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INDUSTRIAL SCALE TESTING OF COPPER CONCENTRATE ROASTING PROCESS INTENSIFICATION IN FLUID-BED ROASTER BY OXYGEN

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ABSTRACT
The paper presents the results of industrial scale testing of sulfide copper concentrate roasting process intensification in commercial fluid-bed roaster by oxygen enriched air in the Copper smelter at Bor (Serbia and Montenegro). Applied roasting conditions were: temperature of 620-650 ^{o}C and air enriched with 21-25.6 % O_2. The following increases have been obtained: specific quantity of oxidized sulphur from 0,305 to 0,453 t/m^3 per hour, the quantity of oxidized sulphur from 100 to 148,5 %, disulphization rate from 43 to 63 % and SO_2 gas content in the range from 13 to 16,5 %.
Key words: Copper, roasting,oksidation,fluidized bed,intensification

1. INTRODUCTION
The fluo-solid reactors for roasting the sulphide copper concentrate, in Copper Smelter Bor, have been in use since 1959. The standard method for copper production is used that includes the roasting process of copper concentrate in fluo-solid reactors, smelting of roasting material in reverberatory furnaces, copper matte converting and copper flame refining [1,2].

Two fluo-solid reactors, type "DORR-OLIVER" with dry charging from roof are installed for roasting the sulphide concentrates. Charging is automatic.Partly roasting with desulphisation of about 45–55 % is carried out in reactor. Regulation of roasting temperature is carried out by addition of water with sprays, installed on reactor roof. Gases from roasting that carry 80 – 85 % of charged material, leave the reactor through hole on roof and go on dedusting. The other 15 – 20 % of roasting material goes out from reactor as overflow over special device, so called "fluosil". Technological layout of roasting process is given in Figure 1,and the basic technological characteristics of fluo-solid reactors are given in Table 1.

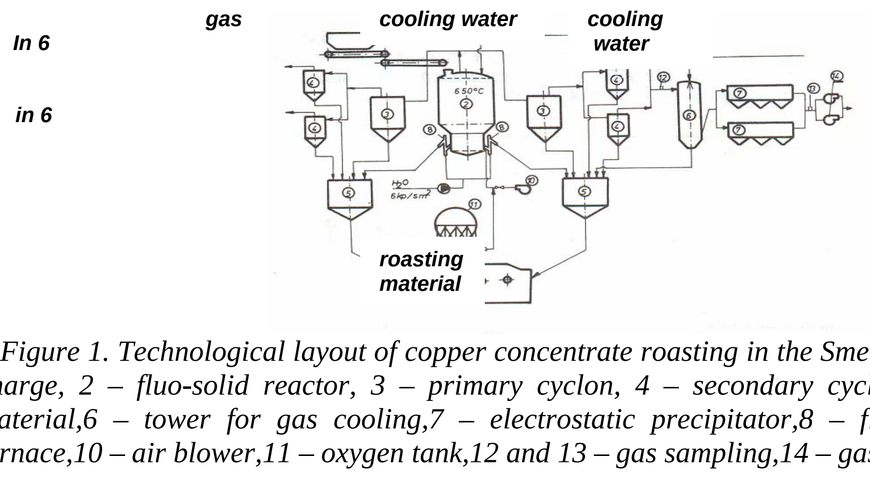

Figure 1. Technological layout of copper concentrate roasting in the Smelting Plant Bor : 1–bin for charge, 2 – fluo-solid reactor, 3 – primary cyclon, 4 – secondary cyclon, 5 – bin for roasting material,6 – tower for gas cooling,7 – electrostatic precipitator,8 – fluosil, 9 – reverberatory furnace,10 – air blower,11 – oxygen tank,12 and 13 – gas sampling,14 – gas blower.

Table 1. Basic characteristics of fluo-solid reactors for roasting the sulphide copper concentrates

	Unit measure	Reactor No. 1	Reactor No. 2
Shaft height	mm	7150	7150
Outer diameter	mm	6400	5200
Internal diameter	mm	5500	4800
Surface at bed level	m^2	23.7	18.1
Air rate through nozzle hole	m/s	65	66
Gas rate through bed	m/s	1.1	1.2
Specific capacity of concentrate treatment	$t/m^2/24$	40.93	47.35
Specific capacity of sulphur combustion	$t/m^2/24$	0.273	0.315

2. EXPERIMENTAL WORK

Investigations of intensification the roasting process of copper concentrates with oxygen enriched air were carried out on industrial type fluo-solid reactor in the Smelting Plant in Bor. The aim of investigations was to establish the possibility of aggregate productability for roasting at constant degree of desulphisation or increase of desulphisation degree with constant treatment capacity. Both parameters : the increase of concentrate treatment and increase of desulphisation degree are in narrow connection with quantity of oxidised sulphur that is with oxygen quantity that is blowed into reactor with technological air. Increase of air quantity that is blowed into reactor results into increase of quantity, rate and dustiness of gases. This increases a part of roasting material that is removed with gases regarding to a part that is removed with overflow. The excessive increase of blowed air quantity results into increase of gas rate through reactor bed over maximum critical rate. Blowing of oxygen enriched air decreases quantity of roasting gases what enables the increase of aggregate productability.

For the aim of investigation the possibility of intensification the fluo-solid reactor with oxygen enriched air, the industrial experiments were carried out with oxygen content in air for roasting from 20.8 – 25.6 %. Mixture of concentrates from Bor, Majdanpek and Veliki Krivelj was used for investigation. From mixture of concentrate and flux, the charge with the following content was formed : *Cu = 19 – 20%, Fe = 24 – 26%, S = 28 – 31%,* SiO_2 *= 14 – 15%, CaO = 2.5 – 3.0%*

Roasting temperature during investigation time was maintained in a range from 620– 650^0C. Except temperature, the following roasting parameters were monitored : quantity and chemical content of charge, flow and content of oxygen in the air for roasting, water quantity for regulation the roasting temperature, chemical content of roasting material, flow and chemical content of roasting gases. During investigation, the quantity of enriched air was 24000 Nm^3/h, and desulphurisation varied from 43 to 62.6 % depending on oxygen content in the enriched air. Gas flow and content were measured at two measuring points,in front and beside gas was used the Orsat's apparatus.

3. INVESTIGATION RESULTS

Investigation results show that use of oxygen enriched air resulted intoincrease of roasting aggregate productability. For evaluation the increase of productability, depending on oxygen content in air for roasting, the following values were used : quantity of oxidised sulphur (t/h) and specific quantity of oxide sulphur ($t/m^2/h$). Figure 2 presents dependence of oxidised sulphur quantity on oxygen quantity in air for roasting.

Increase of productability the roasting reactor, calculated over specific quantity of oxidised sulphur ($t/m^2/h$), with oxygen content increase in air, is presented in Table 2. With oxygen content in the air of 25.6 %, productability of roasting aggregate is 148 % regarding to the operation with non-enriched air [3]. Similar results were obtained in the Smelting Plant G. Damjanov in Bulgaria [4].

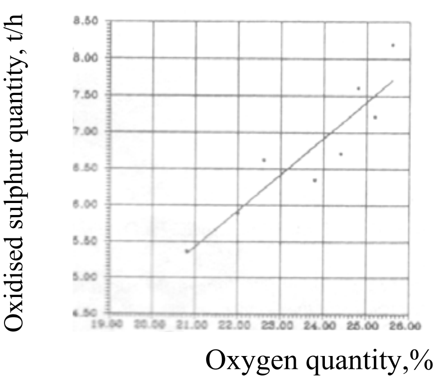

Figure 2.Dependence of oxidised sulphur quantity (t/h) on oxygen quantity in air for roasting in fluo-solid reactor.

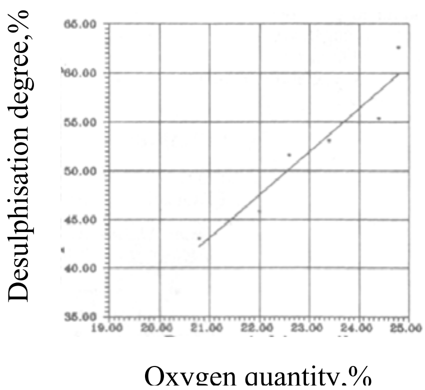

Figure3. Dependence of desulphisation degreee on oxygen content in the enriched air for roasting in fluo-solid reactor.

Rate of gases through bed is often limited factor for increase the productability of fluo-solid reactor. In those conditions, the effective way for capacity increase is oxygen enrichment of air. By air enrichment, total quantity of roasting gases decreses what also decreases their rate through reactor bed.

Table 2. Effect of increase oxygen content in the air for roasting on increase the specific quantity and percent of oxydised sulphur in the fluo-solid reactor.

Oxygen content in air (%)	Specific quantity of oxidised sulphur ($t/m^2/h$)	Increase of specific quantity of oxidised sulphur (%)
20.8	0.305	100.00
22.0	0.325	106.56
22.6	0.337	110.49
23.4	0.365	119.67
23.8	0.351	115.08
24.4	0.371	121.64
24.8	0.420	137.70
25.2	0.399	130.82
25.6	0.453	148.32

One serie of investigations was programed for possible increase of desulphisation degree with increase of oxygen content in the air for roasting. Desulphisation degree in the roasting process, at constant capacity of concentrate treatment and quantity of blowed air, increases with increase of oxygen content in the air as results of increase the total oxygen quantity that is blowed into reactor for roasting. This form of intensification the roasting process has practical value as it keeps the constant capacity of concentrate treatment, and increases copper content in copper matte. It is used in conditions of low-grade copper concentrate when capacity of the converter section is limited factor of production, that is when the converter section presents «the bottle neck» in production. Figure 3 presents dependence of desulphisation degreee on oxygen content in the enriched air, for constant quantity of air and oxygen mixture.

Regulation of roasting temperature during investigation was carried out by addition of water through reactor roof. The increased oxygen content in air decreases the quantity of roasting gases and heat quantity that is moved out with it from reactor. For maintenance the roasting temperature in a range 620 – 650^0C at constant capacity and desulphisation degree, it is necessary to add higher quantities of cooling water. Dependence of cooling water consumption on oxygen content in the air for roasting is presented in Figure 4.

Quantity of cooling water increases with increase of oxygen content in the air for roasting what was limited factor for increase of desulphisation process.

Maximum degree of desulphisation in investigation was 63%, with cooling water consumption of 3.7 m^3/h. Content of SO_2 in roasting gases increases with increase of oxygen content in the air for roasting

(Figure 5).Content of SO_2 in gases was determined at two measuring points (13 and 14) in front of (line 1) and beside the electrostatic precipitator (line 2), Figure 5.

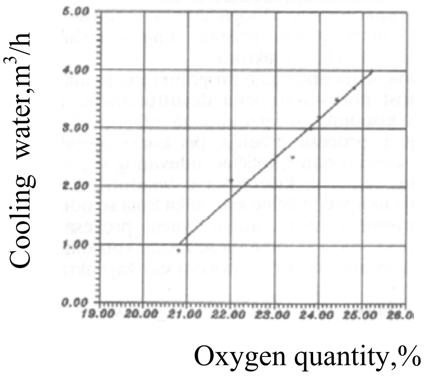

Figure 4. Dependence of cooling water consumption on oxygen content in the air for roasting, for desulphisation degreee 45% ± 1%.

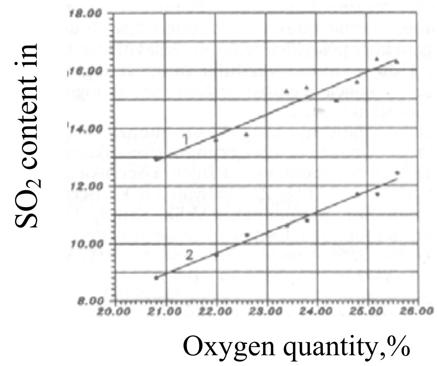

Figure 5. Dependence of SO_2 content in gases of fluo-solid reactor on oxygen content in the air: 1. in front of, 2. beside the electrostatic precipitator

Increase of SO_2 content in roasting gases enables increase of total sulphur revovery. By mixing of reach gases from the roasting process with poor converter gases, total content of SO_2 increases. By this way, a possibility of use the poor converter gases is increased for sulphuric acid production.

4. CONCLUSION

This method of intensification could be used in the following cases: a) when it is necessary to increase the reactor capacity for production increase, b) when it is necessary to increase the desulphisation degree for production increase, c) for the aim of higher degree of sulphur connection and decrease of air pollution.

During roasting in fluo-solid reactor at temperature from 620 – 650^{0}C, with oxygen content in the air from 21 – 25.6% O, the following increases were obtained :

1. Specific capacity of sulphur oxidation from 0.305 – 0.453 t/m^{2}h,
2. Quantity of oxidised sulphur from 100 – 148.5 %,
3. Desulphisation degree from 43 – 63%,
4. Sulphur dioxide content in roasting gases from 13 – 16.5% SO_2.

By mixing of reach gases of roasting from fluo-solid reactor with poor converter gases, the gas with average content higher than 5% SO_2 is obtained, that is suitable for sulphuric acid production.By this way, total sulphur recovery from the smelter gases could be increased for 10% what results into higher air protection and economic operation of the smelter.

5. ACKNOWLEDGEMENT

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6. REFERENCES

[1] Vučurović D., Modern Condition of Smelting Process in Copper Metallurgy in the World, TM Faculty, Belgrade 1985, pgs. 1-139 (in Serbian)
[2] Vučurović D., Č. Knežević., Smelters and Capacities of Copper Metallurgy in the World, «Tehnika» RGM, 39, 1988, No.9, pgs. 797-804 (in Serbian)
[3] J.Marinković, M.Ćirkovic et al, Intensification of Roasting Process the Copper Concentrate by Technical Oxygen in the Fluo-solid Reactor in Bor, Copper Institute Bor, 1987 (in Serbian)
[4] N.Šopov, N.Mihajlov et al, Institut po cvetnoj Metalurgiji Plovdiv, Mesečno naučno tehničko spisanije METALURGIJA 2/1984, str.19-22 (in Bulgarian)