ISSN 2176-3135
ICSTI
6th International Congress on the Science and Technology of Ironmaking - ICSTI
42th Ironmaking and Raw Materials Seminar/ 42º Seminário de Redução de Minério de Ferro e Matérias-primas
13th Brazilian Symposium on Iron Ore/ 13º Seminário Brasileiro de Minério de Ferro

# LOW-CARBON AND ENERGY SAVING TECHNOLOGY APPLIED IN ANSTEEL BAYUQUAN BRANCH COMPANY[1]

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**Abstract**
The technology of energy saving and low-carbon operation in Ansteel Bayuquan Branch Company are introduced in this paper. By adopting Didier external combustion hot stove and preposed combustion stove for preheating, top gas pressure recovery turbine(TRT), combined cycle power plant(CCPP), frequency conversion fan in coal powder carrying system, waste heat utilization in slag granulating process and etc. The energy consumption in whole BF system has been reduced to some extent. At the same time, a series of measures have been taken to lower the fuel rate and approach the low-carbon BF operation, which are using beneficiated burden materials, optimizing charging model and adjusting blowing rule to improve the gas utilization ratio, keeping adapted smelting intensity and cooling intensity. The ongoing project of coke oven gas injection to BF is a significant experiment for the further low-carbon operation.
**Key words:** Low-carbon; Energy-saving; Operation; BF.

[1] *Technical contribution to the 6th International Congress on the Science and Technology of Ironmaking – ICSTI, 42nd International Meeting on Ironmaking and 13th International Symposium on Iron Ore, October 14th to 18th, 2012, Rio de Janeiro, RJ, Brazil.*
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ISSN 2176-3135

## 1 INTRODUCTION

With the aggravation of global warming, low-carbon processing has been highlighted globally, which core content are low energy consumption, low emission and low pollution. The steel industry is one of the main resources of greenhouse gases emission, and contributes nearly 12% CO2 emission in China. The steel industry is also a field with high energy consumption and high pollution, it consumes nearly 14% whole domestic energy consumption each year.[1] In whole process of steel production, the energy consumption in iron making process accounts for nearly 70% of all. Therefore low carbon iron making would play an important role in energy saving. There are two 4038 $m^3$ blast furnaces ( BF) in Bayuquan branch company, Ansteel. By taking a series of measures such as improving gas utilization ratio to reduce fuel rate and energy medium consumption, raising the recycling rate of various resources, the energy consumption in BF system went down gradually. In September, 2009, the energy consumption reached to 365.9kg/t.Fe that kept the domestic advanced level.

## 2 TECHNOLOGY PROGRESS IN LOW CARBON OPERATION

The energy consumption mainly includes solid fuel consumption, motive power consumption and other resources recycling. The solid fuel are coke, coal, coke nut, dedusting powder in coke dry quenching system. Motive power consumption refers to the consumption of gas, water, electricity, steam, oxygen, compressed air, blowing and etc. Resources recycling means recycling and reuse of BF gas, waste heat produced in granulating system, TRT, hot stove waste heat, coke in gas ash and so on.[2] After continuously exploration, a series of achievement has been obtained such as beneficiated material technology, reasonable operation rule, efficient gas utilizaton, lower fuel rate and etc.

### 2.1 Beneficiated Burden Material Technology

Using beneficiated burden material is the basic rule for good performance of BF, and could guarantee a lower fuel consumption. The beneficiated burden material technology includes reasonable burden structure and high-quality materials. Bayuquan Branch Company locates in Bohai bay, nearby Yingkou port with wonderful geographic condition. In order to make use of the advanced condition of logistic, most of raw materials and fuels are imported by sea, in which the ore fines and lump ore account for a large proportion. Based on such an advantage, the BF burden structure was fixed at 70% high basicity sinter, 17% acidic pellet and 13% lump ore, and the sinter basicity varied from 1.95 to 2.10 according to the condition of acid material resources. The material of sinter comes from ore fines (mainly from Australia or Brazil) and was blended with a small proportion of local beneficiated ore. In the way of reasonable mix of magnetite and hematite, as well adoption of low temperature, thick material layer sintering technology, the high-quality sinter with high grade, good physical and metallurgical properties has been produced. The coke plays an irreplaceable role during BF process, especially to the large-scale BF because of the need for superior quality coke. In case of rapid development of large-sized BF, coke has to bear heavier burden and impact force, which easily results in coke degradation seriously. With adoption of optimized coal blending technology that classifies coal by style and two 7m coke oven equiped with dry quenching technology

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were put in production, both cold position and thermal state indexes satisfied BF's operation. Now the index M40 reaches to 88.5%, CSR to 66% and CRI to 23% respectively. The reasonable burden structure, high quality raw material and fule guarantee the lower energy consumption in BF system.

## 2.2 Exploring Reasonable Operation Rule, Raising Utilization Ratio of Inner Gas

The gas generated by combusting in tuyere zone goes upwards through the initial distribution, the second distribution in soft and melting zone and the third distribution at lump zone to the top. The utilization ratio indicates that if the gas could fully contact with burden, the chemical and thermal energy could be efficiently used. Thus rationalized distribution of inner gas is the only way to increase the gas utilization ratio and further leads to lower fuel rate. Since the BF blowing on, a series of technical measures have been taken for this purpose, which include activating hearth, leading upwards gas to keep wall and center gas go smoothly, adjusting the diameter and length of tuyere to ensure a suitable flowing kinetic energy and depth of cycling zone. To the upper charging mode, changing the burden distribution by adjusting charging chute angle to achieve a high gas utilization ratio. They are as follows.

1, trying to form a stable coke platform near the wall and move the ore slightly toward wall.

2, using coke center charging to form a surface shape in: edge platform+ hopper+ center coke to generate an inverted "V" soft and melting zone.

This charging mode could modestly restrain the wall gas flow, slightly lower the resistance in midst part(between wall and center) and make the flow easily go throw the center.

The change of charging mode can been seen in Table 1.

**Table 1.** change of charging mode before and after

| Chute position(total 11 rings) | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Before | O (ore) | | | | | 2 | 2 | 2 | 3 | 4 | 4 | |
| | C (coke) | 4 | | | | 2 | 2 | 2 | 2 | 2 | | |
| After | O (ore) | | | | | 2 | 2 | 2 | 3 | 4 | 3 | |
| | C (coke) | 5 | | | | 2 | 2 | 2 | 2 | 2 | 1 | |

The wall gas flow was also controlled by the small-size sinter charged nearby the wall and the platform.

The adjustment above made the gas distribution across the whole burden more reasonable, the gas utilization ratio approved and the gas distribution between wall and center more stable, which further led to a lower fuel rate. It is showed in Fig.1.

## 2.3 Maintaining Suitable Smelting Intensity, Reduceing Fuel Consumption

In a certain condition, there is a most suitable smelting intensity that matches to the lowest fuel consumption, and the fule rate would rise if the intensity were lower or higher. When the intensity kept too low, the amount of gas generated would be less, which could lead a worse gas distribution, inefficient energy utilization and high fuel rate. On the other hand, once the intensity went to too high, the gas volume would increase, and these overmuch gas could make it hard to form an energy-saving gas distribution in case of a heavier wall gas flow and open-up center gas flow. When the

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gas volume exceeds the limitation of gas permeability at soft and smelting zone, the phenomenon of liquid flooding happens somewhere in BF, which may result in a mess gas distribution and further leads to tubal gas flow and burden collapse. In the above case, the regular operation would be broken, the utilization ratio of gas thermal and chemical energy would go down and further lead to a high fuel rate. The Fig. 2 shows the variation of fuel ratio and integrated smelting intensity in a big company, and from which a "U" curve can been seen to show the variation of fuel rate and smelting intensity.

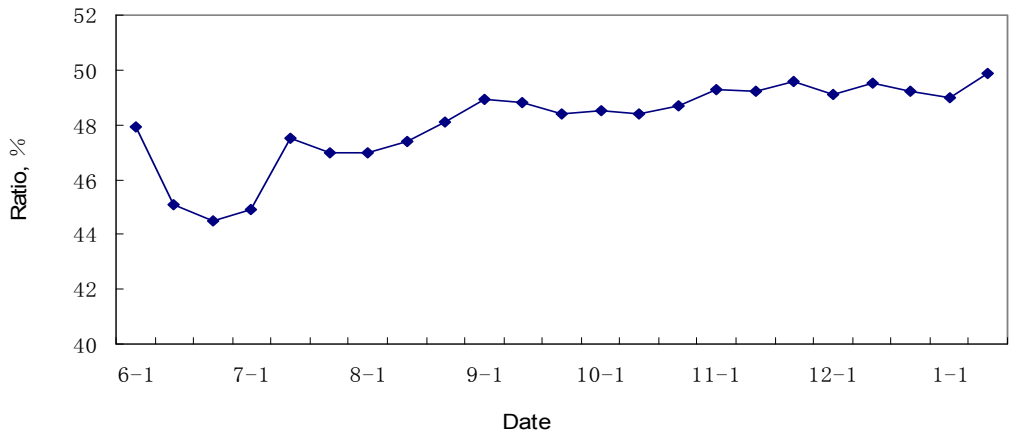


**Figure 1.** Variation of utilization ratio of gas with time in 2011

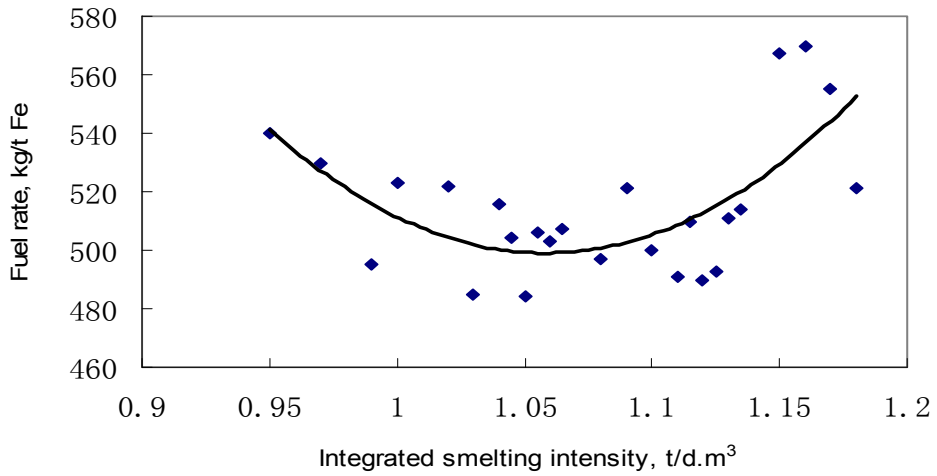


**Figure 2.** Variation of fuel rate and integrated smelting intensity

The measures such as reducing tuyere area to lower smelting intensity, adjusting charging mode for a reasonable gas distribution, modifying thermal and slag rules to make the hearth temperature higher and active, as well keeping a good fluidity for melted iron have been taken in Bayuquan BF system. In the Fig. 3, it can be seen that the fuel rate went down with the drop of smelting intensity, which shows that the prior smelting intensity exceeded the best point of fuel rate. In case of a certain smelting intensity and relative lower fuel ratio, some effective measures such as monitoring material and fuel quality, adjusting operation rules in time should be taken to keep a stable BF operation.

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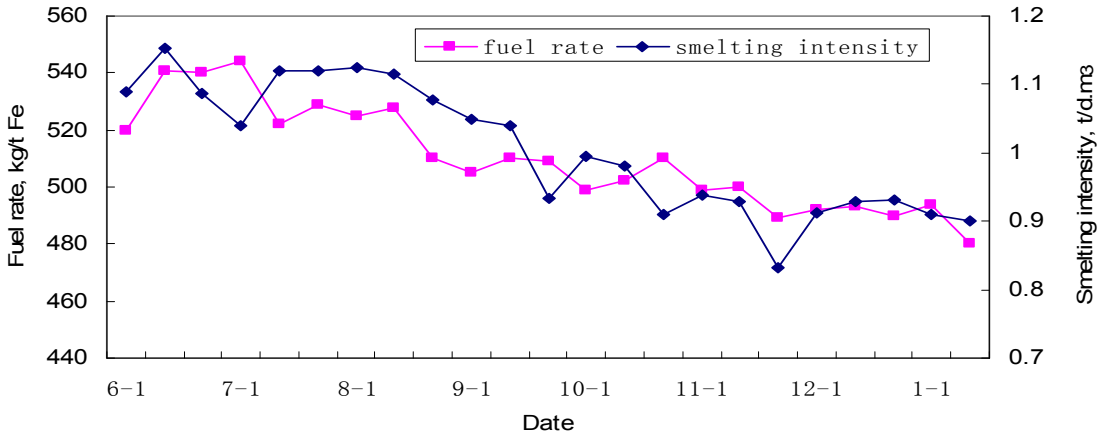


**Figure 3.** Variation of fuel rate and smelting intensity with time in 2011

## 2.4 Suitable Pulverized Coal Injection(PCI) Rate

PCI is one of the main approch in reducing cost of BF system, and by which the coke rate may be decreased greatly. But if just focusing on raising PCI rate, the combustion ratio of coal would go down and the fuel rate would go up. The table 2 shows the variation of C content in gas ash and PCI rate in Bayuquan BF. It can be seen that the amount of unburned coal out of the BF top went up in case of high PCI rate. Thus the suitable PCI rate should be fixed according to material and fuel quality, enriched oxygen, blast temperature and so on to guarantee a best fuel rate.

**Table 2.** Variation of C content in gas ash and PCI rate in Bayuquan BF

| Time | May 2010 | June 2010 | July 2010 | November 2011 | December 2011 | January 2012 |
|---|---|---|---|---|---|---|
| PCI rate(Kg/t) | 182 | 187 | 173 | 145 | 145 | 141 |
| C content in gas ash(%) | 59.3 | 48.7 | 55 | 44 | 29.5 | 46.5 |

In order to make the coal fully burnt in hearth and raise the coal replacing rate, the proportion of soft coal to blind coal in blending coal should be rational. With the character of high carbon content and lower burnning ability for blind coal and of high volatility and fast thermolysis and burning for soft coal respectively, blending these two kinds of coal comes to a complementary effect and could improve coal's burning rate and burning property. For example, in case of 40-50% soft coal,[3] 18-23% volatility of blending coal, more than 80% of -200 mesh coal powder, the burning rate of coal powder may reach a high level. In practice, by combining the four factors in oxygen enrichment, high temperature blowing, PIC rate and blowing air humidity, some operating parameters and rules are fixed, such as controlling the theoretical flame temperature in tuyere area to 2100°C-2300°C, using higher oxygen enrichment and higher blowing temperature to compensate the heat needed by coal powder temperature raising and decomposition, maintaining a higher temperature and active hearth to make the temperature of melted iron to 1490°C -1520°C, and keeping 2.1 productivity, 1225°C blowing temperature, 2% oxygen enrichment rate and etc. After a certain exploration, the suitable PCI rate in current condition should be 140kg/t, which can lead to a lower fuel rate (shown in Fig. 4).

ISSN 2176-3135

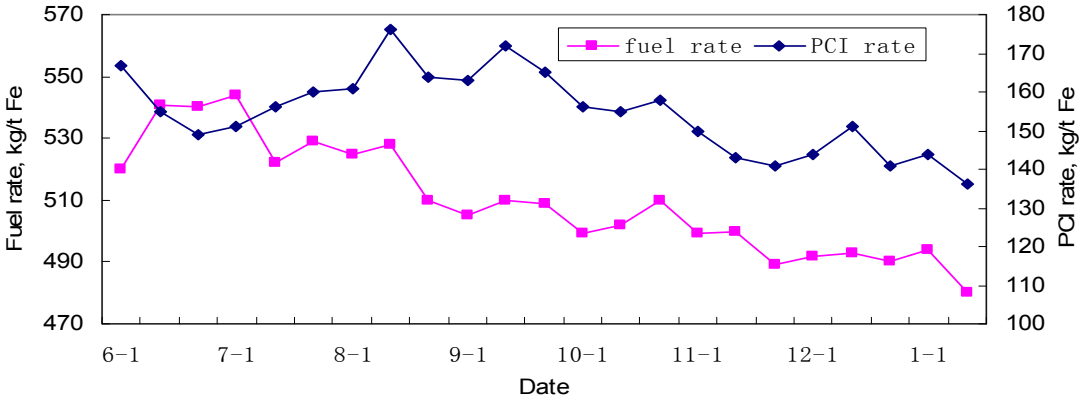


**Fig 4.** Variation of fuel rate and PCI rate with time in 2011

## 2.5 High Blast Temperature Technique

The effect of high blast temperature is obvious in saving energy, by which 10-15kg/t fuel rate could be saved in case of raising 100□ blast temperature. The external combustion Dider hot stoves have been built in Bayuquan with the pattern of three hot stoves matching one BF. The whole hot stove system was set as follows:

- Grid ceramic burner was adopted.
- Silicon brick was sued in the high temperature zone.
- A kind of hydraulic pressure supporting equipment was fixed at the bottom of combustion room.
- The waste gas is utilized to preheat air and gas.
- A combustion stove was built to burn BF gas to create high temperature exhaust gas, which is then mixed with the exhaust gas from hot stove to reach a 600°C mixed exhaust gas. This mixed gas will be used to preheat the combustion-supporting air and gas to 250-300°C.
- The waste gas of hot stove is used to dry coal powder.

The measures above ensure a 1250°C blast temperature in case of only using BF gas. In 2011, the average blast temperature is 1225□ and the gas consumption is 550m3/t Fe.[4]

# 3 APPLICATION OF ENERGY SAVING TECHNOLOGY

## 3.1 BF Top Pressure Recovery Turbine Unit (TRT)

TRT is a facility that transfers BF top pressure energy to mechanical energy and then to electric energy by turbine unit, by which part of the blast energy (normally 45-50% blower energy consumption) could be recovered. Now it has become a main approach of energy saving in BF system. The situation of electric power generation in recent years can be seen in table 3.

**Table 3.** situation of TRT electric power generation in recent years

| Year | 2009 | 2010 | 2011 |
|---|---|---|---|
| Total quantity of electricity Mil. kwh | 172 | 221 | 214 |
| quantity of electricity kwh/t. Fe | 32.63 | 34.35 | 34.95 |

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### 3.2 Technology of Generating Electricity by Recovering Gas

The by-product top gas of BF is mainly used as fuel for hot stove, coke oven and steel rolling system in Bayuquan. In order to recover the redundant gas, avoid the gas out into air to cause environment pollution, the Combined Cycle Power Plant (CCPP) and Gas Power Generating Boiler were built for the goal of gas zero release. The CCPP was put into use in May 28th, 2009, and it has been running very well with 45% power generating efficiency and 150.6 MW capacity. At present, total 1.22 billion kwh electricity is produced per year in case of using 2.63 billion $m^3$ BF gas and a certain amount of coke oven gas. Two Gas Power Generating Boilers were put into production in November, 2011, each of them consists of boiler, gas turbine, generator and etc. The gas consumption is $140\times10^3$ $Nm^3/h$ and the generator capacity is 20MW. The adoption of CCPP and Gas Power Generating Boiler realized 100% utilization ratio of BF gas and zero gas emission, and could further bring great benefit in enegy saving.

### 3.3 Recovery and Use of Hot Water Produced by Slag Granulating System

The waste heat of molten slag that equals to 60kg coal equivalent per ton slag is the only secondary energy not being used properly in steel company. The slag itself has be utilized as a kind of raw material but the use of its waste heat still remains unsolved. Considering the location of Bayuquan Company is in north part of China and lower temperature in winter, a certain percentage of the hot water was put into use in warming system for local resident. In this system, the hot water is pumped into heat supply system with a temperature drop of 10°C (from 80°C to 70°C) after circling. The whole system covers $200\times103m^2$ area and recovers 60MW/h heat. It not only improves the effect of granulating but also saves a great deal of energy during winter.

### 3.4 Saving Electricity Technology

Four high-pressure fans for transporting coal powder were built in Bayuquan with adoption of baffle plates fixed at door to adjust air quantity. In general, open angle of the plate is less than 40°(90°means totally open), which may cause most of energy is consumed at the plate and lower running efficiency with higher energy losing. By means of adopting frequency convertor to control the electric motor in high-pressure fan, plentiful energy has been saved by now. The four fans with frequency convertor have been put into use in March, 2011 and are running well in the effect of 60% electricity saving rate. In next step, a series of frequency techniques will be carried out at burner blowers, dedusting fans, slag granulating pumps and so on to achieve a goal of saving electricity.

### 3.5 Technology of Coke Oven Gas Injection

The amount of coke oven gas produced in Bayuquan each year is about one billion $m^3$, in which nearly 0.16 billion $m^3$ is redundant and sometimes was discharged wastefully into air. Because coke oven contains high percentage of $H_2$, which has great advantage than C and CO such as higher reduction rate, less heat consumption and the reaction product is $H_2O$, injecting coke oven gas into BF would be beneficial in raising BF productivity. By means of replacing high-pressure air with coke oven gas to cool down injection gun, the coke oven gas could be injected into

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BF. For safety reason, the air and gas double-purpose compressor was adopted, and the ball valves were installed in whole system with a remote-control system. Injecting coke oven gas may lower fuel rate, reduce $CO_2$ emission and realize utilization ratio of the high quality gas. Now the project is in the stage of pilot run and would unquestionably be a meaningful attempt for low carbon BF operation.

## 4 CONCLUSIONS

With the help of a series of measures including using beneficiated burden material, adopting reasonable operation rule to raise gas utilization ratio, keeping a suitable smelting intensity and PCI rate, and high-temperature blowing, the fuel consumption has been improved gradually with the increased rationality of the inner gas distribution. At the same time, by using TRT, CCPP, hot water recovery in slag granulation process, frequency convertor in fan, coke oven gas injection and so on, the whole energy consumption in BF system has been further reduced and the goal of low carbon operation is approaching.

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