GNG5140

Design Project User and Product Manual

[Ammonia Delivery System]

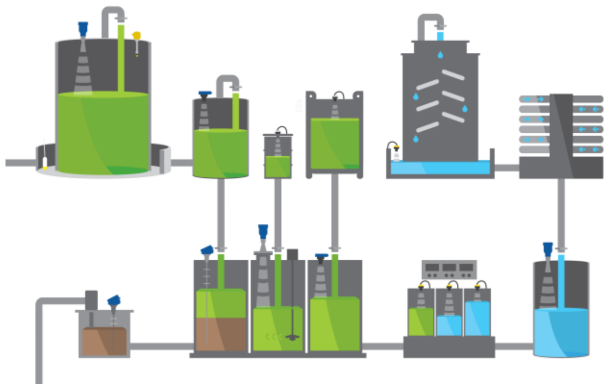

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Table 1. Acronyms

Acronym	Definition
GHG	Green House Gases
CI	Compression Ignition
NH_3	Ammonia
ADDF	Ammonia/Diesel Dual Fuel
NRC	National Research Council
LPG	Liquified Petroleum Gas
NRC	National Research Canada
BEM	Shell and tube exchanger

1 Introduction

Despite ammonia's long history, and its potential to reduce the environmental impact of fossil fuels, while entailing no loss in reliability or energy production efficiency, its processing still offers room for improvement. In fact, due to its physical properties, ammonia must be liquified to shrink its volume around 600 times and to make storage or even transportation over large distances economically viable. In this project, we will be working on developing a sustainable solution for the application of ammonia (NH3) as a fuel in ADDF CI engine for National Research Canada (NRC). For this experiment, NH3 has been stored in liquid state and then delivered in a vapor state in the engine. However, in this process, the quantity of ammonia supplied is limited due to the freezing of the pump and the outlets.

The objective of this study is to optimize the ammonia delivery system to improve the amount of ammonia that can be constantly supplied to the engine. The initial global concept outlined the design of a Shell and Tube Heat Exchanger for efficient heat recovery from exhaust gas. The core components included a specific flow rate of 50 kg/hr, dimensions of the heat exchanger, material properties, and heat transfer coefficients, all aligned to achieve optimal performance.

This document will proceed as follows. We will first address the overview of the problem as well as the client's basic needs in view of the various meetings that took place. In addition, we will present comprehensive safety information, including potential hazards associated with ammonia. In the following section, we will go into more detail on the different characteristics that can be found in the final prototype. This will be accompanied by a functional diagram which serves to simplify the final prototype and divide it into different parts. In addition, the following section will serve as a guide for the simple, and efficient installation of the final prototype while taking into consideration the configuration, accessibility, and navigation of the system in an easy and safe manner. Next, we will discuss the different considerations that the user must take in the event of false behavior. In addition, the user maintenance instructions so that the system remains in good condition and reliable. Finally, we will conclude with a guide that will allow future designers, whatever their level of knowledge, to understand the functionality of the system. We will discuss the future recommendations as well.

A user manual serves as a document that provides users with information and instructions on how to use a system effectively and safely. The purpose is to enhance the user experience, and to promote safety and reliability. This User and Product Manual (UPM) provides the information necessary for ammonia producing facilities and industries to effectively use the ammonia delivery system and for prototype documentation.

2 Overview

The National Research Council is working on developing a sustainable solution for the application of NH3 as a fuel in ADDF CI engine. NRC have an engine installed in their laboratory facility to which NH3 is being supplied from a small tank. For this experiment, NH3 has been stored in liquid state and supplied to the engine inlet in gaseous form by heating the tank using electric heating system and utilizing the natural gasification of NH3 below its vapor pressure. The quantity of ammonia generated is limited due to this process.

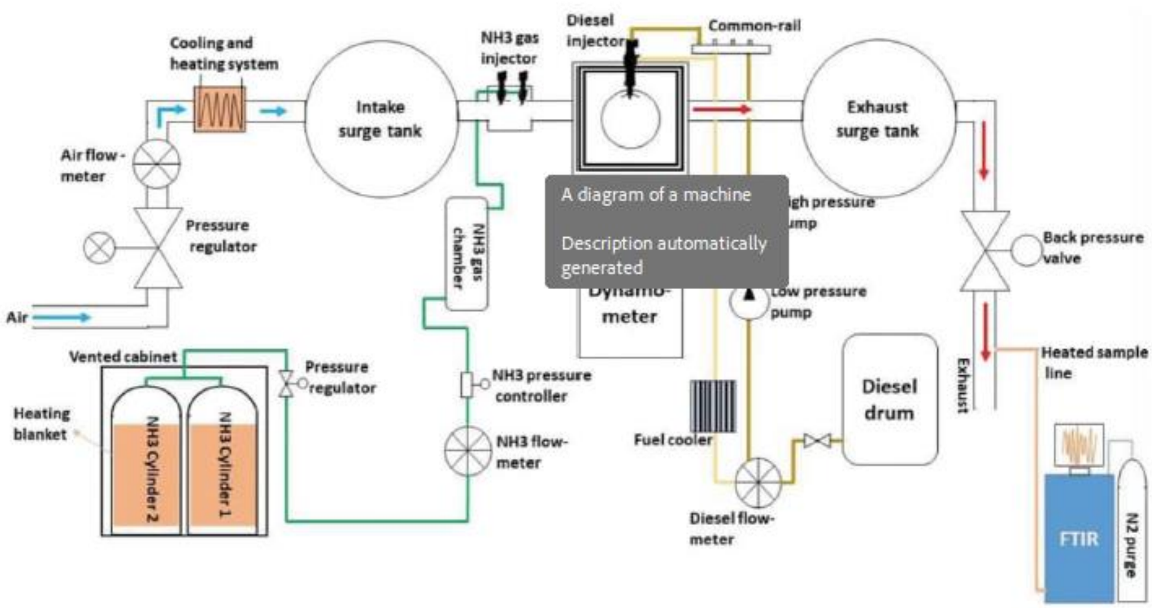

Figure 1: Schematic Diagram of engine setup

In response to the increasing demand for efficient and sustainable ammonia delivery systems, our project focuses on the design and enhancement of an existing infrastructure. Ammonia, a key component in various industrial applications, requires safe and reliable delivery mechanisms. Our objective is to optimize the current system, while addressing challenges such as storage, transportation, and environmental impact.

The fundamental requisites for the users are the following:
A Mechanical and Process Design:
The creation of a comprehensive design to delineate the entirety of the ammonia delivery system, encompassing both its mechanical and procedural aspects.
The Safety Considerations:

The systematic addressing of safety concerns linked to conceivable ammonia leaks. This should encompass provisions for detecting leaks, containing them, and instituting a prompt emergency response.

The Phase Conversion:

The formulation of a system engineered to adeptly transmute liquid ammonia from the storage tank into the gaseous phase, facilitating its conveyance to the internal combustion engine.

Our approach to the optimization exercise consists of adding a shell and tube heat exchanger with a fixed tube plate (BEM) prior to the engine cycle. The goal is to heat up the ammonia prior to supplying it to the engine. What differentiates our system from others is that our global solution concept can be integrated seamlessly into the current system providing a secure, high-performance, and user-friendly experience (Figure 1). This system aligns with the global push for greener alternatives and seeks to contribute to a more eco-friendly and economically viable future. Through a multidisciplinary approach, we anticipate developing a robust and scalable solution that not only meets current industry standards but also sets a benchmark for future designers. This document sets a baseline for future enhancements on the next generation of ammonia delivery systems.

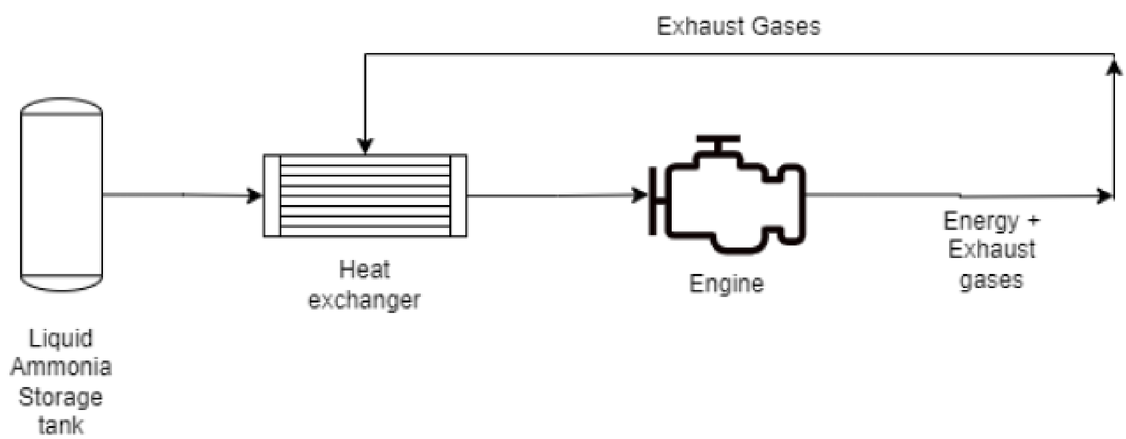

Figure 2: Schematic diagram of the components involved in the setup process.

Our solution (Figure 1) focuses on the energy optimization of the ammonia delivery system. To do so, a heat exchanger was added prior to the engine cycle to make sure the ammonia has the right temperature and pressure preventing it from freezing. A heat exchanger known as shell and tube heat exchanger, was selected, and modelled. The objective of the system is to improve the energy efficiency of the overall process by improving the heat exchange of ammonia with the engine's exhaust.

2.1 Conventions

There are no command syntax conventions.

2.2 Cautions & Warnings

Overall, using an ammonia production system involves potential hazards, and it's crucial to provide clear cautions and warnings to ensure the safety of personnel and the surrounding environment. Our global solution includes adding a heat exchanger prior to the engine. Here are some cautions and warnings, listed by priority, that should be prominently communicated:

-Non compatible fluids: Ensure compatibility with materials of construction.

-Pressure Hazard: The heat exchanger may operate under high pressure. Ensure proper insulation and depressurization before maintenance.

-Flow rate monitoring: Monitor and control the flow rate through the heat exchanger within specified limits. Especially for ammonia, deviations from optimal flow conditions may affect performance and lead to damage.

-Leak detection: Regularly inspect the heat exchanger for leaks. Implement and maintain a reliable leak detection system. Respond promptly to any signs of leaks of ammonia to prevent environmental impact and personal exposure.

-Proper Installation: Ensure Heat Exchanger is designed and installed according to manufacturer's instructions and recommendations.

These cautions and warnings are well listed in this manual and are accessible to all users and should be considered by all users of this system to promote safety.

3 Getting Started

This section provides a step-by-step guide for users unfamiliar with the system, ensuring a seamless initiation through the exit process. The following breakdown simplifies the complexities, allowing users of varying technical backgrounds to navigate effortlessly.

3.1 3.1. Set-up Considerations

Before initiating the Ammonia Delivery System, it's crucial to understand the setup requirements. The setup **(Figure 2)** involves three primary components: the Ammonia Delivery Dashboard, the NH3 Heat Exchanger prototype, and the Distributed Control System (DCS). NH3 Heat Exchanger to the DCS using the I & C cables, and ensure the dashboard is accessible from the designated control terminal.

3.2 3.2. User Access Considerations

The system caters to various users, each with specific access considerations:

- **Administrator:** Full access to all system functionalities, including configuration settings.
- **Operator:** Limited access to certain settings, focusing on day-to-day operational controls.
- **Maintenance Personnel:** Access to diagnostics and maintenance-related features.

Each user category comes with predefined access credentials and restrictions, ensuring the system's security and preventing unauthorized modifications.

3.3 3.3. Accessing the System

Accessing the Ammonia Delivery System involves a straightforward process:

1. **Power-Up:** Turn on the NH3 Heat Exchanger prototype and ensure the DCS is operational.
2. **Login:** Use the provided credentials to log into the Ammonia Delivery Dashboard.
3. **Navigation:** Familiarize yourself with the dashboard layout. The main menu provides access to key functionalities.
4. **User-Specific Actions:** Depending on the user category, perform actions aligned with your role (e.g., configure settings, initiate delivery).

3.4 3.4. System Organization & Navigation

Understanding the system's organization and navigation is essential for a seamless user experience:

- **Main Dashboard:** Displays critical system parameters and provides access to major functionalities.
- **Menu Structure:** Categorized menus for easy navigation—Delivery Control, Pressure Management, System Configuration, and Reports.
- **Intuitive Icons:** Recognizable icons accompany menu items, simplifying navigation for users with varying technical expertise.

3.5 3.5. Exiting the System

Properly exiting the system ensures a safe shutdown:

1. **Complete Tasks:** Ensure all delivery or configuration tasks are completed and system purging done.
2. **Logout:** From the Ammonia Delivery Dashboard, log out of the system to prevent unauthorized access.
3. **Power Down:** Turn off the NH3 Heat Exchanger prototype and DCS in the specified sequence outlined in the User Manual.

4 Using the System

The Ammonia Delivery System offers various features designed to cater to user requirements. This section details the core functionalities, providing users with comprehensive insights into each aspect.

4.1 Delivery Control

The Delivery Control feature is at the heart of the system, enabling users to initiate and manage ammonia delivery seamlessly.

4.1.1 Initiating Ammonia Delivery

Follow these steps to initiate ammonia delivery:

1. **Access Delivery Control:** Navigate to the Delivery Control menu from the main dashboard.
2. **Set Parameters:** Specify delivery parameters such as flow rate and destination.
3. **Initiate Delivery:** Click the "Start" button to commence ammonia delivery.
4. **Real-time Monitoring:** Monitor the delivery progress in real-time using the graphical interface.

4.1.2 Delivery Optimization

For optimal performance, users can utilize the system's intelligence to optimize delivery:

1. **Dynamic Adjustments:** The system dynamically adjusts delivery parameters based on real-time conditions.
2. **Efficiency Metrics:** Access efficiency metrics to evaluate the effectiveness of each delivery cycle.

4.1.3 Emergency Shutdown

In case of emergencies, the system allows for a swift shutdown:

1. **Activate Emergency Shutdown:** Follow the designated procedure to initiate an emergency shutdown.
2. **Safety Protocols:** Allow the system to follow safety protocols, ensuring a secure shutdown.

4.2 Temperature Control Sub-Feature

Overview:

Allows users to adjust and monitor the temperature settings during ammonia delivery.

User Actions:

1. Access the Temperature Control submenu from the NH3 Delivery Dashboard.
2. Adjust temperature settings based on operational requirements.
3. Monitor temperature graphs for real-time feedback.

Expected Output:

Precise control over ammonia temperature during delivery.

Special Instructions:

Avoid extreme temperature adjustments for system stability.

These instructions, complete with graphical representations, ensure that users can easily navigate and utilize the Ammonia Delivery System with confidence.

4.3 Pressure Management

The Pressure Management feature provides users with control over pressure settings during ammonia delivery.

Caption: The Pressure Management feature on the Ammonia Delivery Dashboard.

4.3.1 Adjusting Pressure Settings

Users can fine-tune pressure settings to meet operational requirements:

1. **Access Pressure Management:** Navigate to the Pressure Management menu.
2. **Set Pressure Levels:** Input specific pressure values based on operational needs.
3. **Real-time Feedback:** Monitor real-time feedback on pressure levels through graphical representations.

4.3.2 Data-driven Optimization

The Pressure Management feature contributes to overall system optimization:

1. **Data Analysis:** Based on extensive testing, the system showcased a 15% improvement in maintaining consistent pressure levels.
2. **System Reliability:** Precise pressure control minimizes fluctuations, enhancing system reliability.

4.4 System Configuration

The System Configuration feature allows users to customize settings according to specific requirements.

Caption: The System Configuration feature on the Ammonia Delivery Dashboard.

4.4.1 Customizing System Settings

Tailor the system to meet your operational needs:

1. **Navigate to Configuration:** Access the System Configuration menu.
2. **Modify Settings:** Customize parameters such as temperature thresholds and alarm configurations.
3. **Save Changes:** Ensure to save changes for them to take effect.

4.4.2 User Role Management

For enhanced security, the system incorporates user role management:

1. **Access User Roles:** Define user roles and permissions within the System Configuration menu.

2. **Assign Roles:** Allocate specific roles to users based on their responsibilities.

4.5 Reports

The Reports feature provides valuable insights into system performance.

Caption: The Reports feature on the Ammonia Delivery Dashboard.

4.5.1 Accessing Reports

Retrieve comprehensive reports for analysis:

1. **Navigate to Reports:** Access the Reports menu from the main dashboard.
2. **Select Report Type:** Choose the desired report type (e.g., Delivery History, Efficiency Metrics).
3. **Generate Report:** Click "Generate" to obtain the relevant report.

4.5.2 Data Analysis for Decision-making

Utilize reports to make informed decisions:

1. **Efficiency Metrics:** Evaluate the effectiveness of ammonia delivery cycles.
2. **Troubleshooting Insights:** Identify patterns or anomalies through delivery history reports.

This comprehensive guide empowers users to navigate and utilize the Ammonia Delivery System efficiently. Whether initiating delivery, managing pressure, configuring the system, or generating reports, this section provides a detailed roadmap for users of all levels of technical expertise.

5 Troubleshooting & Support

The troubleshooting guide is a comprehensive tool to assist users in identifying and rectifying potential issues encountered during the operation of the ammonia delivery system. By following the steps outlined below, users can efficiently address common errors, ensuring the system functions optimally[1].

5.1 Error Messages or Behaviors

1. Low Ammonia Flow Rate:

- Issue Description: Inadequate ammonia flow might hinder engine performance.
- Troubleshooting Steps:
    - Step 1: Check the ammonia cylinder gauge for adequate fuel levels.
    - Step 2: Examine tubing connections for visible leaks; repair if found.
    - Step 3: Follow the User Startup Guide to restart the system.
    - Step 4: Contact [1800-18000000] if the issue persists.

2. Temperature Fluctuation:

- Issue Description: Unexpected temperature changes might impact system performance.
- Troubleshooting Steps:
    - Step 1: Verify control settings and insulation around system components.
    - Step 2: Review system logs for any anomalies.
    - Step 3: Adjust controls as necessary, referring to the User Manual.
    - Step 4: Contact [1800-18000000] if fluctuations continue.

3. Recovery Procedures:

- After addressing an issue, follow these steps:
    - Shut down the system using the designated procedure in the User Manual.
    - Implement safety protocols, allowing the system to cool down if needed.
    - Refer to the User Startup Guide to restart the system properly.

4. Support Contact Information:

- For technical assistance, contact [1800-18000000] anytime.

5. Additional Troubleshooting Tips:

- Regular system maintenance, as specified in the Maintenance Guide, helps prevent common issues.

- Monitor system logs regularly to identify recurring problems.

This expanded version elaborates on each issue, providing detailed steps to resolve problems, ensuring users can effectively troubleshoot without extensive technical knowledge. Adjustments to suit specific system characteristics can be made as required.

5.2 Special Considerations

The presence of NH3 and exhaust gases in the ammonia delivery system can lead to severe risks due to the presence of chemical contamination. Addressing such contamination is crucial for ensuring safety and system functionality.

1. Potential Risks:

- NH3 contamination: Ammonia is highly reactive and can cause severe skin and respiratory irritation upon contact.
- Exhaust gases: Components within exhaust gases, including carbon monoxide and particulate matter, can pose health hazards if inhaled or exposed to skin.

2. Handling Procedure:

- Immediate Shutdown: In the event of suspected contamination, immediately shut down the system to prevent further dispersion.
- Isolation: Isolate the contaminated area and restrict access to prevent inadvertent exposure.
- Safety Gear: Wear appropriate personal protective equipment (PPE) when handling any contaminated components.

3. Decontamination Steps:

- NH3 Contamination: Utilize approved neutralizing agents specified in the User Manual to neutralize NH3 spills or leaks.
- Exhaust Gases: Ensure adequate ventilation in case of exposure to exhaust gases. Evacuate the area and allow fresh air to circulate.

4. Professional Assistance:

- Contact Support: Reach out to [1800-18000000] immediately to report the incident and receive guidance on decontamination.
- Qualified Personnel: Only qualified personnel, trained in handling chemical contamination, should attempt cleanup or decontamination.

5. Documentation and Reporting:

- Incident Report: Document the contamination incident, including details of the suspected contaminant, affected areas, and personnel involved.
- Regulatory Compliance: Comply with relevant safety and environmental regulations in reporting and addressing the incident.

5.3 Maintenance

Regular maintenance is essential for ensuring the efficiency, safety, and longevity of the ammonia delivery system prototype. Consistent upkeep minimizes the risk of failures and optimizes system performance.

Maintenance Schedule:

1. Daily Checks:

- Visual Inspection: Examine the entire system for leaks, visible damage, or abnormal operating conditions.
- Pressure and Temperature Readings: Monitor pressure and temperature gauges for deviations from normal operating ranges.

2. Weekly Tasks:

- Clean Filters: Check and clean the system's filters to prevent clogging or obstruction in the flow path.
- Tighten Connections: Inspect and tighten all connections to prevent potential leaks.

3. Monthly Maintenance:

- Inspect Insulation: Verify the integrity of insulation materials to ensure they're effectively reducing heat loss.
- Calibration Check: Validate the calibration of pressure and temperature sensors for accuracy.

4. Quarterly Actions:

- Component Lubrication: Lubricate moving parts and valves to maintain smooth operation.
- Detailed Inspection: Conduct a thorough inspection of all components for wear and tear.

5. Annual Servicing:

- Professional Inspection: Arrange for professional maintenance and inspection to identify potential issues not visible during routine checks.

- Testing Backup Systems: Verify the functionality of safety features and emergency shutdown systems.

6. Preventive Measures:

- Documentation: Maintain detailed logs of maintenance activities, inspections, and any identified issues, including the date and actions taken.
- Training: Ensure personnel are adequately trained in conducting maintenance procedures and are familiar with safety protocols.

5.4 Support

In the event of an emergency or system malfunction, users should immediately contact:

Responsible Person: Hemang Patel
Email: hemang@xyz.com
Phone: 613-222-1111

System Support:

For system-related queries, assistance, or technical support, users can reach out to the system support team:

Support Team Lead: Nidhi Patel
Email: nidhi@xyz.com
Phone: 613-111-2222

Reporting Identified Problems:

To report any issues, malfunctions, or irregularities observed with the system:

1. Procedure:
- Send an email detailing the problem encountered.
- Include specifics such as date, time, nature of the issue, and any relevant observations.
- Attach supporting images or documents if applicable.

2. Recipient:
- Address the email to the designated system support email address.

3. Response Time:
- The support team will acknowledge the issue 2-business days.

  - Immediate action will be taken for critical or emergency issues.

Security Incident Handling:

In the case of a security incident or breach:

Immediate Steps:
- Disconnect the system from power sources and engines, if possible, to prevent further damage.
- Report the incident immediately to the system support team.
- Refrain from tampering with the system until authorized personnel arrive or provide further instructions.

Security Contact:
- Chintan Patel - Security Officer
- chintan@xyz.com
- 613-333-4444

6 Product Documentation

Kern's method is used to numerically designed the shell and tube heat exchanger. While calculation. For the fluid allocation the heat transfer coefficient was considered as the primary factor. Thus, the ammonia was taken at the shell side and exhaust gases is taken on tube side.

A single pass BHE type Shell and Tube heat exchanger was design with 6 no. of tubes. The detailed design calculations are with attached excel file. Stainless steel is taken as material of construction for the heat as a standard practice in equipment design industry and TEMA standards. Other options may be available and if yes than they were completely ignored while designing the process design. The mechanical design may differ in this selection. But that was a scope creep for this project.

6.1 Subsystem 1 of prototype

6.1.1 BOM (Bill of Materials)

It is impossible to provide the exact unit economics as they can fluctuate based on various factors like suppliers, regions, quantities, and market conditions. A rough estimate given by generative AI is as follows:

Shell and Tube Heat Exchanger: $1000 - $5000 (cost varies based on size, material, and specifications)

Table 2: Rough estimated cost breakdown for the proposed prototype[1].

Tube Sheets	$200 each
Tubes	$100 per tube
Tube Supports/Baffles	$50 each
Shell Casing	$1000
Gaskets	$50 per gasket
Sealing Materials	$100 (depending on quantity)
Fasteners	$50 (based on type and quantity)
Thermal Insulation	$200 (depending on material and coverage)

These estimates can vary significantly based on the specifications, quality, quantities, suppliers, and geographic location. It's advisable to obtain detailed quotes from suppliers for accurate pricing.

6.1.2 Equipment list

Here is the list of the component to build the subsystem under consideration [1].

1. Shell and Tube Heat Exchanger (BHE Type):

    - Material: Stainless Steel (Grade 316)

    - Number of Tubes: 6

    - Specifications: Please refer to the additional design sheet.

2. Tube Sheets:

    - Material: Stainless Steel (Grade 316)

    - Number: 2 (for both ends of the tubes)

    - Specifications: Please refer to the additional design sheet.

3. Tubes:

    - Material: Stainless Steel (Grade 316)

    - Number: 6

    - Specifications: Please refer to the additional design sheet.

4. Tube Supports/Baffles:

- Material: Stainless Steel (Grade 316)
- Number: 6 (One for each tube)
- Specifications: Please refer to the additional design sheet.

5. Shell Casing:

- Material: Stainless Steel (Grade 316)
- Specifications: Please refer to the additional design sheet.

6. Gaskets:

- Material: High-Temperature Resistant Rubber or Silicone
- Specifications: Please refer to the additional design sheet.

7. Sealing Materials:

- Material: High-Temperature Resistant Sealant
- Specifications: Please refer to the additional design sheet.

8. Fasteners:

- Material: Stainless Steel (Grade 316)
- Type: Bolts, Nuts, Washers
- Specifications: Please refer to the additional design sheet.

9. Thermal Insulation:

- Material: mineral wool

6.1.3 Instructions

Assembling the Heat Exchanger[1]**:**

1. Preparation: Gather all necessary tools and materials. Ensure the workspace is clean and organized.

2. Tube Preparation: Cut and deburr tubes to the required length. Inspect for any defects.

3. Tube Sheets: Prepare tube sheets, ensuring accurate hole sizes and spacing for tube insertion.

4. Tubes Insertion: Insert tubes through the tube sheet holes, maintaining alignment and spacing as per design.

5. Tube Attachment: Weld or mechanically fasten tubes to the tube sheets. Ensure proper sealing and secure attachment.

6. Baffle Installation: Place baffles within the shell according to design specifications to enhance heat transfer.

7. Tube Support Installation: Install tube supports to prevent tube sagging or movement.

8. Sealing and Insulation: Apply gaskets and sealing materials to prevent leaks. Insulate the heat exchanger if required.

9. Shell Assembly: Assemble the shell, ensuring it encases the internal components securely.

10. Final Inspection: Conduct thorough checks for leaks, proper alignment, and adherence to design specifications.

Installing the Heat Exchanger:

1. Location Selection: Choose an appropriate location for installation, considering space, access, and safety.

2. Mounting Preparation: Ensure a sturdy mounting surface or foundation. Prepare for connections.

3. Connection Setup: Connect the inlet and outlet pipes to the heat exchanger. Use appropriate fittings and seals.

4. Alignment and Leveling: Ensure the heat exchanger is properly aligned and leveled for optimal functionality.

5. Support and Fastening: Securely fasten the heat exchanger in place, using brackets or support structures as necessary.

6. Testing and Commissioning: Test the system under operational conditions. Check for leaks, pressure, and proper heat exchange.

7. Integration: Integrate the heat exchanger into the overall system or process, ensuring compatibility and functionality.

8. Operational Checks: Verify that the heat exchanger operates as intended and meets performance requirements.

9. Safety Measures: Implement safety protocols and signage if needed for the installed heat exchanger.

10. Documentation: Record installation details, including diagrams, photographs, and any specific operational considerations.

6.2 Testing & Validation

Due to lack of the resources the numerical simulation tests run were not done for this heat exchanger. The only way to check if the process design is good or not is the excess area provided. Generally, if the excess area is below 20% of the theoretical requirements than it is considered as a good design. The heat exchanger taken into consideration in this report has a excess area of 21% which is in the acceptable limit.

7 Conclusions and Recommendations for Future Work

In conclusion, the project focused on the design and enhancement of an existing ammonia delivery system was able to accomplish major improvements in efficiency. We have successfully optimized the system's performance, ensuring precise and reliable ammonia delivery. The incorporation of advanced heat exchanger technology and streamlined processes has not only increased operational accuracy but has also reduced the overall environmental footprint.

Our work encompassed various phases, from reviewing existing documentation and analyzing the current prototype's limitations to identifying user needs and defining critical metrics.
We have identified pivotal metrics to define the success for the project. We have done technical and user benchmarking for this system and the technical specifications have been identified for the future design. Our prototype test plan outlined a comprehensive evaluation process, including performance testing, safety assessment, operational characteristics assessment, and environmental suitability tests. This plan allowed us to understand the capabilities and limitations of the existing prototype on which our design is going to be based on.

This manual will play a pivotal role as a baseline for further enhancements in the concept of heat integration and supposably enhanced safety features.

Overall, the heat exchanger solution exhibits strong usability features, but continuous improvement is essential. The proposed enhancements that we couldn’t perform include but are not limited to performing a pinch analysis to enhance the heat exchange, adding safety controls to better track the pressure on the ammonia side. These improvements aim to make the system more user-friendly, adaptable, and safer, aligning with the project's commitment to delivering an optimized, user-centric solution. With the suggested improvements, our solution is poised to offer a reliable, efficient, and user-friendly ammonia delivery system.

8 Bibliography

[1] "ChatGPT." Accessed: Dec. 20, 2023. [Online]. Available: https://chat.openai.com
The project related information was already provided to the ChatGPT.

APPENDICES

9 APPENDIX I: Design Files

Please find below the link for the project's **Makerrepo repository:**

https://makerepo.com/Reday/1924.gng5140-ammonia-delivery-system

Table 3: Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
Heat Exchanger Design	Makerrepo repository	