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CONSULTATIONS ON ALUNITE PROCESSING IN CHINESE PEOPLE'S REPUBLIC

FINAL REPORT

VAMI

V O TECHNOEXPORT

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1988

C O N T E N T S

INTRODUCTION

In conformity with the Contract XP/CPR/88/043 "Consultations on alunite processing" approved and financed by UNIDO a group of Soviet experts from All-Union Aluminium and Magnesium Institute (VAMI) made a visit to Chinese People's Republic from November 23 to December 9, 1988 as UNIDO consultants on subject of integrated processing of CPR alunite ores, including:

Dr.N.A.Kaluzhsky	- Director of VAMI Institute, head of group
G.Z.Nasyrov, M.Sc.	- Chief of laboratory for alunite processing
V.A.Bronevoy M.Sc.	- chief of laboratory for aluminium ores
Yu.P.Levashov	- Project manager of Kirovabad alumina complex

Also participated:

Dr.E.Balazs	- Senior regional counceller for metallurgy, UNIDO (Wienna, Austria)
B.E.Yurasov	- Director of office for UN technical assistance, V/O "Tekhnoexport"

Solution to the problem of the integrated processing of alunite ores in CPR to produce alumina, potassium sulfate and sulfuric acid has a paramount importance, since all above products made from alunite as a results of its integrated processing by reduction-alkaline process are extremely scarce in CPR. The most urgent is the problem of covering the country's demand for growing the most valuable agricultural crops (citrus, tea, tobacco, vegetables, vinegrape, hemp etc). To satisfy the sharp shortage in chlorine-free potassium fertilizer CPR at present has to import about 500,000 tpy of potassium sulfate, with

minimal country's demand being over 1 mln.tpy.

At the same time CPR possesses vast natural reserves of alunite ores with high content of potassium sulfate (alunite deposites in provinces Zhejiang, Anhui, Shandong and Fujian), based on which CPR may establish large commercial production of high-quality commercial products: alumina, potassium sulfate, sulfuric acid.

The largest reserves of alunite ores with high content of potsssium sulfate are concentrated in Fan Shan deposit in Zhejiang province.

Research connected with development of technology and equipment for integrated processing of alunite including pilot-scale tests has been conducted inCPR for nearly 30 years. Research efforts are concentrated in Shanhai Research Institute for chemical industry and Research Institute of alunite ore in Wenzhou. At the initial stage the Shanhai Research Institute conducted the study for development of the process and equipment for integrated conversion of alunite ore of Anhui deposit by the ammonia method.

In 1958 the chemical plant of nitric fertilizers in Nanjing built a pilot unit for testing the ammonia technology for processing alunite. Further research efforts were concentrated at development of reduction-alkaline method. In 1965, the pilot complex was started at the chemical complex in Wenzhou for proecessing of alunite ore from Fan Shan deposit by the reduction-alkaline method. At present the pilot complex turns out 3000 tpy of potassium sulfate, 3000 tpy of sulfuric acid and 5000 tpy of aluminium hydroxide. However, despite of big scope of reaearch

efforts and significiant progress achieved in recent years in improvement of technology and equipment, the reduction-alkaline technology of integrated processing of alunite used at Wenzhou pilot plant is insufficiently advanced, production process is note for relatively high consumption of energy and fuel, and relatively low quality of resulting commercial products. These considerations prevented the taking of decision on construction of a large commercial plant for integrated processing of alunite ore from Fan Shan deposit in CPR.

In response to VAMI initiative, UNIDO made a proposal in 1987 to the Chinese counterpart to study a positive experience of the USSR achieved in the field of commercialisation of the integrated processing of alunite ores of Zaglik deposit at the Kirovabad alumina complex. In 1987 VAMI carried out the study for amenability tests of three samples of alunite ore selected from Fan Shan deposit followed by release of the Report on results of the above study to Chinese counterpart.

In October 1987, three Chinese specialists of Wenzhou chemical complex visited VAMI Institute to discuss the results of the study of the above alunite samples by the Soviet technology.

In September 1988, a high-level delegation from the Ministry of chemical industry of CPR again visited VAMI Institute and Kirovabad alumina complex for familiarisation with achivements of the industrial technology for integrated processing of alunite ore in USSR.

The above meetings and discussions resulted in arising interest from Chinese specialists in utilisation of Soviet experience as a solution to a problem of the integrated processing of alunite ores in CPR.

The return visit by VAMI experts to CPR as UNIDO consultants took place, as stated above, from November 23 to December 9, 1988. The aim and subject of a visit by the Soviet experts: onsite study of local prevailing conditions in CPR, conducting geological prospecting survey and solution to a problem of establishment of the industrial technology for integrated processing of alunite ores; discussions with Chinese counterpart and preparation of the proposals for the conclusion, via UNIDO, of the contracts for ore sampling, and laboratory and commercial tests by the Soviet technology of the representative technological samples of CPR alunite ore in VAMI Institute and Kirovabad alumina complex which will be used as a basis for preparation of the opportunity study of feasibility of industrial processing of alunite ores and later to prepare the Feasibility study for construction of the large industrial plant in CPR for implementation of integrated processing of alunite ores from Fan Shan deposit by the Soviet technology. A mission of UNIDO experts in Beijing met with officials of Ministry for chemical industry. In Shanhai the mission visited the Shanhai research institute for review of organisation of research efforts in the field of production of mineral fertilizers.

In Zhejiang province in Wenzhou city the mission visited the Wenzhou chemical complex, reviewed operations of the pilot plant for processing of alunite ore, inspected possible sites for construction of the proposed chemical complex. The group of experts also visited the Fan Shan deposit of alunites, reviewed alunite mining operations, production of alums, as well as familiarised with the results of prospecting survey at Shuiweiren

section.

In Hanzhou, in Zhejiang province the mission of UNIDO experts was received by the Head of the provincial government, Mr.Sheng Culeng and conducted a final discussions with the specialists in the Administration of chemical and petrochemical industry of Zhejiang province.

The preliminary conclusion of the Soviet experts on feasibility of establishment of the industrial processing plant for alunite ores from Fan Shan deposit in CPR and the recommended program of preparatory works for solution to this problem handed over to Chinese counterpart are annexed as Appendix 5.1.

Protocol of the final discussions conducted with Chinese specialists in the Administration of chemical and petrochemical industry of Zhejiang province is given in Appendix 5.2.

1. STATUS OF GEO-PROSPECTING SURVEY AND PRELIMINARY ASSESSMENT OF RESERVES AND QUALITY OF FAN SHAN ALUNITE ORE

Chinese People's Republic possesses vast reserves of alunite ore in Zhejing and Anhui provinces, as well as in Fujian and Shandong provinces.

The alunite deposit Fan Shan located in Zhejing province 100 km south-west of Wenzhou city is at the most detailed level of surveying.

Overall reserves of this deposit are estimated at 300 mln.t, with 86 mln.t occurring within the limits of Shuiweren section, which is recommended by Chinese specialists as a raw material

base for the proposed new chemical plant in Wenzhou.

Prospecting boreholes in number of 182 were sunk at Shuiweren section to a grid of 400x200 m, 200x200 m, 100x100 m and boreholes started to be drilled to a grid of 100x50 m, which corresponds to the categories of B, C and D adopted in CPR.

The ore body consists of 9 levels with average thickness of 5-7 to 12 m. Overall average thickness of alunite ore at this section is 42 m with overburden thickness (with incorporated gangue strata ignored) amounting to abt 20 m.

Estimation of reserves and average quality of alunite ore is made separately for lean and rich ores under one set of conditions at minimum industrial thickness and maximum thickness of gangue of 2 m and at cut-off grade: non-alunite Al_2O_3 ~ 5%, alunite content - 20% for lean ores, and 35% for rich ores. For characteristics of ores refer to Table 1.1.

Table 1-1

Parameter	Type of ore		
	rich	lean	total
Reserves, mln.t	70.0	16.0	86.0
SO_3, %	18.1	13.9	17.4
Al_2O_3, %	18.9	1611	18.4
with non-alunite components:			
K_2O, %	4.33	3.37	4.17
Na_2O, %	0.64	0.48	0.61
SiO_2, %	43.4-48.1	44.1-55.8	50.0
V_2O_5, %	0.051	0.044	0.0488
Ga, %	0.0023	0.0023	0.0023
Alunite, %	46.5	35.7	44.6
$\frac{K_2O}{K_2O + Na_2O}$, % mole	81.5	81.7	31.8

It was agreed with Chinese counterpart that by the end of February 1989, they would carry out additional estimation of reserves and quality of alunite ore at minimum alunite ore content in individual samples of 37-39-41%.

This estimation will allow determination of possible increase of average content of alunite in industrial sample up to 48-50% and magnitude of reduction of reserves of this raw materials.

Due to insufficient representative nature of 3 alunite samples provided earlier for VAMI, it is required to select new samples for bench-scale tests (up to 150-250 kg in weight) and pilot tests (up to 4,-5,000 t in weight).

Procedure and specifications for selection of these samples shall be developed by Soviet experts in cooperation with Chinese counterpart after estimation of the reserves according to the above additional set of cut-off conditions.

Owing to thickness of the ore body and overburden, Shuiweren section may be mined by the open pit method.

Ore delivery to the plant after coarse and medium crushing at the mine will be by the ropeway system to the sea coast (abt 7 km) and further by sea to the plant site (abt 100 km).

In preparation of the Feasibility study of construction of Wenzhou plant for processing alunite ores all sections related to construction of the alunite mine, coarse and medium crushing plant, and transport of alunite ore to the plant site (ropeway, loading-unloading facilities at sea coast, sea carriers) shall be prepared by specialised CPR organisations.

2. ASSESSMENT OF STATE-OF-THE-ARTS OF EQUIPMENT AND TECHNOLOGY OF PROCESSING OF ALUNITE ORES IN CPR. PROPOSALS ON ABPLICATION OF SOVIET EQUIPMENT AND TECHNOLOGY FOR INTEGRATED PROCESSING ALUNITE ORES IN CPR

As stated above, despite large scope of research efforts and significant progress achieved recently in improvement of technology and equipment the reduction alkaline technology used for processing alunite ores from Fan Shan deposit at present time at Wenzhou pilot plant is insufficiently advanced, production is noted for high consumption of fuel, energy, inputs and relatively low quality of resulting intermediate products and finished produsts. Thus, alunite roasting with hot furnace gases in multifloor furnace is a low efficient process, which requires high fuel demand. Fuel consumption per tonne of product when roasting alunite in the multifloor furnace is more than 3 times higher than that achieved at Kirovabad alumina complex, when roasting alunite in the fluidised bed reactors. Thermal decomposition of alunite at Wenzhou complex is accomplished by the generator gas. As a result this section, as compared with technology of alunite decomposition by elementary sulfur used in the USSR, shows low performance and economic figures.

The main disadvantage of the alunite thermal decomposition process in use is linked to high cost of generator gas consumed for thermal decomposition and formation of complex carbon products in the reactor. The process is also noted for entrainment of large quantitites of alunite dust from the reactor together with the exit gas, passivation of aluminium oxide in the reduced alunite and low quality of sulfurous gas leading to a more

expensive and complex sulfuric acid production facilities.

The process flowsheet used at the plant for hydrometallurgical treatment of reduced alunite is not sufficiently developped either. The plant lacks the process section for conversion of potassium and sodium sulfates; a mix of potassium and sodium sulfates is turned out as a finished product with 65% K_2SO_4. Recovery of aluminium oxide from alunite into product aluminium hydroxide is below 70%.

Based on the above statements it is recommended for the Ministry of chemical industry of CPR, in order to speed up solution to the problem of integrated processing of alunite ores from Fan Shan deposit, to utilise the achievements of the Soviet technology and equipment for integrated processing of alunite ores successfully commercialised at Kârovabad alumina complex.

Amenability study of three alunite samples taken from Fan Shan deposit prepared earlier proved their suitability for conversion by the reduction alkaline process in accordance with the Soviet technology to produce alumina, potassium sulfate and sulfuric acid.

Based on expected chemical and mineral composition of alunite ore from Fan Shan deposit and urgent need for establishment of large-scale production facilities of potassium sulfate in CPR it is recommended to use the following process flowsheet for integrated industrial processing of high-potassium alunite ores of Fan Shan deposit by the reduction alkaline method (Fig.2.1).

According to this flowsheet ground alunite ore is roasted and thermally decomposed in fluidised bed reactors in contact with elementary sulfur to the following equilibrium reaction:

SHEMATIC FLOWSHEET FOR COMPLETE PROCESSING OF ALUNITE ORE

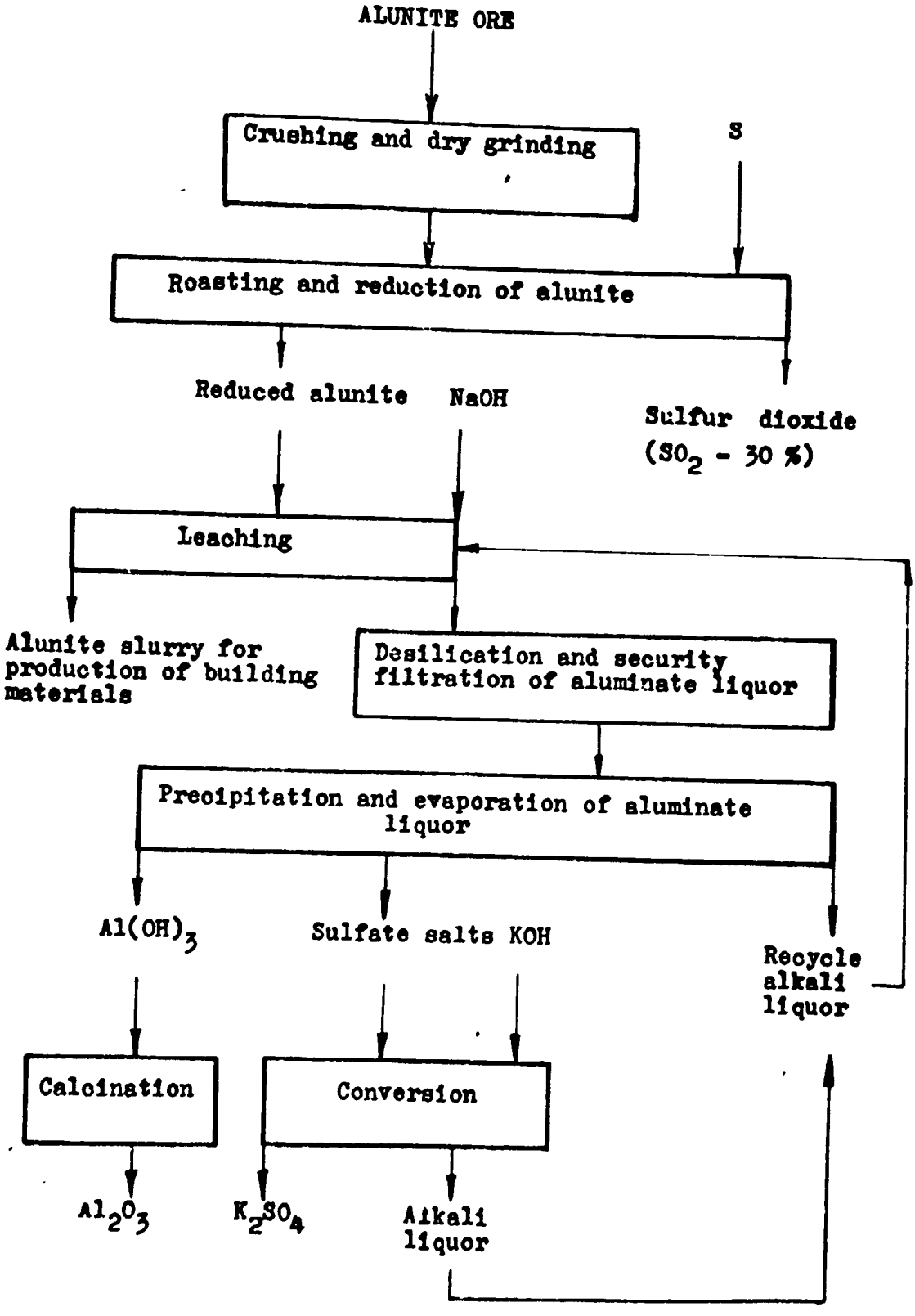

Fig. 2-1

$$K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 2Al_2O_3 + 1.5S \quad K_2SO_4 + 3Al_2O_3 + 4.5SO_2$$

The resulting high-grade sulfurous gas (with concentration of 30-35% SO_2) is used for economic production of high-grade sulfuric acid by the double contact and gas absorption diagram. (If required, liquid sulfur dioxide may be separated from gas). Sulfuric acid produced from gas meets the most stringent specifications for quality of acid under the industrial standard STW 534-82, applied for production of commercial-grade sulfuric acid in CPR.

Table 2-1 below shows extract from the above standard STW 534-82.

Table 2-1

Components	Special high-grade	H_2SO_4	
		I	II
H_2SO_4 min	92.5-98.0	92.5-98	92.5-98
SO_3, %	-	-	-
Total solids, %	0.02	0.03	0.10
Fe, % max	0.005	0.02	-
As, % max	0.0001	0.005	-
Na_2O_3, % max	0.0001	-	-
SO_2, % max	0.01	-	-
Cl, % max	0.001	-	-
Transparency, min	160	150	-

Hydrometallurgical treatment of reduced alunite is by the modified Bayer process. Pregnant liquor produced after digestion

of reduced alunite by recycle spent liquor will be desilicated in pressure vessels (autoclaves) at 135-150°C down to silica module of 250-300. Desilicated pregnant liquor is then subjected to evaporative concentration with separation of potassium sulfates and sodium by settlement. Concentrated pregnant liquor cleane from sulfates is subjected to precipitation after dilution with wash water resulting from washing alunite mud and product aluminium hydrate. This process results in production of alumina whose chemical composition conforms to Grade 1 of cell-grade alumina under the standard STW 814-75 of CPR for cell-grade aluminas.

Table 2-2 below gives an extract from CPR standard for cell-grade aluminas.

Table 2-2

		Content, wt.%				
		Al_2O_3	SiO_2	Fe_2O_3	Na_2O	LOI
I	Al_2O_3 - 1	98.6	0.02	0.03	0.50	0.8
II	Al_2O_3 - 2	98.5	0.04	0.04	0.55	0.8
III	Al_2O_3 - 3	98.4	0.06	0.04	0.60	0.8
IV	Al_2O_3 - 4	98.3	0.08	0.05	0.60	0.8
V	Al_2O_3 - 5	98.2	0.10	0.05	0.60	1.0
VI	Al_2O_3 - 6	97.8	0.15	0.06	0.70	1.2

Mix of potassium and sodium sulfates settled from pregnant liquor during evaporative concentration will be processed into hig grade finished potassium sulfate by conversion with caustic potash solution by the following equilibrium reaction:

$(Na_n + K_m)_2SO_4 + 2nKOH \quad K_2SO_4 + 2nNaOH$

where: $n + m = 1$

Resulting coarse crystalline finished potassium sulfate contains over 95% K_2SO_4, which conforms to Grade 2 of current CPR specifications for commercial-grade potassium sulfate.

Caustic soda solution produced after conversion of mix of sulfates with solution of caustic potash is used at the process section for hydrometallurgical treatment of reduced alunite as make-up caustic soda to compensate for chemical and mechanical losses of soda and for correction of optimum molar ratio of caustic potash and soda in pregnant liquor.

According to a developed mathematical model for determination of optimum balance of liquors in the process cycle in order to increase output of finished potassium sulfate, to ensure the maximum recovery of potassium sulfate from alunite into finished products and to provide for optimum molar ratio of caustic potash and soda in pregnant liquor it would be necessary during the hydrometallurgical treatment of reduced alunite ores from Fan Shan deposit to add up to 0.2 t of sodium sulfate per 1 tonne of finished alumina produced from alunite.

The optimum possibility of supplies of the complex with sufficient amount of caustic potash is establishment of caustic potash production at the complex by means of electrolytical decomposition of potassium chloride solution. Given below in table 2-3 are the expected balance figures of recovery of mineral values from raw materials and inputs into the finished salable product and quantitative ratio of resulting finished products upon the integrated processing of alunite ore of Fan Shan deposit by the reduction-alkaline method according to the recommended

flowsheet.

Table 2-3

	Unit of measure	Al_2O_3 alunite	SO_3	K_2O	Na_2O	Cl
1. Enters the process:						
- with alunite (7.0t)	kg	1272	1330	332	39	-
- with elementary sulphur (0.4 t)	kg	-	1000	-	-	-
- with KCl (0.6 t)	kg	-	-	370	5	280
- with (0.19t)	kg	-	107	-	83	-
TOTAL:		1272	2437	702	127	280
2. Losses in process cycle	kg	276	165	31	90	10
3. Goes into finished product:						
- alumina (1 t)	kg	996	-	1	3	-
- sulphuric acid (2.0 t)	kg	-	1650	-	-	-
- potassium sulphate (1.33 t), K_2O - 51%	kg	-	622	670	44	-
- chlorine	kg	-	-	-	-	-
TOTAL in finished product:	kg	996	2272	671	47	270
YIELD in finished product	%	78.0	93.0	95.5	37.0	96.5

Table 2-4 shows the expected rates of specific consumption of raw materials, main materials, fuel, energy and water necessary for comprehensive processing of alunite by recomended flow-sheet.

Table 2.5 shows the expected annual demand in raw materials, main materials and utilities for processing of the Fanshan alunite ore by reduction-alkaline method according to recommended flow-sheet with annual production of 130-140 thousand tonnes of alumina, 170-180 thousand tonnes of sulphuric acid a 36-39 thousand tonnes of chlorine

Table 2-4

N°		Unit of measure	Expected processing performance
1	Expected specific consumption of raw materials, main materials, fuel and energy:		
	- alunite ore (49% of alunite)	t	7.0
	- elementary sulphur	t	0.4
	- KCl	t	0.6
	- Na_2SO_4	t	0.19
	- electric energy	kW.h	2500
	- steam	Gcal	4.5
	- fuel (7000 kcal/kg)	$T_{conv\ f}$	0.45
	- water	m^3	23
2	Finished products:		
	- alumina	t	1.0
	- sulphuric acid	t	2.0
	- potassium sulphate	t	1.3
	- chlorine (gazeous)	t	0.28

The annual demand of the complex in raw materials, main materials, fuel and energy in given in the Table 2.5.

Table 2-5

	Unit of measure	Amount
1. Output of finished products:		
- alumina	000 t	130-140
- potassium sulphate	-"-	170-180
- sulphuric acid	-"-	260-280
- chlorine (for production of aluminium onichloride and other products)	-"-	36-39
2. Demand in raw materials, main materials and utilities:		
- alunite ore (49% of alunite)	-"-	910-980
- sulphur	-"-	52-56
- potassium chloride	-"-	78-84
- sodium sulphate	-"-	25-27
- electric energy	000 kW.h	330000-350000
- steam (7 atm)	000 Gcal	590-630
- fuel (7000 kcal/kg)	000 $t_{conv\ f}$	60-65
- water	000 m^3	3600-4000

The Chinese People's Republic in one of major consumers of chemical fertilisers for agricultural purposes. Nevertheless the consumption of chemical fertilisers per ha of cultivated land according to statistical data for the year 1985 was only 165 kg which is 2.5 times less than in Japan and Korea (see table 2.6).

The table 2.6 shows the data on fertilisers consumption by countries of the world in 1985 (in kg per ha of cultivated land)

taken from the report of UN World Development Bank; data on China: Phosphorites development project (1986, February, p.43).

Table 2-6

Countries	Nitrogen fertilisers	Phosphorus fertilisers	Potassium fertilisers	Total	Ratio
Netherlands	558.0	92.2	134.2	783.2	100:66:41
Japan	145.9	155.7	128.8	430.4	100:107:81
Korea	198.7	91.9	101.7	392.4	100:46;51
France	127.2	77.5	95.2	300.9	100:61:76
China	135.6	27.4	4.4	167.4	100:20:3
USSR	47.2	32.8	29.4	109.4	100:69:62
Indonesia	662.2	23.9	8.5	94.6	100:37:13
USA	49.9	19.9	24.0	93.8	100:40:48
India	33.7	11.5	5.1	50.3	100:35:15
Morocco	16.2	13.1	6.3	35.6	100:81:39
Brazil	11.2	17.3	14.0	42.5	100:154:125

The consumption of chemical mineral fertilisers in CPR in not the best one. Due to sharp shortage of potassium and partly phosphorus fertilisers the actual ratio of nitrogen, phosphorus and potassium fertilisers as main substance is 100:20:3 against sientifically justified 100:50:20.

Presently 50% of phosphorus fertilisers and 100% of potassium fertilisers are imported.

Due to limited possibility to expand the surface of arable land in CPR the strategy of increasing output of agricultural products will be based on increment of yield due to increased

and balanced use of fertilisers especially potassium and phosphorus.

In 1990 the minimum estimated demand in potassium fertilisers is expected to be 1.76 million tonnes recalculated as K_2O; in 1995 the extimated demand in potassium fertilisers recalculated as K_2O is to be as big as 3.4 million tonnes. According to scientific recommendations the demand in non-chlorine potassium fertilisers used mainly in form of potassium sulphate for cultivation of the most valuable crops (citruses, tea, tobacco, vegetables, grapes, hemp etc) is not less than 20% of total amount of consumed potassium fertilizers.

Presently CPR imports annually about 500000 tonnes of potassium sulphate worth over 100 million dollars. In future the amount of potassium sulphate to be imported will be increasing if there will not be organised large internal industrial production of potassium sulphate.

Due to high rates of development of aluminium production the CPR needs considerable amounts of alumina. According to unofficial data the import of alumina in 1987 was 200000 tonnes. The sulphuric acid demand is not satisfied too.

The speedy solution of the problem of integrated use of available alunite ores reserves in CPR is the major task of the national economy for it will permit to organise the large production of potassium sulphate, alumina and sulphuric acid on the basis of comprehensive processing of alunite ores.

3. RECOMMENDED PROGRAM OF PREPARATORY WORK REALISATION OF WHICH IS NECESSARY TO EXPEDITE THE INDUSTRIAL UTILISATION OF CHINESE ALUNITE ORES

For solution of this problem the following stages of preparatory work are necessary:

3.1. The geological organisations have to make additional estimation of reserve by 3.4 variants of conditions in order to raise the average quality of alunite ores destinated for industrial processing at future chemical plant (up to 48-50% of analysis in ore). The engineering organisation of CPR to carry out rough economical estimation of construction of alunite mine, ropeway and ore harf.

3.2. The Soviet experts together with the Chinese colleagues have to elaborate methods and specifications for preparation and delivery VAMI of representative samples of alunite ore in agreed quantities, obtacned from core samples from geological survey bare holes.

3.3. The Chinese experts have to prepare and deliver to VAMI the representative samples of alunite ore in accordance with the method by item 2.2.

3.4. The VAMI experts have to carry out the bench scale technological testing of representative samples of alunite ores for the choice of optimum process performances for industrial testing of large process sample of alunite ore at Kirovabad alumina integrated plant and to prepare the initial process data for preliminary feasibility estimation of industrial processing of alunite ores of Fanshan deposit, CPR.

3.5. Wenzhou general chemical plant, engineering and other

special organisations of CPR have to prepare and discuss with Soviet experts the necessary initial data for preliminary economic estimation of justifiability of new alunite integrated plant processing the Fanshan deposit alunite ores in Wenzhou basing on the questionnaire which will be transmitted to the Chinese side by VAMI through UNIDO.

3.6. VAMI institute have to prepare the summary report on preliminary economical assessment of feasibility of new alunite integrated plant in CPR on the basis of Fanshan deposit alunite orea and submit it to UNIDO and the Chinese side.

3.7. Considering the big labour expenses and time period for preparation of large ore sample the Chinese side have to prepare industrial sample of Fanshan deposit weighing 4000-5000 tonnes according to method and specifications which must be elaborated by a team of Soviet experts together with the Chinese experts without waiting the completion of work by the item 3.6 and to ship the said sample in the USSR to Kirovabad alumina integrated plant.

3.8. VAMI institute and Kirovabad alumina integrated plant have to carry out industrial testing of Chinese alunite ore, to develop the optimum technological parameters of its processing and submit initial data for elaboration of the FS of construction of chemical integrated plant in Wenzhou processing the Fanshan alunite ores.

3.9. The Chinese organisations have to submit to VAMI initial data necessary for elaboration of the FS according to UNIDO method and develop the corresponding parts of the FS concerning alunite mine, sulphuric acid, caustic, and aluminium exichloride produc-

tion, part facilities, HPS and other infrastructure units.

3.10. VAMI institute have to elaborate summary feasibility report on construction of alunite integrated plant in CPR basing of Fanshan deposit alunite ores according to UNIDO method and submit it to UNIDO and the Chinese side.

The above mentioned work may be carried out according the contract between UNIDO and Technoexport.

In case the Chinese side takes decision to build the alunite integrated plant using VAMI technology the Soviet side will be ready to discuss with the Chinese side the possible amounts and conditions of Soviet organisations participation in creation of chemical integrated plant processing alunite ores in CPR and to examine the possibility of establishment of joint Sino-Soviet venture for processing said ores.

Basing on the results of Soviet experts visit and with their participation senior interregional adviser, Metallurgical Section, UNIDO, Dr. Balazs E. have prepared and submitted to the Chinese side the draft of the document justifying the necessity of a contract among UNIDO and V/O Technoexport concerning participation of the Soviet experts in comprehensive processing of alunite ore from Fanshan deposit, CPR.

4. CONCLUSION

4.1. The Chinese People's Republic possesses the large reserves of alunite ores the comprehensive processing of which will permit to organise large scale production of potassium sulphate, alumina and sulphuric acie which are in great demand in CPR.

The biggest reserves of alunite ores are in Zhejiang province (Fanshan deposit) and in the provinces Anhui, Shandong and Fujian.

The semi-industrial processing of alunite ores is organised at the general chemical plant in Wenzhou with annual turn-out: 3000 tonnes of potassium sulphate, 3000 tonnes of sulphuric acid and 5000 tonnes of aluminium hydroxide. The equipment flow-sheet employed at the plant is not perfect, the production is accompanied with considerable material losses and high energy expenses and the quality of the finished product is low.

4.2. The USSR is the first country in the world to put into practice the large scale industrial highly efficient comprehensive processing of Zaglik alunite ores at Kirovabad integrated alumina plant with high quality end-products: potassium sulphate, sulphuric acid and alumina. Presently the integrated plant turns out 160000 tonnes of alumina, 170000 tonnes of potassium sulphate and 355000 tonnes of sulphuric acid. The further expansion of production is under way. All end products are profitable.

4.3. The preliminary investigations in VAMI consisting in process testing of three alunite ore samples from Fanshan deposit, CPR, proved their suitability for comprehensive processing by Soviet technology with high economic performances.

4.4. To accelerate the solution of the problem of comprehensive processing of Chinese alunite ores it is necessary to carry out the preparatory work programme comprising the detailed process and industrial testing of representative samples of Fanshan deposi alunite ores and using it as a base elaborate the FS on construction of industrial integrated plant for processing of alunite ores

The comprehensive programme of preparatory work is busmitted to the Chinese side and UNIDO.

PRELIMINARY CONCLUION

of UNIDO consultants - Soviet experts of VAMI (Leningrad) on feasibility of industrial processing of Fan Shan alunites, CPR

1. Alunite ore is a valuable raw material for chemical and metallurgical industries.

The USSR was the first country in the world to commercialise a highly efficient integrated process for conversion of Zaglik alunites (Azerbaijan SSR) at Kirovabad alumina complex to produce high quality products: alumina, potassium sulfate and sulfuric acid.

At present the plant turns out 160000 t of alumina, 170000 t of potassium sulfate and 355000 t of sulfuric acid out of alunites each year.

The third process line is being built at the plant (the third stage) and after coming on stream it will increase output of alumina from alunites to 210000 t, potassium sulfate - to 250000 t, sulfuric acid - to 450000 t per annum.

Profitability of the plant by all types of the products from alunites amounts to over 25%.

Quality of alumina, potassium sulfate and sulfuric acid produced conform to the highest standards currently in effect in CPR.

The USSR is also engaged in preliminary activities on construction of the second industrial complex for processing alunite ore from Begansk deposit in Ukraine.

A license on roasting and reduction of alunite ores was sold to USA. Under the UNIDO contract VAMI carried out the

technological project opportunity study of Iranian alunites with results being used for preparation of Feasibility Report for construction of the industrial complex for integrated conversion of Taikant alunites (Iran).

2. CPR has large deposits of alunite ores. The most significant reserves of alunites are those of Fan Shan deposit in province of Zhejiang. There are also alunites deposits in provinces Anhui, Shandong and Fujian.

Research and tests of integrated conversion on Fan Shan deposit alunites are being carried out in CPR since 1958.

In 1965, a pilot plant for processing alunite ores was started at the Wenzhou chemical complex, which after modernisation and expansion currently turns out 3000 t of potassium sulfate, 3000 t of sulfuric acid and about 5000 t of aluminium hydroxide per year. Despite of recent progress, the process flowsheet used at the plant for integrated processing of alunite ores is unsufficiently advanced.

3. The Soviet technology and equipment as commercialised at Kirovabad alumina complex is recommended for integrated processing Fan Shan alunites. It would be expedient to build an industrial plant (hereinafter "alunite complex") in Wenzhou on the basis of Fan Shan alunite deposit to implement integrated processing of alunite ores with the following output per annum:

alumina	130-140 thousand tonnes,
potassium sulfate	170-180 - " -
sulfuric acid	260-280 - " -

The optimum capacity of the proposed alunite complex will be determined at the stage of preparation of Feasibility Report.

The alunite complex will comprise the following

1. The alunite mine in Fan Shan with capacity abt 1 mln.t of ore per annum with a warf for ore shipment to Wenzhou.

2. The chemical complex in Wenzhou for processing alunite ores including:

alumina production facility;

potassium sulfate production facility;

sulfuric acid production facility;

caustic potash production facility (by electrolysis of potassium chloride).

3. Thermal power plant (TPP) or boiler house.

4. General plant support facilities.

5. Port facilities for receiving ore, sulfur, potassium chloride and other materials, as well as for shipment of the alunite complex products.

Expected consumption factors of raw materials, inputs and utilities for integrated processing of alunite ores with alunite content in the ore being 49% are shown in Table 1.

Table 1

Description	Unit of measure	Expected figures
1. Expected consumption factors of raw materials, inputs, fuel and power:		
- alunite ore (49% of alunite)	t	7.0
- elemental sulfur	t	0.4
- KCl	t	0.6
- Na_2SO_4	t	0.19
- electric power	kWh	2500

Description	Unit of measure	Expected figures
- steam	Gcal	4.5
- fuel (7000 kcal/kg)	t	0.45
- water	m^3	23
2. Finished products:		
- alumina	t	1.0
- sulfuric acid	t	2.0
- potassium sulfate	t	1.3
- chlorine gas	t	0.28

For annual demand of raw materials, inputs and utilities by the alunite complex refer to Table 2.

Table 2

Description	Unit of measure	Quantity
1. Output of finished products:		
- alumina	000 t	130-140
- potassium sulfate	000 t	170-180
- sulfuric acid	000 t	260-280
- Chlorine (for production of aluminium oxychloride, etc.)	000 t	36-39
2. Demand for raw materials, inputs and utilities:		
- alunite ore (49% of alunite)	000 t	910-980
- sulfur	000 t	52-56
- potassium chloride	000 t	78-84
- sodium sulfate	000 t	25-27

Description	Unit of measure	Quantity
- electric power	MWh	330000-350000
- steam (7 atm abs)	Gcal	590-630
- fuel (7000 kcal/kg)	000 t	60-65
- water	000 m^3	3600-4000

The finished products produced by the alunite complex (alumina potassium sulfate, sulfuric acid, possibly aluminium oxychloride) are in short supply in CPR, and as such can be efficiently used in CPR economy and exported to other countries of the world. Besides, establishment of the facility at the alunite complex for production of chlorine-free potassium fertilizer (potassium sulfate will allow the import needs to be significantly reduced.

4. According to the Soviet consultants the following preparatory steps should be taken to advance solution to the problem of the integrated processing of the Fan Shan alunites:

4.1. The CPR geological organisations are to additionally estimate the reserves based on 3 to 4 cut-off grades to improve the average quality of alunite ore to be processed at the proposed alunite complex (to 49-50% of alunite content in ore). The engineering organisations are to prepare preliminary feasibility study for construction of the alunite complex, ropeway and sea port facilities.

4.2. The Soviet experts in cooperation with Chinese experts are to develop the procedure and specifications for selection and delivery of the representative samples to the VAMI Institute in

agreed-upon quantity for bench-scale technological tests.

4.3. The Chinese experts are to select and deliver to VAMI the representative samples of ore in accordance with the procedure under para 4.2.

4.4. The VAMI experts are to carry out a detailed bench-scale test of the representative ore samples and to develop the optimum process conditions for industrial tests of a large technological sample of ore at the Kirovabad alumina complex, as well as to prepare the initial technological figures for preparation of the opportunity study of construction of the facility for processing alunite ores in CPR conditions.

4.5. The chemical plant in Wenzhou, design and other specialised organisations in CPR are to prepare and coordinate with Soviet experts the required initial data for the opportunity study of construction of the alunite complex for processing of alunite ores in Wenzhou in accordance with the quastionnaire which will be released to CPR via UNIDO.

4.6. VAMI institute is to prepare the report on opportunity study of construction of the alunite complex in CPR based on alunite ores of the Fan Shan deposit and to release it to UNIDO and CPR.

4.7. Taking into consideration vast labour requirements and time required for selection of large-tonnage ore sample, without waiting for completion of works under para 4.6, CPR is to start with selection of industrial technological sample from Fan Shan deposit in quantity of 4000-5000 t according to the procedure and specifications to be developed by Soviet counterpart in cooperation with the Chinese experts, as well as to ship the above sample to the Kirovabad alumina complex, USSR.

4.8. VAMI Institute and Kirovabad Alumina Plant are to run the industrial test of CPR alunite ores, work out optimum process conditions and provide basic data at input for preparation of the Feasibility Study (FS) of construction of the chemical complex in Wenzhou for processing alunite ores from Fan Shan deposit.

4.9. The Chinese counterpart is to release to VAMI the required basic data for preparation of FS for the alunite mine, production facility of sulfuric acid, caustic potash, aluminium oxychloride, port facilities, TPP and other infrastructure facilities.

4.10. VAMI is to prepare the overall FS for construction of the alunite complex in CPR based on use of alunite ores of Fan-Shan deposit in accordance with UNIDO methodology and release it to UNIDC and CPR.

The above services may be provided by VAMI Institute under a contract between UNIDC and Technoexport.

If the Chinese counterpart takes a decision on construction of the alunite complex based on VAMI technology, the Soviet counterpart is prepared to discuss with the Chinese counterpart the possible scope and conditions for participation of the Soviet organisations in implementation and establishment of the chemical complex for processing alunite ores in CPR, and also conditions of establishment of a joint Sino-Soviet plant for processing these ores.

Head of Soviet mission under
UNIDO contract

Dr.N.A.Kaluzhsky,
Director of VAMI Institute

Hangzhou
December 5, 1988

P R O T O C O L

of discussions in the Bureau of chemical and petrochemical industry of Zhejiang province about comprehensive processing of alunite ores from Panshan deposit, CPR

Hangzhou — December 5-6, 1988

Participants:

Dr.Balazs E. - senior interregional adviser for metallurgy, UNIDO

UNIDO consultants from the USSR according to the Contract N° XP/CPR/88/143

Kaluzhsky N.A. - dead of consultants group, D.Sc., director of the VAMI institute, Leningrad

Yurassov B.J. - head of UN technical assistance department of V/O "Technoexport"

Nassyrov G.Z. - head of alunite processing laboratory, VAMI, Cand.Sc.

Bronevoy V.A. - head of aluminium raw materials laboratory, VAMI, Cand.Sc.

Levashov Y.P. - chief project engineer of Kirovabad alumina integrated plant

Cai Huilin - deputy director of Foreign affairs Department of Ministry of Chemical Industry, CPR

Zheng Youzhu - senior engineer of the Foreign Affairs Department of the Ministry of Chemical Industry, CPR

Liu Aihua - deputy director of department for introduction of foreign capital of Zhejiang provincial planning and economy committee

Shen Peiyong - deputy chief of division of Zhejiang provincial science and technology commission

Chen Haiqing - director of petroleum and chemical industry bureau of Zhejiang province

Ma Xiangbing - senior councellor for technology, petroleum and chemical industry bureau of Zhejiang province

Wang Peide	- vice-mayor, Wenzhou
Liu Zhiming	- director of Wenzhou general chemical works
Qiu Xinmiao	- general engineer of Wenzhou general chemical works

1. In accordance with the Contract XP/CPR/88/143 "Consultations of alunite processing" approved and financed by the UNIDO the consultants group including Dr.Balazs E. the senior interregional advisor for metallurgy (UNIDO) and the team of Soviet technicians from the VAMI (Leningrad) headed by director of the Institute D. Sc. Kaluzhsky N.A. visited CPR from November 24 to December.

The UNIDO consultants froup has met in Beijing the officials of the Ministry of chemical and petrochemical industry of CPR. In Zhejiang province the UNIDO group was received by the Head of the province government Sheng Culeng and had informal talks with Chinese specialists in the Bureau of chemical and petrochemical industry of Zhejiang province. In Wenzhou the group was received by the Mayor Liu Shiseng, visited Wenzhou general chemical plant, came acquainted with the pilot plant processing the alunite ore from Fanshan deposit, visited possible construction sites for future chemical plant in the new Eastern region of city. The group visited the Fanshan alunite deposit, got acquainted with organisation of alunite mining, with industrial alum production as well as with some results of survey at Shuiweisheng region.

In Shanghai the group visited the Shanghai chemical industry research institute. In Wenzhou the Soviet and Chineese specialists exchanged experience on alunite ores processing in the USSR and

CPR and discussed these matters.

The visit of Soviet team in CPR was preceded by two visit of Chineese specialists to the USSR, organised and financed by UNIDO (October 1987 and September 1988) as well as laboratory testing of three chine se alunite ore samples in VAMI.

2. Soviet specialists have appreciated the considerable amount of work carried out in CPR on industrial implementation of comprehensive treatment of alunite ores from Fanshan deposit. Presently at pilot plant of Wenzhou general chemical plant 3000 tonnes of potassium sulphate, 3000 tonnes of sulphuric acid and about 5000 tonnes of aluminium hydroxide are produced. At Fanshan mine industrial production of alums in organized. In spite of successful production the equipment flow-sheet of alunite processing used at Wenzhou plent in far from being perfect.

3. After acquaintance with survey data on Fanshan alunite deposit the Soviet specialists think it possible to create large industrial enterprise basing on alunites from this deposit with annual production:

alumina	130-140 thousand tonnes
potassium sulphate	170-180 thousand tonnes
sulphuric acid	260-280 thousand tonnes

The reserves of Fansha deposit make possible eventual expansion of this production. The optimum capacity of future, its supply with sulphur, caustic soda and other raw materials, energy and utilities, as well as other problems must be carefully examined at the stage of FS on construction of the plant with comprehensive processing of alunite ores.

This needs considerable preparatory work in detailing alunite are reserves at Fanshan, in determination of optimum conditions, choice and laboratory testing of representative samples of ore the results of which will serve as a base for preliminary report on process and economical feasibility of large scale alunite ores processing in CPR. Alongside with this the mining of process ore lot of 4000 tonnes should be organised and its industrial testing at Kirovabad general alumina plant should be carried out together with Chinese specialists. After that in cooperation with Chinese specialists the FS on construction of industrial enterprise in CPR for comprehensive processing of alunite ores from Fanshan deposit should be elaborated. The preliminary conclusion of Soviet consultants of UNIDO on viability of industrial processing of Fanshan alunite ores in CPR is annexed to the present protocol.

4. V/O "Technoexport" and VAMI institute have agreed to participate in all preparatory work for industrial processing of Fanshan alunite ores.

Soviet specialists have informed Chinese side about readiness of the USSR Ministry of non-ferrous metals to discuss with the Chinese side the participation of Soviet enterprises and bodies in construction of future general chemical plant including the establishment of joint Sino-Soviet venture for comprehensive processing of alunite ores in CPR.

5. The Chinese side finds necessary to carry out following work before elaboration of the FS on construction of plant with comprehensive alunite ore processing.

5.1. Additional calculation of reserves and quality of ore

to determine the optimum alunite content. Chinese geologists have carried out big amount of fruitful work, but only one limit content value = 13.5% was used. Chinese geologists have agreed with the proposal of Soviet specialists to carry out additional calculations for four other variants, correspondingly, 13.6%, 14.5%, 15.3% and 16% in order to choose optimum variant of reserve estimation and using this as the base take correctly the representative samples.

Chinese side expressed a wish that Soviet specialists take part in this work together with Chinese specialits financing of the said work being UNIDO's responsibility.

The results of the work have to be handed over to the Chinese side.

5.2. The obtained samples must be carefully investigated in the USSR in order to determine all necessary operational conditions and parameters for processing of Chinese alunite ores from Fanshan deposit. Financial coverage of this work has to be done through the UNDP in UNIDO.

To justify the necessity of industrial technological testing of alunite ore the report have to be based on the results of industrial testing of alunite ore.

Chinese specialists must participate in taking of industrial sample and in its testing at Kirovabad alumina complex. The financing of this work is to be settled with UNDP.

After elaboration of the FS with convincing positive results and prove of viability of plant construction further solution of this problem has to be reported to Chinese authorities.

6. The UNIDO representative explained that in case the

Government of Zhejiang province adress such a request through authorised government institutions of CPR and UNDP to UNIDO and UNIDO will be ready to examine the possibility of financing these works enumerated in items 4.2, [illegible], 4.4 and 4.6 of Conclusion of the group of Soviet experts. The draft of such request made on UNIDO proforma was prepared in English and left in the Bureau of chemical and petrochemical industry of Zhejiang province, the copy will be transmitted to UNDP and UNIDO adviser in Beijing. With that the UNIDO representative means that the Chinese side while adressing UNIDO initiates preliminary introduction of project comprising the work corresponding to items 4.7-4.10 of Soviet consultants conclusion into the programme of UNDP assistance to CPR for the next 5 year period starting in 1990 in case the results of preliminary economic assessment be found satisfactory by UNIDO and Chinese side.

7. Due to the fact that the comprehensive processing of alunites is a major task and needs considerable capital investments the representative of the Ministry of chemical industry of CPR and relevant institutions of Zhejiang province will report to higher authorities of CPR on the proposal of Soviet experts and UNIDO representative for the programme of preliminary work. If the decision be positive the Chinese side will instantly adress UNIDO and UNDP with request for allotment of funds for financing work by this programme.

8. The UNIDO representative and Soviet experts expressed their cordial gratitude for friendly talks and hospitality to the heads of Chinese organizations and to Chinese specialists.

For Chinese side	For UNIDO	For Soviet side
Ce Huilin	Dr.Balazs	Dr.Kaluzhsky N.A.
Chen Hegin		Jurassov B.E.