International
Fertilizer Industry
Association

IFA Technical Conference

Beijing, China
20-23 April 2004

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CURRENT SITUATION AND TECHNICAL PROGRESS OF THE PHOSPHATE FERTILIZER INDUSTRY IN CHINA

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1. ABSTRACT

China's phosphate fertilizer production in 2002 reached 8.057 million metric tons P_2O_5, making up one-fourth of the world's total production. It can meet 80% of domestic demand and all depends on local rock resources. Now, half of its capacity is based upon imported modern technology while the remainder uses technologies developed domestically for low and medium quality phosphate rock.

2. CURRENT SITUATION OF CHINA'S PHOSPHATE FERTILIZER INDUSTRIES

The annual production of chemical fertilizer in China for 2002 was 36.954 million metric tons nutrient and ranked as the world's first. Nitrogen fertilizer accounted for 27.426 million mt N, phosphate fertilizer 8.057 mt P_2O_5, and potash fertilizer 1.471 million mt K_2O. The production of phosphate fertilizer in 2002, made up 24% of the world's total, is the second largest after the United States.

During the year, total amount of chemical fertilizer consumed in China was 43.395 million mt nutrients with nitrogen fertilizer at 21.573 million mt N, phosphate fertilizer, 7.122 million mt P_2O_5, potash fertilizer, 4.225 million mt K_2O, and compound fertilizer, 10.462 million mt NPK's. The proportion of N : P_2O_5: K_2O was 1: 0.42: 0.30. Total amount of phosphate fertilizer consumed in 2002 was 10.609 million mt (P_2O_5), including P_2O_5 contained in compound fertilizer. It reached 27% of world's total consumption, ranked the world's first and 80% of which was supplied by domestic production. The consumed phosphate fertilizer consisted of 67% single fertilizers and 33% compound fertilizers.

China's phosphate fertilizer industry was established in 1949 along with the founding of the People's Republic of China. During the past half decade, its development was closely integrated with national conditions. The varieties increased from low analysis phosphate single fertilizers to high analysis phosphate compound fertilizers. The scale has expanded from small capacity plants to large capacity plants. The local distribution has changed over from nearby markets to the sites of raw materials. The process technology has improved from using both acid process and thermal process to using acid process mainly.

Received 15 January 2004 for presentation at the 2004 IFA Technical Conference, 20-23 April, Beijing, China
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Output of Phosphate Fertilizer in China. unit: 1,000 metric tons P_2O_5

Year	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2002
Output	1	193	688	907	1,531	2,307	2,508	4,116	6,186	7,394	8,057

Output of High Analysis Phosphate Compound Fertilizer (1,000 metric tons P_2O_5) and its Proportion in Production of Phosphate Fertilizer (%)

Year	1955	1965	1975	1980	1985	1990	1995	2000	2002
Output				46	33	240	1,068	2,263	3,680
%				2.0	1.9	5.8	17.3	34.1	45.7

As shown above, in the last ten years there was an yearly average increase of 5.9% for phosphate fertilizer and an yearly average increase of 25.9% respectively for high analysis phosphate compound fertilizer ($P_2O_5 \geq 40\%$).

2.1 Priority for Low Analysis Phosphate Fertilizer from 1950's to 1970's

Owing to the limitation of resource, technology and investment, ground phosphate rock was the main product in early 50's. Since 1958, there established many single superphosphate SSP plants of small capacity from 0.2 – 0.4 million mt/year, or even lower. The annual output reached to a peak, 4.76 million mt P_2O_5 in 1998. Now, SSP still maintains its dominant position with 3.7 million metric tons/year P_20_5, making up 47% of phosphate fertilizer production.

As a new product, fused calcium magnesium phosphate (FMP) was developed by blast furnace process in 1963. Thereafter many unused blast furnace (13 – 82 M^3) were utilized making an annual output of FMP to a peak of 1.2 million mt P_2O_5 in 1995. However, today its annual output has been reduced to less than 0.7 million mt P_2O_5, making up 8% of the total.

2.2 Fast Growth of High Analysis Phosphate Compound Fertilizer since 1980's

Since 1980's, over USD 6 billion has been invested to develop high analysis phosphate compound fertilizers, including monoammonium phosphate, MAP, diammonium phosphate DAP, NPK compound fertilizer , granular triple superphosphate GTSP, nitrophosphate NP, and phosphate rocks , pyrite, potash, etc.

Currently, there are about one hundred operating factories producing high analysis phosphate compound fertilizer. While the annual capacity of phosphoric acid by wet-process amounts to 5.75 million mt P_2O_5, excluding the capacity for calcium hydrogen phosphate for animal feed. Total actual capacity of high analysis phosphate compound fertilizer is 19.08 million mt/year, consisting of MAP 4.12 million mt, DAP 4.90 million mt, NPK (slurry process) 2.12 million mt, NPK (S) 6.15 million mt, NP 0.9 million mt, and GTSP 0.89 million mt. The annual output of high analysis phosphate compound fertilizers in 2002 was 3.68 million mt P_2O_5, making up 45% of the total output of phosphate fertilizer. The average nutrient content of phosphate compound fertilizer products has increased from 16% P_2O_5 in 1997 to 24.4% P_2O_5 in 2002.

It should be noted that the, manufacture of mixed fertilizer, including high analysis mixed fertilizer (nutrient 40%), started from the 80's, mainly by the spherodizing process. Some bulk blending fertilizers (BB fertilizer) are also produced.

Compound fertilizer makes up more than 20% in chemical fertilizer production.

3. TECHNICAL PROGRESS OF PHOSPHATE FERTILIZER INDUSTRY IN CHINA

Since the 1980's, fifteen Chinese fertilizer enterprises have imported various advanced phosphate fertilizer technologies and facilities from abroad, such as:

Wet process phosphoric acid with capacity of 110-1000 MTD P_2O_5 imported from:

- Dihydrate process: RP, Prayon, Dorr-Oliver, Badger, Iprochim;
- Hemihydrate process: OXY;
- Hemihydrate – dihydrate process: Hydro-Agri.
- Thermol process phosphoric acid with capacity of 230 MTD P_2O_5 imported from: Uhde.
- DAP/NPK with capacity of 400-2000 MTD imported from: Davy/TVA, AZF, Jacobs, Hydro-Agri, Espindesa, Incro, Iprochim, K-T.
- GTSP with capacity of 1335-1880 MTD imported from: Hydro-Agri, Krebs.
- NP with capacity of 2973 MTD imported from: Norsk Hydro.
- AlF_3 with capacity of 6000-14000 MTY imported from : A-P, Linz, AlCOA.

All these imported technologies help the Chinese phosphate compound fertilizer industry into the advanced ranks in the world. Moreover, many of them have been improved step by step in those enterprises. These include: Shanxi NP plant, using domestic lower quality rock as feedstock, are able to meet the designed capacity. In Hongfu Co., the current capacity of phosphoric acid unit has increased to 1,300 MTD P_2O_5 from the guaranteed capacity 1,000MTD P_2O_5. Also, in Huangmailing Co., the capacity of phosphoric acid unit increased from 300 MTD to 500 MTD P_2O_5. In Sino-Arab Co., the capacity of NPK unit increased from 480 000 to 720 000 mt/year.

On the other hand, there are also some new technologies developed domestically to suit the properties of local phosphate rock and the shortage of sulfur resources in China.

China is abundant in phosphate rock deposits. Its mines can meet domestic demand fully. The annual output of rocks is 40 million metric tons. However, more than 80% rock are sedimentary, low in phosphorous content and high in undesirable impurities such as iron, aluminium, magnesium, etc. Such rocks are difficult to concentrate and expensive to dress.

Moreover, sulfur resources cannot meet domestic demand. In 2002, 4.095 million metric tons of sulphur was imported for producing sulphuric acid. Output of sulphuric acid was 3.052 million mt, with over two-thirds of it went to phosphate compound fertilizer processing. Raw material construction of sulphuric acid is pyrite 39.5% (annual output about 12 million metric tons), smelters 22.7% and sulphur 36.4%.

Blast furnace process was developed first in 1960's for direct utilization of undressed rock and providing low analysis fused calcium magnesium phosphate FMP. Since the

80’s, in order to produce high analysis phosphate compound fertilizer by direct utilization of undressed medium quality rock (containing P_2O_5 about 28%), some new processes were developed as follow.

3.1 Slurry Process Producing Ammonium Phosphate

The slurry process is mostly employed to produce MAP (containing N≥9-10%, P_2O_5≥41-46%) from undressed rock of medium quality. The difference from conventional process is that dilute phosphoric acid, which is obtained directly from rock extract section, is neutralized directly without concentration. Then, the slurry of ammonium phosphate is concentrated by evaporation, before drying. There is a powdery product from spray dryer or a granular product from spherodizer.

The specificity of the process is indicated in chief processing parameters. For extraction of rock, low concentration phosphoric acid (around 20-25% P_2O_5) is used under high operating temperature (≥80-85°C). Liquid to solid proportion in the slurry is 2.2-3.0: 1. In the operation of spherodizer, very low recycle ratio, around 0.5-1: 1, is kept on.

MAP slurry process unit can also be paralleled with a conventional DAP plant to improve the quality and economic efficiency of DAP plant. The capacity of DAP and MAP unit is in a proportion of 3: 1, and their output can be oriented according to the quality of phosphate rock. In conventional DAP process, slurry acid is ordinarily withdrawn from phosphoric acid storage tank and thereafter returns to the extraction section. However, it causes the fluctuation of DAP quality and additional consumption of raw material. An alternative process is developed by sending the slurry acid to a parallel MAP slurry process unit as one of its feedstock.

Another feedstock is dilute ammonium phosphate solution withdrawn from tail-gas scrubber of DAP plant. After neutralization with ammonia, the slurry is concentrated and spray dried as product of MAP unit. Some existing DAP plants employed such parallel processes very profitably.

Slurry process provides powdery MAP product that possesses a better granulation property than those from conventional process. It is mostly advanced to NPK manufacturing.

Actual annual output of MAP by slurry process in 2002 reached 2.75 million metric tons. The largest capacity of a single line unit for MAP production is 0.3 million tons per year.

3.2 Low Temperature Conversion Process (90-110°C) Producing NPK(S)

The process has been operated in Hongri Group and many other enterprises. Its normal product is NPK(S) compound fertilizer containing N 13.5%, P_2O_5 17%, K_2O 14.5% and S 11% (K_2SO_4 and $(NH_4)_2SO_4$ mainly) with Cl ≤3%. Raw material of the process consists of phosphate rock, sulphuric acid, ammonia, urea and potassium chloride. The design consists of three processes: monoammonium phosphate, potassium sulfate and NPK(S). They were combined together in a very unique form. The flow diagram is much simplified and the cost of production is much lowered too. Consequently, this product is very competitive in market.

In the low temperature conversion section of the diagram, potassium chloride reacts with concentrate sulphuric acid in temperature of 90-110°C producing potassium hydrogen sulfate solution. A huge amount of hydrogen chloride gas releases form hydrochloric acid of 31% concentration as a by product. The release of hydrogen chloride gas keeps on until chlorine content in potassium hydrogen sulfate solution meets its standard. Then the solution is pumped into a mix acid tank to be mixed by dilute phosphoric acid and dilute ammonium phosphate slurry withdrawn from tail gas scrubbing system. In granulation section of the diagram, the dilute slurry of the mix acid tank is pumped into a pipe reactor and reacts with ammonia gas. The reactant immediately goes to a flash tower and allows the water to evaporate. This process takes advantage of the larger reaction heat than the conventional case. Hence the flash tower produces a slurry with lower content of water that is no more concentrated than needed. Then the slurry goes to spherodizer by a slurry pump. Rotary granular and rotary dryers are also applied.

The largest capacity for a single line unit of the combined process reached 0.3 million metric tons/year. Total output of NPK(S) by means of this process was 4.24 million metric tons in 2002.

3.3 Roasting and Decomposition of Phosphogypsum, Producing Sulphuric Acid and Cement

The roasting and decomposition process of phosphogypsum has been operating in a large sulphuric acid plant in Lubei Enterprise Group, Shangdong Province, since 1999. The process consists of roasting phosphogypsum in a kiln and decompositing it in a cyclone heat exchanger.

Outputs of sulphuric acid and cement are 400 000 and 600 000 mt /year respectively. There are also four plants each producing 60 thousand mt sulphuric acid and 80 000 mt cement per year in operation. Cost of production are less than 30 USD /mt for sulphuric acid and 15 USD/mt for cement.

There are some 20 million metric tons per year of phosphogypsum, containing S 18%, as a by-product from the 4 million metric tons P_2O_5 per year wet process phosphoric acid production. In the long run, appropriate utilization of phosphogypsum is in line with the strategy of sustainable development. Competitiveness of the process will be based on large scale production to save cost. Due to the shortage in sulphur resource, this process may have potential.

4. OUTLOOK FOR CHINA'S PHOSPHATE FERTILIZER INDUSTRY

It is anticipated that production of phosphate fertilizer in 2005 will exceed 9.5 million mt P_2O_5, meeting 90% of domestic demand. The increase will be mainly from high analysis phosphate compound fertilizer, such as MAP, DAP and NPK. These products will account for 55% of the total. The remaining 45% are low analysis phosphate fertilizer, SSP and FMP.

Single superphosphate SSP contains low P_2O_5. Nevertheless, it contains many essential nutrients: calcium, sulfur, etc. It takes advantage of low market price, suitable for various soils and crops, using medium quality domestic phosphate rock resources and consuming less sulfuric acid. Therefore, production of SSP is in line with the strategy of sustainable development. Similarly, fused calcium and magnesium phosphate, FMP, also contains multiple nutrients like calcium, magnesium and silicon. And low quality domestic phosphate rock can be used as feedstock directly even without sulfuric acid consumption. Market price of it is low also. Both SSP and FMP can complement the shortage of secondary nutrient elements like calcium, magnesium, and sulfur absent in high analysis phosphate compound fertilizer. Therefore, SSP and FMP are still good and economical fertilizers for farmers, especially for the farms located not far away from sales center. It is estimated that SSP and FMP will be kept in existence in Chinese market for a long time, but their amount will be reduced

The expected production of sulphuric acid in 2005 will exceed 35 million metric tons, 40% of which bases on sulphur as raw material.

In the coming five years, there will be an additional phosphate fertilizer capacity of 3 million metric tons (P_2O_5) to produce MAP, DAP and NPK(S). In order to greatly reduce the investment and cost of production, domestic technologies, designs and facilities will be adopted. Major development will be centered in Yunnan, Guizhou, and Hubei provinces, which are rich in phosphate rock resource. Where there is shortage of resources little development will take place.

The overall strategy for developing phosphate fertilizer industry will continuously focus on improving economic efficiency in order to upgrade the overall competitive ability of China's phosphate compound fertilizers in the global market. To achieve this goal, the authority will take some important measures: encouraging the creation of innovative technologies, enhancing local potential capacities and strengthening management to reduce production cost. From now on, no matter what kind of the facility is, newly established or modernized, the investment should base on a credible fact: that is, to maintain a certain profit of the enterprise even if the market price of the product falls. At the same time, enterprises are going to be merged to increase their consolidation and ignite the collective advantages. The modernization of commodity business will also be accelerated to reduce the cost of transportation, storage and marketing in this cyclical business.