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NEW INDUSTRIAL DEVELOPMENTS IN THE COPPER SMELTING AND REFINING IN BULGARIA 1/

by

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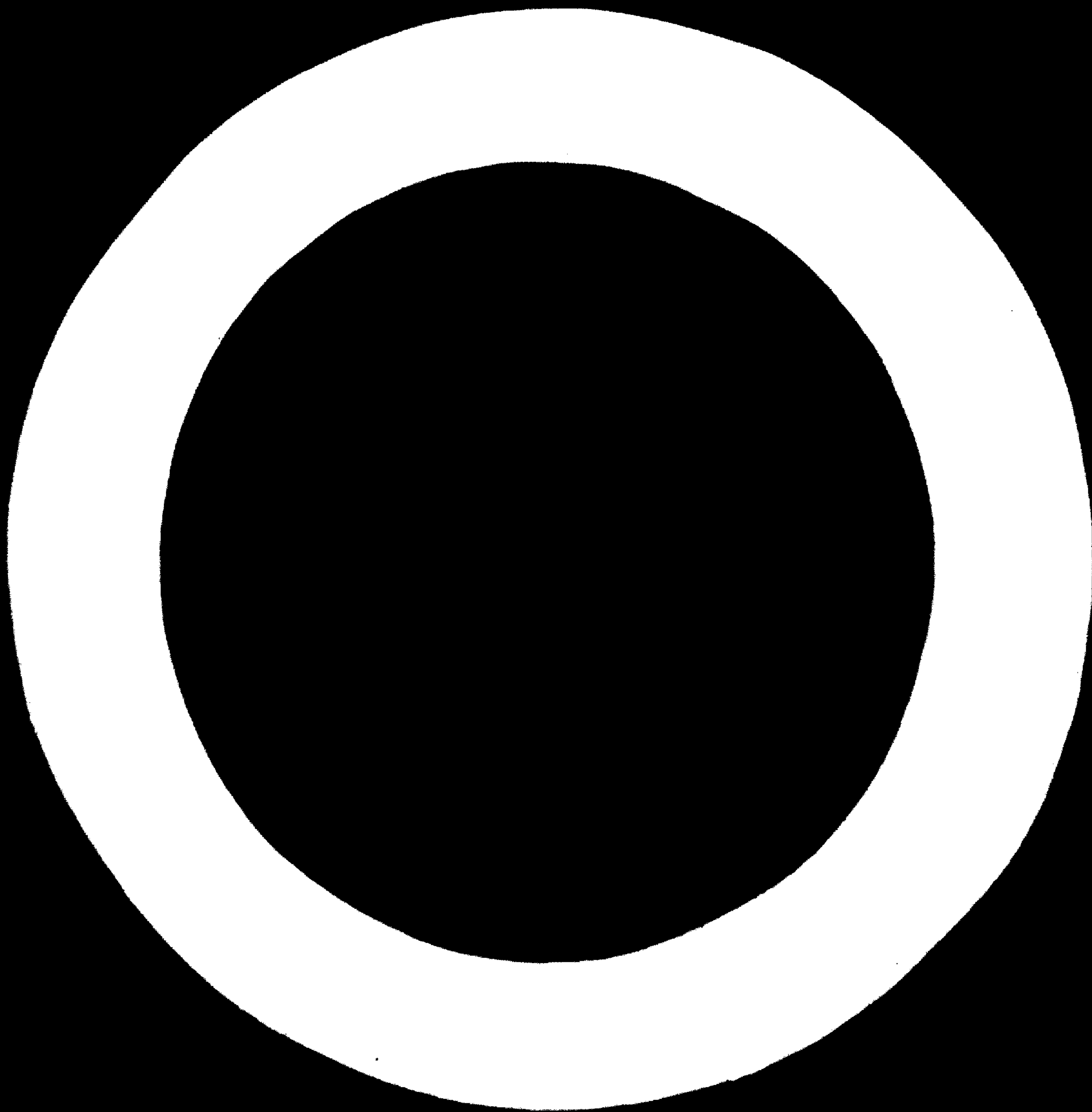

INTRODUCTION

BRIEFLY THE DEVELOPMENT OF THE COPPER PRODUCTION IN PEOPLE'S REPUBLIC OF BULGARIA

1.

New industrial developments in the copper smelting and refining in Bulgaria.

Introduction.-A brief account of the development of copper production in Bulgaria.

The territory of the contemporary People's Republic of Bulgaria has been a source of non-ferrous metals since the ancient times.That is why there are plenty of evidences- even today resudue of Roman days might be found in the vicinity of Vratsa;there could be found old mines,called by the people"Roman galleries".Facts for ore estractions are well known also during the first and the second Bulgarian states as well as during the period of the Turkish sovereignity.

After the liberation of the Bulgarians from the Turks and creation of the third Bulgarian state continued the yielding of non-ferrous ores but in the same insignificant quantities just like before.Actually the beginning of the non-ferrous metallurgy was made after the second world war when Bulgaria was proclaimed as a people's republic. Before the war mainly through foreign capital were yielded some thousands tons of copper ore.

At that time in Bulgaria existed two small metallurgical plants-the one for the production of about 2000 tons lead metal and the other for some hundreds tons of copper metal.

The effective measures for the development of the non-ferrous metallurgy which the government of the People's Republic of Bulgaria took, gave the possibility to be discovered non-ferrous ore deposits on a large scale,which enabled us to several dressing plants to be grounded.

In 1939 were yielded only some thousand tons of non-ferrous ores, while in 1960 the output was some millions tons and in 1970 it will go beyond 13 millions tons.This large growth was available only because of the esteemed technical aid of the Soviet Union and can be illustrated from the following accounting data:

Years	Copper ores		Lead-zinc ores		
	weight in thousand tons	copper content in thousand tons	weightin thous. tons	lead in thous. ton	content of zinc in thous. tons
1939	4	0,4	24	2,9	2,6
1950	83	2,2	285	22,7	17,1
1956	470	5,6	1671	61,0	48,8
1960	1126	11,0	3046	94,8	77,0
1965	4458	29,9	4452	100,1	79,6

The increased necessities of the rapid developing Bulgarian machine industry,electrical industry,building industry,transport and other branches rose the problem of constructing metallurgical enterprises. For a period of about 10 years up to 1965 were constructed and put in operation modern metallurgical enterprises for processing of lead zinc and copper.For a inconceivable short historical period the production of non-ferrous metals in the people'republic of Bulgaria increased many times.

Our country took one of the leading places concerning the production of non-ferrous metals per head of the population.In 1965 according this index Bulgaria was the sixth in production of zine and second in production of lead.According the production of copper our country is amongst the first 10-15 producers.

Simultaneously with this rapid development of the non-ferrous metallurgy a large production and scientific-technical experiment was accumulated.At the same time well qualified technical,economical and scientific specialists were created.The Bulgarian specialists could made some perfections in the processes and equipment of the metallurgy of non-ferrous metals including in the copper metallurgy.

The latter will be the subject of this report.Some fully new-on a world side technologies were created,such as an electrilitic refining of copper by increased density of the current.

People's republic of Bulgaria is reasonably called the country of non-ferrous metallurgy.The experiment of the country in many aspects can be an example for the rapid growth of the non-ferrous metallurgyin the developing countries.

People's republic of Bulgaria at present has at its disposal a respectively developed raw material base for copper extractions.In the characteristics of this raw material base the two world tendencies from the last years for developing the raw materials for copper extraction find reflection.On the one hand are exploited low-grade deposits-presenting porphyry ores,out of which are produced comparatevly pure copper concentrates,and on the other hand are opened up rich ore deposits which assure the production of high grade copper concentrates, which contain often in greather concentration voluable non-ferrous metals.

In Bulgaria are worked porphyry ore mines,with comparativly low grade metal content about o,4%.These ore can be dressed easily,but the yielded concentrates ,in spite of the fact of their purity have not a high copper content-about 16-17%.By the underground method are produced ores with a copper content about 1% or a little more.As a whole the content of copper in the raw material of Bulgaria can not be characterised as a very favorable one,but applying modern methods of dressing and metalurgical processing give a very good technical results which assure effective copper production which can be seen from the following accounting data.

The estracting of copper from the copper ore to blister copper in People's Republic of Bulgaria.

The data are for the purpose of orientations:

indices- years	1962	1963	1964	1965	1966
Copper in the ore	0,958	0,904	0,926	0,67	0,61
Extracting to concentrate	87,66	86,30	86,63	81,12	83,62
Extracting from concentrate to blister copper	92,40	93,30	93,10	93,50	90,30
Collective extracting from the ore to blister copper	80,99	80,52	80,65	75,85	75,51

The above data are mean for the two metallurgical enterprises. The one of them is with an old equipment and processes row materialy with a complex composition, chiefly polymetalic, containing lead, zinc and copper because of which the extracting of copper is comparatively low. The second enterprise -the copper extracting work "G.Damianov" -about which is spoken from now on is with a new and original technology, which guarantee high indeces of processing the raw material in spite of the fact that the content of the raw material is not very advantageous.

Chapter 1. A general scheme of the copper production in People's Republic of Bulgaria.

In the old mine metallurgical plant "G.Dimitrov" are processed restricted quantities of low grade, unpure and complex comcentra ted. Here in 1952 were produced the first quantities of blister copper in Bulgaria and so far/until now/ the plant is producing only blister copper.

The basic part of the copper raw materials are processed in the copper extracting works which was put in operation in 1959. Later on it was enlarged and the new capacity started working in 1966-67. The plant is projected and built according a modern

and original technological scheme with a full cycle of the copper production.The scheme assures a high grade of extractions of the basic component in the raw material - the copper and as well the extracting of some of the concomitant components such as sulphur/just like sulphuric acid,selenium,tellurium,precious metals and others.Out of the exhausted electrolyte and secondary raw materials as copper vitrids is produced.
Generally the scheme is consisting out of seven basic technological operations,which are performed according the following succession:

1. Preparing the charge out of concentrate and quarts fluxes.
2. Drying of the charge
3. Roasting in the fluidized bed roaster
4. Smelting of the roast product in the electro-smelting furnace.
5. Converting of the copper matte.
6. Fire refining of the blister copper and anodes casting
7. Electrolitical refining of the copper anodes.

In the scheme is included the entire metallurgical sycle, supplementary operations as production of sulfuric acid from the gases of the fluidised bed roasters and the converters, processing of the electrolytic mud and extracting the precious metals and the dispersion elements.
The furnace charge is prepared in bunkers and has as a goal the fine homogeneity of the different concentrates with the quartz fluxes,by which to be prepared a charge which will give minimal quantity of slog by the smelting.
The drying of the material is done in order the moisture to be within 5-6%
The fluidise roasting is an intensive and high productive process by which the layer part of the sulfur of the sulfide concentrates is oxidysed to sulfur dioxide for sulphuric acid production.

In the roasted materials remains enough sulphur needed for the formation of the matte.
The smelting of the roasted materials is accomplished in a sixelectrodic electro-smelting furnace by which is produced amtte with a copper content of 30-35%.The description of this modern method is given in detail further bellow.
The converting is accomplished in 40 tons horizontal convertors-classical type.The fire refining and casting the anodes is done according the classical scheme and the anodes casting is fully mechanised and made automatic.

The copper anodes are refined electrolical by high density of the current by which the technological conditions is a Bulgarian original patent.

The management of the production is based on the departement structure.

Manager

Chief head engineer
labour resources and salaries
standart
technical-economical counsel
others

capital investments
production
metallurgicalshop
refinery
sulphuric acid
quality control laboratory

economical director
planning
management
marketing
social living sector

drying section
fluiding bed roaster
convertors
fire refining

It is clear that the production is concentrate in three basic units-metallurgical,electrolitic refining/with processing of the electrolyte mud and copper vitriol/ and sulphuric acid.Attached to the production is also the quality and technical control with the central laboratory.This organising structure gives possibility for operative management and control .

Chapter 2 - Preparing the copper raw materials for metallurgical processing.

The preparing of the raw materials for metallurgical processing comprises the making out of the charge,its drying and roasting.

The making cut of the charge is performed by means of grabbing crane in the bunkers. Because of the different types of concentrates which are processed a part of the bunkers are used the concentrates and the quartz fluxes stocking and the other part for the preparing of the charge.

The composing of the charge is made after sampling the different concentrates with the helps of a well organized plant chemical laboratory, where express as well as control methods of analyses are applied. The charge of the different concentrates is mixed up only with quartz sand. Alkali fluxes are not given because the content of the concentrate permit it. The first project provided the adding and alcalic fluxes but after the operation began the practiceprovided that it is not necessary. This is a fact which undoutely shows that the original project concerning the components of the charge always must be examinated in practice in order simplifying their composition.

The prepared charge is dried up to a condition convinient to be roasted in the fluidized bed roaster namely/5-6%/ This percentage of moisture was selected also as a result of experimental studies. The moisture content of the charge has a peculiar meaning for the fluidized roasting, for it is one of the factor, for any easy transport of the charge to the roasting furnaces and a regulator of the temperature require of the roasting process.
Original is was provided for drying with steam heaters in a multihearth furnace. The production of the latter was incificient and after some constructive calculations and experimental investigations was constructed a drum drier with a mazut heating.
The mixing of the materials is done by freely hung chains lengthwise of the drum.
The construction of the drier is done by Bulgarian specialists and are nearly fully made automatic. The dried up charge by belt conveyer transported per screening and the fine fraction enters the bunkers of the fluidized bed roaster and the fraction over 10 mm in the bunkers for cold supplements.

The roasting is performed in fluidized bed roasters with a floor surface 20 m^2 and hight of the shoft 7 m. The construction of the tuyeres for the blosting of the air for forming a fluidised bed was several times improved. The present construction allows the changing of the bed hight in fixed limits. The temperature of the prozess is regulated by a system of water cooling. But the basic regulation is done by the regulating of the entering quantity of material. The gases from the fluidized bed roasting contain about 10-12% sulphur dioxide. They are subjected to crude prerification from the dust/about 40-60% from the charge/ in cyclones and these to fine purification in electrofilter. By the wasting there is the possibility to be achieved a defined degree of desulphurisation in order to be produced after the smelting matte with a designed composition. The wasting process in fluidized bed roaster is continious and very intensive. Investigations of some authors pointed out that the oxidizing of purites and copper sulfides go for a post of a minute. The process is made fully automatic and is violently exothermical and the by heat can be utilized.

The Bulgarian specialists consider the industrial mastering of the roasting of copper concentrates in fluidized bed roastes as a particular sucsess because it could be rightly said that this mastering was done for a first time in the world in Bulgaria. This success is emphasized from the fact that the Bulgarian copper concentrates are chalcopyrite-pyrite type which velocity of oxidizing is the highest in comparison with all other copper concentrates and the mastering of the process in industrial condition and its running require a serious engeneering and technological ability. The applying of this method assures a high productivity smaller capital investment and labour because the fluidised bed roasters can be fully automatized and the small number of the stuff is there only to watch the control indices of the apparatus and not to perform any physical work.

The latter can occur only by damaging which is a rare phenomenon. We dare to recommend openly this method to all developing countries which are going to organize pyrometallurgical copper industry.

Chapter III

The smelting of the copper raw materials in an electro furnace.
The smelting of the copper raw-materials mainly copper concentrate roasted products from the fluidized bed roasters in Bulgaria is done in the copper works"D.Damianov" -and it is one of the pioneers in mastering of such a process on a large scale.The production has begun from the beginning of 1959,when an electro-smelting furnace with three electrodes was put into operation.It has a rating of 4000 KVA and was projected by "Uniprosmed"-Svredlovsk. In 1960 was mounted and put into operation a second similar furnace and the capacity of the plant was already over 15000 tons of blister copper.
During 1966 is put in running a new enlargement of the plant for 45000 tons blister copper with a six electrodes electro-smelting furnace which has a rating of 24000 KVA,projected by Giproms-zvetmet Moskow.The electro-smelting is a basic technological process in the copper production in our country,because of some specific peculiarities and on the basis of the technic-economical accounts.
In the process of mastering many steps for perfecion of the construction,dust catchers,the system of charging and the technological parameters were made.At the same time scientific investigation work was done for perfection of the technology.
As a result of all these measures at present the industrial electrosmelting of copper raw materials in the plant goes smoothly and the technic economical indecis are good.

The electro-smelting furnace cross-sections are rectangular and the dimensions of the both are:length 22100 mm,width 6000mm, hight of the work space 4200mm,surface of the floor 132.6 m^2.

It is fix d over a ferroconcrete foundation which constenetion allows a free circulation of the air. The furnace insido is lined with chrome magnesite bricks at a hight of 2500 mm and the thickne of the transversely walks is 920 mm, the longitudéval -805mm and the floor 450 mm. The arch and the rest of the walls are from fireclay bricks. The matte is discharged periodically through 3 openings situated on the front side of the furnace at a hight of 500 mm. The slag is discharged through 2 openninge situated at the opposite side at a hight of 1100 mm. Tarough water cooled copper slabs. The furnace employs 6 soderberg electrodes and have a diameter 1500 mm. The space among them is 3000 mm. Its charging with an electrode material is accomplished by 2 tons electrocranes. On the arch of the furnace are situated 6 openning for the electrodes, 6 opennings for the gases and 12 opennings for the material charging. The converter slag is poured through openning, situated in the upper part of the front transversely wall. Some of the principal technical data are given in table №1

№	Name	measure	indeces for 1969	remark
1	rated/power capacity of the monophasic transformer 3 in number			
	a fixed	KVA	24000	
	active	KVA	15500	
2.	degree for tension regulation	numbers	23	from 190 to 360 V
3.	active tension	volts	340	
4.	specific power	KVA/m^2	110	
5.	Deepness of the smelted material			
	a matte	mm	500-800	
	slag			

6 Deepness of the electrode diving mm 300-400

7. Number of cyclones with Ø 800 mm numbers 6

8. Number of the transported equipment for the charging material number 6

In the liquid bath the current proceeds mainly from an electrode to an electrode through the slag which is with a low conductivity. The raw slag actually is not a conductor. By conducting of the current the biggest resistance is in the contact electrode-slag, which assures the overheating of the slag at that spot up to 1600° C. That's why there is a movement of the slag upward the surface of the electrode and from there toward the walls of the furnace which assures intensiver smelting of the charge. Basic in the physico-chemical process by the elector smelting is the interaction of the common sulfides with the oxides of iron. The process of slag forming and decomposing of the magnetite goes on by high temperature according the known reaction.

$$3\,Fe_3O_4 + FeS + 5SiO_2 = 5/2FeO,SiO_2/ + SO_2$$

The investigations show that the magnetite in the furnace does not decompose fully. The examplary balance for the distribution of the magnetite for the period of 16-31 VII.1968 is given in table 2

Table №2

№	Materials and products	Quantity tons	% Fe_3O_4	t. Fe_3O_4	distributing %
	I Income				
1.	Charging material	10688	12.99	1389,00	52,22
2.	Converter slag	4403	22,66	997,72	34,66

3. Cold charge	1210	7,66	92,64	3,53
4. Circulating materials	791	22,21	145,66	6,59
total	17092		2655,02	10000
II. Outlay				
1. Matte	6017	14,08	847,19	31,94
2. Slag	10940	7,29	797,32	30,09
3. Dust	29,90	12,99	3,88	0,15
4. Reduction in the furnace			1006,63	
Total	16986,90		2655,02	100,00

For decreasing the content of the magnetite is necessary suficient quantity of sulphur and quartz in the charge and also reduction gear. As such could be added a magnetic fraction of clinker from the processing of zink mud and about 8% from it from the charge has decreased the content of copper in the slag with about 0,5% and at the same time has assured effective extracting of the useful components from the clinker.

The established practice for the electrolytic smelting is the folowing: the hit wasted material comming out from the bunkers after the fluidized bed wasters is given by means of beard drums in two 38 m in lenght chain conveyors type -"Leie" one which is reserve. The quantity of the wasted material varies from 20 up to 50 tons/hour depending from the regime and the number of the running roasting furnaces. From the chain conveyors № № 1 and 2 the roasted materials is given in a system of chain conveyors situated two by two along the both long sides of the electro smelting furnace. In this conveyor additionally are given the dust from the dry electro filter in quantity of about 2-3% from the roasted material. There exists the posibility through the chain conveyor also a raw drived material and other fine materials in cold to be added.

The circulating materials just like crusts and dust from the converters etc about 5-8% from the charge are added in the furnace by a Belt conveyor through two openings. The moisture of these materials must not be more than 5-6%. The distributing of the charge in the furnace is performed by 10 openings according a definite programme by distance commanding from the furnace desk. It is reccomended the process to go on by a covered bath. The electric current is controlled by the indeces of the ampermeter and is regulated by the operator through changing the state of the electrodes by the help of electrical lifting crane. There is a possibility for an automatic maintenance of the electric current The breaking off of the electrodes is rare and mainly after stopping of the furnace. The slog is let out periodically in 35 tons slag wagons. A project is worked out and soon will be realised for continuously letting out of the slag followed by granulation. The temperature of the slag is controlled by an optical pyrometer and visually. Each quantity of the slag is assayed and the content of Cu and SiO_2 are determined analitically. The opennings are bum through oxygen. The shutting off with clay stoppers is mechanised. The furnace gases are crude purified in cyclones, after which through exhaust blower by velocity gas pipe -Ø 1220 mm. they enter in two dry electrofilter after which are either thrown away through the chimney or are used for the production of sulphuric acid. The smelting section has 11 attendants per shift

The results of the electro-smelting and the basic technic-economical indeces are given in table № 3

Table № 3

Index	Measure	Mean data for 1969 and the firs 6 months of 1970
1. Charge composition		
a roasted material	%	87,00
b. row charge	%	1,50
c. clinker	%	6.50
d. circulating materials	%	5.50
e. converter slag /% from the hard charge /	%	29,00

2. Composition of the wasted material		
copper	%	16.20
sulphur	%	19,00
iron	%	37,00
3. The converter slag composition		
copper	%	2,00
SiO_2	%	23.50
4. Smelting products /in % out of the solid charge/		
matte	%	45
slag	%	84,7
5. Matte composition		
copper	%	31
sulphur	%	25
iron	%	38
6. Slag composition		
copper	%	0,46
SiO_2	%	39
FeO	%	45
CaO+MgO	%	5
AlO_3	%	6
7. Product temperature		
a. Matte	c°	1120
b. slag	c°	1120
c. roasted material	"	450
d. gases after the furnace	"	650

8.	Gas volume	n m^3/h	30000
9.	SO_2 content in the gases	%	2,2
10.	Dust in the gas after the cyclones	gr/n m^3	10,0
11.	Specific production capacity of the furnace	t/m^2 24h	
	a. Solid charge	"	7
	b. in general	"	9,3
12.	Consumption of power concerning dry charge	kilowatt hour/t	307
13.	Degree of desulphurisation	%	22
14.	Distributing of the copper	%	
	in the matte		96,2
	in the slag		3,55
	in the dust		0,25
15.	loss of heat through the walls	kilowatt/hour/t	25,5
16.	electrical efficiency of the furnace	%	95
17.	chemical efficiency	%	70
18.	total efficiency	%	67
19.	cos φ	%	0,980
20.	Consumption of electrode mass concerning the charge	kg/t	2,5
21.	Consumption of sheet iron 2 mm for jackets	kg/t	0,42

The electrosmelting of the copper raw materials roasted in advance in fluidized bed reactor has some technological priorities in comparison with the most technological scheme. The process

The process is appliacable both for small capacity of 8-10 thousand tons copper and for big capacity -100 thousand tons per year. The same can be applied both for low grade copper concentrates and for high grade concentrates. The process can be fully mechanized and automatized and gives the possibility for the fully extraction of the useful components from the charge. By an enough low price of the el power and good organized technology this method is competitive with all classical and modern methods.

From the electro furnace the liquid matte by means of 3.5 m^3 buckets is poured out for processing in blister copper in 3 converter/each 40 tons//the one is reserve/. The process is the classical one. The quantity of air is controlled and registered and is 20-24000 n m^3/h and its pressure is about 0,9-1,2 atm. The maintenance of the tuyeres is hand done. The quantity of one smelting is about 37-40 tons. The duration of the operation is abot 16-18 hours. The dimension of the converter is 6100/3650 mm. It has 32 tuyeres with a diameter 41 mm. The gases are lead away through a water cooling system which consist of 27 coolers. The consumption of waser for cooling thegas is about 140 m^3/ h. Its temperature by the entrance of the gas must not be over 45^0 C. For the adding of quarts flumes and the cold materials there are special bunkers. The consumption of the quarts flumes with a purity of 80% SiO_2 is about 500 kg/t blister copper and the consumption of air is 8000 n m^3/t. The yielded blister copper has a purity of 98,7-[illegible]%. The gas has a content of 3-6% SO_2 and dust 3-4 gr/n m^3 and passes successive through dust precipitation chamber, 4 cyclones with a diameter 1100mm and scrubber electrofilter-6 pieces. After which is used for the production of sulphuric acid. The liquid blister copper enters the anodive furnace for a fire refining.

In the metallurgical department of the "G.Dimitrov Works" at Eliseina according the scheme: pressing into briquettes, smelting in shaft blast furnace are processed some low grade copper raw materials and copper servis.

Because of the high content of lead in some of the raw materials is worked out a technology for their direct smelting in converter recording the method of pyroselection. The materials which are given directly in the converter have the following compositions:

№	Components	Cu %	Fe %	S %	Zn %	Pb %	Sb %	As %
1.	liquid matte	20-32	36-40	22-25	2,0	3-6	1,5	2,5
2.	Speiss	35-50	2,0	5,0	1,0	20,0	8,0	2,0
3.	Matte	21-35	7,0	8,0	3,5	8,15	7,0	8,0

By content of copper in the liquid matte 25-32% the correlation of the liquid matte and the solid matte should be 2:1. For increasing the degree of driving away the lead in the beginning of the end of the process is added a solid reduction gear-coke 1-1,5% of the charge. The content of SiO_2 in the converter slag should not be more than 15%. An important condition for a normal pyroselection is the obtaining of the "white matte"/Fe under 3%/ The turning of the lead in the gas stage is about 88-89%. About 10% of the lead goes in the converter slag, which contains 3-3.8% Cu and 2,4-2,7% Pb.

The converter gas contains about 1,5% SO_2. The filtration of the converter gas goes on in velocity dusters, where a lead mud is obtained with a content of lead about 60%. Afterwards the converter gases are utilized for natrum bisulphite production.

For improving the quality of the yielded blister copper a technology is worked out for eliminating the arsenic and antimony from it by obtaining of two refining slags by the second period of converting by means of adding of CaO and Na_2O and blowing the blister copper just to /, 0,5% O_2. The obtained blister copper has a purity over 98,5% and the content of antimony and arsenic is reduced from 0,6 -0,8% to 0,08-0,12%,which facilitates the furtherer processing and assures the yielding of cathodes with a high quality .The consumption of lime is about 50 kg/t and of calcined soda about 20kg/t.

Chapter IV.Utilising of the sulphur out of the copper raw materials.

The utilising of the sulphur from the copper concentrates is an important fa tor for the complex use and influences the effectivness of the copper extracting.In the "G.Damianov" copper work" is built a department for sulphur acid production with a capacity of about 200 thousand tons,which gives the possibility of high utilisation of SO_2 from the industrial gas.The dust-fume gas system assures the prorification of the gas and sends it into the department for sulphuric acid production.At present for the production of sulphacid the gas from the wasting furnaces are used in quantity of about 35 thousnad n m^3/h with a content of SO_2 about 11%,the gas from the converters about 75 thousand n m^3/h with 2-6% SO_2 and the gas from the electrofurnace about 10 thousand n m^3/h with 2% SO_2. Because of the inconstant character of the converter gas there are some difficulties for the sulphuric acid production-expecially for the optimum regime and ind?ces.

The reasting gas a ter two stage crude purification in cyclone with Ø900 mm and Ø 700 mm by means of exaust blowers are given in four dry electro-filters type OG-4-16/the one in reserve The temperature of the gases by entrance is 320-350° C,an d the dust 12-15 gr/h n ^{3}.The dust by outlet by normal work of the filters is 0,1-0,2 gr/nm^3.The vacuum is very small 1-3 mm water column.The work of the filters is not very good.Their reconstruction is planned for the near future and a third one willbe built.The converter gases are purified in 6 pieces wet scrubber electrofilters with a filter capacity of 10 thousand n m^3 ,and by outlet 0,2-0,3 gr/nm^3.The obtained mud contains about 40% Pb. In order the cycle in the sulphuric acid department to be closed and the utilisation of the washing acids is planned. widening of the system for fine purifying of the converter gases. After purifying of the gases from the different units they are mixed in a general collector before the sulphuric acid department. The superfloures gases are directed in the 160 m high chimney stock.

The sulphuric acid department applies the contact method. It has three systems which were erected consecutive with the increasing of the capacity - the one system is for 20000 n m^3/h and the rest two each for 35000 nm^3/h gas. The gases go successive through the washing towers, wet electrofilters, drying towers and then enter the four apparatus with a contact vanadium mass. From the contact apparatus the gas mixure with 4-6% SO_3 and temperature 130-200^{0}C is directed toward the oleum and monohydate absorbers. The drying towers.

The indeces of the sulphuric acid production are the following:

1. Utilising the gases - 95%
2. Degree of contacting - 97,2%
3. Degree of absorption - 99,8 %
4. Consumption of el. energy -150 KWh/t
5. Content of SO_2 before the contact apparatus 4,[illegible]
6. Temperature of the gases in the contact

After the I contacting - 580^0 C after the III contacting 480^{0}C

" " II " - 560^{0}C after the IV " [illegible]^0 C

7. In one apparatus charged contact mass about 30t.
8. The mean duration of the contact mass 3.5 years.
9. Concentration of the acids
a. Washing towers -3,60%
b. Drying towers 94,5%
c. Monohydrate 98,1%
d. Oleum 19,3% free SO_3

In the "G. Dimitrov" works at Eliseina the converter gases with a low content of SO_2 are utilised effective for the production of natrium bisulphite and anhydrous natrium sulphite.After an wet dust purification in a velocity duster type"Venturi",the gases are absorbed in soda solution in a second degree"Venturi" to an extent of absorption over 97%.The produced bisulphite corresponds to the standart request and is used in the pharmaceutical and paper industries.

Chapter V- General analysis of the blister copper and sulphuric acid production.

The production of blister copper in the "G.Damianov" works is organized as a separate department,consisted of some sections, bound together in the technological process.Full conditions for the continuity of the production is assured by maximum mechanisation of the labour and automatic regulation and maintaining of the basic technological parameters.The mean content of copper in the raw materials is about 14,3%.The consumption of quartz sand for flux is about 650 kg/t blister copper.The consumption of electrical energy is about 50 kg/t blister copper.The quantity of the processed charge is about 300 000 t yearly.The extraction of the copper to blister copper is 93,5%.The loss structure is the following:

in the slag -3,3% ,with the gases 0,4%,mechanical and not determined loss 2,8%.The total number of the persons engaged in the production of blister copper is 370 including 320 workers. The extent of labour mechanisation is 86%.The productivity of labour of one worker is 120 t blister copper per year.The capital investments per 1 t blister copper are about 180 lv.

The structure of the prime cost of the exploitation expenses by the production of blister copper is the following:

1.Materials/without the raw materials/ 11% /quartz sand,quartz ore and electrode mass/	
2.Fuel /masut/	3%
3.Electrical energy	52%
4.Salaries	14%
5.Amortisation	8%
6. Department expenses and current repairs 12%	
total	100%

The profitableness of the production is about 10%.
In the production of sulphuric acid take part direct 95 persons including 82 workers. The extent of labour mechanisation is 98%. The productivity of labour is 2200t acid per worker. The capital investment for 1tacid is about 60 Leva. The total utilising of the sulphur in the plant at present is about 68%. The structure of the prime cost for the production of sulphuric acid is following

1. Raw material - 62%
2. Energy 8%
3. Salaries 2%
4. Department expenses 28%

Total 100%

The profitableness of the production is 14%.

From the pointed out technic-economical data is clear, in spite of the fact of the good results, that there are possibilities for improving some of the indeces -just like the extraction of the copper and sulphur, decreasing the consumption of the power increasing the productivity of labour etc. The outlined measures and the defined developments which are going to be performed in the near future will guarantee the increasing of the copper extraction over 95% and that of the sulphur over 75% and the productivity of labour with 30%. The tendency in this relation is as follows:

Introducing continuously discharging of the liquid products from the electro-smelting furnace, with fully automation. The process of the smelting. Automatic making the transport system in the department. Separate processing of the converter slag and utilising the slag in general.
Hermetically improving the electro-smelting furnace and converter and perfecting the system of the dust-catchers. Enlargement of the installations for sulphuric acid in order to be utilised all the gases through their enrichment and stabilising the regime of the department through burning up elementary sulphur; improving the quality of the concentrate and increasing more the capacity for production blister copper.

Chapter 6- Electrolitic copper refining by increased density of the current.

The original scheme of the electrolytic department by putting the plant in operation was the conventional one -the one applied generally all over the world.The current density was in the limits of 200-220 ampere/m^2.The temperature of the electrolyte through warming up with steam was in the interval 57-63°C;the velocity of the circulation of the electrolyte was an usual one 2-20 l/min.The construction of the bath was a conventional type without any distinctive characteristic.The baths are jointed serial in one electrical circuit and the electrodes in each bath -in series.In the bath is given continuously warmed up electrolyte and the cooled one is led away.The circulation of the electrolyte aids the maintenance of the necessity temperature and reduces the concentration polarization.The even deposit of the copper over the cathodes is faciliated by maintaining a definite colloidal regime by adding of organic substances just like bone-glue,sulphate lye,thiocarbamideets. By this conventional scheme it is not necessary any more details to be given.

During the period when the work was goinh on according the first stage the Bulgarian specialist developed a new method for electrolite refining of the copper with entirely different parameters from those of the before applied method.This method was experimented industrially and during the reconstruction of the electrolitic department was inculcated as -constant method of work.The distinctivness of the method is that by it density of teh current is increased.The method ensures a broad range from 300 Oo 700 A/m^2.The method is registered as a patent in a number of foreign countries and many firms display interest in the licence.The licence is already sold to Italy,Japan and USA.

It might be expected that for the increased sensity of the current would be needed special requirements for the purity of the material which ought to be electrical refined-namely the anodic copper.But in fact,the method is so developed that such requirments are not necessary.The admixures of the anodic copper remain in the cathode copper the same with insignificant exception, as by the conventional electrolitic refining.Of course a careful fire refining is desirable.It is not necessary the composition of the anodic copper to be given because it is well known. Electrolysis regime by increased density of the current has some peculiarities.It is natural that some of them which are the essence of the patent we are not in state to report.The increased density of the current needs respectively selected colloidal regime It could be reported,that in accordance of copper acid sulphuric acid content the composition differs very little from the classical one.There is a difference in the content of chlorine ions,and the temperature is higher.The velocity of the electrolyte circulation is a little bit changed too.There are no particular changes in the department equipment/baths,pumps,heat exchangers,pipe-line, communication lines,etc./which ensures the possibility of a cheap reconstruction of an already built installation.Serious changes are imperative necessary in the current section-electrical rectifier,fi: conductors and contacts.By building a new plant the current conductors would be calculated for a greater strength of the current. By reconstruction of a plant the tire equipment can be used wholly.

To characterise the economical results from the applying the new method conditional we shall give three hypothetical variants:

The installation will work by the following current density:

I.variant	II variant	III variant
$300A/m^2$	$320\ A/m^2$	$350\ A/m^2$

Purposely are chosen these densities,because of the specificity of the local conditions these three variants are the most optimum.

Basic we shall accept the conventional method with the most frequent applied current density-namely 160-180 A/m^2

By these conditions we shall receive the following improvment of some of the technic-economical indeces.

	I.variant	II variant	III.Variant
Increasing of the productivity in % by a base 100%	129	137	150
The consumption of el.power is increased per 1t electrolytic copper with	15%	19%	20%
The consumption of steam for heating of the electrolyte decreases with	20%	30%	40%
The consumption for amortisation of the fixed capital decreases with	20%	28%	42%

	I v.	II v.	III v.
The consumption for repairs and maintenance of the vasic means per 1t copper decreases with	10%	20%	40%
Capital invested in unfinished production decreases with	24%	33%	45%
The consumption of labour for the workers engaged direct in the production per 1 t copper cathodes decreases with	6%	9%	12%

It is clear that the data in the table are for the purpose of orientation and some changes are admissible in accordance of the local conditions.

The quality of the yielded copper cathodes briefly can be characterized as follows:

1. The outside appearance of the cathodes is without dendrites and has compact structure.
2. The chemical composition is the same as by the conventional electrolysis.

Cu -99,96 - 99,97%
As,Sb,Bi,Zn,Ni
Fe,Sn,Pb for each element 0,0001-0,0005%
S - about 0,001%
Au traces to 0,5 gr/t
Ag traces to 15 gr/t

Chapter V.

Conclusion

A. General deductions.

The described briefly development, achievement and successes of the copper metallurgy in People's Republic of Bulgaria lead to some general deductions among which are the following:

1. It is demonstrated that it is possible a copper industry to be developed effective even in a small country by comparatively low grade ores -content of copper about 0,4% by respectively selected technology of ore mining, dressing and metallurgical processing.
2. It is proved that exists the possibility for effective processing of concentrates with relatively not very high copper content by respectively selected and perfection of the metallurgical scheme.
3. It is established that there is a necessity of qualified specialists in order to be achieved favorable economic results in the development of the copper metallurgy in a small country.

4. The expedience from the applying of a high intensive processs for roasting of the sulfide copper concentrates just like the method of fluidized wasting is fully demonstarted.
5. The experience from applying of electrosmelting of roasted copper material is proved.
6. The effectivness of the process for electrolysing of copper by increased density of the current is established.

B. Recommendations for the developing countries about the possibilities of applying the described industrial processes.

We do not admit even the thought of giving recipe for the developing of the copper metallurgy in the developing countries. Our opinion is that the variety in the specific character of the local conditions is a very big one and because of it it is impossible a cliche to be recommendet. The example in the following attitude - in our country is chosen a particular, original metallurgical scheme, which is probably not repeated anywhere in the world and which ensures for the Bulgarian conditions a good effectivness.

That is why the first recommandation for the developing country is by developing their own copper industry not to accept automatic the classical schemes because there is no quarantee that they are the optimum technic-economical decisions.

In any case, we might asset - that is our second recommendation - that by selecting a scheme for roasting of copper sulfide concentrates and ores the roasting in fluidised bed roasters should be chosen. The process is high productive, can be automatised, and ensures a good utilising of the sulphur.

About the smelting of the copper raw materials we might recommend the electrosmelting just like a contemporary metallurgical process, containing in itself a number of inexhaustible reserv

Certainly here should be done a good assessment of a number of factors just like the accessibility of the spot, the price of the electric power, of the labour etc.

According the electrolytic refining the opinions of the Bulgarian specialists is clear established. They definitely accept

that the time of the classical electrolytic refining by density of the current about 200 A/m^2 is already done.
Especially of importance for the developing countries which have copper resources with comparatively high content of copper to draw their attention over the ore stocks along the flanks of the deposits which comparatevely are with a low grade content.
The Bulgarian experiment proves the necessity of such a care,all t the more the presence of copper ores in the world is restricted.

It is also important for the developing countries the selection of such a metallurgical scheme which will ensure a closed metallurgical sycle with the full and complex utilizing of the raw materials.It must not be forgotten that the copper raw material contains and a number of other valuable components.This characteristic of the Bulgarian technology in our article was not discussed because the lack of practical possibility,regardless of all that the Bulgarian example of the development of the copper metallurgy proves the possibility and undelines the experience of the complex idilisation of the copper raw materials.

SUMMARY

In the article istreated the Bulgarian's amazing increase in the production of non-ferrous metals assured in the last 20 years, and especially the new industrial development in the copper smelting and refining.

The artucle comprises 7 chapters,namely

1.A general scheme of the copper production in people's Republik Bulgaria.
2.Preparing of the copper raw materials for metallurgical processing.
3.The smelting of the copper raw materials in an electro-furnace,
4.Utilizing of the sulphur out of the copper raw materials.
5.General analysis of the blister copper and sulphuric acid production
6.Electrolitic copper refining by increased density of the current.
7.Conclusion.

In the preface are given some data which illustrate that a "near miracle" has occured in Bulgaria since the end of World War II. In a period of less than 20 years the non-ferrous metals industry has increased its mining dressing and metal extracting capacity several thenths of times.

In the first chapter is underlined,after fully describing of the modern and original technological scheme of copper production that it assures a high grade of extractions of the main component -the copper as well as the extracting of some of the concomittant components-sulphur,selenium,tellurium,precious metals and others.

The basic technological operations and a scheme of the plant management are given too.

In chapter 2 -the making out,the drying and the roasting of the charge is fully described,The fluidized bed roasters which are fully applied for the roasting of the charge are given with their characteristic and is pointed out that the mastering of this process was done for a first time in the world by the Bulgarian specialis The applying of this process assures a high productivity,smaller capitбal investments and labour and can be fully automatised.

In the third chapter -are treated the problems of electro-smelting,also a new process for which mastering on a large scale the Bulgarian specialists are the pioneers.The electro-smelting is a basic technoligical process in the copper production in Bulgaria because of its specific peculiarities and on the basis of its technic-economical accounts.A full description of the electro-smelting furnace is given and at the same time its gradual development.Some different tables are given pointing out some technical data of the furnace and results of the electro-smelting and the basic technic-economical indeces.A briefly review is given about the converting of the blister copper which is done according the classical scheme.

Chapter IV - considers the utilization of the sulphur and production of sulphuric acid.The dust catchers and the electro filters are fully described,as well as the intention for the future reconstructions in this direction.The sulphuric acid department applies the contact method which give the possibility of utilising the gases up to 95%.,and has an exent of contacting 98% and absorption 99,8%.

In the V chapter -is given the structure of the prime cost of the exploitation expenses by the production of blister copper and sulphuric acid and is pointed out that the profitableness for the first is about 10% and for the second about 14%. In spite of the fact of the good results possibilities for improving some of the indeces are given too.

Chapter 6 -treats the electrolytic copper refining by increased density of the current,Some details are given how the Bulgarian specialists developed this method which assures applying of a broad range of current from 300 to 700 A/m^2. The method is registered as a patent in a number of foreign countries.The license is already sold to Italy,Japan and USA. It is pointed out that nevertheless the expectation for special requirements for the purity of the material -the anodic copper

such requirments are not necessary.The admixures in the anodic copper,after refining according the method remain in the cathodes the same as by the conventional electrolite refining.
To characterize the economical results from the applying the new method conditionally are given three hypothetical variants by current density 300 A/m^2,320 A/M^2 and 350 A/m^2.The improvements of some of the technic economical indeces are given in details.
Chapter 7-treats the problems about the general deductions and recommendations.
From both of them is clearly understood that the Bulgarians could with justification be intensivly proud of the progress they have made in the past 15-20 years in the non-ferrous metallurgy including the copper metallurgy.This paper is written to focus the attention of the specialists of the developing countries to this striking progress in the non-ferrous metallurgy as a whole and especially in the copper metallurgy and to express the readness of the Bulgarian specialists to render their assistance to their colleques from the developing countries.

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