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INFLUENCES OF IRON-BEARING METALLIZATION RATE ON ITS SOFTENING AND DROPPING PROPERTIES INSIDE BLAST FURNACE[1]

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Abstract

The paper mainly studies that the inferences of burden metallization rate on softening-melting dropping properties through softening-melting dropping test of three kinds of different metallization rate of burden, and analyzes shrinkage and pressure difference variety of charge column. The results indicated that the softening interval of pre-reduction mixed burden is bigger compared with the primeval mixed burden, the melting interval narrow with the rise of metallization rate of ferric burden as well as dropping temperature interval. The average pressure difference, maximum pressure difference, and permeability of charge column decrease with the rise of metallization rate of ferric burden as well as softening-melting dropping properties eigenvalue. Besides, the dropping temperature of burden reduces with the rise of carbon content of molten iron. The combination high metallized burden and higher carbon content of molten iron is benefit to decreasing thickness of cohesive zone and improve permeability of cohesive zone.

Key words: Iron-bearing burden; Metallization rate; Softening-melting dropping properties; Blast furnace.

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1 INTRODUCTION

In order to meet the need of the global "low carbon economy", energy savings and pollutant reductions on blast furnace ironmaking process is becoming a strategic problem to be solved in iron and steel industry. Softening-melting dropping property (SDP) of iron-bearing burden has great effect on blast furnace operation[1] such as smooth operation, productivity, fuel consumption and molten iron components and so on.

Excellent softening-melting dropping property of iron-bearing burden inside blast furnace is an important index in ironmaking research. Although lots of works such as the influences of iron-bearing burden proportion, Fe content, MgO content and binary basicity on SDP have been studied before[2-6], few work focused on the effect of metallization rate on SDP.

Besides, it is possible to use some metallized burden in blast furnace with implement of sponge iron production process with rotary hearth furnace[7-9]. Study shows that the innovation process based on ore-coke coupling reaction is expected to increase metallization degree of burden[10,11]. The influence of these metallized burdens on SDP is becoming the hot spot in ironmaking research.

In order to investigate and master the varied law of SDP, experiments are conducted about different degrees of metalized burden. Relationships between SDP and correlative factors i.e. metallization rate and carbon concentration of the iron-bearing burden, carburizing rate, carbon content in hot metal are deeply studied in this paper.

2 EXPERIMENT AND METHODS

The softening-melting dropping properties of metallized burden indicate the softening-melting zone properties in blast furnace. The softening-melting dropping properties of different metallization rate ferric burden in high temperature are different and the dropping temperature depends on burden carbon content to a certain extent.

Experiments have been conducted on the softening-melting dropping properties of unreduced ferric burden (A) and pre-reduced burden (B,C), and the T_s, T_m, T_d shrinkage characteristic, pressure difference and SMD difference of them are compared.

The composition of different kinds of burden is listed in Table 1. Ferric burden B and C are pre-reduced burden which are made from ferric burden A of 200 g reduced to metallization rate of 45% and 75% respectively. The grain size of the experiment coke from Baosteel is 6.3~10 mm.

Table 1. Ferric burden properties /%

Burden	Metallization rate	FeO	C	Sinter	Pellet	Lump ore
A	0	5.55	0	65.7	19.8	14.5
B	45	51.21	0.10	65.7	19.8	14.5
C	78	24.82	1.10	65.7	19.8	14.5

The softening-melting dropping experiment were conducted as follows: The mixed materials were charged into the graphite reaction tube (inner diameter 48 mm, length 270 mm) by distributing 20 g coke at the top and bottom of the charge column separately and ferric burden in the middle. The experiment started on the conditions listed in Table 2, and the burden load was 1 kg/cm^2. Experiment was finished once the molten iron dropped. The dropping molten iron was collected in a crucible at the bottom of the corundum tube in furnace. The equipment and burden distribution of the

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softening-melting dropping experiments is shown as Figure 1. The experiment data such as temperature, column thickness and pressure are all real time recorded in the computer.

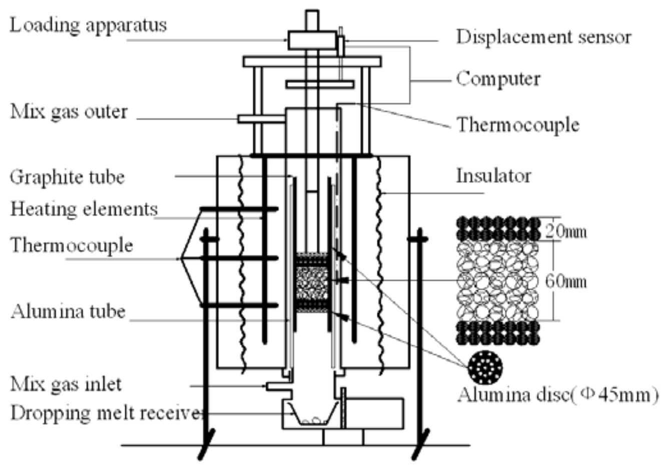

Figure 1. Schematic diagram of softening-melting dropping apparatus and charging.

Table 2. Melting and dripping experiment condition of ferric burden

Ferric burden	before 900℃			after 900℃			
	N_2	Gas flow	Hearting rate	N_2	CO	Gas flow	Heating rate
	%	L/min	℃/min	%	%	L/min	℃/min
A							
B	100	5	10	70	30	12	5
C							

3 RESULTS AND DISCUSSION

3.1 Experiment Results

The process parameters of ferric burden under softening-melting dropping are shown in Table 3. Results of the softening-melting dropping experiments of ferric burden A, B and C are shown in Figures 2-7 and Tables 4-5. The softening-melting dropping zone can be divided into three zones, namely softening-melting zone, melting zone and dropping zone in order to study the influence of ferric burden metallization rate on the softening-melting dropping properties. On the above basic the ferric burden softening-melting property eigenvalue (SMD_1), the melting property eigenvalue (SMD_2), the dropping property eigenvalue (SMD_3) and the softening-melting dropping properties eigenvalue (SMD) are further studied.

ISSN 2176-3135

Table 3. Process parameters of ferric burden under softening-melting dropping

Symbol	Meaning	Unit
T_s	Temperature when bed shrinkage rate increase obviously or unit bed pressure difference markedly elevated	℃
T_m	Temperature which pressure difference began steep rise	℃
T_{Pmax}	Temperature of unit bed maximal pressure difference	℃
T_d	Temperature when molten iron begin to drop	℃
T_1	Softening-melting temperature interval（$T_1= T_m- T_s$）	℃
T_2	Melting temperature interval（$T_2= T_{Pmax}- T_m$）	℃
T_3	Dropping temperature interval（$T_3= T_d- T_{Pmax}$）	℃
$T_{1\sim3}$	Softening-melting dropping temperature interval（$T_{1\sim3}= T_d- T_s$）	℃
S_1	Shrinkage range of burden column in softening-melting temperature interval	%
S_2	Shrinkage range of burden column in melting temperature interval	%
S_3	Shrinkage range of burden column in dropping temperature interval	%
C_{Pig}	Carbon content of molten iron	%
P_{av1}	Average pressure difference in softening-melting temperature interval	Pa
P_{av2}	Average pressure difference in melting temperature interval	Pa
P_{av3}	Average pressure difference in dropping temperature interval	Pa
P_{av}	Average pressure difference in softening-melting dropping temperature interval	Pa
$P_{s\text{-}m}$	Pressure difference range in softening and melting temperature interval	Pa
$P_{m\text{-}Pmax}$	Pressure difference range in melting temperature interval	Pa
$P_{Pmax\text{-}d}$	Pressure difference range in dropping temperature interval	Pa
$P_{s\text{-}d}$	Pressure difference range in softening-melting dropping temperature interval	Pa
$P_{u(s\text{-}m)}$	Pressure difference range of unit bed in softening-melting temperature interval	Pa/mm
$P_{u(m\text{-}Pmax)}$	Pressure difference range of unit bed in melting temperature interval	Pa/mm
$P_{u(Pmax-d)}$	Pressure difference range of unit bed in dropping temperature interval	Pa/mm
$P_{u(s\text{-}d)}$	Pressure difference range of unit bed in softening-melting dropping temperature interval	Pa/mm
P_{max}	Maximal pressure difference of unit bed in softening-melting dropping temperature interval	Pa/mm
SMD_1	Integral of pressure difference to temperature in softening-melting temperature interval	kPa·℃
SMD_2	Integral of pressure difference to temperature in melting temperature interval	kPa·℃
SMD_3	Integral of pressure difference to temperature in dropping temperature interval	kPa·℃
SMD	Integral of pressure difference to temperature in softening-melting dropping temperature interval	kPa·℃

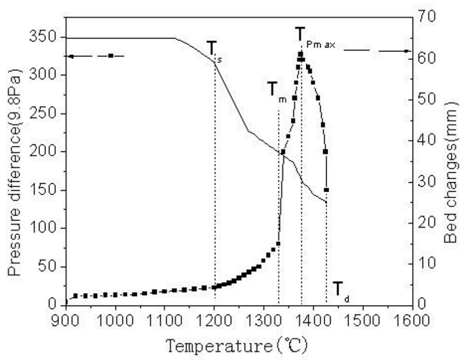

Figure 2. Pressure difference and bed changes of charging column of burden A.

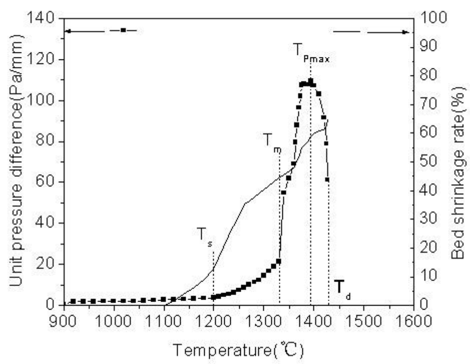

Figure 3. Unit pressure difference and bed shrinkage rate of charging column of burden A.

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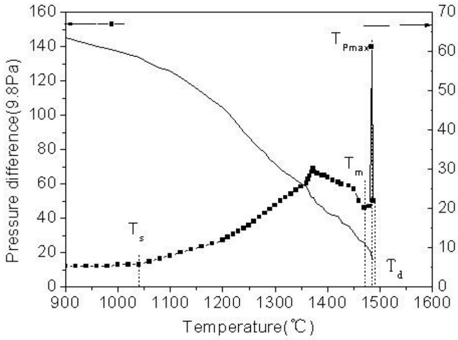

Figure 4. Pressure difference and bed changes of charging column of burden B.

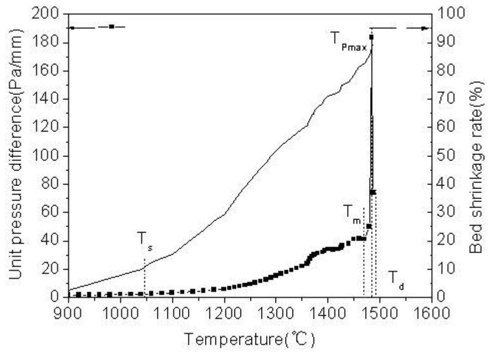

Figure 5. Unit pressure difference and bed shrinkage rate of charging column of burden B.

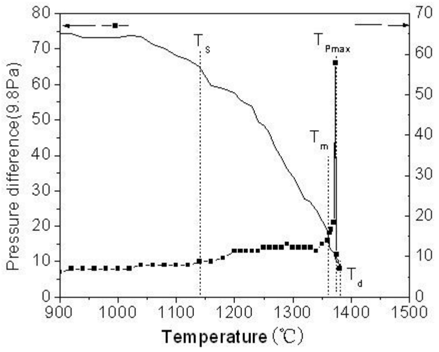

Figure 6. Pressure difference and bed changes of charging column of burden C.

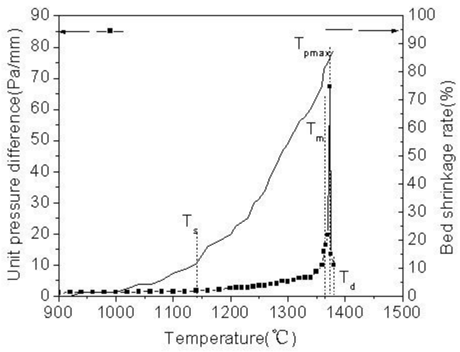

Figure 7. Unit pressure difference and bed shrinkage rate of charging column of burden C.

Table 4. Temperature interval parameters and shrinkage range of burden

Burden	C_{Pig}	Ts	Tm	T_{Pmax}	T_d	T_1	T_2	T_3	$T_{1\sim3}$	S_1	S_2	S_3
	%	℃								%		
A	3.16	1200	1335	1394	1425	135	59	31	225	12.8~44.3	44.3~58.7	58.7~65.2
B	2.95	1045	1470	1484	1487	425	14	3	442	9.9~82.8	82.8~88.2	88.2~89.7
C	3.93	1146	1370	1373	1375	224	3	2	229	12.5~83.5	83.5~84.9	84.9~86.3

Table 5. Pressure drop and SMD of ferric burden under softening-melting dropping state

Burden	Pav_1	Pav_2	Pav_3	Pav	SMD_1	SMD_2	SMD_3	SMD
	Pa				kPa·℃			
A	440	2530	2590	1342	57	162	85	304
B	390	599	950	393	167	8	3	178
C	141	435	390	148	24	1.3	0.8	26.1

3.2 Analysis of Experiment Results

3.2.1 Variation of charge column

3.2.1.1 Softening-melting temperature interval

Experiment results are shown in Figure 2-8. The order of T_s is: A＞C＞B. As for T_m, the order is: B＞C＞A. And the order of T_1 is: B＞C＞A.

The reduction process of ferric burden A is $Fe_2O_3 \rightarrow Fe_3O_4 \rightarrow FeO \rightarrow Fe$, and that of burden B and C is $FeO \rightarrow Fe$. Reductions of $Fe_2O_3 \rightarrow Fe_3O_4$ and $Fe_3O_4 \rightarrow FeO$ need some time to finish, which results that the charge column of burden A needs a longer time to reach T_s and T_s of burden A has exceeded that of ferric burden B and C. FeO contents in ferric burden B and C are respectively 51.21% and 24.82% at the

beginning of reduction of 900°C, which begin to decrease as the reduction goes on. Therefore T_s of ferric burden B is lower than that of burden C.
The main reason why T_m of burden A is higher than that of burden B is that the metallization rate of burden B is 45% at the beginning of reduction and the metallization rate becomes higher with the reduction, and the whole ferric burden B is almost reduced to spongy iron which is difficult to produce low melting point mineral.
The main reason T_m of burden B is higher than that of burden C is that all of ferric burden B and C are almost reduced to iron and the liquid appearance temperature of charge burden decreases as carbon content of burden increases according to blue lines in the Fe-C diagram in Figure 9. Therefore, the carbon content of ferric burden C is higher than that of burden B.

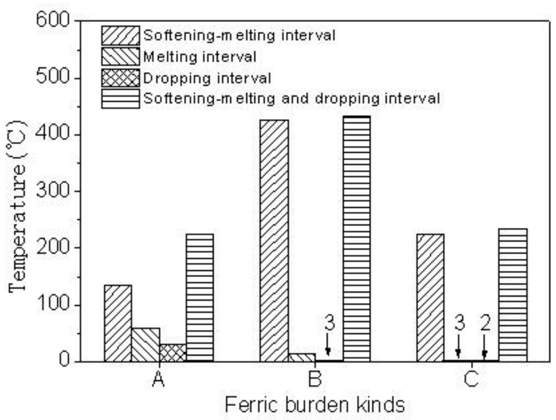

Figure 8. Effect of different metallic ferric burden on its softening-melting dropping interval.

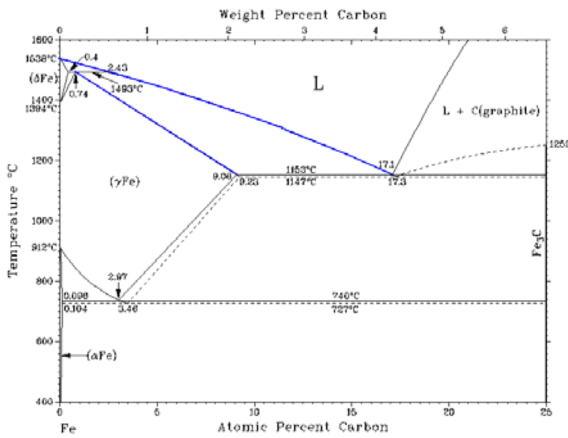

Figure 9. Fe-C diagram.

Ferric burden shrinkage range is mainly determined by burden softening-melting properties. Table 4 shows that in the softening-melting temperature range, the shrinkage range of burden column (S_1) A is the minimum and that of burden B is the next and that of burden C is the maximum. The main reason is analyzed as following. Compared with ferric burden B, T_s of burden A is higher, and T_1 is narrower, the liquid formation rate is relatively fast, thus the shrinkage rate is smaller.
While T_1 of burden B is wider, and the softening-melting shrinkage is slower, and S_1 corresponding to T_m is relatively large, therefore softening-melting process is more completed. Compared with ferric burden B, T_m of ferric burden C is rather low, but S_1 is relatively large, while shrinkage value has less difference with burden B.

3.2.1.2 Melting temperature interval

Melting temperature interval (T_2) of ferric burden is defined as difference values between melting starting temperature of charging column (T_m) and melting ending temperature (T_{Pmax}). The value reflects the high temperature melting properties of ferric burden to some extent. T_2 of ferric burden A is the maximum, and burden B is the next, and burden C is the minimum, which is presented in Figures 2-8 and Table 4. Obviously, burden metallization rate is larger, the narrower T_2.
Compared with ferric burden A, T_{Pmax} of burden B is much higher. The main reason is that T_{Pmax} of ferric burden increases with rising metallization rate and decreases with rising FeO content in charging column. T_{Pmax} of burden C is the lowest among ferric burden A, B and C. The main reason is higher carbon content in ferric burden C at the melting process, which can be verified by the blue lines in Fe-C diagram in Figures 9-10. Therefore, T_{Pmax} of ferric burden is mainly determined by metallization

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rate of charging burden and carbon content, and the higher carbon content is at the same metallization rate condition, the lower T_{Pmax} becomes.

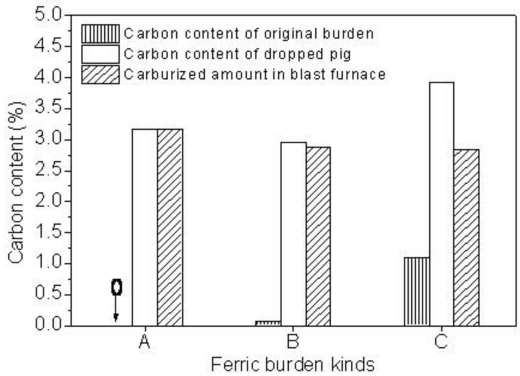

Figure 10. Relationship between different metallic ferric burden and carburizing rate of hot metal.

As can be seen from Table 4, the charge column shrinkage range(S_2) of ferric burden A, B and C in melting temperature range are 44.3~58.7%, 82.8~88.2% and 83.5~84.9% respectively. The T_2 of burden B and C is rather narrow in comparison with burden A. The reason is that the liquid content of burden B and C increase rapidly to the maximum, and the sharp increasing interval of liquid content is rather narrow. T_2 of ferric burden C is narrower than burden B, which because that the metallization rate of burden C is larger than that of burden B. Therefore, in melting temperature interval, the S_2 decreased with the rise of metallization rate, and the higher the burden metallization rate is, and the lower the increased value of shrinkage rate is.

3.2.1.3 Dropping temperature interval(T_3)

The dropping temperatures(T_d) of ferric burden A, B and C a 1,425°C, 1,487°C and 1,375°C respectively, and the dropping temperature ranges are 31°C, 3°C and 3°C, which is illustrated in Figures 2-8. T_d of ferric burden mainly depends on the carbon content in molten iron and Figures 9-10 indicate that T_d of molten iron is related with the carbon content in molten iron (C_{Pig}), which shows that the higher C_{Pig} is, the lower T_d becomes. T_3 of burden A, B and C reduces in turn, which is mainly because of the rise of burden metallization rate leading to the narrowing of dropping temperature interval. The high metallization rate of ferric burden causes T_3 only 2-3°C, which drops immediately after burden melted. So T_d of burden decreases with the increase of C_{Pig}, and T_3 narrows with the rise of the metallization rate. As can be seen from Figure10, the carburized amount of burden in melting and dropping furnace is less related to metallization rate and carbon content of raw material, and C_{Pig} is directly correlated to the carbon content of the ferric burden before charging into melting and dropping furnace.

In dropping temperature interval, S_3 of ferric burden A, B and C are 58.7~65.2%, 88.3~89.6% and 84.9~87.7% respectively, and S_3 value of burden A, B and C are 6.5%, 1.5% and 1.4% respectively, which is listed in Figures 2-8 and Table 4. The higher the metallization rate is, the smaller the corresponding S_3 value in dropping temperature range is. The main reason is that all of ferric burden has melted to liquid in dropping temperature interval, and the thickness of charging column is minimum, which leads to charging column not shrink again in theory, while there is a little change actually, and this is mainly caused by the decrease of surface viscosity of liquid making the surface liquid drop into coke layer. The molten slag and iron viscosity of

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burden A is rather high and the no-dropping temperature interval is much wider than burden B. While the molten slag and iron viscosity of burden B and C is rather low, the no-dropping temperature interval of which is much narrow and the interval value is only 2-3°C. And the slag and molten iron residence time in dropping temperature interval becomes short with the rise of the metallization rate. Therefore, the high metallization rate burden is beneficial to decrease the molten slag and iron viscosity and the width of dropping temperature interval.
In conclusion, the T_1 and $T_{1\sim3}$ of burden A are narrower than that of burden B and C. And T_2 and T_3 of burden A, B and C becomes narrow with the increase of metallization rate. The charging column shrinkage value of burden B and C is much larger than burden A. considering T_1 alone, it seems that the softening-melting dropping properties of unreduced ferric burden is better than metallized burden. However whether wider T_1 indicate bad soften-melting dropping properties needs to be studied further. The discussion of the influence of metallization rate of ferric burden on charging column pressure difference is shown as following.

3.2.2 Pressure drop changes of charge column

The cohesive zone is the maximum pressure difference ($P_{s\text{-}d}$) in blast furnace. The pressure difference is about 60% of the total pressure difference, and it determines the stable of blast furnace smelting operation[12]. It is important to study the influence of metallization rate of ferric burden on the pressure differential in softening-melting dropping process.
As can be seen from Figures 2, 4 and 6, with rising charging column temperature, the charging column pressure difference of burden A increases rapidly to maximum and then decreases slowly and at this moment the molten iron starts dropping. Charging column pressure difference of burden B firstly increases slowly to the higher point, then increases sharply to the maximum, at this moment the molten iron starts dropping. While pressure difference of burden C increases steeply and then decreases immediately before the molten iron drops. In the softening-melting interval, the unit pressure difference ($P_{u(s\text{-}m)}$) of burden A, B and C increase slowly, and when the charging column temperature reaches to melting starting temperature, the unit pressure difference ($P_{u(m\text{-}Pmax)}$) sharply increases to maximum for the decrease of lacuna in charging column caused by the rapidly melting of burden, which is listed in Figures 3, 5 and 7. Melting terminates at the moment, but the molten iron will not drop immediately for higher viscosity.
Seen from charging column permeability in softening-melting temperature interval, the unit charging column pressure difference ($P_{u(s\text{-}m)}$) of burden A, B and Call increase slowly. As can be seen from Table 5 and Figure 11, both $P_{u(s\text{-}m)}$ and maximum pressure difference decrease with increasing metallization rate, thus the charging column permeability of burden A is the worst, that of burden B is better, and that of burden C is the best. Therefore, the charging column permeability is improved with the rise of the metallization rate in softening-melting temperature interval.
As for the charging column permeability in melting temperature interval, the unit charging column pressure difference ($P_{u(m\text{-}Pmax)}$) of burden A, B and C all increase rapidly to maximum, which are listed in Figures 3, 5, 7 and Table 5. The pressure difference ranges of burden A, B and C in melting temperature interval are 800~3,270Pa, 460~1,400Pa and 210~660Pa respectively, which indicates that the charging column permeability of burden A, B and C is improved gradually. As can be seen from Figure 11, both the average pressure difference(P_{av2}) and maximum pressure difference (P_{max}) decrease with the rise of metallization rate in melting

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temperature interval, it again shows that the higher the metallization rate is, the better the charging column permeability is.
The variation of charging column permeability in the dropping temperature interval is presented in Figures 2-8 and Table 5. In general, the charging column pressure difference reduces gradually or sharply in dropping temperature interval. As is shown in Table 5, the pressure difference ranges of burden A, B and C are 3,050~1,500Pa, 1,400~500Pa and 660~80Pa. Compared with burden B, the unit charging column pressure difference range of burden A moves to high pressure difference direction. While the unit charging column pressure difference ($P_{u(Pmax-d)}$) of the burden B moves to low pressure difference direction. Besides, the P_{max} and average pressure difference (P_{av3}) of ferric burden decreased with the rise of metallization rate in dropping temperature interval.

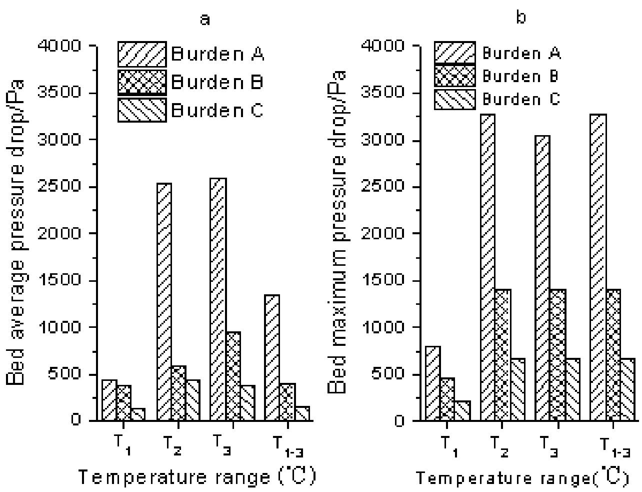

Figure 11. Effect of different metallic ferric burden on pressure difference of material layer.

Above analysis illustrates that the charging column pressure difference is mainly related to the liquid phase volume of slag and iron and the melting condition of iron metal. The reduction process of burden A is much long, and the FeO content increases to the maximum and then decreases slowly with the rise of temperature. So the higher pressure difference range of burden A is rather large.
While the average pressure difference and maximum pressure difference of burden B and C are small in softening-melting dropping interval, and maximum pressure difference interval is narrow, it indicates that the iron in charge column of pre-reduced burden melts rapidly at a certain temperature, then penetrates into the coke passages, and drop in a flash. This causes the peak value interval of maximum pressure is only 2-3°C. So the higher the metallization of ferric burden is, the better the permeability of charge column is.

3.2.3 Evaluation of Burden Softening-Melting dropping Characteristic

The charge column lacuna of ferric burden gradually decreases to disappear from softening-melting starting temperature to dropping temperature. The charging column shrinkage in softening-melting, melting and dropping temperature interval all affect the burden smelting. Evaluating exactly softening-melting, melting, and dropping properties makes an important significance on blast furnace ironmaking.
The softening-melting dropping property eigenvalue (SMD) is defined as the sum of the temperature integral of pressure difference function in softening-melting, melting and dropping temperature interval. In order to calculate conveniently, the calculation

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with infinitesimal method for pressure difference function needs to be fitted with the experiment data[13]. Each interval SMD is calculated by formula 1.

$$SMD = \int_{T_s}^{T_d} P(T)\,dT = SMD_1 + SMD_2 + SMD_3 = \int_{T_s}^{T_m} P(T)\,dT + \int_{T_m}^{T_{P\max}} P(T)\,dT + \int_{T_{P\max}}^{T_d} P(T)\,dT$$
$$= \frac{1}{2}\sum_{i=1}^{n}(P_{i+1} + P_i)\times(T_{i+1} - T_i)$$

Formula 1

This formula indicates that SMD is the integral of pressure difference to temperature from T_s to T_d range. Each temperature interval indicates the width of T_1, T_2 and T_3. The integral of pressure difference to temperature each temperature interval is defined as softening-melting property eigenvalue (SMD_1), the melting property eigenvalue (SMD_2) and dropping property eigenvalue (SMD_3), which are shown in Table 7. T_i is arbitrary temperature value from T_s to T_d. P_i is the corresponding pressure difference value of temperature T_i. The formula is helpful to further understanding about the width of T_1, T_2 and T_3 of each ferric burden, and the pressure difference variance of charging column and the property eigenvalue are also characterized by it. Use the formula is beneficial to correctly evaluate the SMD of ferric burden. By formula 1 known, in the same temperature interval, the smaller the eigenvalue of SMD is, the better the permeability of cohesive zone becomes in blast furnace.

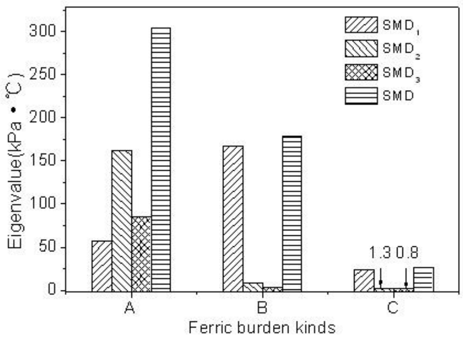

Figure 12. Effect of different metallic ferric burden on its softening melting property eigenvalue.

The SMD calculated by formula 1 is shown in Table 5 and Figure 12. The SMD_1 of burden B is the maximum, SMD_1 of burden A is the next and SMD_1 of burden C is the minimum. The Fe_2O_3 in burden A is gradually reduced to FeO, and part of FeO is also reduced to Fe with rising temperature. FeO would not affect the charging column permeability until FeO content is accumulated to a certain level in a higher temperature. Compared with burden A, the FeO content of burden B is the maximum and the value is 51.21% when burden B begin to be reduced at 900°C, which produces much of low melting temperature substance. Lacuna of charging column reduces, and pressure difference rises, and the permeability becomes worse for the softening-melting of low melting temperature substance. In addition, T_s of burden B becomes lower, and T_1 becomes wider because of the maximum FeO content at the beginning of reduction. Therefore, SMD_1 of burden A is larger than that of burden B in softening-melting temperature interval. While the FeO content in burden C is much smaller at the beginning of reduction, FeO gradually reduces to Fe with rising temperature. This leads to the low melting temperature substance produced by FeO and oxides in gangue minerals is much low, which has little influence on the permeability of charging column, so the charging column pressure difference of burden C is rather low and the permeability is the best.

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As can be seen from Table 5 and Figure12, the SMD_2 of ferric burden of burden A is the maximum, that of burden B is larger and that of burden C is minimum. The maximum SMD_2 of burden A is caused by wider T_2 and higher pressure difference of the charging column, which can be verified in Figures 2-3. While the maximum liquid volume of burden A in melting temperature interval causes the pressure difference of charging column larger. The SMD_2 of burden B and C is 8k Pa·°C and 1.3k Pa·°C respectively. This indicates that burden B and C are almost turned to Fe, which makes the temperature interval rather narrow and pressure difference much low. This can be verified in Figures 4-7. In conclusion, SMD_2 of ferric burden decreases with increasing metallization rate.

SMD_3 of ferric burden A is the maximum, burden B is the next and burden C is the minimum. According to Table 5 and Figure 12, SMD_3 of burden A is larger than that of burden B and C. The main reason is that the viscosity of melting slag and iron of burden A is much high in the dropping temperature interval, the no-dropping temperature interval of melting slag and iron is much wider, that is the duration of the higher pressure difference is rather long. While SMD_3 of burden B and C is much small, because that the much low viscosity of melting slag and iron of high metallization rate cause it to drop immediately after melted and layered, which results in the narrow dropping temperature interval.

The softening-melting dropping interval ($T_{1\sim3}$) of burden A, B and C is 225°C, 432°C and 229°C, while the average pressure difference(P_{av}) of burden is 1,342Pa, 393Pa and 148Pa respectively. SMD of ferric burden decreases with the rise of the metallization rate. In conclusion, the softening-melting dropping properties of ferric burden cannot be evaluated only by softening-melting dropping temperature range, because the pressure difference is much important than the temperature range. Therefore the softening-melting dropping properties ought to be evaluated by real time differential pressure combined with temperature range.

4 CONCLUSIONS

- As the softening-melting starting temperature of ferric burden decreases, the softening-melting temperature interval becomes wide, the total pressure difference of softening-melting layer obviously decreases and permeability is improved with the rise of metallization rate of ferric burden.
- As the steep rising temperature of pressure difference increases, the melting temperature interval becomes narrow, and the maximum pressure difference and average pressure difference decrease, the permeability is improved with rise of metallization rate of ferric burden.
- Compared with unreduced burden A, the carburization reaction of metallized burden becomes weak, and the dropping temperature increases with the decreases of carbon content of metallized burden. The carbon content of molten iron increases with rising carbon content of metallized burden that resulting in decreasing dropping temperature of burden.
- The combination high metallized burden and higher carbon content of molten iron can decrease the liquid volume of charging column in high temperature, improve the softening-melting dropping properties of ferric burden and decrease the pressure difference of cohesive zone, and improve the permeability.

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