Research Article: Open Access

DOI: 10.35840/2631-5076/9274

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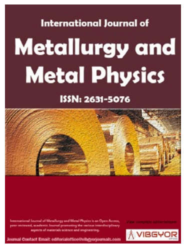
International Journal of
Metallurgy and Metal Physics



ISSN: 2631-5076

A Novel Method for the Production of Pig Iron in "Hadisolb" Company (Industrial-Scale Experiments)

Elsayed MA Rassoul[1,2] and Roshdy Abdel Rassoul[3*]

[1]Faculty of Engineering, Mansoura University, Mansoura, Egypt

[2]Member, American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME), Pennsylvania, USA

[3]Arab Academy for Science & Technology, Alexandria, Egypt

Abstract

The chairman of "Hadisolb" had submitted a memorandum in 1977 in which he claimed that the company will never achieve its designed capacity unless it gets rid of the threatening impurities - high alkalis & MnO - in the blast furnace burden. Meanwhile, the DR steel companies are suffering from the generated accumulated wastes which contain > 67% Fe, 0% alkalis and traces of MnO.

The novel idea here is finding the best ratio between El-Gedida ore and the waste material (W.M.). In a previous investigation [1] a series of pilot-scale sintering experiments were performed, and it was concluded that the blend containing 70% W.M. and 30% Ore has produced the best sinter. In this investigation, a series of industrial-scale experiments on sintering that best blend, followed by using the produced sinter as the only iron-bearing material in the burden of the industrial blast furnace experiments.

The technical and the economic indices for the performed industrial-scale experiments proved the validity of the novel idea, to use blends composed of 70% W.M. and 30% El-Bahareya (El-Gedida) Ore as the only iron-bearing material in the blast furnaces of "Hadisolb" in order to get rid of the threatening impurities in El-Bahareya iron ores.

Keywords

Pig iron, Blast furnace, Alkalis, Iron & steel, Iron ore

Introduction

The iron ores were first discovered in Egypt in 1903 in "Ghorabi" in the Eastern desert, then in Aswan in 1907 and 1917 [1]. These discoveries have initiated a dream to establish a company for steel production. This dream was realized in 1954 when the German company "Demag" had submitted to the Egyptian authority for industrialization an offer to establish the Egyptian iron and steel company (Hadisolb) in Helwan. At that time, "Hadisolb" consisted of two small blast furnaces, each of size 575 m^3, a mixer and two small Tomas converters (since Aswan iron ores contained a relatively high content of P_2O_5). At that time, "Hadisolb" had to import the coke required for the blast furnaces. "Hadisolb" was established in Helwan City in the neighborhood of Cairo, while the iron ore mines are

***Corresponding author:** *Roshdy Abdel Rassoul, College of Engineering and Technology, Arab Academy for Science & Technology, Alexandria, Egypt*

Accepted: January 05, 2024; **Published:** January 07, 2024

Rassoul et al. Int J Metall Met Phys 2024, 8:074

Citation: Rassoul EMA, Rassoul RA (2024) A Novel Method for the Production of Pig Iron in "Hadisolb" Company (Industrial-Scale Experiments). Int J Metall Met Phys 8:074

Table 1: Average chemical composition and the reserves of the three localities in El-Gedida [2].

Locality	Fe %	Cl %	MnO %	SiO_2 %	CaO %	Al_2O_3 %	Reserves M. Tons
Plateau	58.20	0.74	1.40	10.50	4.50	3.60	39.60
West Valley	50.20	0.47	3.75	8.50	3.50	3.50	60.00
East Valley	48.82	0.22	1.55	12.20	3.50	2.00	11.98
Total Reserves							111.58

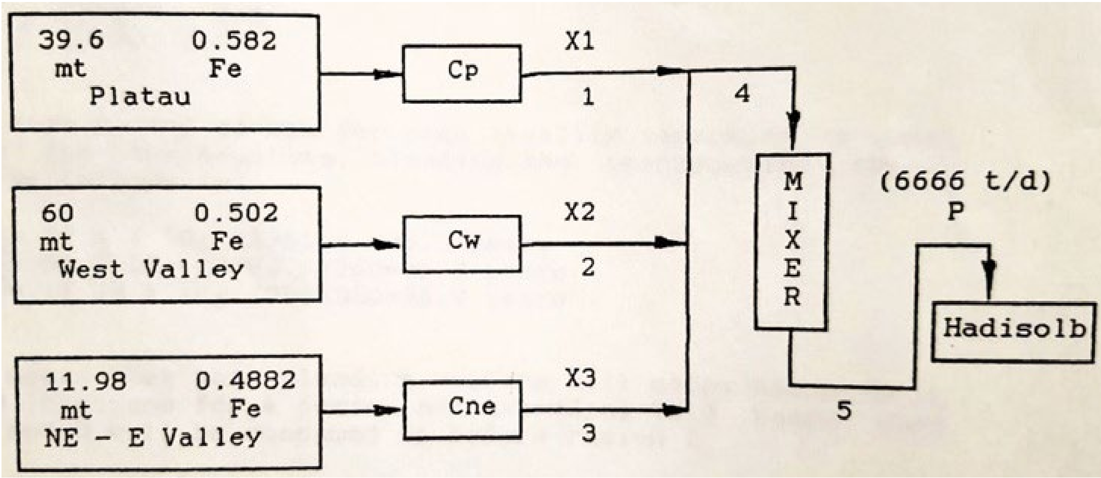


Figure 1: Flow sheet for blend preparation [3].

located east of Aswan city 1000 km far to the south of Helwan where "Hadisolb" was established, while the imported coke is about 300 km far to the north of Helwan.

It did not take long time (~10 years) for "Hadisolb" to find out that the iron ore coming from Aswan does not meet the blast furnaces agreed-upon specifications any longer. "Hadisolb" realized that the adoption of selective mining exploitation was behind such catastrophic situation. Accordingly, "Hadisolb" was in bad need for a miracle to find another local iron ore with the same quality and price. "Hadisolb" was lucky indeed when the geologists of the Egyptian geological survey authority announced in 1964 their discovery of the ore mines located in El-Gedida region in El-Bahareya oasis. The iron ore in El-Gedida location has the chemical composition of the reserves three localities, as shown in Table 1 [2].

Procedure

The process of mining the ore from all three localities and storing each in a separate storage before feeding each to separate batteries of crushers to grind it to the suitable size and uniform mass of known average chemical composition, before feeding to a large mixer or blender, as shown in a qualitative flow diagram in Figure 1 [3].

Beneficiation of El-Gedida Iron Ores

Optimization techniques were applied to set a plan for using the three localities. Calculations for determining the proper quantities of ore from each locality to be blended to suit the cut off limits for: Fe > 51%, Cl < 0.06%, MnO < 2.4%, SiO_2 < 8.5%, CaO < 8%, and Al_2O_3 < 3.5%. Other alternatives for optimizing the time span of utilization and to produce that blend which "Hadisolb" tolerates effectively are given in [2].

After the discovery and the evaluation of El-Gedida mines, "Hadisolb" began to look for the expansion that was during the year 1963. Meanwhile, the Teagrom export authority was willing to accomplish what "Hadisolb" is looking for, and thus a protocol was signed between the two interested partners in 1964. According to the protocol "Hadisolb" will have a sintering plant capable to produce more than 2.4 Mt of sinter/year with the same above-mentioned specifications. That means that the iron-bearing material in the blast furnace burden will be composed of 100% sinter.

Table 2: Melting and boiling points of the most common alkali species which may exist in a blast furnace [6].

Substance	m.p. °C	b.p. °C	Substance	m.p. °C	b.p. °C
K	62.30	760	KCN	634.50	
Na	97.50	880		622.00	1625
KCl	790.00	1500	NaCN	563.70	1496
NaCl	800.40	1413		562.00	1530
$CaCl_2$	772.00	1600	K_2CO_3	891.00	Dec.
	772.00	(1935)		907.00	Dec.
K_2O Sub.	881.00		K_2SiO_3	076.00	
Na_2O	1132.00			997.00	
			Na_2SiO_2	1089.00	

According to the protocol, “Hadisolb” will have a blast furnace plant with all the required equipment and accessories. The new two blast furnaces are of medium size; 1033 m^3 each, similar to the blast furnace the soviets have in Cherepovets. According to the protocol, each blast furnace is supposed to produce 2500 metric tons of pig iron/d, referring to their designed capacity mentioned in the protocol, while the furnace of the same size in Cherepovets is producing only 1730 Mt of pig iron [3], and the blast furnace of the size 1520 m^3 in Armco Steel Corporation is the one which is capable to produce ~2500 Mt/d, according to the same reference, meanwhile, Teagrom export authority ought to choose such size of blast furnace for “Hadisolb”, as a matter of fact, the B.Sc. students in the Mechanical Engineering Department, Assuit University had concluded in 1965 in their graduation project titled “Design of a blast furnace capable to produce 2500 Mt. of pig iron/d”, that the useful volume for such blast furnace is 1550 m^3, which is very close to that in Armco Steel Corporation.

Choosing smaller size blast furnaces was not the only serious drawback in the technical report, in fact, the most serious drawback was indeed the negligence of the high content of alkalis in the ore, which creates a lot of problems in both the sintering and the blast furnace processes, such as: [4]

i. Formation of scaffolds and scaps on the furnace lining which reduces its useful volume,

ii. Excessive coke disintegration which leads to higher coke consumption,

iii. Enhances the swelling properties of the iron-bearing materials,

iv. Shortens the lifetime of the lining,

v. Shortens the lifetime of the sintering machine.

Abraham, et al. [5] had investigated the behavior and circulation of alkalis in the blast furnace. The most common species involved in the alkali circulation in a blast furnace are K and Na vapors, their cyanides in solid, liquid or vapor phase, their carbonates, or silicates either in the solid and/or liquid phase. The melting points of these species are given in Table 2 [4].

Utilization of El-Bahareya Iron Ores

In this investigation we shall be concerned with the minimization of the detrimental effect of the alkali halides in both the sintering and the blast furnace processes [5-7]. The iron ore deposits in El-Bahareya oasis in El-Gedida region are the only iron bearing material used in the Iron & Steel Company (Hadisolb) at Helwan. The iron ores in El-Gedida region are located in three localities, with different qualities and quantities. “Hadisolb” requires 6666 Mt./d (2.4 Mt./y) of a blend in which Fe is > 51%, Cl < 0.3%, and MnO < 2.4%.

An optimization technique was used to put a plan for the use of El-Gedida ores in the burden. Proper amounts of each locality in the blend were determined to suit the cut-off limits for: Fe, Cl, and Mn contents.

The novelty of this suggested method is the finding of a fourth locality or source with almost 0% alkalis and traces of MnO, to be blended with the other three localities. Here, it comes to mention that there are four DR steel companies which may produce highly rich iron oxide fines and sludge as waste materials. The chemical composition of such waste materials (W.M.) is given in Table 3.

Table 3: Chemical composition of (W.M.) from DR companies.

Waste material	Fe %	CaO %	SiO_2 %	Al_2O_3 %	MnO %	Alkalis %
Oxide fines	67.80	0.80	1.10	0.16	0.10	nil
Sludge	68.10	1.20	1.80	0.16	0.20	nil

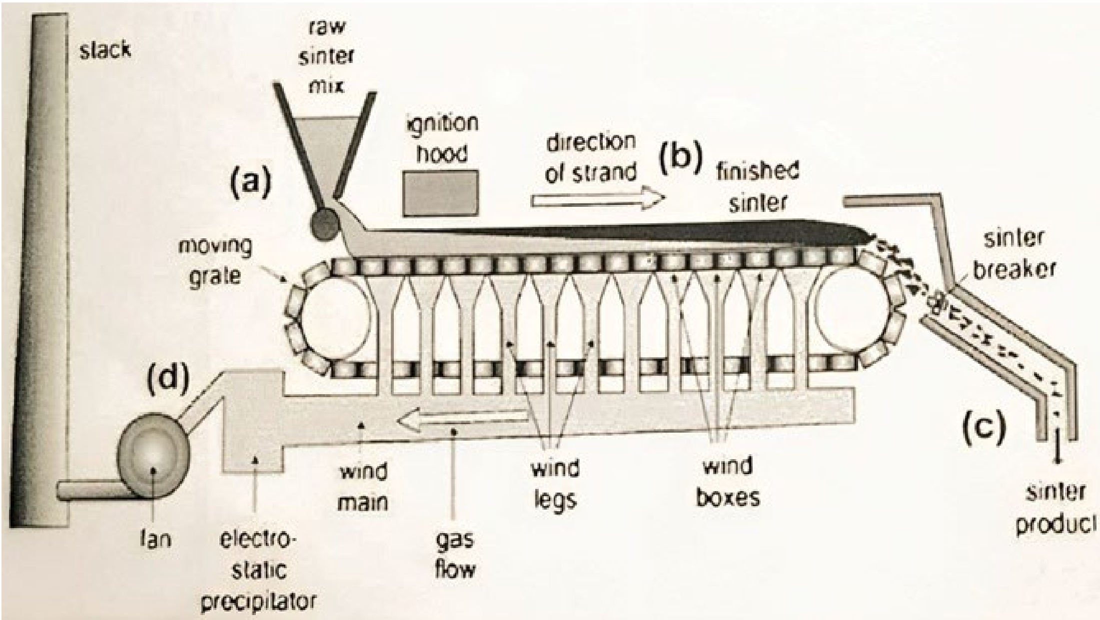


Figure 2: The sintering machine used in performing the experiments (hearth area = 50 m²).

Materials and industrial-scale experiments

"Hadisolb" is an integrated company; it adopts the sintering-blast furnace – B.O.F. route, which necessitates from the first beginning iron-bearing of high quality, and consequently high-quality sinter. The sintering charge usually includes, beside the iron ore, the required amounts of L.S. as a flux, coke and water [7,8]. It is needless to say that El-Bahareya iron ores with all its handicaps is practically considered the only available iron-bearing material that "Hadisolb" can economically afford. The chairman of "Hadisolb" had declared in the memorandum he submitted in 1977, in which he stated that the company should find a way of getting rid of the threatening impurities in the iron ore, such as the alkalis and lower MnO percent.

Materials: The previously determined blend ratios from the three localities of El-Gedida mines in El-Bahareya oasis -after so many years of exploitation (> 40 years)- became unable to fulfill the previously agreed upon obligations. A discovery of another source beside the three localities became very necessary. Here, the metallurgists had discovered that source. It was a luck to find that this source contains zero% alkalis and very low MnO%. This source was nothing but the waste material (W.M.) resulting in the DR steel companies.

A series of pilot-scale sintering experiments for different blends of W.M. with El-Gedida ores were performed to determine the best blend which will be used in the industrial-scale experiments [9]. The best blend ratio was determined based on the indices of the produced sinter, accordingly, the sinter produced from a blend composed from 70% W.M. together with 30% of El-Bahareya iron ores had the best indices, and thus a blend with that ratio will be used in the industrial-scale sintering experiments.

Industrial-scale experiments

Sintering of a blend composed of 70% W.M. and 30% E-Bahareya ores: Based on the results of the previous investigations, a blend composed of 70% W.M., which has 67% Fe, 0% alkalis and traces of MnO, and 30 E-Bahareya iron ores, in which Fe is 45% and Cl is ~0.8% and MnO is 2.5%.

Figure 2 illustrates the sintering machine with hearth area of 50 m² used in performing the

Table 4: Average chemical composition and drum results for the produced sinter (70% W.M. and 30% El-Bahareya area) [12].

Blending ratio %	Fe%	FeO%	SiO_2%	Al_2O_3%	MgO%	CaO%	Cl	basicity	L.O.I.*	Mechanical Pr. Drum test - 5 ml %
70% WM / 30% Ore	60.10	19.60	5.60	1.60	1.60	6.05	0.09	1.03	To 100%	10.50

*Loss on Ignition

experiments. The bed depth for all experiments was 30 cm. The details of the sintering process to get self-fluxed sinter were described in [9-11]. The chemical analysis and mechanical properties of the produced sinter are given in Table 4 [12].

Pig iron production: The small furnace of useful volume 575 m^3 which was constructed by the German company "Demag" was chosen for performing the industrial experiments. The target of such experiments was to examine the validity of our novel suggestion about blending El-Bahareya iron ore in which there is 45% Fe, ~2.5% MnO, and alkalis ~0.8%, with W.M. in which 67% Fe, 0% alkalis and traces of MnO, with a ratio of W.M.:B.O. 7:3, respectively.

The characteristics of the operating data for the chosen blast furnace according to [13] are as follows: Useful volume is 575 m^3, hearth diameter is 5.49 m, blast volume is 74000 m^3/h, blast temperature is 800 °C, blast pressure is 1.24 kg/cm^2, coke consumption is 600 kg/ton pig iron, Gross burden is 1500 kg/ton iron, basicity is 1.04, slag volume is 350 kg/ton pi iron, pig iron production is 900 t/d, blast furnace coefficient is 1.56 tons/m^3. The burden is composed from 100% self-fluxed sinter. It is worth it to state here that according to "Hadisolb" confirmed information, every 1% increase in the iron content of the burden will lead to an increase in the produced pig iron by 1.8% and a decrease in the coke consumption by 1.1 kg/t of pig iron.

Discussion and Conclusion

The target of this investigation is to prove the validity of the novel suggestion, i.e., the possibility of having an iron-bearing material with acceptable amounts of alkali halides and MnO content for the beneficiation of El-Gedida iron ores in the blast furnaces of "Hadisolb".

The novel suggestion did not only lower the alkali halides content in the blend, but had caused a lot of gains for both partners; "Hadisolb" and the DR companies, as follows:

DR Companies Gains

i. The companies will stop importing the cast iron they need, since they have a secure local source, "Hadisolb" of course, by giving their waste material to "Hadisolb" and getting instead an equivalent amount of cast iron.

ii. The protocol between the partners is very similar to a win-win projects and may be considered a model for cooperation between other companies and in different industrial sectors.

"Hadisolb" Gains

i. The W.M. composed from ~67% Fe and 0% alkalis with an annual generation of 1 million tons/y can be considered as a highly rich iron oxide mine of endless lifetime and increasing reserve.

ii. The lifetime of El-Bahareya iron ore mines will be extended.

iii. A noticeable decrease in coke consumption in both the sintering and the blast furnace processes.

iv. An increase in the productivity of the blast furnaces by about 200 kg/d, since 1% increase in the iron content in the iron-bearing material will cause an increase in the produced pig iron by 1.8%.

v. The lifetime of the sintering grid and the rest of the sintering machine utilities will be extended.

vi. The lifetime of the L.S. quarries will be extended.

vii. The decrease of Mn in the pig iron will be positively reflected on the steel making process.

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DOI: 10.35840/2631-5076/9274

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