

# Patent 3900721 overview of JFE Steel Company

## Production of high quality low silica sintered ore

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### Problem to be solved

To provide a producing method of sintered ore with high productivity and high yield. And this sintered ore has high reducibility (RI), good reduction disintegration behavior (RDI) and high-temperature character with low content of  $\text{SiO}_2$ .

### Solution

In the production of the sintered ore for blast furnace having  $<4.6\%$   $\text{SiO}_2$ , 1.0–3.0 basicity and  $>0.5\%$  MgO, as the MgO adding source, Magnesite and/or Brucite are used without using either of  $\text{SiO}_2$ . MgO base auxiliary raw material, such as Serpentine, and CaO/MgO base auxiliary raw material, such as Dolomite, and also, the Magnesite and the Brucite are used to both having 30% (mass) of  $\leq 1$  mm grain size. The sintered ore excellent in the reducibility and reduced powdering property can stably be produced in the high producing ratio and the high yield, and the fuel ratio and the slag ratio in the blast furnace are reduced and the operation of high ratio of fine powdery coal injection can be attained.

In a method of manufacturing a high quality with low  $\text{SiO}_2$  contented sintered ore, in which the content of  $\text{SiO}_2$  does not exceed 4.6%, basicity is in the range 1.0–3.0 and the content of MgO is not lower than 0.5%, as a MgO auxiliary Magnesite or/and Brucite is used while Serpentine and Dolomite, which is widely used, are not used. And about the size distribution of above mentioned Magnesite and Brucite which is characterized that under 1mm size is not more than 30% (mass). And by this product the quality component of slag can be controlled.

### Points regarding about Brucite

It is generally known that the method to improve the basicity and high-temperature characteristics of sintered ore is to decrease the slag creation, it means  $\text{SiO}_2$  content, in sintered product. But by lower contents of  $\text{SiO}_2$  in sinter product causes weak cold physical strength, lower productivity and worse reduction disintegration behavior of sinter product. It is very difficult to solve this contrary at the same time.

It is used two methods to reduce the content of  $\text{SiO}_2$  in sinter product. 1) use iron ore with low content of  $\text{SiO}_2$  and 2) use lower amount of  $\text{SiO}_2$  contain auxiliary material such as silica stone and Serpentine. By the former method is not often adopted because it is expected to use high quality iron ore and therefore it is difficult to keep the situation for a long term in the market and it needs more cost, and therefore the latter way is widely

used. For example, in the patent (Application No. 1983-1180) explains that a silica stone as an auxiliary material is crushed to under 1 mm and the patent (Application No. 1977-721) writes the method using nickel-slag as the control material of pseudo coarse size material. But these method can't be a final resolution because they use the flux for slag, which are originally useless material and which need surplus auxiliary materials and not passed for the purpose of low-SiO<sub>2</sub> sintered ore production.

It is known that it is effective to reduce a using of MgO-SiO<sub>2</sub> contained auxiliary by compounding the sinter raw materials to product a sintered ore with low-SiO<sub>2</sub> content. But by this way it is difficult to keep enough MgO content in sintered ore and an optimal high-temperature character in the blast furnace can't be achieved. And for the control of the slag viscosity in the blast furnace, surplus MgO as an auxiliary material is expected to be charged to the furnace and as the result the slag ratio, which is the factor of slag quantity by producing of 1ton molten iron, can't be reduced. Therefore, for example, in the patent (Application No. 1997-143580) the method, which use Dolomite and calcined Dolomite etc. are used as MgO-CaO contain auxiliary material, to keep lower level of SiO<sub>2</sub> and higher level of MgO at the same time and the production using the size distribution control of these auxiliary material and mixing facility are explained. But these solutions, which use MgO-CaO auxiliary material, cannot achieve an increased productivity, because it occurs a shortage of free-CaO to product in a molten iron, as the result of insufficient melting of MgO at the firing temperature.

For the ideal auxiliary materials, which contains a higher MgO and especially lower SiO<sub>2</sub> and does not have or have a very few quantity of undesirable substance as a slag composition, are Magnesite and Brucite. Magnesite and Brucite have an enough MgCO<sub>3</sub> and lower content of SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub> and CaO. Their ignition residue is mainly consisting by MgO and 1/2 -1/3 of these materials are L.O.I.(Loss of Ignition), which is released by the heating at the sintering. And Magnesite and Brucite are not expensive and enough quantities are available in the market. When Magnesite and/or Brucite are used as MgO resource as auxiliary material and at the same time Serpentine as SiO<sub>2</sub>-MgO auxiliary and Dolomite as CaO-MgO auxiliary are not used, the above mentioned problems can be solved.

This invention is based from above mentioned knowledge and the points of this invention are following.

The manufacturing method of the high quality with low SiO<sub>2</sub> sintered ore with SiO<sub>2</sub> max 4.6%, basicity 1.0-3.0 and MgO min 0.5%, which is mentioned in the claim 1 of this invention is characterized to use Magnesite or/and Brucite as MgO auxiliary material without using Serpentine and Dolomite. Under 1mm of the size distribution of these auxiliary materials do not excess over 30%. And the control of the component of slag can be carried out by these auxiliary materials.

### About Magnesite and Brucite

It is important to keep an enough MgO component in sintered ore to keep a desirable high-temperature characteristic and disintegration of sinter structure in the blast furnace. If the content of MgO is under 0.5%, the MgO-effect in furnace can't be enough expected under the unstable condition of other auxiliary materials. If the MgO content exceeds above 2.0%, the productivity at the sintering goes down, because the melting of slag in

the sintering process should be worse. 1.5% MgO is the enough level for the good effect. Off course it is better to reduce the amount of MgO to cut a cost. It is not needed to set the upper limit of the MgO content. As the result the lower limit of MgO is set by 0.5%.

### About SiO<sub>2</sub>

It is expected that the content of SiO<sub>2</sub> in the sinter ore should be set lower level, because high-SiO<sub>2</sub> in sinter materials give worse influence to basicity and high-temperature characteristic, when the contents of SiO<sub>2</sub> is not limited in the blast furnace operation, except in some other operation, for example, in which it is not set the upper limitation of the content of Al<sub>2</sub>O<sub>3</sub>. But as the solution to use high-quality iron ore with low content of SiO<sub>2</sub> is not recommended, because of cost and long term stability of supply of this kind of the raw iron ore. In other hand recycled SiO<sub>2</sub>, that comes from the own steel mill facilities, should be consumed. That means it is expected that other SiO<sub>2</sub> contain material should not be charged as auxiliary material and the specified quality of sinter product must be secured. This specified quality can varies according to the sinter facility and the operation condition of the blast furnace. Generally it is said JIS-Reducibility (RI) must over around 70%, Reduction-disintegration Index (RDI) must over 40% and tumbler index (TI) must over 70%, and the limitation for SiO<sub>2</sub> is set under 4.6%. Keeping lower level of SiO<sub>2</sub> content in sintered ore reduce the creation of Fayalite (Fe<sub>2</sub>SiO<sub>4</sub>), which is not easy to be reduced, and as the result reducibility of sintered material is better.

Using above mentioned operation method, the reducibility and reduction disintegration of sintered products would be much better by the practical operation test 1 — test 3 by keeping productivity, yield rate and physical strength of sinter product.

The sinter product by the practical operation test show a lower content of SiO<sub>2</sub>, and MgO content is secured to a specified level. The quality of these products show a good reducibility and reduction disintegration character and physical strength with a good productivity and product yield ratio. This result can be achieved by only using size controlled Magnesite and/or Brucite without using Serpentine as an auxiliary material of SiO<sub>2</sub>-MgO, Dolomite and calcined Dolomite as an auxiliary material of CaO-MgO. And it can reduce a rising content of SiO<sub>2</sub> and avoid an unmelted MgO.

### Effect of the Invention

As above mentioned, it can be produced the low-Si sinter product with SiO<sub>2</sub> content under 4.6% and MgO content over 0.5%, using the control of MgO, without using Serpentine as SiO<sub>2</sub>-MgO and Dolomite as CaO-MgO auxiliary materials. By this solution the control of MgO content of slag in blast furnace is not necessarily. It can be maintained a good productivity and product yield ratio as former operation and a lower SiO<sub>2</sub> content, better reducibility, good reduction disintegration and good high-temperature characteristics can be achieved at lower cost. As the result, the reduce of fuel ratio at the blast furnace, lower slag ratio and high powdery coal injection operation can be realized. It can be expected a huge merit for the industry by this invented production method of high quality sintered ore.

## Appendix

Table 1

		Chemical components						
		T.Fe	FeO	SiO <sub>2</sub>	CaO	Al <sub>2</sub> O <sub>3</sub>	MgO	IgLoss
Iron Ore	Hamerslay (Australia)	62.76	0.25	3.7	0.14	2.25	0.05	3.36
	Mixed powder	60.45	4.71	4.35	3.13	1.71	0.5	4
Magnesite		0.5	0.34	0.9	0.59	0.02	45.72	50.5
Brucite		0.79	0.15	2.23	0.55	0.41	64.77	30.63
Dolomite		0.26	0.08	0.97	33.69	0.15	19.01	46.95
Serpentine		5.27	2.53	38.29	1.04	0.89	38.34	13.2
Powder coke		0.54	0	6.37	0.39	3.59	0.12	87.97
Return product		57.8	5.01	4.98	9.43	1.88	1.1	0
Quick lime		0.13	0.01	0.68	81.2	1.43	1.12	13.3
Limestone		0.27	0.15	0.9	55.83	1.08	0.38	41.99

Table 2

		Composition				
		Conventional ex.1	Conventional ex.2	Comparison ex.1	Comparison ex.2	Comparison ex.3
Iron Ore	Hamerslay (Australia)	10	10	10	10	10
	Mixed powder	90	90	90	90	90
Magnesite		0	0	2.45	0	1.01
Brucite		0	0	0	1.72	1
Dolomite		0	5.9	0	0	0
Serpentine		3	0	0	0	0
Powder coke		3.5	3.5	3.5	3.5	3.5
Return product		15	15	15	15	15
Quick lime		1.5	1.5	1.5	1.5	1.5
Limestone		13.6	5.9	9.4	9.5	9.5
Target value of SiO <sub>2</sub> in sintered Ore		5.3	4.5	4.5	4.5	4.5
Target value of SiO <sub>2</sub> in sintered Ore		1.5	1.5	1.5	1.5	1.5

Table 3

		Composition		
		Operation ex.1	Operation ex.2	Operation ex.3
Iron Ore	Hamerslay (Australia)	10	10	10
	Mixed powder	90	90	90
Magnesite		2.45	0	1.01
Brucite		0	1.72	1
Dolomite		0	0	0
Serpentine		0	0	0
Powder coke		3.5	3.5	3.5
Return product		15	15	15
Quick lime		1.5	1.5	1.5
Limestone		9.4	9.5	9.5
Target value of SiO <sub>2</sub> in sintered Ore		4.5	4.5	4.5
Target value of SiO <sub>2</sub> in sintered Ore		1.5	1.5	1.5

Table 4

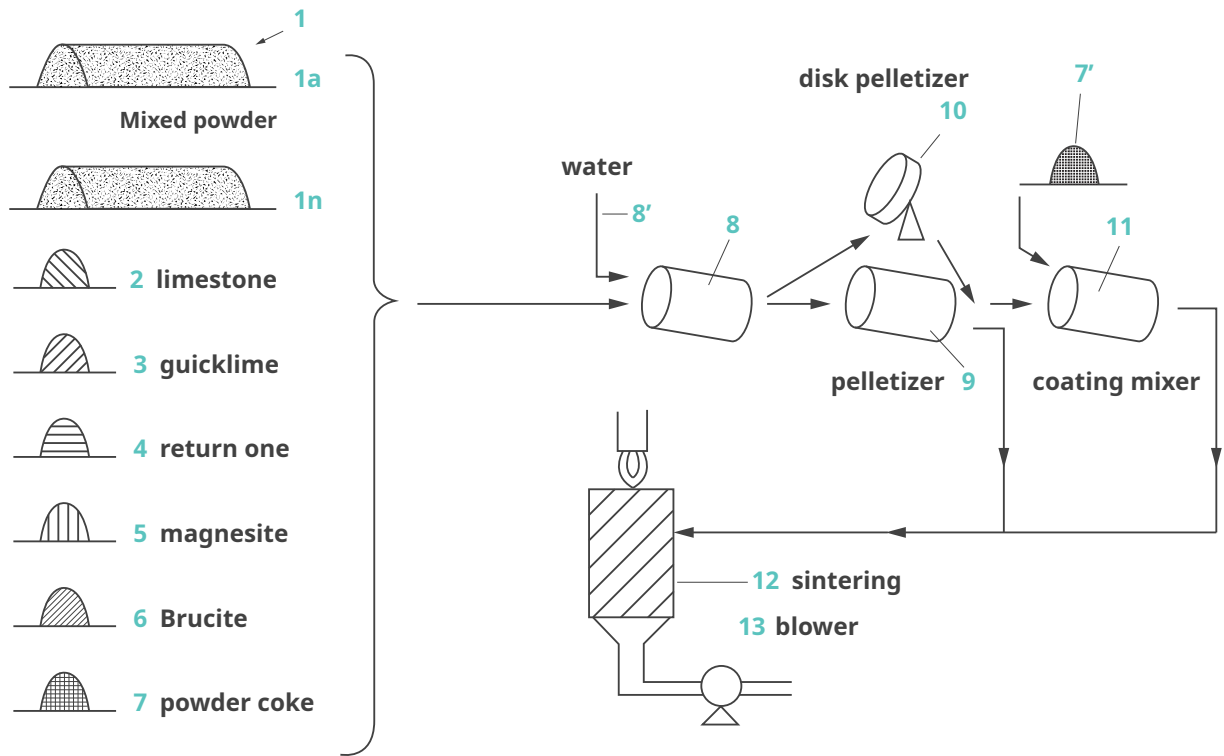
	Powder size, mm					
	+8.00	8.00~4.75	4.75~2.80	2.80~2.00	2.00~1.00	-1.00
Comparison ex.1	0.4	8.1	12.5	21.3	12.6	45.1
Comparison ex.2	0.2	7.5	15.5	26.3	17.0	33.5
Comparison ex.3	0.4	8.0	14.8	23.7	14.9	38.2
Operation ex.1	0.6	8.6	16.4	26.8	18.4	29.2
Operation ex.2	0.3	9.5	20.1	29.0	19.4	21.7
Operation ex.3	0.4	8.9	18.5	28.7	19.2	24.3

Table 5

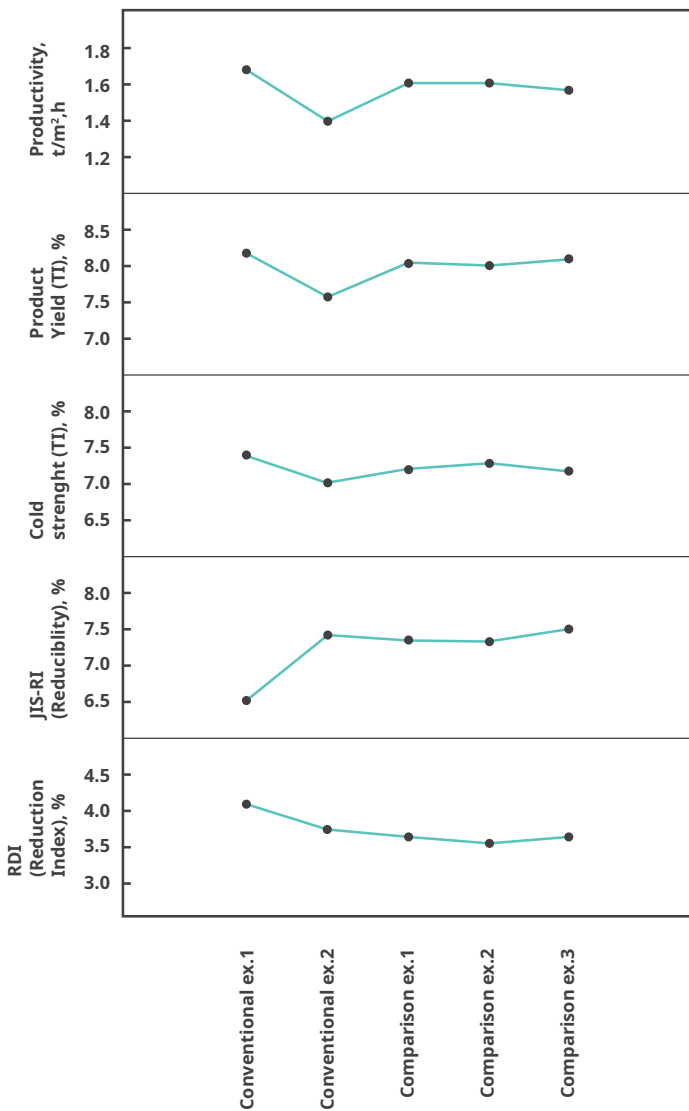
	Chemical components, %						
	T.Fe	FeO	SiO <sub>2</sub>	CaO	Al <sub>2</sub> O <sub>3</sub>	MgO	C/S
Conventional ex.1	56.34	5.84	5.33	10.81	1.92	1.52	2.03
Conventional ex.2	58.20	4.95	4.52	9.03	1.91	1.51	2.00
Comparison ex.1	58.23	5.10	4.53	9.01	1.90	1.49	1.99
Comparison ex.2	58.15	5.04	4.50	9.01	1.94	1.51	2.00
Comparison ex.3	58.08	4.98	4.48	8.95	1.89	1.52	2.00

Table 6

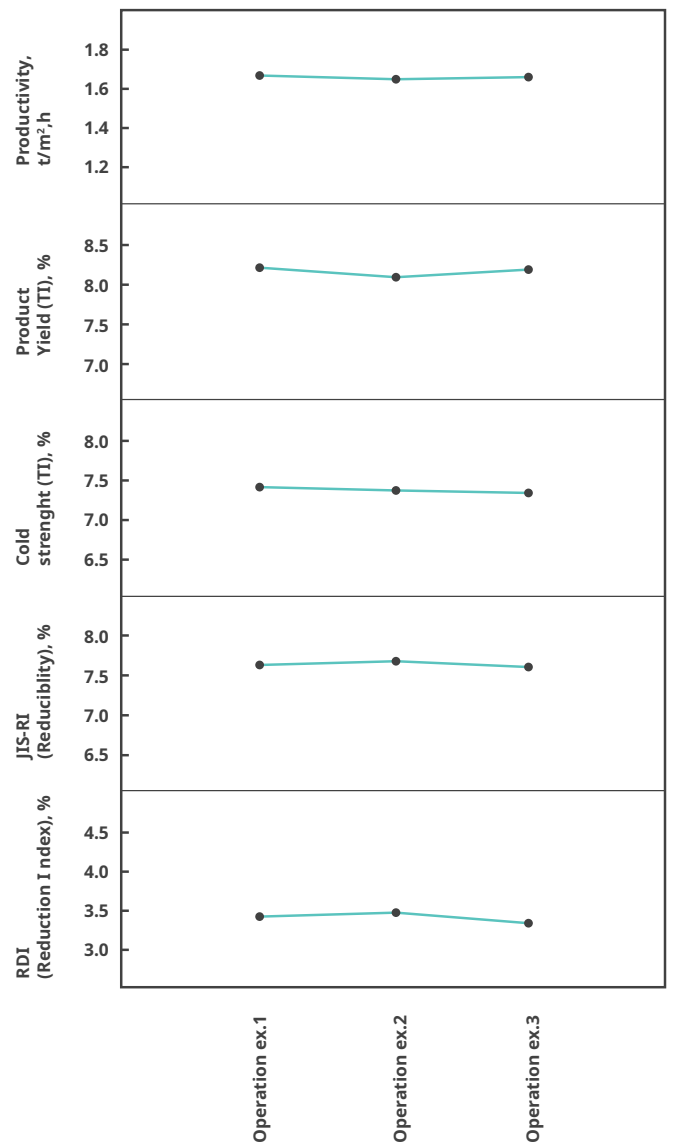
	Chemical components, %						
	T.Fe	FeO	SiO <sub>2</sub>	CaO	Al <sub>2</sub> O <sub>3</sub>	MgO	C/S
Operation ex.1	58.31	5.12	4.49	9.05	1.86	1.48	2.02
Operation ex.2	58.20	5.07	4.51	9.03	1.92	1.51	2.00
Operation ex.3	58.15	4.99	4.50	9.01	1.91	1.50	2.00



Picture 1

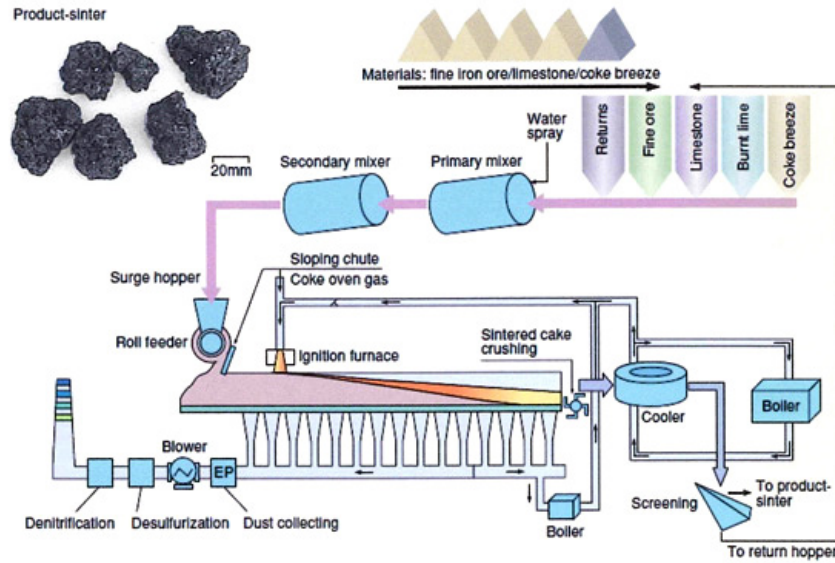


Picture 2

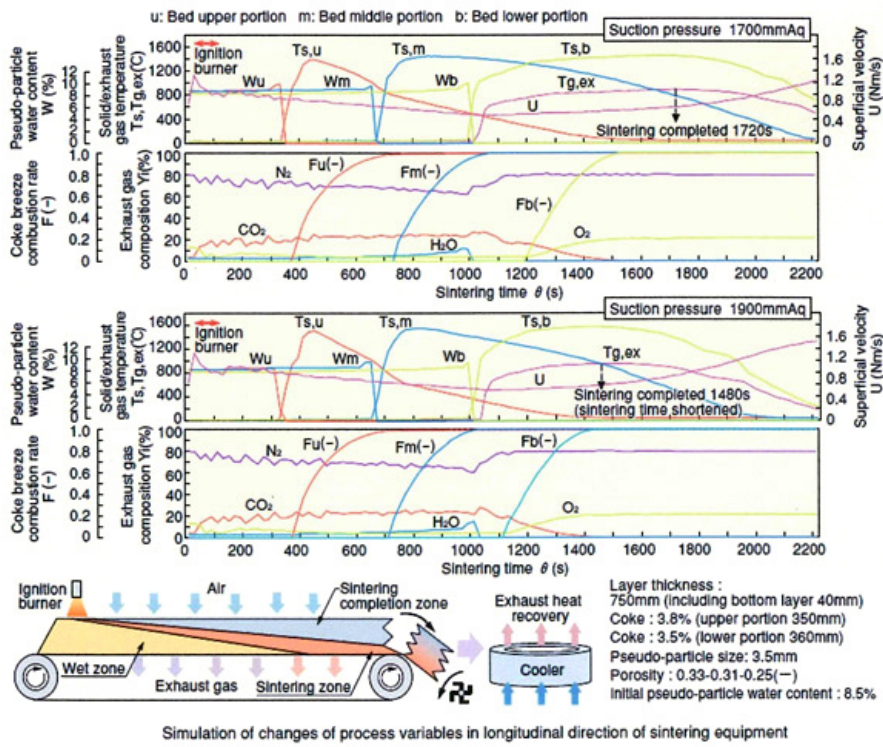


Picture 3

Reference (not in the patent document)



Picture 4



Picture 5