ANALYSIS OF POLYMETAL ORES TREATMENT POSSIBILITY BY METALLIZATION METHOD

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Iron-ore raw materials porous structure (pellets, agglomerates, briquettes) formed as a result of sintering, is a universal indication of their quality, as it defines such important metallurgical properties, as «cold» and «hot» strength, restorability, and metallization extent. That's why the questions of forming and analyzing the final porous structure are dealt with in a lot of works.

Most researchers describe the structure effect on strength by an empiric formula:

$$P = a \exp(-B), \qquad (1)$$

where P is strength; a is a factor taking into account sintering mode parameters; B is the structure parameter.

As an example of B there is used either the general porosity value or the pore average radius value. Such an approach in studying strength characteristics is adequate because these parameters are the indication of the sintering process completeness. However, studying the porous structure as an object of studying mass-exchange processes, require a completely different approach both in the methodological and in experimental relation. Such mass exchange processes are the process of oxidation during sintering, restoration during sintering and metallization. It's evident, that these processes completeness defines finally the quality of the product obtained.

In work [1] there was shown that the intensity of mass exchange processes is mainly defined by the character of the porous structure and, particularly, by such parameters, as general volumetric porosity, pores distribution by their sizes, and pores surface accessible for reacting.

In the present work there is studied the process of pore formation, their distribution by the size in the sintering process depending on different factors. Besides, the approach to studying the porous structure was formed from the point of view of mass exchange processes possibility.

For studies there were used briquettes of iron-ore concentrate of different density. The value of density in damp briquettes varied by the value of compacting pressure from 130 till 1200 kg/смм^2. The damp briquettes porous structure was studied with the help of mercury porometry [2]. Then the briquettes were sintered in the air at the temperature 1250 °C, the time of sintering varied from 3 till 40 minutes. The samples obtained by such a way, were studied with the help of mercury porometry. The results of studying are shown in Table 1.

Table 1

Parameters of porous structure depending on compacting pressure and sintering time

Number one after another	Sintering time, min	0		3		8		20		40	
	Compacting pressure, kg/cm^2	L	V S	L	V S	L	V S	L	V S	L	V S
1	130	42	0,0879 1,5048	37	0,0551 0,8874	28	0,0453 0,548	25	0,0359 0,328	23	0,0301 0,214
2	380	35	0, 063 1,202	31	0,0429 0,612	24	0,0319 0,404	21	0,0236 0,0261	18	0,025 0,198
3	1200	28	0,051 0,908	24	0,0309 0,384	20	0,0231 0,204	17	0,0198 0,146	15	0,0136 0,106

N o t e . L is open porosity, %; V is pores specific volume, cm^3/g; S is pores specific surface, m^2/g.

According to the pores classification suggested in [3], all the pores can be divided into four groups by their size:

I group: macropores, size over 2 mkm;

II group: mesopores, size 2-0,5 mkm;

III group: micropores, size 0,5-0,02 mkm;

IV group: inner-particle pores, size less than 0,02 mkm.

Besides, it's necessary to note that there was considered only open porosity, i.e. accessible for mass exchange processes and chemical reacting.

The analysis of Table 1 data showed that a damp briquette density effects significantly the character of distribution by the size. The briquette density increase leads to macropores number decreasing and, respectively, to meso- and macropores number increasing. However similar studies of sintered briquettes showed that the difference in pores distribution in damp briquettes of different density is practically leveled after sintering. F All the sintered briquettes are characterized by the tendency to decrease macro- and micropores number and to increase mesopores number. In other words, the character of pores distribution by their size in sintered briquettes is almost the same and doesn't depend on the starting distribution. This is connected with developing the processes of diffusion and pores coalescence during sintering.

Alongside with the starting density effect on the pores distribution character, there was also studied time and sintering temperature effect. The sintering time varied from 3 till 40 minutes, the sintering temperature varied from 1000 till 1300 °C. The analysis of the data obtained showed that the general tendency of pores distribution character changing consists in the following.

At the first stages of sintering there goes on an active healing of all the pore groups, the speed of the briquette shrinkage is great. At the next stages of sintering the process of pores healing is accompanied by forming closed pores, coalescences and smoothing the relief of pores surface. At the final stages of sintering the process of closed pores forming becomes predominating and is accompanied by a sharp decreasing of open porosity. Based on this it can be said that to obtain a product with good gas-permeability the sintering process is to be carried out no longer than 8 minutes.

Pores surface changing in the sintering time is described by the following equation:

$$S_t = S_o \cdot \exp(-k\tau), \tag{2}$$

where S_o is pores surface in the starting briquette; k is a coefficient depending on the nature of the material sintered and sintering time; τ is the sintering time.

Equation (2) reflects rather completely the physical sense of the process of pores surface changing during sintering: at $\tau = 0$ $S_t = S_o$; at $\tau \to \infty$, $S \to 0$. Indeed, at an indefinitely great time of sintering there develops the process of pores coalescence, and in ideal all the pores merge in a single pore located in the poreless matrix and having an extremely small surface.

Thus, knowing the pores starting surface in a damp sample and taking into consideration equation (2), there can be predicted the value of pores surface S_t at any moment of the sintering process.

As it was noted in work [4], the pores surface value can be controlled with the help of the sintering mode: the temperature and the time of isothermal exposure. To check this statement there were carried out the following tests. Iron-ore briquettes were sintered in the air at the temperatures 1200 and 1000 °C till the shrinkage value 5 % with various sintering time. Then the samples were studied with the help of mercury porometry, the results are presented in Table 2.

Table 2

Porous structure parameters depending on sintering temperature

Parameter controlled	Shrinkage extent 5 %			Sintering time 40 min.		
Sintering temperature, °C	Sintering time, min	Pores sp.volume, cm³/g	Pores sp.surface, m²/g	Shrinkage, %	Pores sp.volume, cm³/g	Pores sp.surface, m²/g
1200	8	0,0473	0,5516	8,9	0,0401	0,203
1000	18	0,0443	0,3314	6,4	0.0301	0,211

As it's clear from Table 2, at the same shrinkage the sintering temperature decreasing leads to the pores surface decrease. It's easily explained if it's taken into consideration that at decreased sintering temperatures the surface migration process prevails over the matter volumetric flowing. At the same tine the sintering temperature increasing with the same activity of isothermal exposure leads to the logical volume and pores surface decrease due to the more completeness of the sintering process.

Thus, at other equal conditions the pores surface value changing in the sintering process is effected by: the pores starting surface, sintering temperature and the time of isothermal exposure. The data of these factors effect are shown in Table 3.

Porous structure parameters depending on the sintering mode

Mode	Balling time, min	Sintering time, min	Sintering temp, °C	Pores opening, %	Pores volume, cm^3/g	Pores surface, m^2/g
1	2	9	1240	37	0,0453	0,328
2	14	3	1240	26	0,0309	0,256
3	2	3	1300	22	0,0296	0,198
4	14	9	1300	19	0,0203	0,119
The main level	8	6	1270	22	0,0300	0,293
Varying interval	6	3	30	-	-	-

By the data of Table 3 there was carried out the quantitative analysis of the balling time effect (starting pores surface), sintering temperature and time. As a result there was obtained the following equation of regression:

$$S_t = 0,221 - 0,037\tau_{ok} - 0,06t - 0,0017\tau_{sp}. \quad (3)$$

Starting from the values of coefficients in equation (3), all the factors effecting pores surface decreasing can be placed in the following order: sintering temperature, balling time (pores starting surface), and the time of isothermal exposure of sintering.

Conclusions

1. In studying the porous structure as an object of mass exchange processes the greatest role is played not by the absolute porosity but the pores surface and pores distribution by their size.

2. At the existing temperatures of iron ore raw material burning the sintering process is to be carried out no longer than 8 minutes, otherwise there develops the process of pores coalescence that leads to the product gas permeability decrease.

3. By the effect on the pores surface decreasing in the sintering process the factors can be placed in the following order: sintering temperature, balling time (pores starting surface), and the time of isothermal exposure of sintering. Consequently, when controlling these factors, we can regulate the pores surface and, thus, the strength properties and gas-permeability of the product.

References

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