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Design of Urea Production Process with Annual Output of 150,000 Tons

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Abstract

Urea as a raw material in industry and an important fertilizer in agriculture has been widely used in the world. This design uses the water solution full circulation method to carry on the process design to the annual production process of 150,000 tons of urea. The pressure is selected as 19.172 MPa, and the temperature is selected as 188 ℃. Then the material balance and heat balance are carried out. Finally, the synthesis tower is designed. The design results are as follows: the effective volume of the urea synthesis tower is 47.62 m3, the diameter of the tower is 2.2 m, and the height of the tower is 20 m.

Keywords

Urea; Total cycle method; Process design; Synthetic tower.

1. Introduction

Urea reacts with acids, bases and enzymes to hydrolyze to produce ammonia and carbon dioxide, which is thermally unstable [1]. Urea can be used as a fertilizer [2]. In addition, it is used in medicine, feed additives, petroleum dewaxing, refractory materials, laboratory applications, environmentally friendly engine fuel, tooth whitening, textiles and leather tanning.

Urea production process is one of the typical chemical production processes [3]. At present, urea production processes at home and abroad mainly include carbon dioxide stripping, total circulation of aqueous solution and ammonia stripping [4]. Advantages of full cycle urea process in aqueous solution: its main equipment includes liquid ammonia preheater, urea synthesis tower and pump type high pressure equipment. In addition, the process also requires medium pressure, low pressure and vacuum equipment. Therefore, the technical transformation of this process is relatively easy and time-consuming, without a large amount of cost investment, has obvious development potential and prospect, and is easy to popularize and study.

2. Urea Production Process Flow

Professor The urea production process with full circulation of aqueous solution is a urea production process developed in China in the 1960s by referring to foreign technologies [5] and combining with domestic technologies. It has the advantages of low investment, high localization rate of equipment, easy quality control of urea products and great transformation potential. For urea manufacturers in China, there are many urea manufacturers producing urea by the total circulation method of aqueous solution [6]. The full circulation method of aqueous solution also has disadvantages. Due to the high pressure of the high pressure system, the load of liquid ammonia pump is also large, which leads to the high maintenance cost. Another drawback of this process is that the plant is designed to have a low production capacity, which has led some companies to expand the plant to improve urea productivity.

2.1. Total Cycle Process of Aqueous Solution

The process flow of the total circulation method of the aqueous solution is as follows: the purity of the carbon dioxide gas is 98.5%, the oxygen content of the carbon dioxide gas should be controlled within 0.5% ~ 0.7%, the carbon dioxide gas is sent to the compressor, and then it is compressed into the urea synthesis tower after five stages. The liquid ammonia comes out of the ammonia tank, and then enters the liquid ammonia buffer tank through the liquid ammonia filter [7, 8], mixes with the returning ammonia, enters the high-pressure ammonia pump, and finally enters the urea synthesis tower again through the ammonia preheater for the following synthesis. The carbon dioxide compressor is sent to the bottom of the synthesis tower, after which the next step of synthesis is carried out.

After the urine comes out of the synthesis tower, it adjusts the pressure regulating valve of the synthesis tower, and then enters the pre-separator and is conveyed to the decomposition tower. The urine flashes in the first-stage decomposition tower, and the urine liquid phase in the distillation section carries out partial separation by countercurrent heat transfer with the gas in the separator of the first-stage external condenser. The liquid phase is heated in a decomposition heater, and the urine is heated and separated in a decomposition separator to form a gaseous liquid. Air is usually added to the liquid inlet pipe of the decomposition heater to prevent corrosion of the equipment pipe [9]. The urine from the stage 1 separator enters the top of the stage 2 decomposition tower. The gas from the second stage decomposition tower enters the first cooling device of the second cycle and the second cooling condensation absorption device of the second cycle in turn, and then enters the inert washing device. Urine from the secondary decomposition tower is successively entered into a vacuum concentrator, an evaporative separator and a pelletizing package.

Dilute ammonium carbamate solution from the low pressure ammonium carbamate pump and gas from the first stage decomposition tower enter the first stage evaporation heater and then enter the bottom of the first stage absorption tower. The water in the gas and ammonia cooler in the first section of the absorber is cooled to the liquid ammonia and flows into the liquid ammonia buffer tank. The gas from the ammonia cooler passes through the inert gas scrubber, and the ammonia water in it is absorbed. The gas from the inert gas scrubber enters the exhaust absorber together with the gas from the secondary circulation and secondary cooling. Washing is carried out to discharge the residual gas, among which the remaining liquid is returned to the ammonium bicarbonate tank [10].

The urine enters the flash tank through the secondary decomposition tower for flash distillation [11], and then flows into the first-stage evaporation heater. The urine is heated to a second evaporator. Once again through the steam heating between the tubes, into the second evaporation separator, gas and liquid phase separation. The molten urea in the liquid phase is pumped to the granulation unit by melting. The flash vapor phase and the first stage evaporative gas phase enter the first stage evaporative surface cooler and condense into ammonium bicarbonate liquid. The vapor phase of the second stage evaporator enters the condenser of the second stage evaporator through the booster for condensation.

3. Process Calculation

3.1. Material Balance of Absorber

The normal temperature of operating liquid on the top of absorption tower is 40 °C. The desorption tower is heated directly by steam. According to the calculation formula of heat balance, the amount of steam is 48.46 Kg. The operating pressure of the desorption tower is 392.27 kPa. The temperature of the solution at the top of the desorption tower is 85 °C, and the temperature of the gas at the outlet is 110 °C. The water content of desorption tower is 32.8% (weight). The ammonia concentration in the inert gas scrubber is 54% (weight percentage,

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excluding urea CO2). The operating temperature is T = 45 °C, the ammonia partial pressure is 784.5kPa, and the inert gas partial pressure is 0.274 kmol. The quantity of ammonia in the outlet gas is 0.216 kmol.

Table 1. Balance sheet of material input of exhaust absorption tower

Input component	Kg	Kmol
A section of evaporative condensate	379.746	20.768
CO_2	11.136	0.253
NH_3	13.40	0.788
H_2O	354.81	19.71
Urea	0.40	0.0067
Inert detergent gas	11.44	0.48555
NH_3	3.68	0.22
O_2	2.60	0.08125
N_2	5.16	0.1843
Total	391.186	21.2536

Table 2. Balance sheet of material output of exhaust gas absorption tower

Input component	Kg	Kmol
Absorber outlet liquid	382.246	20.92
CO_2	11.136	0.253
NH_3	16.44	0.97
H_2O	354.27	19.682
Urea	0.40	0.0067
Vent	8.94	0.3336
H_2O	0.54	0.03
NH_3	0.64	0.038
O_2	2.60	0.08125
N_2	5.16	0.1843
Total	391.186	21.2536

3.2. Material Balance of Desorption Tower

Composition of gas at the outlet of desorption tower:

Table 3. Material balance input table of desorption tower

Input component	Kg	Kmol
Absorber tower to the solution	382.246	20.92
CO_2	11.136	0.253
NH_3	16.44	0.97
H_2O	354.27	19.682
Urea	0.40	0.0067
Heating steam	48.46	2.69
Total	430.706	23.61

Table 4. Output table of desorption tower material balance

Output component	Kg	Kmol
Desorption gas	40.1875	1.937
CO_2	10.836	0.247
NH_3	16.17	0.96
H_2O	13.1815	0.73
Desorption waste liquid	380.25	21.66
CO_2	0.30	0.01
NH_3	0.27	0.016
H_2O	389.36	21.63
Urea	0.40	0.0067
Total	420.4375	23.597

4. Equipment Selection

Ammonium carbamate, an intermediate product of urea, is highly corrosive to iron and steel, especially in parts that operate at the highest temperature and concentration of carbamate in the plant, so the lining of the inner wall is made of corrosion resistant materials. The urea synthesis tower needs to be operated under high pressure, so the industry mostly uses the reaction tower with large height to diameter ratio. The shell of the synthesis tower needs heat nondiffusion, and because the synthesis of urea takes a certain amount of time [12], the shell adopts multi-layer steel plate coils or whole-forged high-pressure cylinders [13, 14], and the top cover is the sealing structure of the cylinder body. Lined synthesis tower has high volume utilization, and the case is stainless steel, which is corrosion resistant. Secondly, the lining tower has the advantages of less material consumption, reliable use, convenient operation and easy maintenance. The hemispherical head is hot pressed by thick plate, and the inner part is welded with high manganese strip electrode as corrosion resistant layer. Because most of the urea production system is urine or NH3-CO2-H2O ternary solution [15], their melting point is relatively high, the use of plate tower is easy to block, so the tower equipment in urea production usually adopts packed tower.

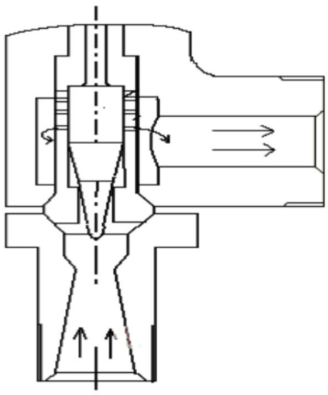

Figure 1. Lining type synthesizer

5. Wastewater Treatment

In the process of urea production, it is inevitable to produce a large amount of waste water. Because the waste water contains urea, it must be treated, otherwise it will pollute the water body and affect human health. Therefore, a good technical scheme of urea wastewater will meet the requirements.

we use the computer control system for urea wastewater treatment. The specific treatment method includes the following steps:

1) Concentrate containing urea wastewater discharged into reaction pool, through computer programming control waste water height, after reach a certain height, the cock into the reaction pool close, now add 26% hydrochloric acid, open the agitator, the pH value of 4~7, after reaction in the pool pH value detector, data into the computer, the computer control system will be sent off hydrochloric acid control valve.

2)The computer is introduced to detect the content of urea in each liter of sewage, according to the urea ratio of 100:1, the mass percentage of H2O2 concentration of 29%, when the system detected H2O2 test reached a predetermined value, the flow sensor sent a signal to the computer, and then the computer system issued a closed hydrogen peroxide valve instruction.

3)After the hydrogen peroxide valve is closed for 120 min, the computer control system will add the catalyst according to the ratio of H2O2 and catalyst 1:0.8. After adding the right amount of catalyst, the sensor will feedback, close the catalyst valve, and then enter the stirring step, stirring time can be controlled within 30min.

4)When the stirring time reaches 30min, the outlet valve of the reaction tank can be opened to discharge the reacted wastewater; when the waste liquid in the reaction tank is completely discharged, the outlet valve can be closed. After that, the above steps are repeated to continue to treat the urea wastewater until the discharge requirements are met.

6. Conclusion

This graduation design through the synthesis tower some parameters change to design an annual output of 150,000 tons of urea, the use of aqueous solution full cycle method, the synthesis tower, tail gas absorption tower, analytical tower and other equipment to do the material balance, can get the total circulation method of aqueous solution through the transformation in recent years, has shown a huge competitive advantage.

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