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POTENTIAL OF ILMENITE SAND APPLICATION IN THE IRON ORE MATERIALS AGGLOMERATION

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The aim of this work was to asses the concrete ilmenite sand for its application in the process of the fine grain materials aggregation or pelletizing. The above intention was based on the knowledge of the titanium positive effect upon the formation of the protective brush matting in the blast furnace hearth on the base of the titanium carbon – nitrides. The assessment and analysis of the material was carried out for this purpose, as well as the laboratory experiments aimed to the balling properties. Results achieved from this work predicate the possible exploitation of the ilmenite sand in for of the sinter or pellets production with the higher titanium content.

Key words: blast furnace, sintering, ilmenite sand, titanium, mixture

INTRODUCTION

Natural wearing of the lining under the conditions of the pig iron production in the blast furnace is subject of the nature and conditions of the process conducted in the blast furnace. The mostly affected section of the blast furnace is the blast furnace hearth, where high demands are placed upon the resistance against the thermal and chemical load caused by the melted phase. Possible solution how to increase the life of the lining of the hearth is the formation of so called penetration layer of titanium carbides and nitrides at the lining inside surface [1 – 6]. To create such protection layer it is necessary to assume the titanium addition and combining it with carbon and nitrogen when the hard to melt carbide-nitride compounds are formed. Feasibility of the titanium-bearing material addition depends on its physical and chemical properties, as well as on the concrete strategy and particular approach of the individual plants or concrete furnaces. From the point of the application continuity, in practice exploited is either preventive or impulse method of the titanium bearing materials addition into the blast furnace charge. The selection of the titanium-bearing material is important from the point of way of its addition. Lumpy titanium ores are fed directly from the top. The fine grain titanium materials may not be added through the furnace top due to the unsuitable granulation. They may be injected through the tuyers (which is highly technically demanded), or granulometrically treated (pelletized, briquettised, agglomerated) [7 - 9]. Another constraint connected with the blast furnace iron production is the maximum allowed titanium content in the pig iron and slag. If exceeded, then the technological conditions and blast furnace melting and quality parameters are worsened. Amount of titanium in furnace should be controlled according to Ti content in the metal and this should be around 0,10 to 0,19 %. If its content is lower than 0,10 % Ti, only small amount of carbonitrides is formed and above the level of 0,19 %, viscosity of the metallic melts starts to rise. As the critical level of its content in the pig iron, considered is the content of 0,25 – 0,30 % Ti. Should this level be achieved or even exceeded, than the titanium bearing material feeding must stop until the stabilisation of conditions is set. Similarly the problem related to the viscosity occurs with the slag where the optimum TiO_2 content should be within the range of 1,0 – 2,5 % TiO_2, the critical content correspond to 3 % [10, 11].

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MATERIAL AND METHODS

Tested material was the ilmenite sand (IS), chemical composition of which is given in Table 1.

Table 1 **Chemical composition of the ilmenite sand / wt. %**

Fe_{TOT}	FeO	Fe_2O_3	CaO	MgO	SiO_2	Al_2O_3
55,85	22,13	55,33	0,294	1,24	1,088	0,54
TiO_2	Mn	P	S	Zn	Na_2O	K_2O
18,198	0,17	0,404	0,073	0,020	0,053	0,111
C	Cr	V	Ni	Cd	Pb	Hg
0,035	0,060	0,23	0,010	<0,010	<0,010	<0,001

Methodology of the experiments included the estimation of the chemical composition, granulometry analysis, optical microstructure and phase analysis of the ilmenite sand. To estimate the chemical composition exploited were the following instruments: ICP IRIS Intrepid XSP, LECO 230 and Niton XL3t GOLDD+.

Granulometric analysis was carried out on the vibrating screen LPzE-2e, manufacturer Multiserv -

Morek. Optical observation was carried out with the microscope Olympus BX-51. The sample was prepared by pressing the mixture of the ilmenite sand and synthetic powder resin Lucit in the ratio 3:2 and ground gradually until the granulation 4000 was achieved. Microstructural analysis was carried out exploiting the electron microscopy (SEM) and energy - dispersion analysis (EDAX). The phase analysis was carried out with the diffractometer fy Seifert XRD 3003/PTS. Diffraction record was analysed using the software ZDS-Search Match with the database PDF2 and software TOPAS.

Followingly tested were the balling properties of the ilmenite sand and the modelled mixtures. Tests of the balling properties of the ilmenite sand were carried out exploiting the method of the "free drop" and method of the capillary absorptivity. The formation of the micro pellets and raw balls was carried out on the laboratory balling dish.

RESULTS AND DISCUSSION

The chemical analysis of the ilmenite sand (Table 1) indicates that this is a material with relatively high iron and titanium content, as well as with very low content of Si, Ca, Mg and Al oxides. The basicity of the material is at the level of 0,9 representing the positive effect of the additives on the resultant basicity of the sintering or pelletizing mixture. The content of the unwanted elements is at the level of the iron-bearing concentrates.

Based on the results of the sieve analysis, carried out on the screens with sieve size 0,250; 0,180; 0,125; 0,090; 0,063 mm, the cumulative curve was constructed (Figure 1). The cumulative curve of ilmenite sand shows that the grains are mostly of the same size and the majority proportion of the grains is within the interval 0,1 – 0,18 mm. The calculated mean diameter of the grains was MK_{calc} = 0,137 mm. The median diameter as another measure of central tendency was at the level of d_{50} = 0,140 mm. 75 % out of the total ilmenite weight, when neglecting the proportions below 0,02 mm, are of the dimension d_{75} = 0,117 mm. Value of d_{25} is equal 0,161 mm. The quartile ratio $S = d_{75}/d_{25}$ is at the level of 72,2 %.

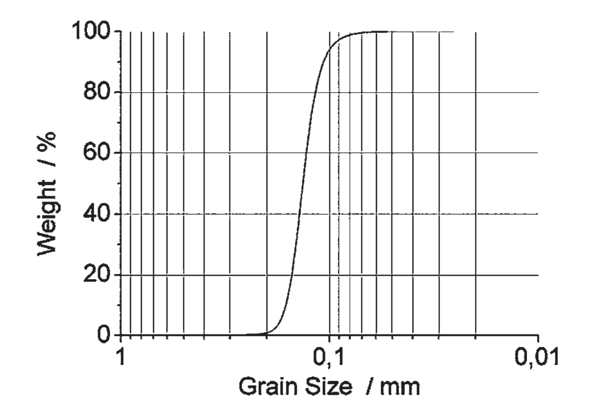


Figure 1 Cumulative granulometric curve of ilmenite sand

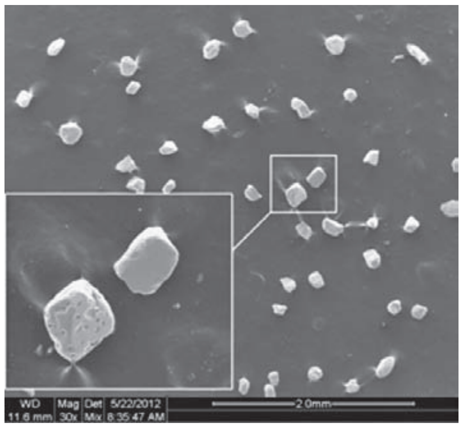


Figure 2 Detail of the ilmenite sand grains

The optical observation of the tested commodity was carried out with the objective to determine the morphology of the grains. Figure 2 confirms that the morphology of grains i s relatively uniform. The individual grains are of the irregular shape of the polyhedrons, free of the significant sharp edges. They are prevailingly present as the grains with the shape of the quadrangle or pentagon. Shape factor of such grains is within the range of 0,7 – 0,8.

Scanning electron microscopy and energy-dispersion analysis of the studied material confirmed the majority representation of iron and titanium in the oxidised form (Figure 3). Corresponding elemental analysis of the spectra is provided in Table 2.

Table 2 **Content of the individual elements in the ilmenite sand of the scanned surfaces / wt. %**

Area	1	2	3	4
Element	wt. %	wt. %	wt. %	wt. %
CK	4,53	5,35	-	9,66
OK	21,19	33,66	23,45	30,70
MgK	1,03	1,08	0,66	0,79
AlK	-	0,90	0,43	0,68
SiK	-	0,76	-	1,04
TiK	18,33	16,89	19,54	14,17
FeK	54,93	41,35	55,92	42,96

The phase analysis of the ilmenite sand was carried out by the X-ray powder diffractometry (XRD). The results from the XRD of the ilmenite sand (Figure 4) confirmed that hematite and ilmenite are the major phases.

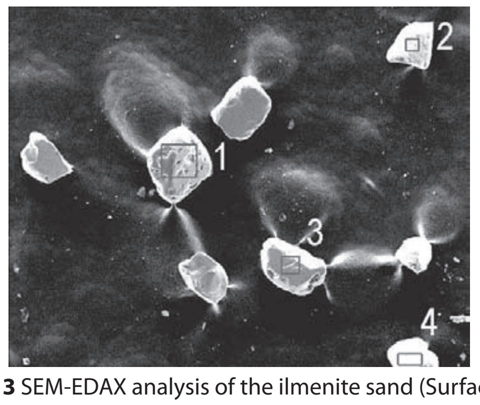


Figure 3 SEM-EDAX analysis of the ilmenite sand (Surface 1, 2, 3, 4)

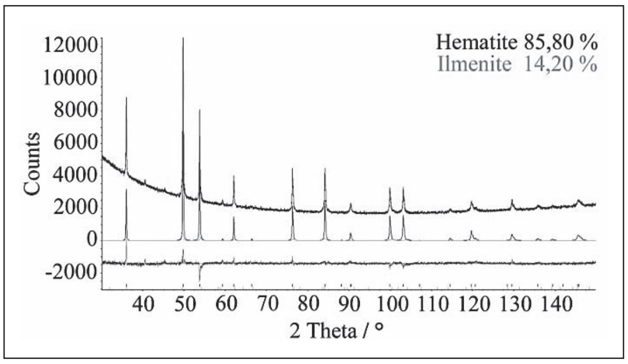


Figure 4 XRD record of the measured sample of the ilmenite sand

Balling tests of the ilmenite sand were carried out with the objective to evaluate the possibilities of its application in the processes of the fine grain materials agglomeration, as is the case of the sintering and pelletizing processes. Balling of the fine grain materials is the result of the interaction of several factors, first of all the granulometry composition of the material, shape and surface properties of its grains and chemical and physical composition. Formation of the green pellets with the absence of the mechanical effects action was observed applying the methods of "free drop". Results from the laboratory experiments shown relatively good self-pelletizing ability, however the absence of the clay components based on the plain ilmenite sand caused their complete degradation (Figure 5). In case of the quick lime addition application, expressed was its positive effect upon the self-hardening, when among the individual grains formed are so-called mortar bridges.

The micro-pelletizing as well as the formation of the green pellets on the laboratory dish confirmed the suitability of the ilmenite sand application in the blended feed for the sinter production, as well as for pellets production. The following figure (Figure 6) demonstrates the pelletizing ability of the ilmenite sand for the conditions of the iron-ore sintering process as well as for pelletizing process.

CONCLUSION

Based on the results of the experimental work and the tests of the ilmenite sand, it may be said that this material possesses the high utility value and has broader exploration in the metallurgy of pig iron production. The results of the analysis confirmed relatively high iron and titanium content and that those metals are preliminary combined in form of hematite and ilmenite. Material contains small amount of the ballast components. This fact, when comparing with ore determined for sintering with the same amount of total iron, represents its higher utility value. Based on the granulometry analysis, it may be classified among the fine grain materials, similar to the iron-bearing concentrates with the majority share of the grains within the interval of 0,10 to 0,18 mm. The calculated mean diameter of the grains MK_{calc} = 0,137 mm and regularity of the granulation at the level of 72,2 % is a good prerequisite for maintaining the homogeneity and granulometry condition of the processed fine grain materials applying the technologies of sintering and pelletizing. The optical observation of the tested commodity proved that morphology of the grains is relatively uniform. The individual grains are of irregular shape of the polyhedrons free of the prominent sharp edges. Here may be found grains having prevailingly shape of quadrangles and pentagons. The results of laboratory experiments showns the relatively good self-balling ability, however the absence of the clay components caused their complete degradation after the containing water evaporation. The significant factor affecting the micro-pelletizing or pelletizing of the ilmenite sand was the addition of quick lime. The optimum level of CaO addition was estimated as 10 % wt. In frame of the balling process determined were also the optimum parameters of the balling facility. The provided knowledge related to the properties of the tested material are the good prerequisites for its further laboratory testing under the conditions of the firing of the sintering feed, as well as for the conditions of iron-bearing pellets firing.

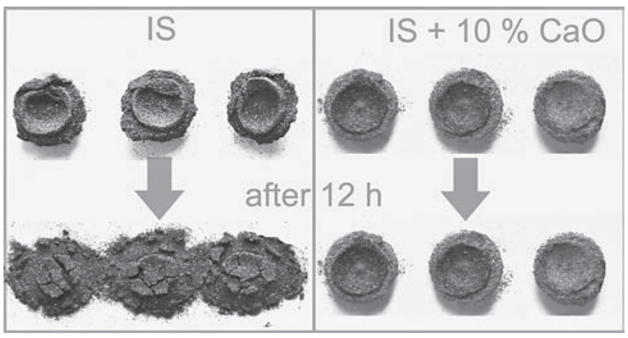
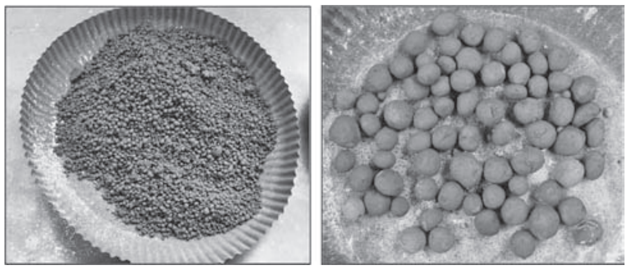


Figure 5 Self-pellets of ilmenite sand with or without quick lime addition (before and after 12 hours)



a) b)

Figure 6 Micro pellets (a) and green pellets (b) on the basis of IS

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Note: The responsible for English Language is Assoc. Prof. I. Repasova, PhD. Košice, Slovakia