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SMALL SIZED AMMONIA PLANTS IN CHINA

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Abstract

China has a population that accounts for 25% of the world total, but its area under cultivation amounts to only 7% of the total world arable area. It is therefore a heavy task to solve the feeding problem. China has been paying great attention to the developments of chemical fertilizer production.

China has built more than decade of large-scale ammonia plants each with an annual capacity of 300,000 tons of ammonia and a number of medium ones each with capacity in the range of 100,000 to 200,000 tons per year. Nevertheless, there are numerous small-sized ammonia plants still in operation each with annual capacity of 5,000 to 20,000 tons and their output accounts for 55% of the national total. The paper describes the special features of such small plants that adopt the "Integrated Ammonia Bicarbonate Process" based on anthracite as feedstock and ammonium bicarbonate as end product.

China has a population of one billion, accounting for one-fourth of the world total, but its area under cultivation amounts to only 7% of the total world arable land, that is 1.5 mu per person in average. The figure is relatively much smaller as compared with that of many other countries. Feeding the people in China has ever become a knotty problem and one of its solutions is to raise the grain yield. That is why great attention has been paid to the development of chemical fertilizer production in China. From 1949 to 1980, the output of chemical fertilizer in China increased at an average annual growth rate of 28% and the total output in 1980 was over 12.30 million tons (calculated on the basis of N, P_2O_5 and K_2O) with about 10 millions, 2.30 millions and 20,000 tons of nitrogenous, phosphorous and potassium fertilizers respectively.

Chemical fertilizer production, especially that of nitrogenous fertilizers, requires large amount of energy both for raw materials and fuel. Abundant energy resources in China give great prospect for their development which, however, still could not meet the requirements of the increase of national economy. Consequently, each line of industry should be developed according to its own merits and the conditions prevailing in China.

In order to accelerate the expansion of its chemical fertilizer industry, China imported thirteen 1000T/D ammonia plants in early 1970s. Much work has been done for the management of these imported plants with satisfactory results, which have made great contribution to the agricultural production. Meanwhile, over 1300 small ammonia plants each with annual capacity of 5,000 to 20,000 tons have been built during the last two decades, which are still being operated. These small plants produced about 8.20 million tons of ammonia in 1980, accounting for approximately 55% of the total national ammonia production, and have become an important strength in our chemical fertilizer industry.

To build such small ammonia plants in China, and in many other developing countries as well, has many advantages and special features which may be deserved to make a presentation as follows.

(I) As the requirements of small-sized ammonia plants can be readily satisfied, the metallurgical and mechanical capacities in less-industrialised localities could provide complete sets of equipment for those plants, including all the processing equipment, instrumentation devices and facilities for utilities, as well as the catalysts and additives needed in the process. It is therefore easier to find a site for building such a small plant. Meanwhile, the installation of small-sized ammonia plants also promotes the development of other industries in less-industrialized districts.

At an early stage, we used to build small-sized ammonia plants each with a capacity of 3,000 or 5,000 tons per year, some of which have been expanded gradually, and now a plant with annual capacity of 15,000 tons is considered to be appropriate.

(II) Coal as Feedstock : Energy consumption of ammonia plant using natural gas and naphtha oil as raw materials is lower in comparison with coal. However, just as the case in the world, coal deposits in China are much richer than either the natural gas or petroleum resources. Anthracite is also abundant in China. which is commonly used as raw materials for ammonia production because of its low prices.

It is important to make the economic evaluation. Considering that to get the same heat energy by petroleum costs three times more than by coal (calculated on the basis of present prices), it is reasonable to prefer coal even though its consumption per ton ammonia produced may double that of petroleum as feedstocks. It is like somebody used to say : we must consider not only energy, but also dollars.

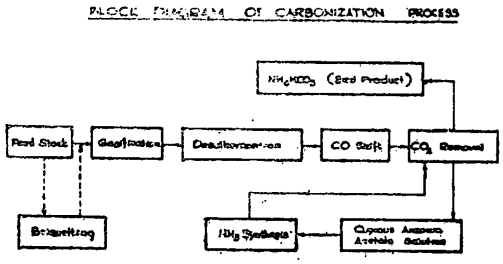
More important is the fact that a small-sized ammonia plant with the capacity of 10,000 to 15,000 tons requires only 20,000 to 30,000 tons of anthracite per year. Such a small plant has the merits not only of being able to fully utilize scattered coal resources not worthwhile mining in large scale, but also to save energy consumption for transportation.

The fixed bed gas generators call for coal of 13 to 60 mm in size, yet lump coal accounts for only 20 to 30% of the total output due to the effect of mechanical mining. In order to meet the requirements for ammonia production, we have to use briquettes formed from coal fines with various kinds of binding agents. The carbonated lime coal briquettes are being successfully and widely used for making syngas in ammonia plants because of its pretty good compression strength of 60 kg/single briquette. At present, over 600 small-sized ammonia plants in China are using this kind of briquettes to make crude syngas.

(III) Advantages of this Process . . . all the simple :

The process adopted in small-sized ammonia plants is all the simple and its main steps could be described as follows :

- Semi-water gas is produced from the fixed bed gas generator loaded with lump coal or briquettes;
- Desulphurization of semi-water gas is carried out with diluted aqueous ammonia recovered from the process;
- The CO-shift-to-CO_2 reaction is done under a given elevated pressure;
- CO_2 in the converted gas is removed by means of aqueou$_2$ ammonia (the residual CO_2 should be less than 0.2% in the effluent), simultaneously with the formation of end product . . . crystal ammonium bicarbonate;
- The synthesis gas is finally purified with cuprous ammonium acetate solution to remove all the residual CO and CO_2;
- The synthesis of ammonia is carried out under 320 or 200 atmosphere.



The process is different from the traditional one only in carbonization section where ammonium bicarbonate is formed during removal of CO_2. To produce 1 ton of nitrogen by this process consumes only 10^6 kcal, while the energy consumption of CO_2 removal by high pressure water is 0.6 x 10^6 kcal/ton ammonia, and additional energy of 7.5 x 10^6 kcal. is required for 1.72 to 1.8 tons of urea from 1 ton ammonia, or 3.9 x 10^6 kcal. for ammonium nitrate. What is more, the complete set of ammonia processing equipment is eliminated. The number of equipment is reduced by 12% and 30% in comparison with the production of urea and ammonium nitrate respectively.

(IV) Ammonium bicarbonate belongs to the category of neutral fertilizers. Hence, it is suitable for various kinds of soils and crops growth with no harmful acid redical remained. But its nitrogen content (17%) is low, only about one third of urea, hence its transportation and storage are more expensive. Ammonium bicarbonate is liable to dissociate under ambient conditions and agglomerate during storage. In order to reduce the loss due to dissociation and agglomeration, we add a binding agent to get bigger crystals, the water content of which reduces from 5% to 3.5%. This method is being adopted in more than 100 ammonia plants. Another way to reduce dissociation loss is to manure the field deep under the surface.

It is better to bag ammonium bicarbonate with plastic film which has a good sealing property though its breaking strength calls for our attention.

Ammonium bicarbonate does not suit long distance transportation because of its low nitrogen content. The "in-the-field" costs of ammonium bicarbonate, urea and ammonium nitrate (taking 25 kilometers as the average radius of highway transportation of the product to the consumers) are 100, 103.07 and 114.55, respectively.

(V) **Conclusion**

Over 1300 small-sized ammonia plants have been built in China for more than 20 years. Heat utilization in these plants is rather poor due to their small size, consuming more energy than large or medium-sized plants. However, their energy consumption can be lowered if management is strengthened and waste heat is recovered and utilized. Of course, technical innovation must be introduced, for example, automatic regulation of H_2 and N_2, utilization of the purged gas from the synthesis loop, recovery of waste heat from ammonia converter, new catalysts, etc.

At present, by taking some measures, some of the small plants in China have already lowered their energy consumption, close to that of medium-sized plants. This fact gives the evidence that under certain conditions, it is feasible and of practical significance to build small-sized ammonia plants in China as well as in many other developing countries.

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