An ammonia plant saves millions annually with a few medium-term measures.

By Ven V. Venkatesan, Energy Columnist

Feb 07, 2013

An ammonia fertilizer plant in Oklahoma evaluated its steam system and found important energy-savings opportunities that could reduce energy use, costs, emissions and improve productivity. Here is their success story.

“Plant management consistently encouraged efforts to improve energy efficiency.”

The highly integrated manufacturing site includes two plants that produce a total 2.2 million tons of urea ammonium nitrate solutions and 1.1 million tons of ammonia per year. The plant requires significant amounts of natural gas to make hydrogen. In 2006, the U.S. Department of Energy (DOE) sponsored the initial assessment to identify opportunities to improve the plant's steam system efficiency and reduce natural gas consumption. Natural gas cost around $7/MMBtu during the assessment and implementation period.

ASSESSMENT RECOMMENDATIONS

The DOE assessment identified potential energy-savings opportunities and categorized them as near-term, medium-term, and long-term, depending on expected energy savings and payback periods.

1. Recover flash steam from blowdown water (near term). After flashing to a low-pressure header, a substantial amount of blowdown water was still sent to a cooling tower at 50 psig and 300°F. About 1,200-lb/hr of additional flash steam from blowdown water could be routed directly to the deaerator with an estimated savings of $105,000 per year.

2. Implement a steam trap maintenance program (near term). A partial steam trap audit identified that some steam traps were poorly positioned and some weren't even operating. Adopting better trap installation techniques and maintaining the existing steam traps could result in estimated annual savings of $86,000.

3. Modify synthesis loop (medium term.) The existing synthesis loop in Plant No. 2 was operating inefficiently, requiring large amounts of high-pressure steam. Reversing the circulation in the ammonia condensing loop could improve the plant's efficiency by 0.4% and reduce demand for high-pressure steam by 20,000 lb/hr. Estimated energy cost savings: $1.9 million/year.

4. Upgrade turbine (medium term). Plant No. 2 uses two back-pressure turbines, letting down 545-psig steam to the 50-psig steam header that continually vents excess 50-psig steam. Replacing those turbines with condensing ones would reduce high-pressure steam demand and low-pressure venting. This change would yield an annual energy cost savings of $1.2 million.

5. Improve operation of condensing turbines (medium term). The vacuum in the surface condensers of the condensing turbines in Plant No. 1 is maintained between 24-in. and 26-in. Hg, depending on the season. Installing an absorption chiller powered by low-level waste heat to lower the cooling tower water temperature and increase vacuum by 0.5-in. Hg could save $1.2 million per year.

6. Build a high-pressure natural gas pipeline (long term). The local utility delivers natural gas to the plant at 185 psig, while its main grid moves gas at pressures exceeding 600 psig. Because the plant compresses natural gas again (to 550 psig) for its processes, obtaining high-pressure (HP) natural gas directly by connecting to the HP pipeline, which is a couple of miles away, could save an estimated $6 million per year.

7. Improve efficiency of auxiliary boiler (long term). The assessment found the efficiency of the auxiliary boiler in Plant No. 1 could be improved by reducing the stack temperatures from 400°F to 320°F. Installing an air preheater on the boiler's stack could recover some of its heat and save $945,000 annually.

If all measures are implemented, the estimated annual energy cost savings would total about $11.5 million.

RESULTS

Plant management has consistently encouraged efforts to improve energy efficiency. So, when the assessment uncovered and quantified such opportunities, plant personnel didn't hesitate to implement two of the medium-term recommendations (3 and 4 above).

In addition, the plant hired a consultant to audit and repair broken or poorly functioning steam traps, and purchased an infrared leak detector to locate and repair steam leaks. All implemented measures saved approximately $3.5 million through December 2008. Total implementation cost just over $3.1 million, giving a simple payback of less than 11 months.

Next month's column will examine a petrochemical plant's efforts to save energy costs.

Implementing two near-term measures saves a petrochemical plant millions

By Ven V. Venkatesan, Energy Columnist

Mar 13, 2013

In 2005, a Michigan-based global petrochemical company that manufactures diverse products ranging from plastics to specialty chemicals established a goal of improving its energy efficiency by 25% by the year 2015. To meet these goals, employees at the company's Louisiana site were well aware they needed to act decisively to control energy waste. This column highlights their successful efforts.

"To meet corporate goals, employees were well aware they needed to act decisively."

POTENTIAL PROJECT AREA

Steam is the most significant energy utility at the Louisiana site. The site produces steam for distillation, evaporation, concentration, process heating and catalytic cracking, besides electricity generation. Plant personnel, in conjunction with the U.S. Department of Energy (DOE), conducted a steam system energy savings assessment. The DOE's steam system assessment tool (SSAT) identified seven energy-savings opportunities and evaluated "what if" implementation scenarios for optimal energy savings. Natural gas cost $7.25 per MM Btu during the assessment period.

Four of the energy-savings opportunities were classified as near-term opportunities and are briefly described below.

Implement a steam trap repair project. A recent steam trap survey identified all failing steam traps. Entering the number of failed traps at the different pressure headers into the SSAT and modeling the impact of implementing a steam trap repair project generated an accurate estimate of steam leakage stemming from the failed traps. Annual savings in natural gas and costs were estimated to be 112,128 MMBtu and $881,000, respectively.

Increase condensate recovery. At the time of the assessment, only about 50% of steam condensate was recovered from the low-pressure (LP) steam users. Based on analysis of LP steam users that are mixing steam directly with the process, about 80% of the LP steam use at the entire site was recoverable. A condensate recovery rate of 75% is possible by fixing issues such as excessive back pressure in return lines and failed condensate pumps. The increased condensate recovery would result in an estimated natural gas and cost savings of 87,600 MMBtu and $649,000.

Improve insulation. A plant inspection pinpointed several areas of the steam distribution network that lacked sufficient insulation. Using 3EPlus, DOE's insulation calculation program, the team estimated total insulation losses to be approximately 1%. By reducing these insulation losses to 0.1%, the assessment showed that annual natural gas and cost savings of 3,030 MMBtu and $25,000 could be achieved.

The fourth near-term opportunity was to fix the observed steam leaks.

Three other savings opportunities — ones classified as medium term — also were identified:

Install a blowdown heat recovery exchanger. Although the blowdown water from the high pressure boilers was sent to a flash tank to recover LP steam, draining the blowdown water resulted in the loss of significant amounts of thermal energy. Installing a heat recovery exchanger upstream of the blowdown tank could recover substantial heat from the blowdown water and could be used to preheat boiler makeup water. The assessment estimated annual natural gas and cost savings at approximately 31,000 MMBtu and $200,000.

Preheat reactor feed with 75-psig steam. The assessment found that some of the heat needed to preheat the reactor feed from ambient to reaction temperatures could be supplied by 75-psig steam instead the 600-psig steam generated at the site. While this opportunity wouldn't save natural gas, it would allow additional electricity generation from the 600-psig steam that wasn't being used to preheat the reactor feed. This could reduce electricity purchases, leading to estimated annual electricity and cost savings of 1,277 MWh and $79,000.

Install a back-pressure turbine drive: Although the site generates steam at 600 psig, most applications require steam at 200 psig. Installing a back-pressure turbine drive could generate enough electricity to serve some of the plant's specific critical powered equipment. Annual electricity and cost savings were estimated at 1,946 MWh and $121,000.

Site management implemented two of the four near-term measures. The steam trap retrofit resulted in an annual energy savings of 109,000 MMBtu and energy cost savings of approximately $792,000. The steam leak repairs provided an annual energy savings of 163,000 MMBtu, worth a little more than $1.1 million. Total annual energy and energy cost savings were 272,000 MMBtu and $1.9 million, respectively. With total implementation costs of approximately $225,000, simple payback was slightly more than six weeks.

Waste heat can provide cooling via ammonia absorption refrigeration.

By Ven V. Venkatesan, Energy Columnist

Apr 10, 2013

Plant engineers generally believe their site's process heating and cooling systems are optimally designed. Often, they hesitate to respond to any opportunity to recover additional heat from existing processes. However, they typically welcome additional cooling that could help the process, such as from an absorption refrigeration system using wasted low-level heat. Generally, low-level heat from process streams is rejected to atmosphere either through air-fin coolers or cooling towers. It's also common to find flash steam rejected at low pressure levels. Absorption refrigeration converts this waste heat into high-value refrigeration duty.

A multinational chemical company in Illinois that produces p-xylene, a commodity chemical commonly oxidized to terephthalic acid (PTA) and further refined to produce purified terephthalic acid, successfully added absorption refrigeration to its process to achieve energy efficiency. A fact sheet from the Office of Industrial Technologies, Energy Efficiency, U.S. Department of Energy goes into detail on what was done. Here're the highlights.

Recovery of p-xylene generally involves one of two competitive processes, namely, low-temperature crystallization and selective adsorption on a molecular sieve. When using low-temperature crystallization, approximately 60% of the total electricity consumed is used to run the refrigeration system, mostly with conventional compressors. The refrigeration system typically uses cascaded ethylene and propane or propylene refrigeration loops.

Ammonia absorption refrigeration can replace the propane or propylene loop, leading to savings of approximately 37% of the total electricity use or 19% of the total energy cost. The reduced electricity consumption also results in lower indirect CO2 emissions associated with electricity generation. Absorption refrigeration requires two units of heat input per one unit of refrigeration duty. However, the heat source for absorption refrigeration is free, because the low-temperature waste heat would be lost if not used.

Absorption refrigeration operates with high- and low-pressure regions, and also with vapor and liquid regimes. Ammonia evaporated at low pressure creates the refrigeration. The evaporation pressure determines the temperature, which can drop to as low as -45ºC. To reach this low temperature, multiple refrigeration loops are applied in a cascaded manner. Absorption refrigeration is suitable for the crystallization of p-xylene and ethylene condensation (earlier stages of the cascaded loops).

The use of waste heat reduced the electricity consumption of p-xylene units by 30 to 40%, depending on the feedstock and the p-xylene recovery process. For a 400 KMTA (thousand metric tons per annum) p-xylene unit, estimated annual electricity savings are 4.5 megawatts, while reductions in indirect CO_2 emissions are estimated at 41 KMTA.

Progress and Milestones

To ensure success, the project occurred in four stages:

1. Technical feasibility determination: A quick study by waste heat recovery experts and refrigeration system vendors revealed the technical feasibility and economic incentive of adding an absorption refrigeration system to the existing refrigeration loops. Generally, this step involves matching the available low-level heat to the process cooling or chilling needs upon converting through an absorption refrigeration cycle. An estimate of economic benefits and the preliminary project cost at this stage will help management decide to move forward.

2. Design development: Several options considering the field conditions of the existing set up of cooling loops were reviewed to select the optimal design for enhancing the performance of the cooling loops and the recovery of p-xylene. This step provides a better definition of project scope, helping management to decide to proceed further.

3. Detailed engineering design: Once the project scope is defined clearly, the plant obtained a design package with all necessary engineering details and firm quotes from vendors for the commercial unit and its auxiliaries. A more accurate economic analysis at this stage helps the management to allocate necessary funds and financial authorization to move forward.

4. Project execution phase: Relevant in-plant personnel, who worked with partners to procure project components and construction contractors to complete the project within the cost and time, were given project management responsibility.

Gate reviews were conducted at the end of each stage before passing to the commissioning and operational phase. Upon successful completion, this multinational chemical company is considering commercializing this process. For further details on this specific project, contact Dickson.ozokwelu@ee.doe.gov.