Anhydrous Ammonia Considerations for SCR Reagents

By Shannon McAvoy, Colorado School of Mines

Environmental legislation has caused many utilities and heavy industries to implement new NO_x reduction technology. One option to comply with these regulations is a SCR (selective catalytic reduction) which can reduce NO_x by 90 percent. The SCR operates by injecting ammonia into the flue gas upstream of the catalyst. The ammonia and NOx react in temperatures between 550 to 750 F with the catalyst to form nitrogen and water vapor.

There are several options of ammonia reagents that can be used in an SCR: anhydrous ammonia, aqueous ammonia or urea. For capital and operations and maintenance (O&M) costs typically, anhydrous ammonia is the most cost effective option, followed by 29 percent aqueous ammonia, 19 percent aqueous ammonia and urea.

Aqueous ammonia solutions are not as cost effective or efficient as anhydrous ammonia but they are safer for transportation and use. The solution must be hydrolyzed before it can be used in an SCR application. This requires additional equipment, steam and electricity attributing to the additional costs. A greater volume of the reagent is necessary to achieve the same NO_x reduction because of the additional water. By removing the water, aqueous solutions are converted back to anhydrous ammonia.

Twenty-nine percent aqueous ammonia is regulated and will require a Program 2 risk management program (RMP) if more than 20,000 lbs. are stored onsite. Currently, 19 percent aqueous ammonia is not regulated.

Urea is the safest ammonia reagent however it requires conversion to ammonia through thermal decomposition in order to be used in an SCR. Urea is generally the most costly reagent because the thermal decomposition requires sustained high temperatures and additional equipment within an enclosed area. At times when anhydrous ammonia is not feasible, urea may be the lowest cost alternative compared to an aqueous solution (this would be typical of large scale facilities).

Anhydrous ammonia is the most cost effective and efficient reagent because no additional equipment is needed to convert it for use in an SCR application and less volume of reagent is needed because it is pure ammonia.

However, anhydrous ammonia is a toxic chemical that has the potential to be lethal. It is therefore regulated by 29 CFR 1910, 40 CFR 68 and 6 CFR 27. Each of these regulations has a governing agency: Occupational Safety and Health Administration (OSHA), Environmental Protection Agency (EPA) and Department of Homeland Security (DHS), respectively.

OSHA requires a process safety management plan (PSM), EPA requires a risk management plan (RMP) and DHS requires compliance with chemical facility anti-terrorism standards (CFATS). This is only necessary if anhydrous ammonia is stored onsite in quantities greater than 10,000 lbs.

The PSM/RMP is a combined plan for anhydrous ammonia because several aspects of each plan overlap with each other. This document includes information pertaining to employee participation, process safety information, process hazard analysis, operating procedures, training, contractors, pre-startup safety review, mechanical integrity, hot work permit, management of change, incident investigation, emergency planning and response, compliance audits, off-site consequence analysis, five-year accident history and registration for the facility (for EPA data submitting through RMP*eSubmit). This plan is reviewed and updated every five years and refresher training on the process and associated chemicals be performed every three years.

For Homeland Security and CFATS a Top-Screen procedure is completed. Anhydrous ammonia is listed in 6 CFR 27 Appendix A: Chemicals of Interest List. To determine if a facility meets the requirements of the CFATS a Chemical Security Assessment Tool was created, Top-Screen.

To complete the Top-Screen, it is necessary to register with DHS to gain access. Preferably three people, a "preparer," "submitter" and "authorizer," complete the Top-Screen process. The preparer enters the data into the CSAT system and sends the Top-Screen to the submitter. The submitter can revise and submit the information to DHS. The authorizer provides assurance to DHS that the submitter and preparer were authorized to complete the information.

The questionnaire should be completed within 60 days of gaining access to Top-Screen. DHS will designate the facility with a preliminary tier level (levels are labeled 1 to 4 with 1 being the highest security risk) after reviewing the Top-Screen. After the preliminary tier level is distinguished several additional plans must be submitted.

The security vulnerability assessment (SVA) collects facility identification information, information about the chemicals onsite and information on assets pertaining to the chemical of interest. The tool provides information on possible terrorist attack scenarios which is then used to identify necessary security measures.

After reviewing the SVA, DHS will designate a final tier level. After the SVA is submitted, a site security pan (SSP) or alternative security plan (ASP) must be submitted. The SSP details information for the facility, information on security measures for the entire facility, and security measures for particular assets.

DHS has been prohibited from denying an SSP due to the presence or absence of a particular security measure. Security measures that are implemented must demonstrate a standard of reliability according to the specific tier level. These standards are outlined in the risk-based performance Standards set by the DHS.

The ASP must address each security/vulnerability issued identified in the SVA and how the security measures in place address the risk-based performance standards and potential terrorist threats. DHS can approve an ASP in whole or in part, or subject to revisions or supplements. After the necessary reports are submitted and approved, a letter of authorization will be sent to the facility.

How DHS specifically determines the tier level for each facility is classified. DHS does consider the consequence, vulnerability and threat that pertain to each facility. Anhydrous ammonia is flagged in Appendix A because if released it is toxic.

Several aspects should be considered when anhydrous ammonia is evaluated for a particular site. How many people will be impacted by a release? What environmental receptors will be affected? How can the facility be attacked? What is the worst-case release scenario if anhydrous ammonia is released? How will the facility respond to a toxic release? What redundancies can be used to render the chemical non-hazardous? What security measures are necessary to deter a threat? Why would this particular facility be attacked? What liability will be assumed if anhydrous ammonia is used?

If the answers to these questions create a scenario of minimal consequence for the surrounding area, limited vulnerabilities for the facility, and a reasonably minor threat level is expected, then it may be necessary to evaluate to cost differences between anhydrous ammonia, aqueous ammonia and urea for the facility in question, including the cost of additional safety and security; not just capital and O&M expenditures.

Typically, some have avoided anhydrous ammonia because of the PSM/RMP and DHS requirements, but for an 85 percent NO_x reduction in a 500 MW coal-fired unit costs savings from the reagent alone are greater than $1 million annually when compared with 19 percent aqueous ammonia. The cost savings increase dramatically as unit size increases.

In many cases, anhydrous ammonia may be the most efficient and cost-effective option even after additional costs are added as a result of regulations for additional safety and security precautions. Anhydrous ammonia may need to be evaluated by many utilities as a result of emission regulations. pe

Gasification Offers a Cleaner Coal Solution

By Jeffrey Goldmeer, Ph.D, Fuel Flexibility Manager, GE Energy

The use of coal for power generation presents a dilemma: how to create energy from this abundant, fairly inexpensive resource without releasing high levels of carbon dioxide (CO_2) into the atmosphere. A way to resolve that dilemma is with a technological one-two punch: an integrated gasification combined-cycle (IGCC) process to convert synthesis gas (syngas) into essentially carbon-free, high-hydrogen (H_2) fuel and advanced syngas turbines to efficiently convert the hydrogen to power.

There are several reasons why coal is becoming more attractive. Other conventional fuels are costlier, subject to volatile price shifts and vulnerable to supply disruptions caused by political instability; recoverable oil reserves are dwindling; and competition for resources is growing. Moreover, coal is plentiful, with many countries relying on it for their own power—including China and the U.S. (which generates half of its electricity from coal)—while others, such as Australia, have surplus coal they export.

But compared to natural gas—the other primary alternative to oil—coal has two disadvantages: its uncontrolled carbon emissions are more than twice as high as those from natural gas and coal-to-energy technologies are less efficient. Climate change is ramping up the pressure to cut greenhouse gas (GHG) discharges, so governments are implementing regulatory and tax policies to control carbon. To generate the cleaner, more affordable and more secure energy the times demand, formulation for commercial application of the CCS-64X product platform (See Figure 1).

The decrease in efficiency at Stoich 1.4 resulted from exceeding design capacity of the nozzles by more than 200 percent to achieve the highest Stoich with the existing pump system. Despite the undetermined chemical waste caused by high flows, an SO_2 reduction of 45 percent was still achieved. The dosage was then reduced to 10 gpm, 7 gpm and 0, resulting in an upward trend of SO_2 readings back to the baseline. This data reiterates the importance of droplet size for performance efficiency. Product utilization was determined to be greater than 60 percent throughout the demonstration.

PCC Results: With all the feed going through the two over fire air ports at 1.3 stoich, a reduction of 56 percent was achieved. The economics of removing SO_2 from the furnace are improved since the removal efficiency is so high. For example, to remove 70 percent SO_2 using a DSI system in the back end with trona only and an electrostatic precipitator collection device, the stoich levels will be five to six time times NSR. To remove this from the furnace would be 1.9 to 2 times NSR with CCS-64X.

EES and ECI are working on improved nozzle design and a hybrid sorbent injection scheme that incorporates both furnace sorbent injection and direct sorbent injection to meet the U.S. Environmental Protection Agency's Cross State Air Pollution Rule requirements. EES is targeting SO_2 reduction costs to be in the range of $400 to $600/ton SO_2 removed. pe

Small Bearings at Concentrated Solar Plants

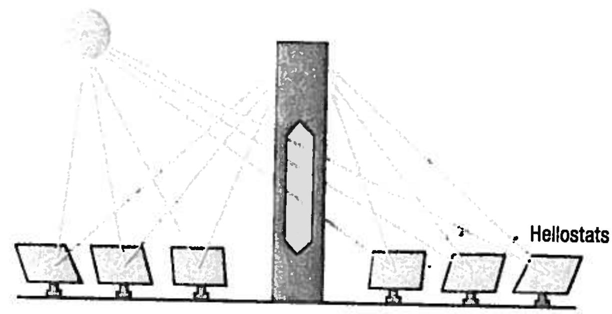
By Janaki Weiden, Global Market Manager, Solglide

Solar energy is a huge and important trend. And it is infinite and free, with the total amount of energy irradiated from the sun to the earth's surface each year providing enough for annual global consumption 10,000 times over. The benefits of solar power are both compelling and obvious, from reducing carbon emissions to providing a sustainable energy source.

So what makes the huge solar power trend work? Small parts, of course. To meet the ongoing demand for energy, it is crucial to continually enhance the longevity of the concentrated solar power (CSP) plant. The small parts that make up these large plants help to keep the applications maintenance free, long lasting and moving efficiently, extending overall facility life and productivity.

The key for any CSP plant is bearings, devices designed to reduce friction between two parts in motion, which saves energy by facilitating movement. There are many bearing options and the choice of bearings can have a major impact on plant productivity. The wrong technology could cause CSP plants to need continuous maintenance over the years, adding additional costs and uncertainty. The right technology can enable rapid scale-up to keep up with the booming solar industry, ensure minimum maintenance and keep the amount of energy to power the technology low, keeping plants running efficiently over the coming years.

FIGURE 2 POWER TOWER



Part of the Puzzle

Small parts play a huge difference in a technology's success, evidenced by the role bearings play in CSP plants. Solar power is produced by collecting sunlight and converting it into heat and finally electricity. This is done through the use of tracking structures equipped with flat or curved mirrors to concentrate the sunlight in a focused point or line.

In order to achieve the high temperatures required, solar radiation must be concentrated. Parabolic trough collectors represent the most advanced technology for use in doing this (see Figure 1). These troughs are attached together to form a "collector" that can be from 100 meters to 150 meters long. For solar power plants, the total length will be several kilometers. The troughs track the sun over the course of the day and focus the resulting radiation along the lines of the mirrors onto absorber tube receivers. Comprising 80 to 90 percent of the technology used in CSP plants, parabolic troughs are by far the most commonly employed solar power technology. Many parallel rows of solar collectors span the plant's solar field, tracking the sun as it moves. To collect sunlight, CSP plants may also use larger power towers in the middle of the solar field, surrounded by an array of flat, movable mirrors, known as heliostats (see Figure 2), which reflect sunlight to it.

Applied at the pivot points on the major tracking systems used to collect sunlight, specifically parabolic troughs and power towers, bearings enable the troughs to move easily and with little or no friction (see Figure 3).

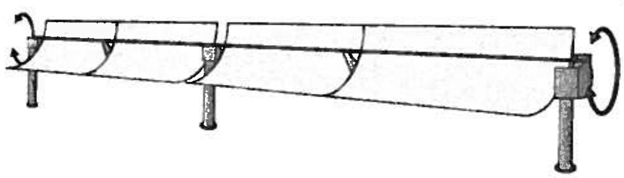
While bearings are small components, they can make a big difference to the bottom line. Since not all bearings are created equal, CSP plant owners can look for certain features to optimize efficiency.

It is important to source bearings that are chemical and water resistant as well as weatherproof. This will lead to less corrosion from external elements and longer-lasting application, reducing replacement and maintenance costs. To be truly effective, the bearings also need to withstand extreme temperatures ranging from 0 C to 70 C.

Bearings that contain proprietary polytetrafluoroethylene (PTFE) compounds feature the lowest coefficient of friction of all solid materials, meaning smoother movements and extremely high wear resistance for CSP technologies. Low coefficient of friction of solid materials will result in less steel-on-steel action, less friction and, therefore, less wear and a longer life. This reduced friction and avoidance of stick-slip effects in the tracking systems allows mirrors to move more easily towards the sun with less energy usage. PTFE, with its extreme weather resistance and high corrosion resistance, can increase the long-term operational efficiency of solar equipment, reduce energy usage and decrease long-term costs.

Manufacturers must also consider different backing layers on the bearings they choose. Ideal options include normal steel protected with a proprietary corrosion protection system, and aluminum or stainless steel backings, all of which do not rust and therefore, never need replacing.

FIGURE 1 PARABOLIC TROUGH



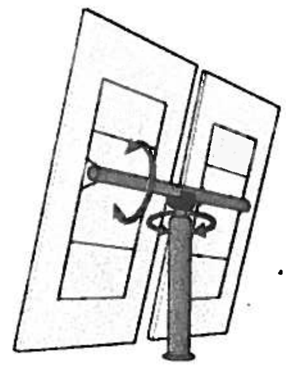
To comply with environmental regulations, bearings that feature lightweight materials are ideal, as well as those that are also free of heavy metals and banned chemicals such as chrome VI and perfluorooctanoic acid (PfOA). Additionally, it is worthy to note that bearings that can operate without grease can help plant operators avoid cleaning costs needed to remove drippings from the structures, which impedes effectiveness.

Choosing the Right Supplier

The importance of small parts cannot be undervalued. CSP directors, owners and engineers must choose their suppliers with care to ensure long-term support and scalability as demand rises. The key is to partner with experienced global companies with high-performance solutions and innovation teams that keep up with this rapidly advancing field.

Other factors to evaluate include testing and research and development (R&D) capabilities. Selecting bearings with a proven track record is ideal to guarantee performance, so partner with companies that can provide thorough testing data supporting resistance to temperature, water and friction as well as the influence of various shaft surfaces and coatings.

FIGURE 3 HELIOSTAT



Bearings can offer clear-cut solutions for CSP plants, by being able to offer different PTFE blends to fit the needs of the plant. Bearings help to reduce maintenance costs while increasing overall efficiency of the technologies on CSP plants, not such a small part after all. pe