

The Small-Scale Ammonia Production of China in the Time of Mao Zedong

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Japan

1. Introduction

It is said that the fear for the supply shortage of raw materials of explosives forced engineers to invent the technology to synthesize ammonia from the air. Computers, radars etc. were developed during the wartime. We can say that the war develops the technical progress generally speaking. In the early time of People's Republic of China, however, the reversal phenomenon was observed. It appears that technical progress turned reversely backward to the pre-war initial level due to the fear of the war with USA and USSR. Namely China sought and pursued small scale production under the Chairman Mao Ze Dong's self-reliance policy. The ammonia production was the typical case of such small-scale production.

2. Ammonia Production in China

1) Middle scale production

The first ammonia plant with 50,000 t/y production capacity was constructed in Dalian by Japan in 1935. Besides Fan Xudong and Hou Debang of Yongli Company of PR China constructed the ammonia plant with 33,000 t/y production capacity in Nanjing in 1937 under the aid of the government of PR China. Dalian ammonia plant process was Uhde of Germany and Nanjing plant process is NEC of the United States. Both of them were one of the most advanced process among the pre-war ammonia technologies.

In 1949 the new government of China was formed. The economy of the new China was recovered to the prewar level in 1952 and the ammonia plants in Dalian and Nanjing were reconstructed and re-started production. During the First 5-Year (1953-57) Plan additionally 3 more ammonia plants were constructed in Jilin, Lanzhou and Taiyuan with 50,000t/y production capacity each under the technical and financial aid of USSR.

Thus the newly born China succeeded in getting the technology to construct and operate the middle-scale, namely 50,000t/y, ammonia plants, through the reconstruction of the old plants and the construction of new plants. Then China constructed 15 middle-scale ammonia plants additionally by 1965 without depending on foreign companies. As a result ammonia production in China at that time were mostly from middle scale plants, covering 88% of national production in 1965.

Table1 shows ammonia production by plant capacity scale during 1952-1983. In 1952, 97% of national production in China was from middle scale plants. In 1957, the year Chinese economy was very active due to the First 5 Year Plan, 100% of ammonia production was from middle scale plants. The share of the production from middle scale plants, however, decreased afterwards throughout 1960's, 1970's and 1980's as the Table1 shows. The share in 1983 was only 22%, despite the share of 100% in 1957.

年	Large scale			Middle scale			Small scale			Total 1000t
	No. of plants	Production		No. of plants	Production		No. of plants	Production		
		1000t	%		1000t	%		1000t	%	
1952				2	37	97	1	1	3	38
1957				3	153	100				153
1962				8	455	94	45	28	6	483
1965				22	1,301	88		185	12	1,484
1970				30	1,445	59	300	1,000	41	2,445
1973				38	2,155	45	961	2,589	55	4,744
1974				42	2,074	44	1,078	2,651	56	4,725
1975				45	2,533	42	1,199	3,544	58	6,077
1976	4	170	3	47	2,334	38	1,319	3,681	59	6,185
1977	5	1,245	14	49	2,579	30	1,450	4,880	56	8,704
1978	8	2,061	17	53	3,190	27	1,533	6,584	56	11,835
1979	10	2,706	20	54	3,518	26	1,539	7,257	54	13,481
1980	13	3,127	21	56	3,655	24	1,439	8,194	55	14,975
1981	13	3,359	23	56	3,667	25	1,357	7,808	52	14,833
1982	13	3,448	22	56	3,637	24	1,279	8,378	54	15,464
1983	13	3,631	21	56	3,683	22	1,244	9,457	57	16,771

Remark: Large scale is imported technology, Middle scale is 10,000–50,000 t/y, Small scale is less than 10,000 t/y.
Source: DANDAI ZHONGGUO DE HUAXUE GONGYE, 1986, Appendix Table 5.

2) Small scale production

On the one hand China developed the small scale, namely 800 t/y, ammonia plant in 1958 in Dalian. The world famous chemist Hou Debang was the leader of the newly developed small scale plant. Furthermore 2,000 t/y plant was developed in Shanghai. But the development of the ammonia production from small scale plants was moderate until 1965.

Ammonia production from the small scale plants began to increase from 1965. 12% of the national production was from small scale plants this year. After the second half of 1960's a number of small-scale ammonia plants were constructed in the rural area of China under the self-sufficient strategy. In 1970 the number of small scale plants increased to 300 and 41% of national production was from small scale plants. The number of small scale plants continued to increase during 1970's to more than 1,500, resulting the share near 60% of the total national production.

The small scale production was peculiar to China in the time of Mao Zedong. In other words Mao Ze Dong, facing the containment strategy by USA and USSR, began to consider that USA and/or USSR will attack and invade into China. China feared that the concentration of production will cause a serious damage on the Chinese economy in case USA and /or USSR attack China.

Thus, under the Chairman Mao's leadership, China walked the way of the geographically dispersed small scale production structure. Despite the ability of constructing the middle scale ammonia plants, China newly developed the technology of small scale ammonia plants, namely 800 t/y or 2,000t/y. More than 1,500 small-scaled ammonia plants were constructed in the rural area of all over China during end 1960's and early 1970's, the period when Chairman Mao was seriously afraid of USA's attack on China.

3) Large scale production

The meeting of Mao Zedong and Nixon in 1972 changed drastically the fundamental relation between China and USA. In 1973 China contracted importation of 13 large-scale ammonia plants with 330,000 t/y capacity and urea plants with 500-600,000 t/y capacity with the companies of USA, Japan and Europe.

We can see the situation in Table 1. The first large-scale ammonia/urea plant started production in 1976 in Sichuan Province and afterwards large-scale fertilizer plant started production one after another. The share of the large scale plants has increased to over 20% in the early 1980's.

4) The reversal development of the ammonia production technology in China

We have observed that the ammonia production in China developed from the middle scale plant to the small scale plant and then from the small scale plant to the large scale plant. Namely, China shifted from the middle-scale to the small-scale, resulting 55% of national ammonia production from the small-scale plants in 1973, though only 6% in 1962.

The main stream of the world ammonia industry in 1960's is toward the large-scale plants with 330,000 t/y capacity. For example, the first ammonia plant capacity in pre-war Japan was 5 t/d, namely 1,650 t/y, according to the monument in Shimonoseki City. Ammonia plant capacity of the company (Toyo Koatsu Industries) was then increased to 8,910 t/y in Omuta City and then to 66,500 t/y in Sunagawa City during WW II. Japan's development model is from small scale to middle scale and from middle scale to large scale: 1,650 t/y → 8,910 t/y → 66,500 t/y → 330,000 t/y. China's development model is from middle-scale to small-scale: 50,000 t/y → 800t/y (or 2,000 t/y) → 330,000 t/y.

The reversal movement to the pre-war initial technology in China was caused by the Mao Ze Dong's self-reliance policy. Under the self-reliance policy China denied the division of labor and aimed to construct the self-sufficient economy in each rural area. The denial of the division of labor prevented the technical progress development and ammonia production technology reversed to the pre-war small-scale level.

3. Nitrogen fertilizer production in China

1) Variety of nitrogen fertilizers

Ammonia is the raw material of the nitrogen fertilizers, and the major nitrogen fertilizer which Chinese farmers used in the prewar China was ammonium sulphate. In the prewar China ammonium sulphate was the only nitrogen fertilizer domestically produced. Ammonium nitrate was newly introduced during the first 5-year plan by USSR. Ammonium chloride was produced as the by-product of soda ash production. Besides, the technology of urea was developed and a new urea plant with 40,000 t/y capacity was constructed in 1965 in Wujing as the symbol of the self-reliance technology¹.

2) Ammonium bicarbonate (AB) as the fertilizer

When the first small-scale ammonia of 800 t/y capacity was constructed in Dalian in 1958, most of the ammonia produced was used as the liquid fertilizer by adding water to ammonia. Soon later China developed the technology to use ammonia from the small-scale

¹ According to the company brochure the production capacity was designed as follows: ammonia 50,000 t/y, sulphuric acid 80,000 t/y, ammonium sulphate 100,000 t/y, urea 40,000 t/y.

plant as the raw material for the production of AB (ammonium bicarbonate: NH_4HCO_3) which was utilized as the fertilizer. Under the supervision of worldwide famous chemist Hou Debang the model plant of 8000 t/y AB and 2,000 t/y ammonia plant was developed in Shanghai. AB with only 17.5% nitrogen content is not an effective fertilizer since it is easy to deteriorate during storage and transportation.

Although AB is not an efficient fertilizer AB plant is easy to construct and operate. Besides the cost of AB is very cheap. The geographically dispersed small-scale production reduced the loss during transportation and storage and covered the defects of AB. The raw material of AB is coal which can be obtained easily all over the nation. As a result China constructed more than 1,500 AB plants all over the rural areas supplying the fertilizer to the poor farmers. Construction of small-scale ammonia and AB increased dramatically during the latter half of 1960's when Chairman Mao feared the possible war with USA and USSR. The more than 50% of nitrogen fertilizer after 1970 was from small-scale ammonia, though near 100% from middle-scale ammonia during 1950's. China is the only nation in the world which utilized AB as the fertilizer.

Table 2 shows the small scale nitrogen fertilizer production in China. The small scale nitrogen fertilizer production started in 1958 in Dalian, using 800 t/y ammonia as the raw material for AB. Then AB plant was improved in Shanghai and the model plant developed in Shanghai spread throughout the nation. Thus AB became the major nitrogen fertilizer. AB production increased rapidly after the second half of 1960's when the war between China and USA might break out. In 1968 AB share in the total national nitrogen production reached 50%. Since that time the share of AB continued to be more than 50% until 1992.

Table2 Small Scale Nitrogen Fertilizer Production in China

	Small scale ammonia		Small scale N fertilizer		Small scale urea		AB	
	production 1000t	share %	production 1000t	share %	production 1000t	share %	production 1000t	share %
1958	1.1	0.5	0.7	0.5			4.1	0.5
1959	1.3	0.4	0.9	0.6			5.3	0.6
1960	2.7	0.6	2.1	1.1			12.4	1.1
1961	15.5	5.1	10.4	6.0			61.2	6.0
1962	28.1	5.8	19.4	5.7			114.1	5.7
1963	46.7	7.3	32.6	7.1			191.8	7.1
1964	87.2	9.4	60.3	8.9			354.7	8.9
1965	183.5	12.4	126.8	12.2			745.9	12.2
1966	405.8	19.1	281.4	19.3			1,655.3	19.3
1967	403.1	26.5	279.3	27.5			1,642.9	27.5
1968	370.4	35.4	341.9	50.0			2,011.2	50.0
1969	578.3	35.9	364.1	35.6			2,141.8	35.6
1970	1,000.4	40.9	764.9	50.2			4,473.1	50.2
1971	1,349.3	43.5	967.8	50.8			5,659.6	50.8
1972	1,971.4	49.8	1,377.0	53.9			8,052.6	53.9
1973	2,589.3	54.6	1,798.9	60.0			10,508.2	60.0
1974	2,451.3	54.2	1,656.8	58.6			9,688.9	58.6
1975	3,544.2	58.3	2,321.3	62.6			13,574.9	62.6
1976	3,681.0	59.5	2,421.9	63.5			14,163.2	63.5
1977	4,879.9	56.1	3,212.7	58.2			18,787.7	58.3
1978	6,484.5	54.8	4,348.9	57.5			25,432.2	57.5
1979	7,257.0	53.8	4,809.8	54.5			28,127.5	54.5
1980	8,193.5	54.7	5,528.5	55.3			32,330.4	55.3
1981	7,807.9	52.6	5,258.6	53.4			30,752.0	53.4
1982	8,378.5	54.2	5,461.4	53.4			31,938.0	53.4
1983	9,457.2	56.4	6,401.1	57.7			37,433.3	57.7
1984	10,525.9	57.3	7,121.2	58.3			41,644.4	58.3
1985	8,202.5	50.0	6,061.8	53.0			35,449.1	53.0
1986	8,343.3	50.3	6,103.5	52.7	193.3	0.8	34,562.6	51.9
1987	10,637.2	54.9	7,617.0	56.8	211.5	0.7	43,307.0	56.0
1988	11,292.0	57.1	7,894.1	55.6	245.7	0.8	44,727.5	54.8
1989	11,615.3	56.1	8,143.4	56.1	323.8	1.0	45,728.7	55.1
1990	11,950.6	56.1	8,398.0	56.4	312.0	1.0	47,286.5	55.4
1991	12,389.6	56.3	8,430.2	55.8	916.1	2.8	43,942.1	53.0
1992	13,033.4	56.7	7,484.8	56.7	1,230.4	4.3	36,575.4	52.4
1993	12,300.0	55.7	6,921.0	54.5	1,537.7	5.6	31,481.3	42.4
1994	13,836.5	56.7	7,107.1	56.0	2,140.6	7.8	29,043.9	48.2
1995	15,187.0	54.9	9,850.5	53.1	3,569.4	8.8	36,731.6	44.2
1996	18,251.0	59.6	11,962.5	57.6	5,311.3	11.8	38,895.9	45.9
1997	17,038.0	56.7	11,421.0	53.2	6,767.0	29.4	48,872.0	38.7
1998	17,311.0	54.3	11,541.0	52.6	7,540.0	29.4	47,486.0	36.8
1999	18,730.0	54.3	12,649.0	52.6	9,870.0	33.6	47,560.0	34.0
2000	19,373.0	57.6	11,436.0	51.9	11,575.0	38.0	37,023.0	26.4
2001	19,189.0	56.3	12,162.0	56.0	12,848.0	40.8	33,626.0	23.0
2002	22,321.0	60.5	14,686.0	59.1	15,100.0	44.0	38,391.0	25.5
2003	23,838.0	62.9	14,967.0	61.3	16,812.0	47.2	35,692.0	23.7
2004	26,575.0	62.9	16,721.0	61.0	18,617.0	47.6	38,955.0	22.3
2005	30,562.7	66.0	18,484.8	63.3	20,982.6	50.6	39,756.5	21.2
2006	33,614.0	68.1	21,301.0	66.1	25,011.0	54.6	37,919.0	19.1
2007	35,698.0	69.2	23,215.0	67.7	28,981.0	58.1	32,750.0	15.0
2008								13
2009								12
2010								11
2011								10
2012								
2013								
2014								
2015								6.5

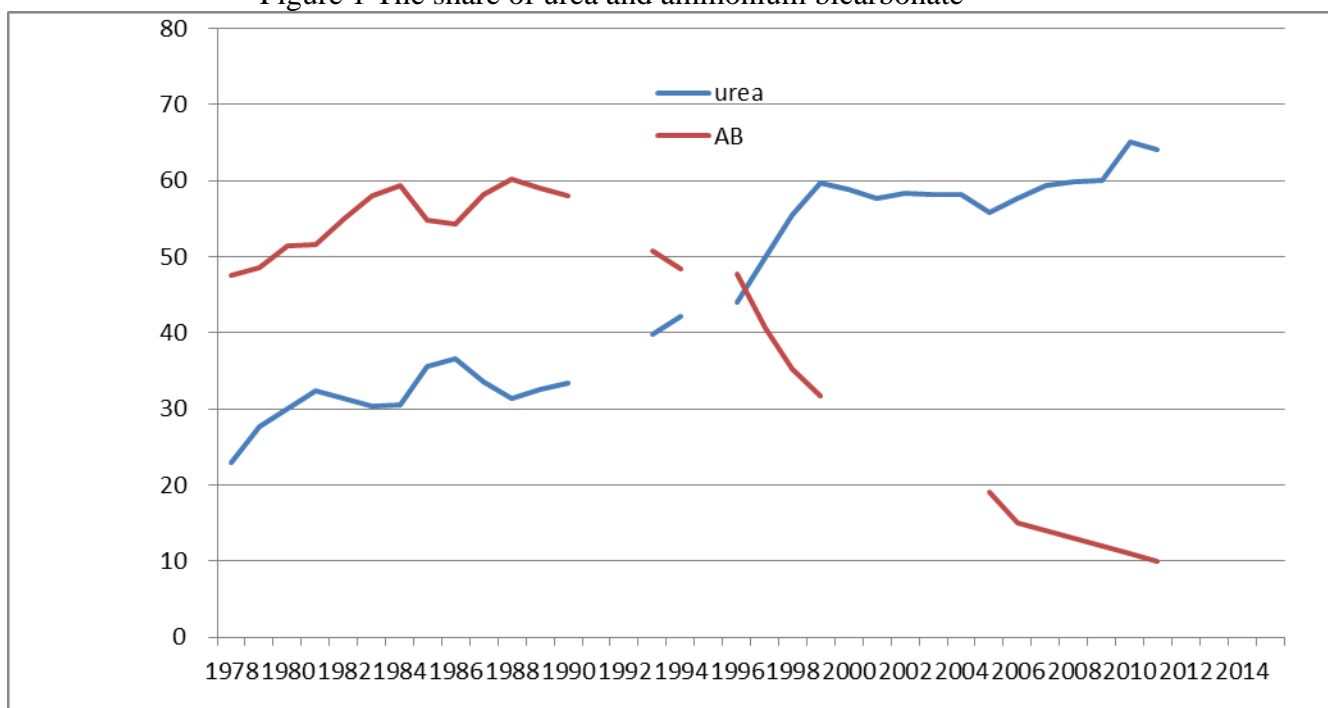
Remark: Small scale nitrogen fertilizer production is in terms of nitrogen 100%.

Source: *Zhongguo Xiao Danfei Gongye Dashiji 1958-2008*, 2008 and internet information on AB.

3) Significance of AB as the nitrogen fertilizer

AB played an important role contributing poor farmers in the days of Mao Zedong. AB continued to play an important role even in the days of the reform and open-up policy. Figure 1 illustrates such kind of the situation. In 1978 the share of AB is 48% and the share of urea is 23% in the national total nitrogen fertilizers. AB production and share still increased afterwards and the share reached 60% in 1988. After 1989 the share of AB began to decrease slightly but the share in 1996 is still near to 50%. On the other hand the share of urea increased consistently and the share in 1997 reached 50%, exceeding the share of AB 41%. In the latter half of 1990's AB share decreased rapidly. After 2000 there is no data concerning AB in *China Chemical Industry Yearbook*. It is quite hard at present to get consistent information data on AB. It is said that AB share is planned to be 6.5% in 2015 in the 12th 5-Year Plan.

Figure 1 The share of urea and ammonium bicarbonate



It is noteworthy that Shanghai Research Institute of Chemical Industry developed the technology to convert AB plant into urea plant in mid 1980's. We can see the situation in Table 2. 193,300 tons of urea were produced in 1986 in such from AB converted urea plants, namely small scale urea plant. The model plant capacity developed by Shanghai Research Institute of Chemical Industry is 40,000 t/y. Therefore more than several AB plants seemed to be converted into small scale urea plants and started production in this year. The production of small scale urea plants increased year by year. Near 30million tons of urea was produced in 2007, counting 58.1% of the national urea production.

4. Implication

1) Reversal development of technology

China's technology level turned back to the pre-war primitive level due to the denial of the division of labor and self-sufficient economy. Namely, because of the containment by USA and USSR, Mao Zedong selected the self-reliance policy, and China walked the way of self-sufficient economy. The people's commune was the base of the self-sufficient economy. The people's commune denied the division of labor which brought about the technology

development of capitalism. We can say that China's ammonia production technology developed reversely to the pre-war level due to the fear of the war with USA and USSR.

2) AB as the appropriate technology

AB (Ammonia Bicarbonate) was the so-called 'appropriate technology' at the time of Mao Zedong. AB is easy to deteriorate during storage and transportation but easy to construct and operate, and the price is very cheap. Construction of plants in rural area reduced the loss during storage and transportation. Production of ammonium sulfate, the most standard nitrogen fertilizer at the early time of Mao Zedong, consumes a lot of sulfuric acid which consumes a lot of sulphur, a scarce resource in China. Production of urea needs stainless steel whose supply was limited in the time of Mao Zedong.

3) Starting year of China's open-up policy

The small scale production was the widespread industrial structure in the time of Mao Zedong. From the viewpoint of production technology development, China's reform and open-up policy appears to have started in 1972. Because soon after the meeting of Mao Zedong and Nixon in 1972 China decided the import of 13 large-scale ammonia/urea plants from USA, Japan and Europe. Since that time China began to seek the same large-scale production technology as western countries. People say that reform and open-up policy started in 1978. It appears from the viewpoint of the production technology, however, that China started open-up policy in 1972, rather than in 1978.