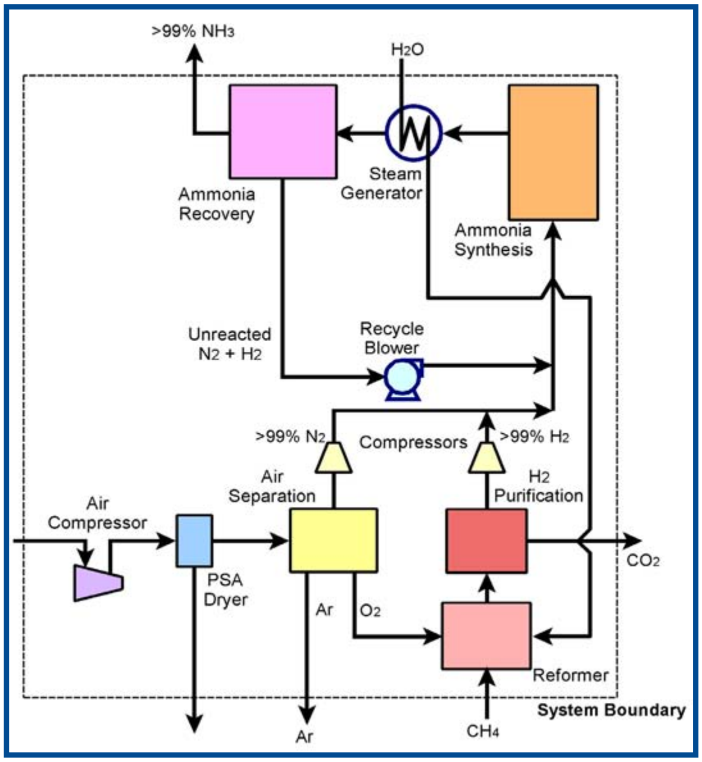
Ammonia Production Using Pressure Swing Adsorption

Use of Pressure Swing Adsorption for Reactant and Product Purification Will Reduce Natural Gas Feedstock and Process Energy Consumption

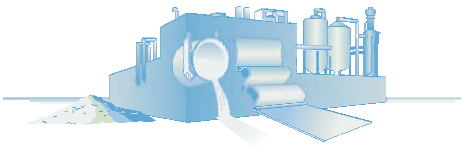
Pressure swing adsorption (PSA) technology enables the energy-efficient recovery of specific compounds from a gas under pressure. At high pressure, gas molecules are preferentially adsorbed onto the adsorbent material depending on their molecular characteristics and affinity for the adsorbent; when the pressure is lowered, the adsorbed molecules are released (desorbed). PSA is currently used for the production of relatively pure oxygen or nitrogen from air and other applications in the petrochemical and gas industries.

Researchers are developing an ammonia production process that will incorporate PSA for recovery of ammonia from the product gas and purification of the process reactants, nitrogen (from air) and hydrogen (from steam methane reforming, SMR). Current ammonia processes react air and syngas (gas mixture of nitrogen and hydrogen) to form ammonia which is recovered via energy-intensive refrigeration and condensation. The new approach will increase ammonia yield and reduce natural gas feedstock and fuel consumption. Improved process heat integration will further reduce energy consumption of the new process and enable generation of excess steam.

The improved ammonia process will find application in the U.S. chemical industry, which produced 23.7 billion pounds of ammonia in 2004. Ammonia is also used at power plants in selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) system which reduce NO_x and CO_2 emissions. The new process will be scaleable and enable on-demand ammonia production.



Process schematic for ammonia production using pressure swing adsorption.



Benefits for Our Industry and Our Nation

The improved ammonia process utilizing pressure swing adsorption will help reduce energy consumption and costs. The estimated energy savings by 2030 are in excess of 7 trillion Btu. At power plants and other facilities that use ammonia in their SCR and SNCR systems, the scaleable, on-demand process will also eliminate the need to transport and store large amounts of ammonia, helping to improve worker and plant safety.

Applications in Our Nation's Industry

Ammonia is primarily used in agricultural fertilizers and production is strongly tied to that sector. In addition, it is used in NO_x-reducing technologies that are used in combustion applications across the industrial and power generation sectors to meet stringent air quality requirements. Ammonia has been ranked within the top fifteen chemicals produced in the United States for over thirty years.

Project Description

The overall objective of the proposed project is to develop and demonstrate a technically feasible and commercially viable system that integrates reaction to produce ammonia along with recovery of the products by adsorption separation methods and significantly decrease the energy requirement in ammonia production.

Barriers

- Development of PSA technology that is optimized for ammonia recovery
- Improvement of the PSA nitrogen purifier unit performance
- Pilot-scale demonstration of the improved ammonia production process

Pathways

The following key goals have been developed to achieve the project's objective:

- Design the ammonia recovery system by pressure swing adsorption
- Investigate to determine and select the demonstration process conditions which support recovery of ammonia (without the need for refrigeration compressor work requirements).
- Design, build, and test integrated pilot scale unit that demonstrate the performance needed for a commercial process.
- Perform economic analysis and compare the expected capital and operating costs of the ammonia process to conventional processes.

Progress and Milestones

This project started in September 2006.

- Phase 1 – Proof of concept to determine viability of the overall system. This includes setting up initial bench-scale experiments to determine potentially suitable adsorbents and a comprehensive economic analysis (completed)
- Phase 2 – Validation of simulation results for ammonia recovery; and more in-depth determination of the adsorbent stability, life span, and performance, as well as further economic analysis of the adsorbent for the operating conditions. (completed)
- Phase 3 – Set up integrated bench scale or pilot prototype and run it for a period of time to demonstrate the units operating together and conduct a comparative economic analysis using the test results.
- Phase 4 – Application of technology to real power plant and how it can be transferred to potential users.

Commercialization

If Phase I and Phase II are successful, then a field demonstration will take place by operating an ammonia system in an existing power plant. After the technology is demonstrated to be commercially viable, the team will transition the technology for industrial use through a strategic alliance with selected potential end-users, while ensuring that the appropriate technical and economic targets are met.

Project Partners

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Other partners are:

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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

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Bringing you a prosperous future where energy is clean, abundant, reliable and affordable

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