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EFFECT OF EL-DEKHAILA IRON OXIDE PELLET FINES ADDITION ON THE SINTERING OF HIGH MANGANESE IRON ORE

Summary. El-Baharia iron ore, which is the only ore currently Helwan and Steel complex is using has manganese and alkali contents higher than the allowable values. It is expected that manganese content predominantly MnO will reach more than 5% and this amount is expected to be doubled in the next few years.

The sintering plant and blast furnace are subjected to excessive corrosion and scaffold formation on using sinter of high alkali content, and accordingly the productivity of both plants is mush lower than the designed capacity and the coke consumption is higher than the designed values. A high manganese content in the sinter leads to an increase in coke consumption in blast furnace (2-3%) for each 1% manganese, it also decreases the productivity of the blast furnace by ≈ (0.5-1.5%) and the splashes in oxygen converter which take place during steel making.

Thus the aim of this work is concerned with the utilization of wastes of El-Dekhaila pellet fines with El-Baharia iron ore in the sintering process to minimize the manganese content in the produced sinter.

WPŁYW UDZIAŁU ODSIEWU GRUDEK Z RUDY EL-DEKHAILA W SPIEKANEJ MIESZANCE Z RUDY Z PODWYŻSZONĄ ZAWARTOŚCIĄ MANGANU

Streszczenie. W referacie przedstawiono laboratoryjne wyniki badań nad wpływem udziału odsiewu grudek z rudy El-Dekhaila (około 67% Fe) w mieszance z rudy El-Baharia zawierającej podwyższoną ilość MnO (~ 5,2%) i alkaliów (~ 0,7% K_2O + Na_2O) na parametry procesu i własności spieku.

Introduction

Iron and steel industry in Egypt depends mainly on ore preparation for blast furnace. Sintering is the only main process for preparation of El-Baharia iron ores for blast furnace operations. Unfortunately, El-Baharia iron ore, which is the only ore currently Helwan and Steel complex is using has manganese and alkali contents higher than the allowable values. It is expected that manganese content predominantly MnO will reach more than 5% and this amount is expected to be doubled in the next few years.

The Helwan Iron and Steel complex officials once seriously thought to import iron oxides of low manganese and alkali content to improve the properties of El-Baharia iron ore and keep the percentage of the alkali and manganese within the accepted norms (2.8% MnO). Due to the high alkali content the sintering plant and blast furnace are subjected to excessive corrosion and scaffold formation and accordingly the productivity of both plants is mush lower than the designed capacity and the coke consumption is higher than the designed values [1-12]. A high manganese content in the sinter leads to an increase in coke consumption in blast furnace (2-3%) for each 1% manganese, it also decreases the productivity of the blast furnace by ≈ (0.5-1.5%) [13] and the splashes in oxygen converter which take place during the production of steel making.

The importance of the reuse of steel making wastes was discussed by several workers. Botha et al. [14], found that the use of mill scale and slag from the electric arc furnace save the cost of raw materials (flux-fuel), reduce pollution, also metallurgical properties and operational parameters of the sintering process are affected. These results are in good agreement with those observed by Nippon Kokan K. K. Jpn.[15,16], when sintering iron ore with limestone dust, mill scale and recycle ore. They attributed these findings to the improvement of size distribution, gas permeability of sinter mix.

Kravstov and coworkers [17], found that the addition of oily scale from rolling mills increase the vertical rate of sintering process and the technological parameters are greatly enhanced.

Bodik and his coworkers [18], reported that, an increase in the technological indices of the sintering process when sintering iron ores with mill roll scale, sludge and coke fines in an additional layer. They suggested that these waste materials could be used without any purification.

Shalabi, El-Afifi and coworkers [19], investigated the utilization of mill scale waste through sintering process. They found that the addition of mill scale has a beneficial effect on production rate and strength, whereas the mineralogical composition of sinter has apparent effect.

Knoblauch [20], study the possibility of recycling non-ferrous metal containing waste such as filter dust, slags, ashes, shavings and electrolysis sludge.

Huguet [21], found that recycled by-products improve the performance of sintering process. While Nosovitskii [22], found that the addition of metallic iron, blast furnace dust and waste powder to Krivoirog and Kursk iron ores favours crystallization of ferrite phases, decreases hematite content in the sinter cake, gives high bulk density, high mechanical strength and high reducibility to the sinter.

Demcik [23], they found that the utilization of blast furnace and steel making wastes in the sintering process improves productivity and reduce sintering time.

Gau [24], found that the sintering process are particularly suitable for recycling blast furnace sludge and O-furnace slurry without dehydration into sludge from the stand point of good productivity and saved coke breeze consumption.

Ionkov and coworkers [25], added Fe in the form of open hearth-furnace scale (containing 70% Fe) to the sinter mix, they found a significant decrease in Mn content of produced sinter.

2. Material and experimental

2.1. Materials

The raw materials used in the sintering process are El-Baharia Oasis high manganese iron ore (El-Gedida iron ore deposits) , El-Dekhaila iron oxide pellet fines, limestone, recycled sinter (sinter return) and coke breeze. The chemical composition of the raw materials are given in table 1.

Table 1

Chemical composition of raw materials

Component, %	Iron ore	Limestone	Coke breeze	Sinter return	El-Dekhila
Fetotal	48.99	----	2.24	51.5	67.1
FeO	----	----	----	18.93	0.4
Femet	----	----	----	0.49	----
Fe_2O_3	69.86	----	3.203	----	----
SiO_2	9.09	1.4	4.55	10.39	1.2
CaO	0.275	53.21	0.73	11.12	1.1
MnO	5.2	----	----	2.18	----
Al_2O_3	2.92	0.76	2.2	1.57	0.4
MgO	0.74	0.24	0.082	0.27	0.8
Na_2O	0.31	0.074	0.04	0.193	----
K_2O	0.365	0.027	0.106	0.04	----
Cl^-	0.42	0.1	----	0.07	----
CO_2	----	42.2	----	----	----
P_2O_5	0.58	0.07	0.022	----	0.01
S	0.39	0.04	1.08	0.12	----
C	----	----	88.39	----	----
TiO	0.11	----	----	----	----
L.O.I.	8.85	----	1.23	----	----
BaO	0.605	----	----	----	----
ZnO	0.245	----	----	----	----

2.2. Apparatus and Technique

2.2.1. Sintering Apparatus and Sintering Procedure

Sintering experiments were conducted in a laboratory down draft sinter pot, (3 kg). Air flow was provided by two fans in series which were capable of producing suction pressure in excess of 11.76 KPa. The temperature of the waste gas which gives an indication of the end of the sintering process was measured by Pt-Pt.Rh. thermocouple. The raw materials were blended together and the amount of water (7 or 9% of the charge) was added thorough the mixing of raw material. A sinter bed of 0.5 Kg sinter (+10 mm) was placed over the grate of the pot to protect it against the high temperature during the sintering operation. The green mix was loaded over the sinter bed layer (hearth layer) in the sinter pot.

The green mix was ignited with a gas flame over a period of 3 minutes. The ignition was done under suction pressure of 5.88 KPa, while the sintering process was done under suction pressure of 11.76 KPa. The sintering time was determined by the time elapsed from the start of ignition until the exhaust gas temperature reached a maximum value [13,26,27]. At the end of the sintering experiment the sinter cake was dropped from the sinter pot on to a steel plate laid on concrete.

The productivity of the sintering machine was calculated according to the following relation [13].

$$P = 14.4\ V.\ K.\rho$$

where:

P = Productivity of sintering machine (+7 mm), ton/(m^2 day),

V = Vertical velocity of sintering machine, (V= H /T) m/ min,

H= height of the charge, m,

T= time of sintering, min,

K= Percentage of ready made sinter from the charge, (+7 mm),

ρ = bulk density, ton/m^3.

The sinter cake was screened over a sieve of +10 mm [13,14], then the sinter of + 10 mm was taken and dropped four times from a height of 2 m (Fig. 2.6). Then out sinter after shatter tester was screened over a sieve of 7 mm. The sinter strength (W) was calculated as the percentage of (-7 mm) sinter relative to +10 mm [24,84].

$$\text{Sinter Strength (W) \%} = M_1 \times 100 / M_2$$

where:

M_1 = weight of sinter of -7 mm after shatter test, kg.

M_2 = weight of sinter of + 10 mm before shatter test, kg.

Notes. When (W) is high value this means the strength of sinter is low, while when (W) is low value , this means the strength of sinter is high.

The productivity at blast furnace yard was calculated according to the following relation [28,29]:

$$P_{B.F} = P \times (100 - W) / 100$$

where:

$P_{B.F}$ = Productivity at blast furnace yard, ton/(m^2 day),

P = Productivity of sintering machine, ton/(m^2day),

W = Shatter index (-7 mm),%.

The reducibility is done in H_2 atmosphere under the followig conditions (temperature of reduction = 800°C, flow rate of H_2 = 1.5 l/min. and time of reduction = 30 min).

3. Results and discussion

3.1. Effect of addition of El-Dekhaila pellet fines on the technological parameters of the produced sinter

Experimental results concerning the addition of El-Dekhaila pellet fines to the sinter mix conducted at coke breeze rate 7 and 9% are shown in Figs 1-4.

The percentage of ready made sinter (+7 mm) (Fig. 1) increases with the addition of El-Dekhaila fines and reaches ~ 72% and 78% at 7 and 9% coke breeze respectively at 50% fines addition. This is may be attributed to the addition of iron oxide fines which mainly contain high percent of Fe_2O_3 to the sinter mix, will be at the expense of El-Baharia ore, which is characterized by high heat consumption (Baharia ore consists mainly of hydrated geothite and limonite ores). Thus as the percentage of coke is constant, the excess heat will be consumed in improving melt formation and complete the reactions between the different minerals [30] and accelerate the dissociation of hematite to magnetite resulting in increasing sinter strength Fig. 2 and accordingly the percentage of ready made sinter increase [31].

The mathematical relatoionship between the amount of ready made sinter (+7 mm), (R%) and the amount of El-Dekhaila pellet fines (X %) can be computed as follows:

for 7% coke breeze

$$R = 60.09325 + 0.61075X - 0.01919X^2 + 0.00023X^3$$

for 9% coke breeze

$$R = 72.10714 + 0.11988X - 0.00925X^2 + 0.00018X^3$$

While the relationship between the sinter strength + 7mm after shatter test (W, %) and the amount of El-Dekhaila pellet fines (X, %) can be represented by the following equation:

for 7% coke breeze

$$W = 62.42857 + 0.13095X - 0.00036X^2 + 0.00008X^3$$

for 9% coke breeze

$$W = 74.15873 + 0.28394X - 0.01017X^2 + 0.00017X^3$$

From Figs. 3, also it is clear that for a given percentage of El-Dekhaila fines, the increase of coke breeze rate from 7 to 9% leads to a decrease in vertical velocity. This decrease is attributed to the excess melt formed which aggravate the permeability of the sinter charge.

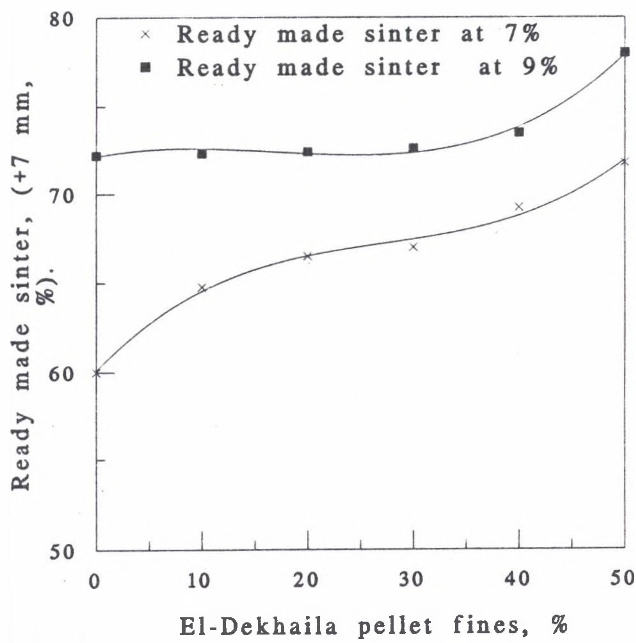

Fig.1. Effect of El-Dekhaila pellet fines addition on the amount of ready made sinter produced where 7 and 9% coke was used

Rys.1. Wpływ udziału odsiewu grudek z rudy El-Dekhaila na uzyski spieku przy 7 i 9% dodatku koksiku

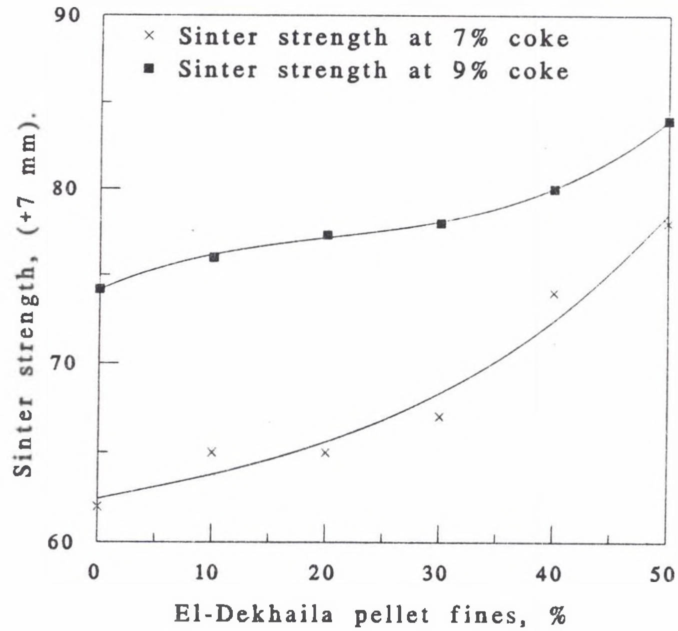

Fig. 2. Effect of El-Dekhaila pellet fines addition on the strength of the produced sinter where 7 and 9% coke was used

Rys.2. Wpływ udziału odsiewu grudek z rudy El-Dekhaila na wytrzymałość spieku przy 7 i 9% dodatku koksiku

The effect of the amount of El-Dekhaila pellet fines (X, %) on the vertical velocity of the sintering process (V, mm/min.) was illustrated by the following equations:

for 7% coke breeze

$$V = 30.17857 + 0.90893X - 0.02589X^2 + 0.0025X^3$$

for 9% coke breeze

$$V = 24.92381 + 0.20984X + 0.00302X^2 - 0.00007X^3$$

It was found that with increasing the amount of El-Dekhaila fines in the sinter mix to 50%, the productivity of the sintering cup as well as the productivity at the blast furnace yard increases reaching 51.4 t/m^2 day, 36.5 t/m^2 day and 41.4 t/m^2 day, 34.8 t/m^2 day at 7 and 9% coke respectively as shown in Fig. 4. The effect of addition of El-Dekhaila fines on the productivity of the sintering machine at any constant value of coke breeze is due to:

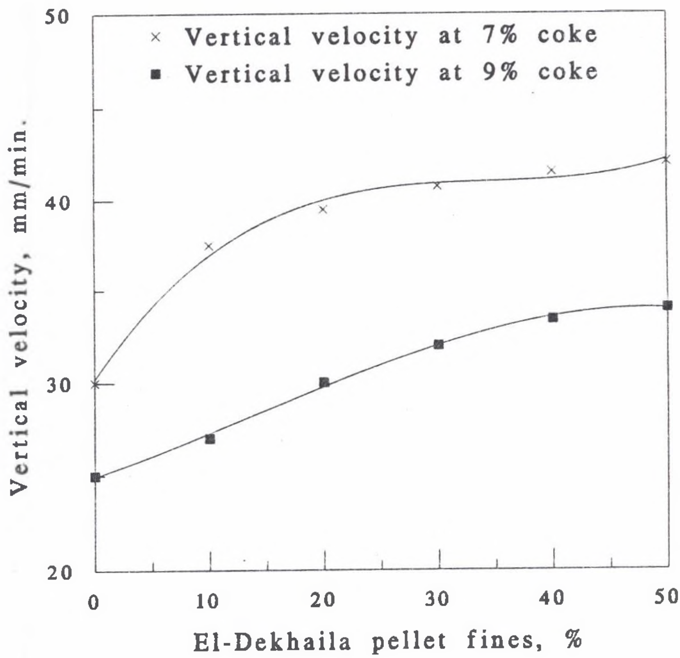

Fig. 3. Effect of El-Dekhaila pellet fines addition on the vertical velocity of the sintering process where 7 and 9% coke was used

Rys.3. Wpływ dodatku odsiewu grudek z rudy El-Dekhaila na pionową szybkość spiekania przy 7 i 9% dodatku koksiku

1. Increasing the percentage of ready made sinter by increasing the percentage of pellet fines.
2. Increasing the vertical velocity of the sintering machine by increasing the percentage of pellet fines. This could be attributed to the improvement in the granulation process followed by the improvement in the permeability which in turn improve vertical velocity, heat transfer and strength of the produced sinter.

The productivity at blast-furnace yard is enhanced by addition of El-Dekhaila pellet fines. This could be explained by the improvement of productivity of sintering machine and the strength of the produced sinter by adding these pellet fines Figs. 2 & 4.

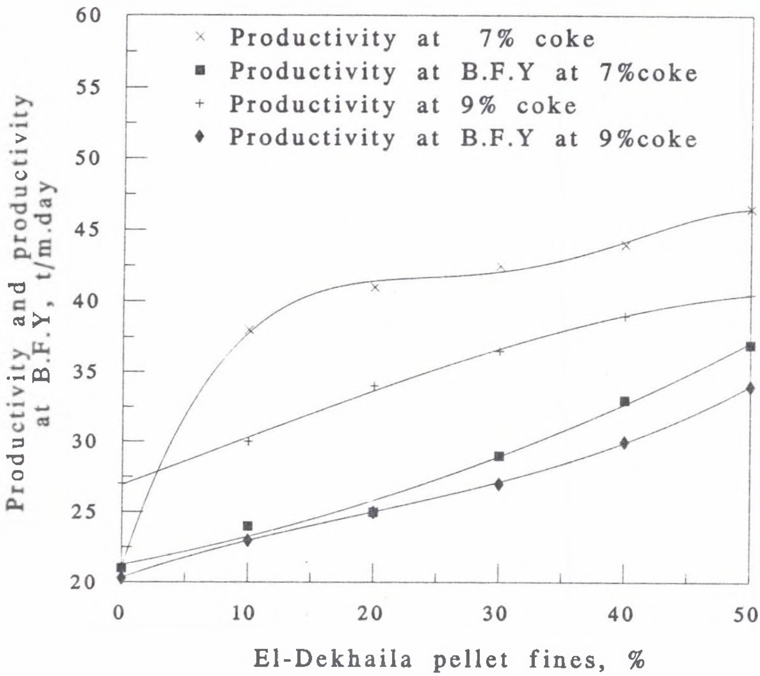

Fig. 4. Effect of El-Dekhaila pellet fine addition on the productivity and productivity at blast furnace yard where 7 and 9% coke was used

Rys.4. Wpływ udziału odsiewu grudek z rudy El-Dekhaila na wydajność procesu spiekania i procesu wielkopiecowego przewidywana przy dodatku 7 i 9% koksiku

Both the productivity and productivity at Blast-Furnace yard decrease with increasing coke breeze rate from 7 to 9% (Fig. 4.) due to the decrease in the vertical velocity at any constant percentage of El-Dekhaila fines Figs. 3.

The effect of El-Dekhaila pellet fines addition (X, %) on the productivity of the sintering machine (P, t/m^2 day) and productivity at B. F. Yard ($P_{B.F.}$, t/m^2 day), can be computed as follows:

for 7% coke breeze

$$P = 21.04167 + 2.81389X - 0.14281X^2 + 0.00313X^3 - 0.00002X^4$$

$$P_{B.F.} = 21.2222 + 0.17804X + 0.00234X^2 + 0.00001X^3$$

for 9% coke breeze

$$P = 26.92063 + 0.32791X + 0.00141X^2 - 0.00005X^3$$

$$P_{B.F.} = 20.31984 + 0.31356X - 0.00611X^2 + 0.00011X^3$$

3.2. Effect of Addition of El-Dekhaila Pellet Fines on the Chemical Composition, Reducibility, Porosity and Softening Temperatures

From Table 2, it is noticed that, the increase of the contents of FeO and Fe_{met} by increasing the amount of El-Dekhaila pellet fines is due to the use of high content iron oxide wastes (containing 68% Fe_2O_3) at the expense of El-Baharia ore which is mainly hydrated salts, so that the excess heat will be consumed in the dissociation of higher iron oxides (Fe_2O_3) to lower iron oxides(Fe_3O_4, FeO) and accordingly their percentages increase in the produced sinter.

Also from Table 2 it is clear that, at a given percentage of El-Dekhaila fines, the increase of coke breeze content from 7 to 9% leads to increase of FeO and Fe_{met} contents. This is due to the increase in the heat input created from the gasifcation of coke, such a reducing atmosphere leads to the reduction of higher oxides to lower ones.

At a given coke breeze rate , the decrease in the manganese oxide content with addition of El-Dekhaila pellet fines is shown in table 2, this is attributed to the dilution effect by the addition of very low content manganese oxide ores (El-Dekhaila pellet fine).

The increase of coke content from 7 to 9% (Table 2) leads to an increase in MnO content due to the high heat input which causes the dissociation of higher oxides of manganese and iron to lower ones (i.e. decrease the total weight of the sinter cake).

Also Table 2 shows that the addition of El-Dekhaila fines leads to the decrease in sulphur content this is due to the addition of low sulphur content pellet fines. Also by increasing coke rate from 7 to 9% the sulphur content decreases due to the improvement of sulphur removal by increasing temperature at higher coke rates.

From table 2, it is clear that, at constant coke breeze rate the content of sodium and potassium ions decrease due to the addition of pellet fines highly free from Na^+ and K^+ with respect to El-Baharia ores, also the excess heat caused by the addition of iron oxide fines helps in the sublimation of these ions. Increasing the rate of coke breeze from 7 to 9%, at a constant percentage of El-Dekhaila fines improves the sublimation process as well.

Table 2

Effect of El-Dekhaila pellet fines on the chemical composition of the produced sinter

El-Dekhaila Pellet fines, %.	Coke breeze %	Chemical composition, %.									
		Fe_{tot}	FeO	Fe_{met}	Na^+	K^+	MnO	S	C	CaO	SiO_2
0	9	47.6	16.0	0.5	0.280	0.111	5.04	0.21	0.15	13.9	10.8
	7	48.9	6.05	----	0.290	0.140	5.00	0.24	0.14	11.8	10.3
10	9	50.8	17.8	0.7	0.290	0.084	4.32	0.19	0.14	9.58	7.28
	7	49.0	11.97	0.3	0.295	0.086	4.27	0.23	0.17	9.24	7.21
20	9	51.9	18.0	0.8	0.254	0.068	4.10	0.14	0.12	9.14	7.00
	7	50.0	12.2	0.5	0.254	0.074	4.03	0.20	0.14	9.00	7.03
30	9	52.9	20.1	1.0	0.224	0.078	3.82	0.10	0.11	9.00	6.47
	7	50.7	13.3	0.65	0.264	0.086	3.31	0.17	0.14	8.80	6.8
40	9	54.4	20.6	1.2	0.192	0.065	3.48	0.09	0.10	8.75	6.36
	7	51.4	15.0	0.9	0.235	0.065	3.00	0.16	0.12	8.50	6.64
50	9	55.8	24.32	1.6	0.160	0.066	3.38	0.08	0.10	8.30	6.36
	7	52.9	17.0	1.0	0.160	0.070	2.95	0.12	0.11	8.0	6.36

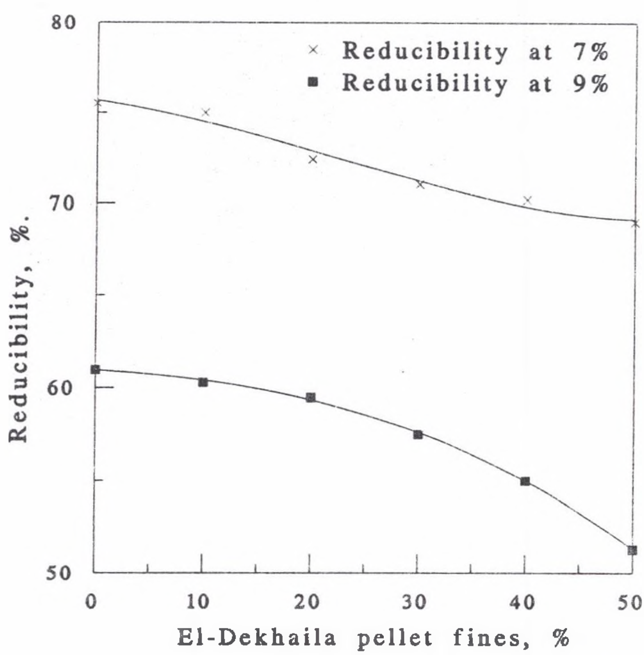

Fig. 5. Effect of El-Dekhaila pellet fine addition on the reducibility of the produced sinter where 7 and 9% coke was used

Rys.5. Wpływ udziału odsiewu grudek z rudy El-Dekhaila na stopień redukcji spieku przy 7 i 9% dodatku koksiku

The effect of addition of El-Dekhaila iron oxide fines on the reducibility of produced sinter is shown in Fig. 5. It may be seen that the addition of these pellet fines has a negative effect on the reducibility. The reducibility decrease markedly with addition of pellet fines. The noticed decrease in reduction can be interpreted in terms of two main factors. Firstly, the higher percentage addition of low porosity pellet fines at the expense of El-Baharia ores results in a decrease in porosity of the produced sinter Fig. 6, and thus its reducibility will decrease. Secondly, addition of iron oxide fines which is mainly Fe_2O_3 will be at the expense of El-Baharia ores leads to an increase in the heat input which causes the dissociation of higher oxides to lower oxides (as confirmed by the effect of addition of El-Dekhaila fines on FeO, Fe_{met} contents). Thus high FeO percentage is produced which consequently decreases the reducibility.

The relationship between the reducibility of the sinter (R_e, %) and the amount of El-Dekhaila pellet fines addition (X, %) can be computed as follows:

for 7% coke breeze

$$R_e = 75.66746 - 0.08604X - 0.00399X^2 + 0.00006X^3$$

for 9% coke breeze

$$R_e = 60.97302 - 0.0382X - 0.00153X^2 - 0.00003X^3$$

While the mathematical relationship between the total porosity (Tp,%) and the amount of El-Dekhaila pellet fines, (X, %) can be represnted by the following equation:

for 7% coke breeze

$$Tp = 21.42937 - 0.04136X + 0.00266X^2 - 0.00006X^3$$

for 9% coke breeze

$$Tp = 17.69921 - 0.01554X - 0.00031X^2 - 0.00001X^3$$

It is clear from Fig. 7, that the softening temperatures (Ti & Tf) for 9 and 7% coke breeze rate increase with increasing the amount of El-Dekhaila pellet fines. This is due to the high FeO content and low porosity [30] as shown in table 2. At a constant percentage of El-Dekhaila fines, higher softening temperatures are observed at 9% coke than at 7% coke which is due to lower porosity and higher FeO content as clear in Fig. 6 and table 2.

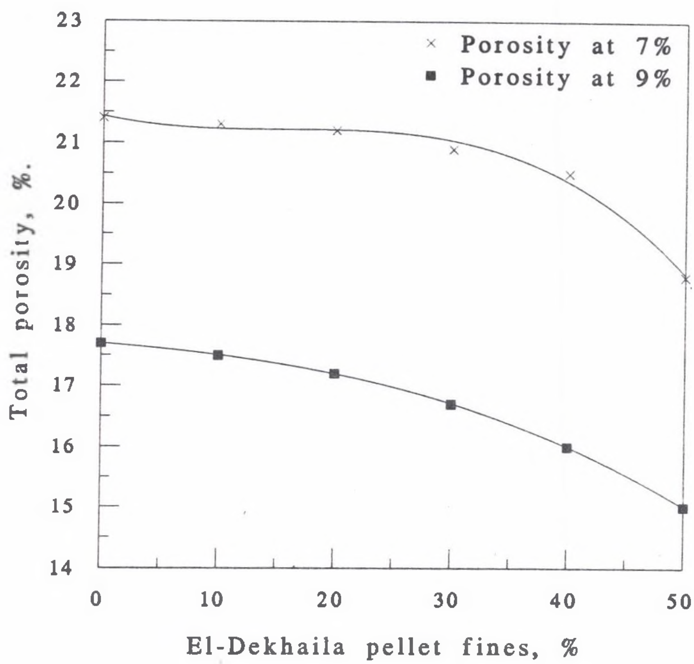

Fig. 6. Effect of El-Dekhaila pellet fines addition on the total porosity of the produced sinter where 7 and 9% coke was used

Rys.6. Wpływ udziału odsiewu grudek z rudy El-Dekhaila na porowatość ogólną spieku przy dodatku 7 i 9% koksiku

The relationship between the softening temperatures of the sinter (Ti, Tf) and the amount of El-Dekhaila pellet fines addition (X, %) can be computed as follows:

for 7% coke breeze

$$Ti = 850.0 + 0.31667X - 0.00750X^2 + 0.00008X^3$$

$$Tf = 859.90079 + 0.01911X + 0.0841X^2 - 0.00003X^3$$

for 9% coke breeze

$$Ti = 854.01190 + 0.24980X - 0.00042X^2 - 0.00003X^3$$

$$Tf = 863.48413 + 0.33320X - 0.00879X^2 + 0.00011X^3$$

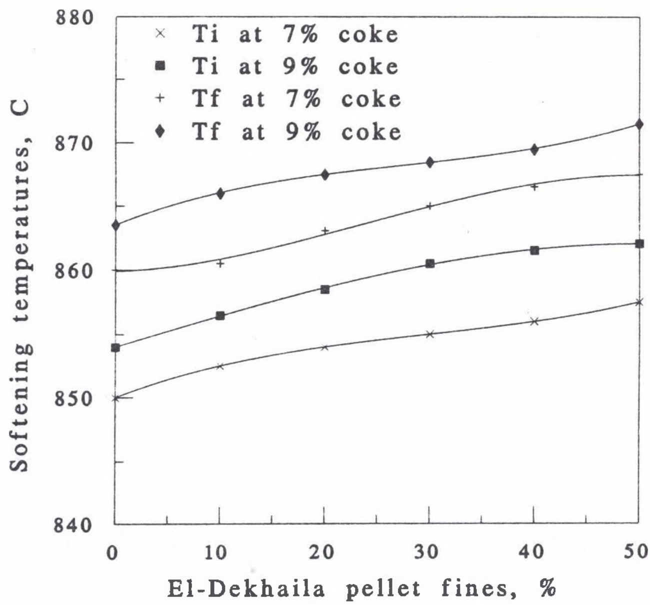

Fig. 7. Effect of El-Dekhaila pellet fines addition on the softening temperatures of the produced sinter where 7 and 9% coke was used

Rys.7. Wpływ udziału odsiewu grudek z rudy El-Dekhaila na temperaturę mięknięcia przy 7 i 9% dodatku koksiku

3.3. Effect of Addition of El-Dekhaila Pellet Fines on the Petrography of the Produced sinter

Inspection of the X-ray diffractograms of the studied samples are shown in Fig. 8, the following phases can be easily identified; magnetite, wustite and maghmatite as the main constituent minerals of the produced sinter, calcium ferrite and manganese ferrite. It was observed that the magnetite is increased when the coke breeze is increased from 7 to 9%.

The morphology and the texture of the produced sinter are shown by photomicrographs Figs. 9 & 10. This figures reveals that crystalline magnetite, and calcium ferrite can be detected in different textures as embedded phases in silicate matrix. It was observed that the sinter produced when using 7% coke breeze contains more pores than that produced in case of using 9% coke, and is this explained by the increase in melt formation.

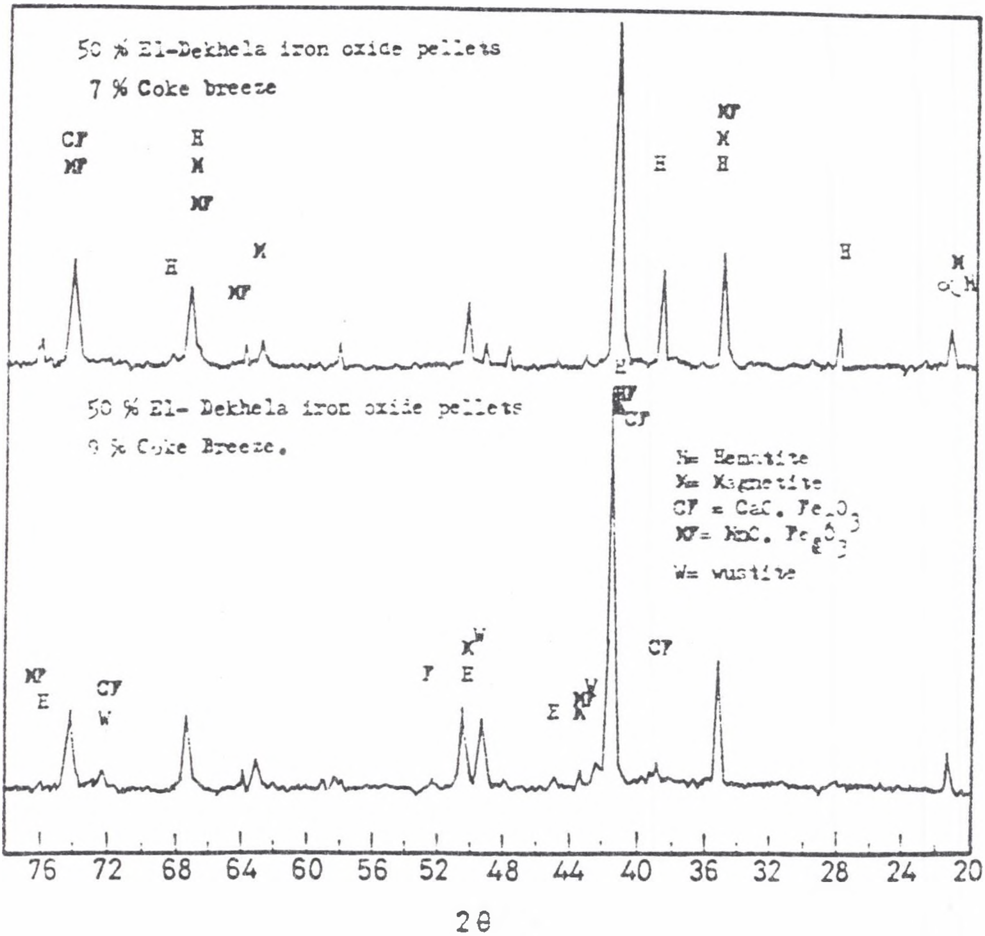

Fig.8. X-Rey differactogram of sinter agglomerate produced from addition El-Dekhela iron oxide pellets fines to El-Baharia iron ore

Rys.8. Dyfraktogram spieku wyprodukowanego z udziałem mikrogrudek z rudy El-Dekhaila w mieszance z rudą El-Baharia

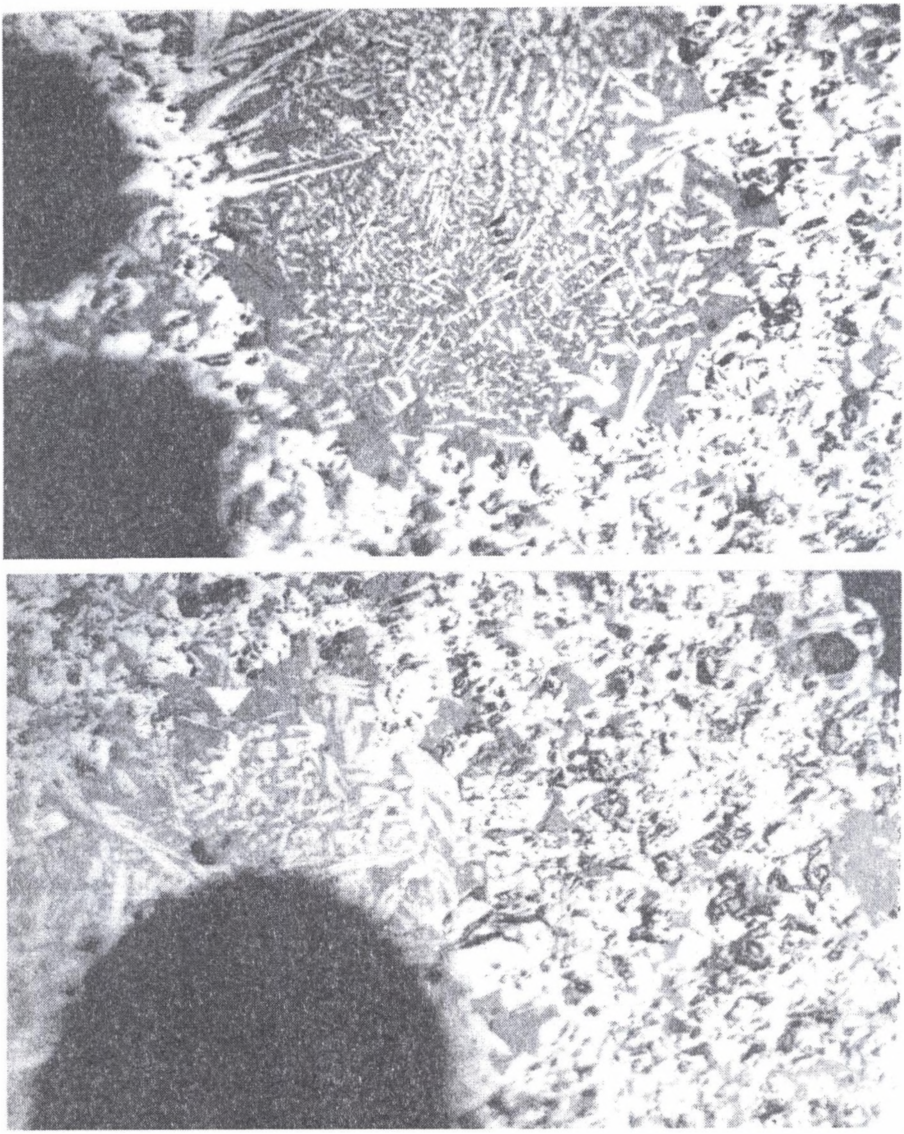

Fig.9. Microstructure of sinter produced when 50% of El-Dekhaila fines is added to the sinter mix (7% coke breeze). Magnetite in different phases (white) with dicalcium ferrite (grey) and pore (black) embedded in silicate matrix (X 200)

Rys.9. Mikrostruktura spieku z mieszanki z udziałem 50% odsiewu grudek z rudy El-Dekhaila i dodatku 7% koksiku. Magnetyt (biały), ferryt dwuwapniowy (szary), pory (czarny), osnowa krzemiany

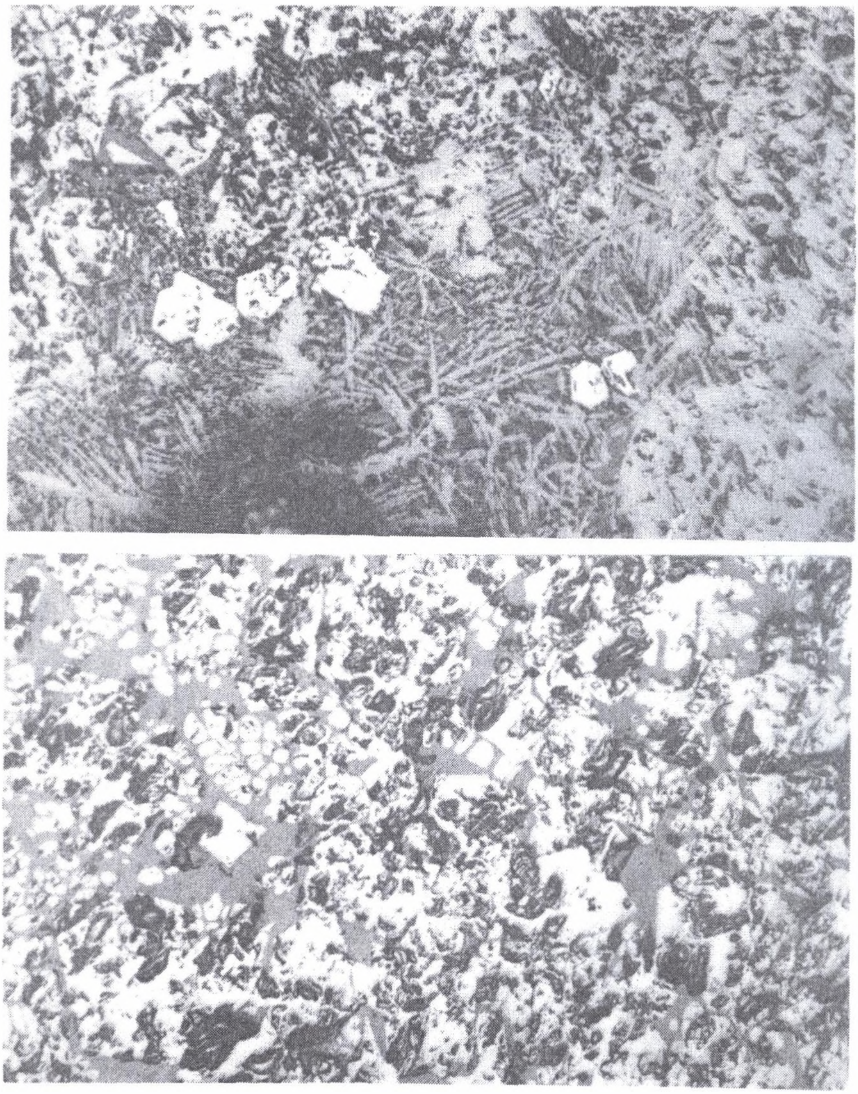

Fig.10. Microstructure of sinter produced when 50% of El-Dekhaila fines is added to the sinter mix. (9% coke breeze). Magnetite (white), calcium ferrite (white, grey), silicate matrix (grey) and pore (black) (X 200)
Rys.10. Mikrostruktura spieku z mieszanki z udziałem 50% odsiewu grudek z rudy El-Dekhaila (dodatek 9% koksiku). Magnetyt (biały), ferryty wapnia (białe, szare), krzemiany (szare), pory (czarne)

Conclusion

1. The percentage of ready made sinter increases with the addition of El-Dekhaila fines and reaches about 72% and 78% at 7% and 9% coke breeze respectively at 50% addition of fines.
2. The addition of 50% El-Dekhaila fines to the raw mix leads to an increase in the productivity of the sintering machine and the productivity at blastfurnace yard reaching 51.4, 36.5 t/m^2 day and 41.4 and 34.8 t/m^2 day at 7 and 9% coke breeze respectively.
3. The productivity of sintering machine and the productivity at blast-furnace yard at 50% addition of El-Dekhaila fines decrease when the amount of coke breeze is increased.
4. The amount of FeO and Fe_{total} increase when fine pellets is used. Also the amount of MnO decreases with the addition of fine pellets.
5. At 7% coke breeze, and 50% addition of pellet fines, the amount of MnO in the produced sinters is 2.95% i.e. slightly higher than that standard operating conditions of Iron and Steel Company which is 2.26%.
6. The amount of sodium and potassium ions decrease with the increase of the amount of El-Dekhaila fines in the sinter.
7. The addition of pellet fines has a negative effect on the reducibility of the produced sinter.
8. Softening temperature of the produced sinter increase with increasing the amount of El-Dekhaila fines.

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Streszczenie

W referacie przedstawiono laboratoryjne wyniki badań nad wpływem udziału odsiewu grudek z rudy El-Dekhaila (około 67% Fe) w mieszance z rudy El-Baharia zawierającej podwyższoną ilość MnO (~ 5,2%) i alkaliów (~ 0,7% K_2O + Na_2O) na parametry procesu i własności spieku. Zużywanie spieku z podwyższoną ilością manganu i alkaliów powoduje trudności w pracy i pogorszenie parametrów pracy wielkich pieców. Dla poprawy jakości spieku spiekano mieszanki z udziałem 0 do 50% odsiewu z grudek, przy dodatku 7 i 9% koksiku. Ustalono, że:

- w miarę wzrostu udziału odsiewu grudek obniża się ilość Mn i alkaliów. Dodatek koksiku decyduje o stopniu utlenienia spieku;
- zarówno udział odsiewu jak i dodatek koksiku wpływa korzystnie na wytrzymałość spieku i jego uzysk. Obserwuje się przy tym pogorszenie porowatości i redukcyjność spieku; spiek z udziałem odsiewu spieku winien wpłynąć korzystnie na przewidywaną wydajność wielkich pieców.