USE OF SABAH HBI IN FOUNDRY OPERATIONS

Introduction

Hot briquetted iron (HBI) has been shipped by Sabah Gas Industries to various sectors of the international iron and steel industry since the plant started production in late 1984. To date, more than 1 million metric tons (tonnes) of HBI have been used in electric arc furnace steel mills for products ranging from rebar and wire rod to flat rolls, alloy steels, and stainless steels. Another 400,000 tonnes of HBI have been used in basic oxygen furnace and open hearth furnace operations.

However, the use of Sabah HBI is gaining recognition most rapidly in the foundry industry. Its size is optimum for charging into cupolas and induction furnaces. Its clean and consistent chemistry is ideal for contaminant-sensitive ductile iron production, and its low sulfur and phosphorous content is particularly important to operations where desulfurization and dephosphorization are both time consuming and costly.

Left: Stock pile on-site at SGI's MIDREX Plant on Labuan Island, Malaysia.

	FEED	PRODUCT	PRODUCT	PRODUCT	PRODUCT	PRODUCT	PRODUCT
Met (%)		94.500	94.500	94.500	94.500	94.500	94.500
Fe total (%)		94.366	94.271	94.175	94.080	93.985	93.889
Fe as FeO(%)		5.190	5.185	5.180	5.174	5.169	5.164
Fe	68.270						
Fe Met		89.176	89.086	88.996	88.906	88.816	88.726
FeO		6.749	6.742	6.735	6.728	6.722	6.715
C		1.000	1.100	1.200	1.300	1.400	1.500
SiO_2	0.993	1.373	1.372	1.370	1.369	1.368	1.366
Al_2O_3	0.401	0.554	0.554	0.553	0.552	0.552	0.551
MgO	0.236	0.326	0.326	0.325	0.325	0.325	0.324
CaO	0.618	0.855	0.854	0.853	0.852	0.851	0.850
S	0.004	0.002	0.002	0.002	0.002	0.002	0.002
P	0.010	0.014	0.014	0.014	0.014	0.014	0.014
Mn	0.041	0.057	0.057	0.057	0.057	0.056	0.056
Cu	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ti	0.015	0.021	0.021	0.021	0.021	0.021	0.021
Cr	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ni	0.002	0.003	0.003	0.003	0.003	0.003	0.003
Traces	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Loss on ignition (LOI)	0.027						
TOTAL	**70.619**	**100.000**	**100.000**	**100.000**	**100.000**	**100.000**	**100.000**
Total gangue in HBI		3.075	3.072	3.069	3.066	3.063	3.060
Min. C for FeO reduction (EAF)		1.170	1.169	1.168	1.167	1.165	1.164
C addition for steelmaking		0.000	0.000	0.032	0.134	0.235	0.336
Basicity ratio of HBI		0.613	0.613	0.613	0.613	0.613	0.613

Table I Typical analysis of Sabah HBI.

Characteristics of Sabah HBI

The highest quality iron ore is used to produce Sabah HBI since the quality of the raw material is critical to the chemical and physical characteristics of the HBI. Table I shows the chemical composition of Sabah HBI at various levels of carbon content. The carbon content of the HBI is adjusted so that the amount of additional carbon required to reduce FeO in the briquettes during further processing steps is minimal.

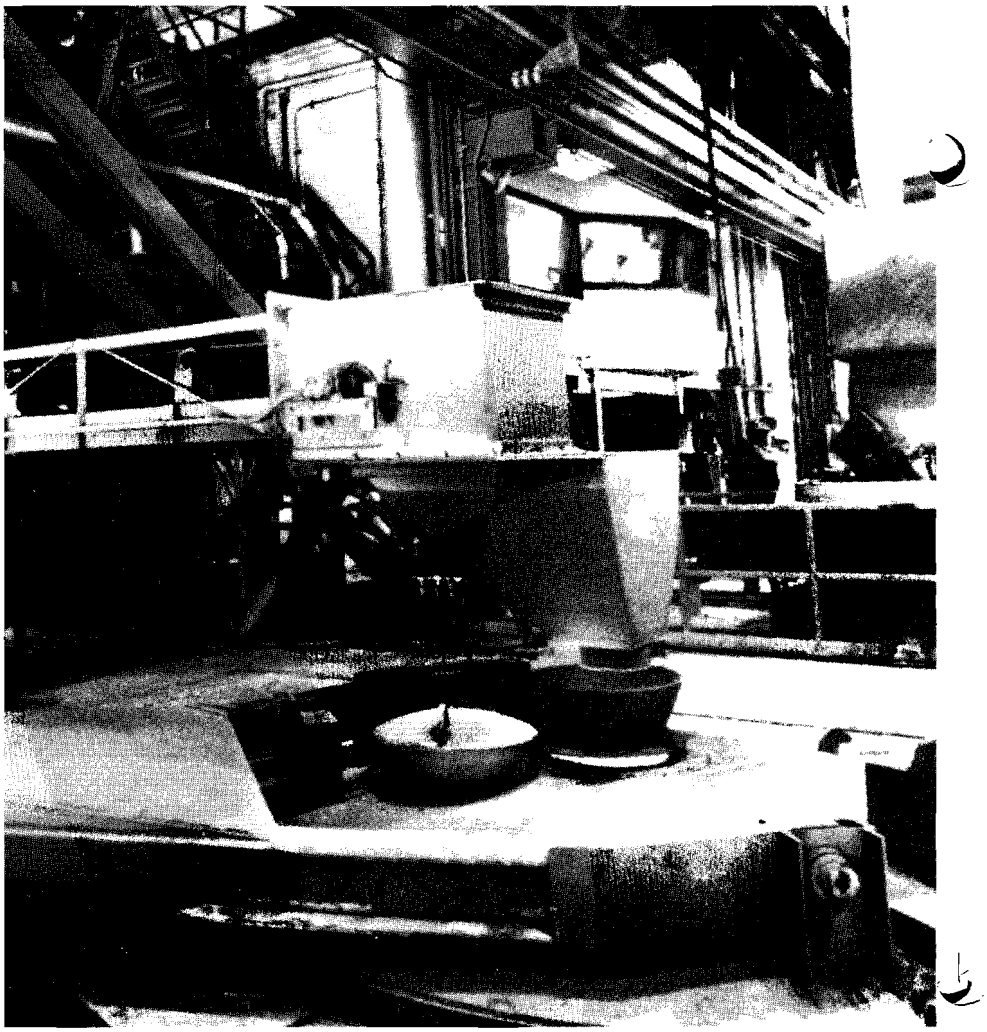
The highly densified HBI (5.5 g/c.c.) has much less surface area per unit weight to react with atmospheric air as compared with other forms of direct reduced iron and hence, is non-pyrophoric. This contributes to easy handling, safe shipping, and convenient covered or open storage. Reactivity and weathering tests have shown an average of 0.8 percent per month loss of metallization during open storage in the tropical, humid atmosphere of Labuan Island, Malaysia, where SGI's MIDREX Plant is located. The tests also showed a gradual decline in temperature of the briquette pile following discharge from the furnace and virtually no deterioration of the briquettes beneath the surface of the pile.

Table II shows the average typical chemical analysis of Sabah HBI shipments delivered to date. It can be seen that the actual chemical composition of the HBI shipments far exceeded the guaranteed specifications.

Use In Foundry Operations

To date, Sabah HBI has been used by the foundry industries of Europe and Japan. It has been charged into cupolas and induction furnaces largely for production of spheroidal graphite iron and compact graphite castings. A series of studies has been conducted to monitor the melting and the economics of producing ferritic spheroidal graphite iron when using Sabah HBI, charcoal pig iron, and foundry pig iron.

The results of the studies showed that relatively high levels of manganese and tramp elements in the pig iron acted as stabilizers for pearlite formation. In contrast, Sabah HBI contained only traces of manganese and tramp elements, and with carbon and silicon adjustments, it was possible to obtain the specified levels for the spheroidal graphite castings. Furthermore, the use of Sabah HBI allowed control of undesirable elements. Its low sulfur and phosphorous content minimized product rejections.



Continuous charging is the recommended method for introducing HBI into the coreless induction furnace.

CHEMICAL SPECIFICATIONS	GUARANTEE	TYPICAL*
Fe Total	93.00% min.	93.78%
Metallization	93.00% min.	93.88%
Fe Metallic	86.50% min.	88.04%
Carbon	1.2% ±0.3%	1.16%
Sulfur	0.015% max.	0.001%
Phosphorus	0.04% max.	0.029%
Non-ferrous gangue	3.80% max.	3.21%
Cu, Sn, Cr, Ni, Pb, Zn	Traces	Traces
PHYSICAL SPECIFICATIONS		
Bulk Density	2.5-2.6mt/m^3	2.6mt/m^3
Apparent Density	5.5 g/c.c.	5.5 g/c.c.
Size Distribution		
-200 mm + 4 mm	96% min.	98.5%
Below 4 mm	4% max.	1.5%

*Typical is the average analysis of more than 1.5 million tonnes of Sabah HBI shipped from 1984 to date.

Table II Sabah HBI chemical and physical specifications.

HEAT	Mg ADDITION	C	Si	Mn	P	S	Cu	Ni	Cr	Mg	Fe
H1	0.05	3.76	2.9	0.09	0.04	0.015	0.017	-	-	0.023	Bal
H2	0.05	3.73	2.9	0.09	0.05	0.012	0.016	-	-	0.039	Bal
H3	0.05	3.92	2.64	0.13	0.026	0.01	0.03	0.04	0.01	0.026	Bal
H4	0.07	3.92	2.71	0.41	0.10	0.019	0.03	0.04	0.02	0.026	Bal

H1 - 100% Sabah HBI, H2 - 50% Sabah HBI/50% Silicon Steel Scrap, H3 -Charcoal Pig Iron,
H4 - Pig Iron (Foundry Grade)

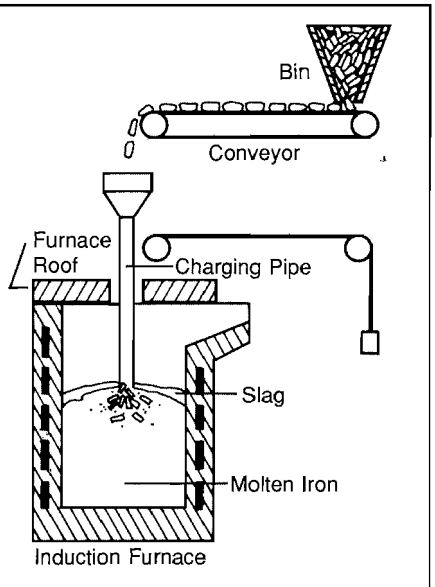
Table III Chemical composition of castings after inoculation.

HEAT	H1	H2	H3	H4
Spheroidal Rating (%)	85	100	90	100
Spheroidal Count/mm^2	125	150	125	150
ASTM Graphite Size (No.)	6	6	6	6
Ferrite (%)	90	95	88	80

Table IV Microstructure rating of the spheroidal graphite iron.

HEAT	H1	H2	H3	H4
Tensile Strength (N/mm^2)	384	475	530	534
Yield Strength (N/mm^2)	303	333	397	399
Elongation (%)	19	23	14	13
Hardness	149	152	189	168

Table V Mechanical properties of spheroidal graphite iron.



System for continuously charging HBI into the induction furnace.

Tables III and IV show the composition and microstructure ratings of various spheroidal graphite iron castings made from Sabah HBI and different grades of foundry pig iron. From the composition and metallurgical analysis, it can be seen that Heat H1 (100 percent Sabah HBI), at a relatively lower magnesium content of 0.023 percent, exhibited a significant percentage of spheroidization, good nodular graphite structure, and 90 percent ferrite in the matrix (Table IV). This can be attributed to the high purity of Sabah HBI.

Heat H2 (50 percent Sabah HBI and 50 percent silicon steel scrap), containing 0.05 percent magnesium, achieved 100 percent spheroidal graphite and 95 percent ferritic structure in the matrix. Charcoal pig iron (Heat H3) needed 0.05 percent magnesium to achieve 90 percent graphite spheroidization and 88 percent ferritic structure in the matrix while castings from another grade of foundry pig iron (Heat H4) required 0.07 percent magnesium to achieve 100 percent graphite spheroidization and 80 percent ferritic structure in the matrix.

The mechanical properties of the spheroidal graphite castings are summarized in Table V. All have properties of spheroidal graphite iron; however, H1 and H2 (using Sabah HBI) have much higher ductility compared with castings made from the two foundry grades of pig iron (H3 and H4).

Conclusion

The clean and consistent chemistry of Sabah HBI provides many benefits and advantages to steelmaking and foundry operations. Downgrading, diversions, and off-grade heats are significantly reduced when using Sabah HBI. The size, shape, and density of Sabah HBI facilitates handling, shipping, and storing of the product.

The most notable advantages of using Sabah HBI in foundry operations are:

- Significant increases in product ductility due to low pearlite matrix.
- Reduction in the use of spheroidizing agent (innoculator), thus providing cost savings.
- Lower levels of manganese and tramp elements in product when used as a scrap diluent.
- Improved product consistency and reduced rejection rates.

This article was developed from a paper titled, "Use of Sabah Hot Briquetted Iron In The Steelmaking and Foundry Industries - A Review" by Victor S. Lourdes, Dr. Frederick Chong, and Dominic C. S. Lu of Sabah Gas Industries Sdn. Bhd.