Start-Up and Operation of the First U2A™ Urea to Ammonia Conversion System at AES Alamitos Station

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Summary

The demand for highly efficient NO_x control results in increased consumption of ammonia which is the necessary reducing agent for both SCR and SNCR. Due to its high volatility and noxious nature the risks associated with storage, transport, and handling of ammonia have prompted local authorities to place increasing restriction on the use of ammonia and utilities are actively seeking alternatives.

Typically, utilities planning to install SCR systems have had a choice between anhydrous (pure liquefied ammonia) or aqueous (19-29% solution) ammonia as the reagent source. Anhydrous ammonia is regarded as a highly toxic substance and is subject to strict OSHA (Occupational Safety and Health Administration) and EPA (Environmental Protection Agency) regulations. Although less concentrated, aqueous ammonia poses similar risks and is becoming increasingly regulated. For large SCR installations the use of aqueous ammonia results in high energy consumption and large storage facilities, which also make this option unattractive.

The Urea to Ammonia (U2A™) system uses urea as the feedstock chemical and entirely avoids risks associated with transportation and storage while providing ammonia as needed to the NOx control system. Compared to aqueous ammonia systems, the U2A™ process has lower operating costs, making the process economically attractive.

The first commercial scale U2A™ system was started up in October 2000 at AES Alamitos station to provide ammonia to an existing SCR as a demonstration project. The operation at AES Alamitos has been a success, leading to formal acceptance by AES and a contract for permanent installation of two U2A™ reactors at their Huntington Beach Station.

AES Alamitos Unit 6, is a super-critical, 480MW, gas-fired B&W boiler with an SCR supplied by Noell with two sections of honeycomb catalyst, designed for an overall NO_x reduction of 87.3%.

The U2A™ reactor for Alamitos is sized to produce 340 lb/hr of ammonia and to consume up to 1,768,000 BTUs/hr of steam. Through January 2001 the system operated for approximately 1500 hours over a range of 50-280 lb/hr NH3 following system load in

automatic controlled operation to meet SCR process demand. Overall turndown of the system is achieved over a better than 20:1 range.

In the U2A™ process, urea solution is heated under controlled conditions. Thermal hydrolysis of urea solution produces a product gas, which contains only ammonia, carbon dioxide and water vapor.

U2A(tm) is a once through process. This reactor comes to a dynamic equilibrium where the ammonia content of the reactor liquid is determined by the pressure and temperature of the reactor. The equilibrium concentration of ammonia in the reactor liquid is approximately 2%. The composition of the product gas matches the equivalent composition of the feed solution The hydrolysis reaction proceeds from urea to ammonium carbamate and then to ammonia, carbon dioxide and water vapor according to the following:

$$NH_2CONH_2 + (1+x)\ H_2O \dashrightarrow NH_4COONH_2 + (x)H_2O \dashrightarrow 2NH_3 + CO_2 + (x)H_2O$$

The overall reaction is endothermic and therefore can be controlled by regulating the heat input. The urea reactor requires approximately 4,500 BTU to generate one pound of ammonia when the reactor is fed a 40% urea solution. Additional heat input is also required to handle transient conditions such as ramping to meet process demands. Heat input to the reactor can be controlled such that the reactor operates at constant gas pressure, which simplifies the control system for ammonia gas delivery to the SCR process.

The control of the reactor is based on three primary PID loops. A demand signal based on NOx control requirements regulates flow of ammonia gas to the process via a flow control valve. A level controller adjusts urea solution feed to maintain constant liquid level in the reactor. A constant gas pressure of product gas is maintained by controlling the steam input to the heating coils.

The reaction kinetics for U2A™ are well understood and the reactor design is now confirmed in at commercial scale. Data from the process development was used to size the reactor at a scale factor of 400 compared to the pilot unit. At full scale operation at AES, the reactor operated within a few degrees of the predicted operating temperature vs. specific reaction rate. Predictive models for the U2A(tm) reactor allow close prediction of reactor peformance for various feed concentrations, temperature and pressures.

The U2A™ reactor is a kettle-style “BKU” reboiler heat exchanger. The reactor is a pressure vessel rated at 300psig and is fitted with a closed steam U-coil for heat input. Heat is provided by a nominal 150-psig steam supply. All metal surfaces in contact with urea solution are 316L stainless steel.

In side-by-side tests at full load, the U2A™ system demonstrated equivalent performance vs. the original aqueous ammonia system in place at Alamitos. During the operation of the unit NO_x reduction ranged from 87-95% and was always in compliance. Procedures for start-up, shut-down, idle mode were demonstrated.

The U2A™ system is an economically attractive, reliable, and safe alternative to ammonia for post-combustion NO_x control strategies. By showing full scale ammonia production, compliant NO_x reduction, excellent load following and stable operation, the U2A™ system has proven its technical viability in a commercial application.

AES has committed to a permanent installation of the U2A™ system to provide ammonia for the SCRs on Units 1,2,3&4 of their Huntington Beach Plant with operation slated to start in the spring of 2001. Other U.S. utilities have also chosen to proceed with urea-to-ammonia systems and to date more than 8000 MW of utility capacity has committed to this system with reactors being designed to 4000 lb/hr NH3 rating.

The U2A™ process (US Patent No. 6,077,491) was developed by EC&C technologies of La Canada, California and co-exclusive licenses are held by Hamon Research-Cottrell of Somerville, NJ and Wahlco, Inc., of Santa Ana, CA.