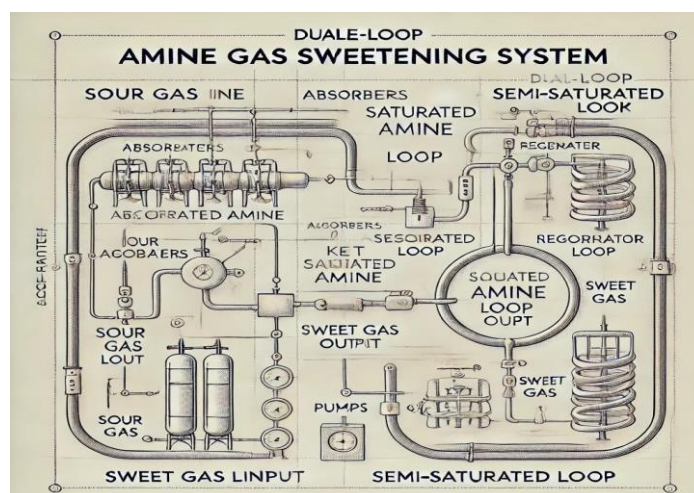

Figure 3. *Traditional dual-loop scheme of amine gas purification*

Practical implementation of a dual-loop or two-circuit diagram amine gas cleaning system was carried out in Kazakhstan. The main equipment and piping are shown in Figure 4 using the HYSYS program.
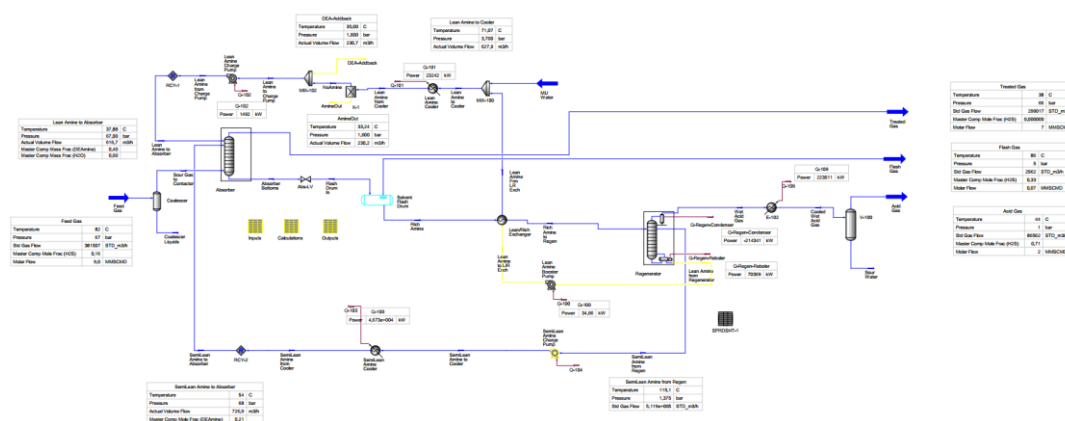

Figure 4. *Existing B Plant Two-Circuit Diagram*

B Plant - Dual-Loop System

Design: Two loops—semi-saturated and saturated—for staged gas treatment.

Key Features:

- Handles variable gas compositions effectively.
- Current throughput: 9 MMSCMD at 40% amine concentration.

Performance: Greater adaptability but increased complexity and potential bottlenecks

The preceding chapters have detailed the operational philosophies, technological advancements, and practical implementations of single-loop and dual-loop amine gas treatment systems. These discussions highlight the advantages and trade-offs of each system, emphasizing factors such as energy efficiency, adaptability, and environmental compliance. Building on these insights, the following chapter delves into the economic implications, evaluating the financial viability of these systems.

3.3 Comparison between A Plant and B Plant

The comparative analysis between A Plant and B Plant reveals fundamental differences in their amine treatment strategies (See table 1.). A Plant achieves maximum gas processing efficiency through a single-loop amine system, which directly contributes to additional oil production.

Table 1. *Comparison Plant A and B*

Feature	A Plant (Single-Loop)	B Plant (Dual-Loop)
Throughput (MMSCMD)	14 (one train)	9 (one train)
Amine Concentration (%)	33	40
Energy Efficiency	Moderate	Higher due to staged loops
Flexibility	Limited	High
Maintenance Needs	Low	High

In contrast, the two-loop amine system at B Plant acts as a bottleneck, limiting daily production increases. Converting the two-loop system at B Plant to a single-loop system could significantly enhance associated gas processing, enabling an equivalent oil production increase of 25 kbopd. This finding underscores the potential for operational and economic improvements through targeted upgrades.

4. ECONOMIC ANALYSIS

In contrast to the single-loop system, the dual-loop amine system at B Plant is explored, emphasizing its adaptability and advanced capabilities for processing variable sour gas compositions.

Calculations of economic efficiency were performed relative to the minimum modification of the amine plant during the transition from a two-circuit purification to a single-circuit one. Calculations for capital (CAPEX) and operating (OPEX) costs were made using the Questor program. The calculation results showed the following data: CAPEX = \$86 million dollars; OPEX = \$72 million dollars. Revenues from additional production in the amount of 25 kbopd amount to \$1.75 million dollars per day at an oil price of \$70 dollars per barrel. Additional production per month and per year amounts to 750 kbopd and 9 MMBY, respectively. Thus, the invested capital investments pay off in the same year. And brings net income annually in the amount of \$600 million dollars.

☐ **Transition Costs:** Converting B Plant to a single-loop system:

- **CAPEX: \$86 million**
- **OPEX: \$72 million**

☐ **Revenue Generation:**

- Additional production: 25 kbopd (\$1.75 million/day at \$70/barrel).
- Annual net income: \$600 million.

☐ **Payback Period:** Within one year.

5. RECOMMENDATIONS

1. **Transition to Single-Loop System at B Plant:**
   - o Expected 25 kbopd production increase.
   - o Simplified operations and cost savings.

2. **Implement Dedicated Amine Filtration:**
   - o Minimize solution loss and improve efficiency.

3. **Upgrade Internal Components of Absorbers:**

   o   Replace tray columns with IMTP packings to reduce pressure drops and foaming.

4. **Optimize Amine Solution Concentrations:**

   o   Tailor concentrations and flow rates for higher absorption efficiency.

5. **Modernize Sulfur Recovery and Gas Dehydration Units:**

   o   Ensure alignment with increased gas volumes.

6. **Leverage Advanced Simulation Tools:**

   o   Use software like HYSYS for continuous performance monitoring and bottleneck identification.

CONCLUSION

This study underscores the importance of adapting technological solutions to the specific needs of oil and gas processing plants. By implementing recommended upgrades at B Plant, substantial economic and operational benefits can be achieved, aligning its performance with best practices observed at A Plant. These measures offer a pathway to sustainable and efficient industry practices.

REFERENCES

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