Discussion on the Process of Preparing Ammonia by Pyrolysis of a Urea

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**Abstract.** The process of preparing ammonia gas by urea pyrolysis is often used in denitrification of coal-fired power stations. Because of its safe and stable operation and low investment price, it is widely studied and used. This paper analyses the equipment and site layout of ammonia steam process by conventional urea pyrolysis. Give professional advice on new or rebuilt power plants.

1. **Introduction**

The urea pyrolysis ammonia system includes a urea storage room, a bucket elevator, a urea dissolution tank, a urea solution feed pump, a urea solution storage tank, a liquid supply pump, a metering and distribution device, a back pressure control valve, and an adiabatic decomposition chamber (including Ejectors) and control devices. The urea is stored in the storage room, and is transported to the dissolution tank by the bucket lifter. The dry urea is dissolved into a urea solution of about 50% by mass with demineralized water, and is sent to the urea solution storage tank through the urea solution feed pump. The urea solution is decomposed into the adiabatic decomposer via a liquid supply pump, a metering and distribution device, an atomizing nozzle, etc. to generate NH3, H2O and CO2, and the decomposition product is uniformly mixed with the dilution air and sprayed into the denitration system[1, 2].

The urea ammonia production process designed by the process should meet the requirements: the supply of reducing agent can meet the requirements of different load and denitration efficiency of the boiler, and the adjustment is convenient, flexible and reliable. The urea storage area should have a certain safety fire distance with other equipment and workshops, and an outdoor fireproof plug should be installed at an appropriate position, and a lightning protection and anti-static grounding device should be provided. The urea ammonia process should be equipped with a good control system. The urea dissolution tank, the urea solution storage tank, the urea solution feed pump, the urea solution metering and distribution device, etc. are common to the SCR systems of the two units[3, 4].

2. **Main equipment**

2.1. **Urea storage room**

The process designs a urea storage room for the buyer. The capacity of the urea granule storage room is designed according to the amount of urea required for continuous operation for 5 days (24h per day) under the design conditions of the two units of denitrification system.
2.2. Urea dissolving tank
Set a stainless steel urea dissolution tank, and each urea dissolution tank is equipped with a bucket lifter. The urea is delivered to the dissolution tank. In the dissolution tank, about 50% of the urea solution was made by removing the brine. When the urea solution temperature is too low, the steam heating system is activated to bring the temperature of the solution above 80 °C (to ensure no crystallization). The material is SS304 stainless steel. The effective volume is designed for one day under the conditions of two boilers BMCR. The urea solution feeding pump is a stainless steel body, a centrifugal pump with a silicon carbide mechanical seal, and two pumps are provided one by one and arranged side by side. In addition, the solution feed pump circulates the urea solution using a circulation line configured in the dissolving tank for better mixing.

2.3. Urea solution storage tank
The urea solution enters the urea solution storage tank via the urea solution feed pump. Set two urea solution storage tanks to meet the requirements of system dosage (40~60% urea solution) for 5 days. The tank is made of SS304 stainless steel. The storage tank is a vertical flat bottom structure, equipped with a liquid surface, a temperature display instrument, a manhole, a ladder, a ventilating hole and a steam heating device (to ensure that the solution temperature is higher than the crystallization temperature corresponding to the concentration of 5 °C). The foundation of the storage tank is a concrete structure. When the storage tank is placed in the open air, an isolation fence is added around the tank, and other variables on the site including seismic zone, wind load, snow load and temperature change should be considered. Insulation is carried out outside the can. Set up a urea solution heating pipe system. The urea solution pipeline is hydrophobically heated by the urea dissolution tank and the heating steam of the storage tank. The steam pipe will be connected from the auxiliary steam main pipe of the plant.

2.4. Urea solution circulation device
A urea solution supply and circulation device is provided, and the circulation line supplies a urea solution to the denitration devices of the two boilers. The urea solution circulation unit consists of 2 full-flow multi-stage SS centrifugal pumps (with frequency converter, one for one), one set of embedded double-connected filters, one back pressure valve and for remote control and monitoring of the circulation system. The pressure, temperature, flow rate and concentration of the instrument, etc., the hydrophobic heat tracing should be able to compensate the heat loss of the urea solution in the pipeline transportation.

2.5. Metering and distribution device
The metering and distribution device of the urea solution should be capable of accurately measuring and controlling the flow of the urea solution delivered to the decomposition chamber. Each furnace is provided with a set of metering and distributing devices for controlling the flow rate of each urea solution injector and the pressure and flow of atomizing and cooling air.

2.6. Adiabatic decomposition chamber
Each boiler is provided with a urea solution decomposition chamber. The urea solution is atomized by a nozzle made of 316 L stainless steel and sprayed into a decomposition chamber. Under high temperature hot air/flue gas conditions of 350 to 600 °C, the urea droplets are decomposed into NH3, H2O, and CO2.

The urea pyrolysis uses high temperature air, and the high temperature air is heated to about 600 °C by the primary air outlet heater at about 300 °C. The hot air duct is taken from the pipe interface designated by the buyer and is designed and supplied by the piping system downstream of the process responsible interface. The electric heating voltage level is 6000V. The steel part of the tail of the pyrolysis furnace is 16Mn, the maximum allowable temperature is 450 °C, and the operating temperature is about 100 °C. Each pyrolysis furnace outlet to the SCR reactor piping requires a flow measuring device and a corresponding regulating valve. The quality requirements of the atomizing air
of the pyrolysis furnace must meet the long-term reliable operation of the atomization system. The process will ensure complete decomposition of urea, and prevent the occurrence of recrystallization in the ammonia gas mixture tube or the deposition of fly ash in the heated air. If the above problems occur, the process is unconditionally solved. The process provides a volumetric ratio of NH3 to HNCO in the pyrolysis furnace outlet product and ensures that the intermediate product HNCO has no potential negative impact on the downstream flue equipment. The pyrolysis furnace is placed above the denitration support. The pyrolysis furnace is provided with a cold air purging pipeline system, and is usually taken from the secondary air cooling end to the pyrolysis furnace for use as an emergency pyrolysis furnace for purging and cooling. The primary air valve of the pyrolysis furnace is an electric valve.

2.7. Heat tracing system
For the urea solution delivery pipeline, the process should be equipped with a heat tracing system. The gas ammonia pipeline after the pyrolysis furnace is reasonably insulated to ensure that the temperature before the ammonia injection system is not lower than 300 °C.

2.8. Pumps, pipes, valves and other equipment in contact with urea are made of stainless steel.
When the urea solution is transported, when the nominal diameter of the pipeline is less than DN50, the flow rate of the urea solution in the pipeline is not more than 1 m/s; when the nominal diameter of the pipeline is greater than DN50, the flow rate of the urea solution in the pipeline is not more than 2 m/s.

2.9. Water flushing system
The urea solution pipeline should have insulation measures to avoid crystallization of the urea solution. A complete desalinated water flushing system should be set up on the urea solution pipeline to eliminate the influence of the urea solution crystallization. The rinse water eventually returns to the urea dissolution tank.

2.10. Heating steam and hydrophobic recovery system
The urea dissolution tank and the solution storage tank adopt a steam heating system, and the urea solution pipeline adopts a steam hydrophobic heat tracing system. The process side takes the steam from the interface of the main plant steam main pipe or the boiler auxiliary steam pipe designated by the buyer, and reuses the hydrophobicity of the heat tracing system.

3. Conclusion
The process designs the urea preparation zone of the denitration system, arranges it to the open space of the plant, and provides the general layout. The size of the urea workshop is 29m*15m, which occupies 435m3 of the ground. The layout of the general plan is shown in the layout of the urea area. It is necessary to find the open space inside the power plant site. The location of the urea plant should be close to the SCR device. Various pipelines and channels within the working range of the process, including overhead pipelines, direct buried pipelines, and when connected to the outer island channel, the location, elevation, pipe diameter or channel section size, slope, etc. shall be indicated at the design boundary. The direction of the slope, the name of the trench, where to lead, and so on. The overhead clearance of an overhead pipe passing through a car is 5 meters, and the clearance height at the bottom channel of the indoor pipe support beam is 2.2 meters. The process pipeline (urea pipeline) from the urea zone to the SCR zone uses the integrated pipe rack and the boiler zone steel frame in the original plant as much as possible, and is not in the new stand. The regional environmental noise of the denitration urea system meets the Class II standard of GB12350 “Industrial Enterprise Boundary Noise Standard”; the equipment running noise is less than 85 decibels (measured 1 meter away from the equipment); if the equipment noise level or multiple operating equipment noise superimposition exceeds the standard, Soundproofing measures are available. The entire structure, structure and foundation of the urea zone are designed by process. The newly added urea pyrolysis equipment in the SCR area is
mainly a pyrolysis furnace, an electric heater, etc., and it is necessary to increase the steel frame support and maintenance platform.

References

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