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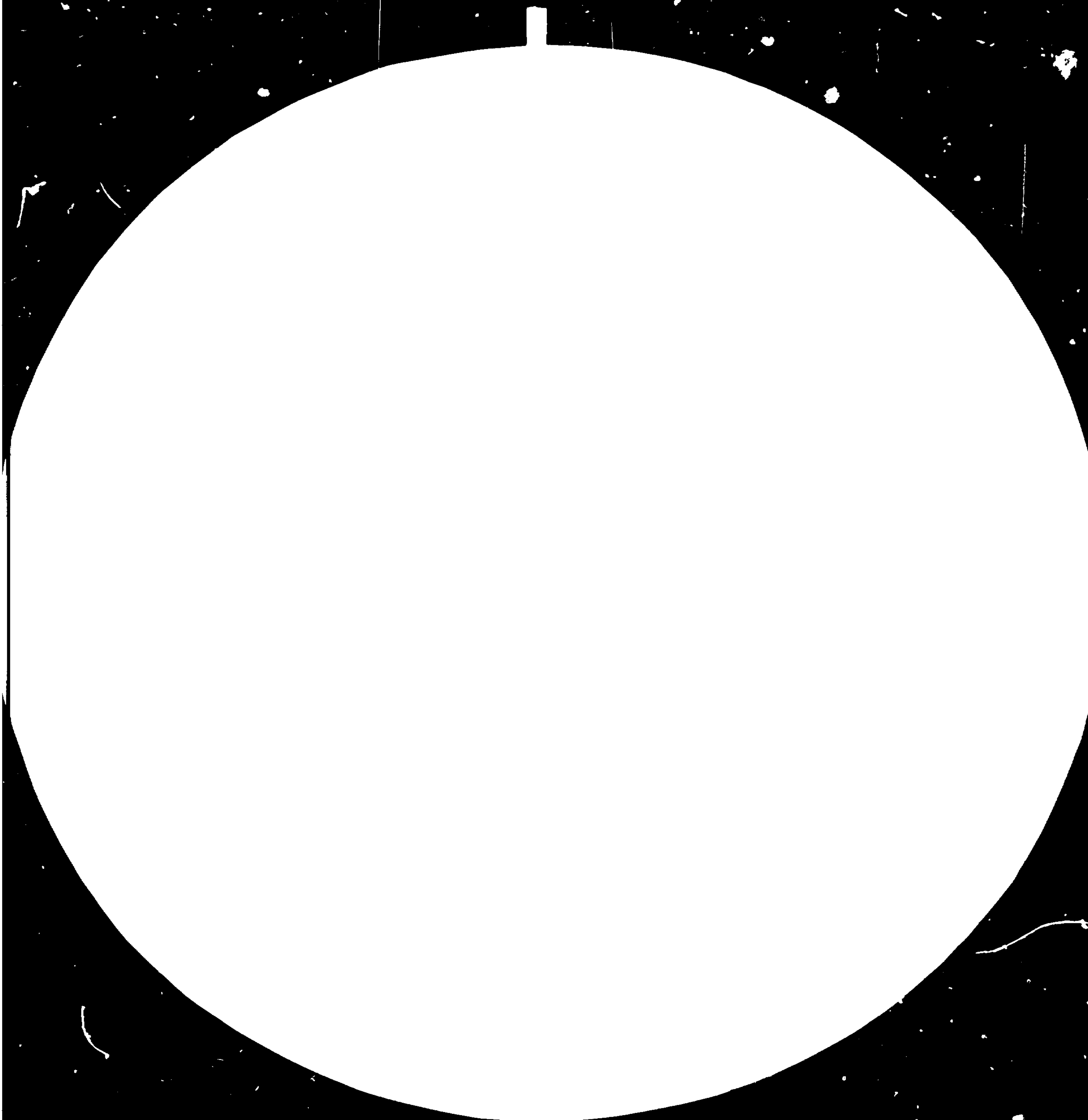

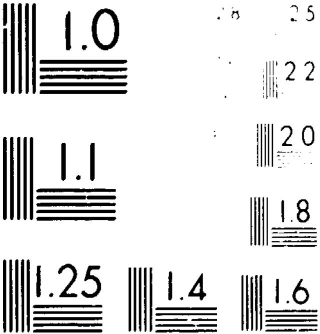
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THE TECHNO-ECONOMIC EVALUATION OF THE 10000 TONS/YEAR AMMONIA PLANT*

by

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Abstract

This paper describes the features of the small sized ammonia plants producing ammonium bi-carbonate as the end product, with capacities in the range of 3000 to 15000MT NH_3/year in China.

The techno-economic comparison of processes and the conditions for its development are discussed . Also the optimum plant scale is evaluated.

I. Preface

Numerous ammonia plants with a capacity of 3000 and 5000 tons per year have been built over the past two decades in China. There were more than 1300 such ammonia plants in operation in 1980, some of them had been expanded up to 10000 tons ammonia per year, and some even larger. These plants have supplied the Chinese agriculture with a great amount of nitrogenous fertilizer---- mainly as ammonium bicarbonate, and their production constituted 55% of the total ammonia production of China in that year. With ammonium bicarbonate as fertilizer,we have accumulated adequate experiences in bagging, storage, transportation and application, and have trained a fairly large number of experienced engineers, supervisors and technicians for the design, construction and operation of ammonia plant.

Furthermore, capability of metallurgical,mechanical and chemical industries in the localities were developed to provide complete sets of equipment for those plants including all the processing equipment, instrumentation devices, facilities of utilities, as well as the catalysts and additives etc.

The small sized ammonia plants of our country adopted the "Integrated Ammonium Bicarbonate" process. The outstanding advantage of this process is to integrate the co removal of the ammonia synthesis gas and the ammonia processing in one step. This makes it possible to produce solid nitrogenous fertilizer directly from ammonia without the processing section inherent to conventional schemes. By using the "integrated ammonium bicarbonate" technology, the small sized ammonia plants can be built very quickly with less investment, and the product can be produced at lower cost.

II. The Conditions for the Development of small sized ammonia Plants in China

1. Feedstock

Since our country is abundant in coal resources, over 90% of our small sized ammonia plants are based on anthracite and coke as feedstock.

The small sized ammonia plants show wide adaptability towards the lump size of feedstock. Normally the lump of over 40 millimeters or not less than 25 millimeters is to be desired, however, the smaller lumps or even fines which become more available as a result of mechanical mining can also be used after briquetting.

A small sized plant with an annual capacity of 10000-

15000T ammonia needs only 20000--30000 T anthracite as feedstock which can be provided by the local small mines.

Similarly the requirements of the small sized ammonia plants for water, electricity and steam are also less and can be readily satisfied in the vast areas nearby the medium and small citie s in our country.

(2) Process description

The production scheme is composed of preparation of feedstock, coal crushing, gasification, desulphurization, compression, co conversion, CO2 removal and carbonization, copper liquor scrubbing and ammonia synthesis etc. Namely:

The briquetting of anthracite fines with binder;

The production of semi-water gas in the fixed bed gas generater;

The desulphurization of semi-water gas with diluted aqueous ammonia recovered from the process;

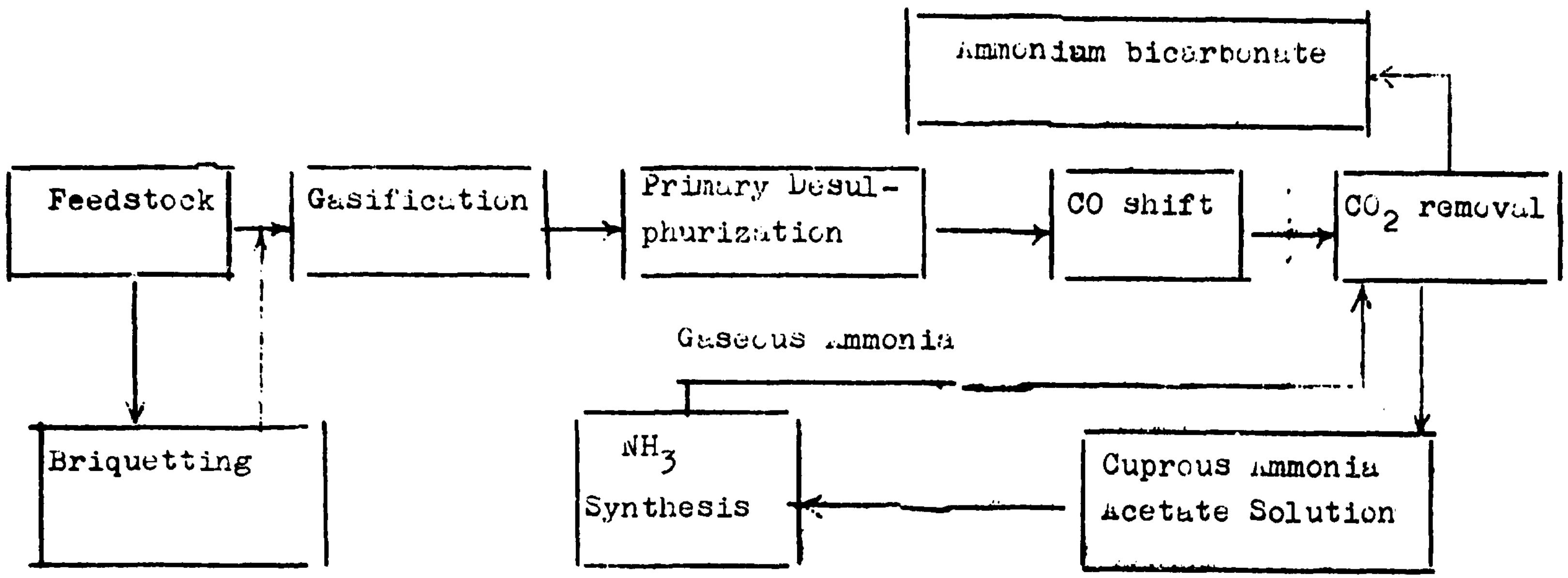
The CO shift reaction under a given presure;

The CO2 removal by means of aqueous ammonia with the formation of crystal ammonium bicarbonate;

The final purification of the synthesis gas with cuprous ammonia acetate,solution;

The synthesis of ammonia under 320 atmosphere (or 200 atmosphere).

The block diagram of this process is shown as follows;



Ammonium bicarbonate
Feedstock
Gasification
Primary Desul-
phurization
CO shift
CO_2 removal
Gaseous Ammonia
Briquetting
NH_3
Synthesis
Cuprous Ammonia
Acetate Solution

The advantages of this process are:

1. The process is simple.

2. The CO in the converted gas is removed by means of concentrated aqueous ammonia with the formation of end product, ammonium bicarbonate simultaneously, thus eliminating the complete set of ammonia processing qequipment. The number of equipment is reduced by 12%, and 30% in comparison with the production of urea and of ammonium nitrate respectively.

3. The CO_2 removal provides the additional desulphurization , reducing the hydrogen sulfide content in the synthesis gas down to 5--10 Mg/NM^3 to meet the requirements of cuprous ammonia acetate solution wash, hence the secondary desulphurization step is not necessary.

4. The concentrated aqueous ammonia not only shows high CO_2 abosorbing capacity of 100 M^3 CO_2 in each M^3 of solution but also ensures high degree of purification with the residual CO_2 less than 0.2 % in the effluent. The absorption proceeds at ambient temperature and low pressure, without additional heating and refrigeration facilities.

5. The ammonia is recycled as feedstock to the carbonization section in gaseous state at low pressure, hence the refrigeration energy is saved.

6. The carbonization process is comparatively simple;

the number of equipment are not many, and the manufacture of equipment is not complicated. Most of the equipment are made of common carbon steel and only a small amount of stainless.steel is required.

It must be noted that the product ammonium bicarbonate as a neutral fertilizer, does not impair the soil. But the nitrogen content (17%) is low, only equivalent to 1/2.7 urea, hence the cost of product per unit nitrogen content including the bagging, transportation and storage expenses etc, are 2.7 times as high as that of urea. Furthermore, if the storage time is too long, ammonium bicarbonate tends to agglomerate and suffer loss in weight, therefore one has to consider whether it is economical to scale up production.

(3). Labor source

In the 10000T·NH_3/year ammonia plant,the wages of the workers account for about 5% of the production cost. The abundant labour resource is favourable to the development of 10000 ton ammonia plants.

(4) Transportation conditions

Such ammonia plants use the raw materials supplied by the localities and the fertilizer products are consumed locally. In most cases the transportation radius is within 25 kilometers. The selling prices of the products are favourable both to the manufacturers and customers.

III. The techno-economic characteristics of the small sized ammonia plants.

A comparison is made for an ammonia plant with an annual capacity of 15000 ton ammonia producing three different end products, ammonium bicarbonate, ammonium nitrate and urea respectively.

(1) Process

Ammonium bicarbonate: the "integrated ammonium bicarbonate" process is used.

Ammonium nitrate: the Medium Pressure Nitric Acid Process is used for nitric acid production. The ammonium nitrate is produced in gronular form by atmospheric neutralization vaccum evaporation and granulation.

Urea: The Medium Pressure Integrated Urea Process is used. This process is being tried out in an industrial demonstration plant.

(2) Techno-economic criteria(compatisons were made on the basis of a ton of nitrogen product).

1. Capital investment, (see table I) was broken down to ammonia unit, ammonia processing unit and utilitics. The miscellaneous items consists of the costs of test run, training, administration of construction, and other unforeseen expenditures.

2. Energy consumption.

The total energy consumptions of the ammonia synthesis and ammonia processing are comapried for different products, (see table II)

The energy consumption per ton of nitrogen is used as the index for comparison.

$$\text{Total energy consumption index} = \frac{\text{energy consumption of } NH_3 \text{ consumed by the product} + \text{other energy consumed by the product}}{\text{nitrogen content in the product}}$$

Table I. The capital Investments of the three Products

	Ammonia Production	Ammonia processing	Utilities	Miscellaneous items	Total sum of the whole plant	Capital Investment per ton N/year
Ammonium bicarbonate	100	100	100	100	100	100
Ammonium Nitrate (including nitric-acid)	114.26	466.47	137.77	128.06	169.37	166.4
Urea	115.55	267.37	140.74	116.85	141.66	136.1

Table II. The comparison among the energy consumptions of the three products

	Energy consuption of Ammonia Synthesis 1×10^6 kcal/ton N	Energy consumption of Ammonia processing 1×10^6 kcal/ton N	Total energy consumption index 1×10^6 kcal/ton N	Comparison %
Ammonium bicarbonate	22.09	1.0	23.09	100
Ammonium Nitrate	23.44	3.92	27.36	118
Urea	23.18	7.49	30.67	133

3. Cost

Cost of product and transportation charges (taking 25 km as the average radius of transportation of the product to th the consumers) are listed for comparison.

Table III. The comparison among the in-the-field costs of the three products

unit: %

	plant cost	transportation charges	total
Ammonium bicarbonate	100	100	100
Ammonium nitrate	119.63	49.41	114.55
Urea	108.12	36.96	103.07

IV. The determination of the plant scale of small ammonia plant.

It is evident from the above "in-the-field" cost comparison that the plant cost of the ammonium bicarbonate is the lowest, whereas the transportation charges for ammonium bicarbonate are the highest. Therefore, the production scale of the ammonium bicarbonate plant will be influenced by the sale distance to a greater extent than the urea plant

The in-the-field cost of ammonium bicarbonate from ammonia plant with different capacities are shown in table IV.

Table IV.

The capacity of ammonia plant Ton/year	4000	8000	15000	25000	30000	40000
Average transportation distance (km)	15	20	25	30	35	40
Transportation charges (%)	60.29	76.47	100	116.18	130.88	144.12
Plant cost (yuan/ton)	115.38	106.38	100	97.29	95.65	94.39
The with-field consumer cost (yuan/ton)	111.98	104.54	100	98.46	97.82	97.46

Basis for the comparison in the above table:

The amount of the fertilizer consumed in the field-- 8kg Nitrogen/mu

Note: 6.6 mu equal to an acre. Transportation means transportation by truck.

It is evident from the above table that the in-the-~~table~~ field cost of the products for the plant with a capacity of 4000-8000 ton ammonia/year are rather high. Although there is some decrease in the in-the-field cost with plant scale over 15000 ton NH_3/year, the margin is small. Considering the difficulties with bagging ,storage and reverse transportation after further scale-up. The capacity of 15,000 ton of NH_3 per year is considered to be economically optimum for the small ammonia plant.

Besides, it can also be seen from the table III that the cost of the ammonium bicarbonate is by only 3% cheaper than that of urea, when the plant has a capacity of 15,000 ton of ammonia. If the ammonia production reaches 23000 t/year, the in-the-field cost of both products are basically the same. But in case the ammonia production is over 30000 t/year the cost of urea becomes lower than that of ammonium bicarbonate. If there are opportunities to build an ammonia plant with an annual capacity of 25,000 tons, it is more preferable toprocessing the NH_3 into urea. For this reason, we plan to switch the product from ammonium bicarbonate to urea in some 25000 tons small sized ammonia plants.

V. Conclusion

1. Our country has developed the small sized ammonia p plants over the past twenty years, which have supplied our agriculture with a large amount of nitrogen fertilizers.

2. For the small sized ammonia plants using anthracite as feedstock has enabled us to fully utilize the medium and small coal deposits scattered over various areas.

3. In the small sized ammonia plants, the "Integrated Ammonium Bicarbonate" process is used to produce the

solid fertilizer-ammonium bicarbonate. The combination of co removal with ammonia processing in one step, has reduced the investment cost and lowered the production cost.

4. As the ammonium bicarbonate has the disadvantages of low nitrogen content and tendency to decompose, it is not suitable for the prolonged storage and long distance transportation. Therefore, the ideal size of such ammonia plants should be about 15000 tons per year.