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Analysis of the Energy Efficiency in the Large Enterprises from an Industrial Ecology Perspective: Case Study from BaoGang Group

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Abstract

According to the industry ecology theory, in the simulating flowing way between substance and energy in the nature ecology, to design the industrial production systems can use less resource reasonably and reduce emissions. As the most important large iron & steel enterprise in Inner Mongolia, applying the theory of industrial ecology, the Baogang Group gains great achievement in energy saving and emission reduction in recent years. Based on the industrial ecology theory, this paper mainly analyzes the practice of energy-saving and ejection-decreasing of the BaoGang Group.

Keywords: Industry Ecology, Energy-Saving and Ejection-Decreasing, Energy Comprehensive Utilization

1. Introduction

Iron and steel industry is not only a pillar industry in national economic development, but also an energy-intensive industry. The problem in the traditional iron and steel industry is that the irrational industrial structure, backward technology and equipment, low productivity is very conspicuous[1]. The situation of high energy consumption, high pollution and low efficiency caused the over-consumption of the natural resources and the deterioration of ecological environment[2]. Resources, environment and other factors become the bottleneck of sustainable development of iron and steel industry. To solve these prominent problems such as resource waste and environment pollution, iron and steel industry currently facing in the process of the development of iron and steel industry, we must change the resources-
products-waste model of development which was used foretime, through the resources-products-renewable resources feedback process to achieve low extraction, high efficiency and low emissions, make resources and energy recycle as much as possible, and make the impact of the activities of the iron and steel industry on environment reducing as little as possible, which is the key to the sustainable development strategy of the iron and steel industry [3].

Industrial Ecological Theory [4] (Robert Frosch & Nicolas Gallopoulos, 1989) pointed, we can design an industrial production system which is a new and ecological industrial production system or a formation of industrial production organization, which based on ecological principles of nature, from the business community and the regional level to start, models on material and energy flow patterns of the natural ecosystem. The theory of industrial ecology has been widely used, after years of its development. Its application is divided into three levels: the first level is within the enterprises, discussing how to use resources most reasonably and reduce emissions from the overall perspective of the enterprise, including life cycle analysis, environmental design and ecological efficiency; the second level is to consider in mutual cooperation between different enterprises and constituted a complete industrial ecological chain in an industrial system, in order to obtain more benefits than individual behavior of individual enterprise, through optimizing the overall benefits which is available to get off individual behavior of individual enterprises; the third level is to consider a regional network of the eco-industrial. [5]

Since the beginning of the “11th Five”, the BaoGang Group has implement the theory of industrial ecology, invested heavily and gradually established a covered all aspects of production of resource recycling system, made steel industry advanced technology for energy conservation (include six categories of 32) which is widely used. In the ranking of China Energy Green Enterprises “Top 50”, the enterprise ranked the first for the first time.

2. Analysis of motivation of the application of industrial ecology theory in the BaoGang Group

Before 2005, the reasonable utilization of energy and energy-saving and ejection-decreasing and environmental protection of the BaoGang Group is relatively backward. We will take the 2003 as example.

2.1. The production structure is unreasonable, economic and technological indexes are backward

From Table 1, we can find that the main economic and technological indexes of the BaoGang Group are lagging behind basically in 2003; the comprehensive energy consumption of per ton steel is higher than the average of the major domestic steel enterprises 160kgce/t, all the energy consumption of the raw material system process is high, the energy consumption of three major production process (iron, sinter, coke) is all higher than the average of the major domestic steel enterprises 70kgce/t, this is one of the main reason that caused the higher energy comprehensive consumption of per ton steel, and the ratio is higher that reached up to 1.01:1 in 2003, higher than the average of the major domestic steel enterprises 0.049, made the energy comprehensive consumption increase 35kgce/t, the problem is the structure of production is irrational.

Table 1 the comparative table of technical and economic indexes between the BaoGang Group and the major domestic steel enterprises

<table>
<thead>
<tr>
<th>Enterprise</th>
<th>AG</th>
<th>SG</th>
<th>WG</th>
<th>BG</th>
<th>MG</th>
<th>TG</th>
<th>PG</th>
<th>HG</th>
<th>BG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy consumption of per ton steel(kgce/t)</td>
<td>889</td>
<td>794</td>
<td>786</td>
<td>994</td>
<td>780</td>
<td>761</td>
<td>946</td>
<td>776</td>
<td>1019</td>
</tr>
<tr>
<td>Energy consumption of</td>
<td>158</td>
<td>168</td>
<td>135</td>
<td>146</td>
<td>162</td>
<td>156</td>
<td>108</td>
<td>126</td>
<td>166</td>
</tr>
</tbody>
</table>
2.2. Large energy consumption, low recovery ratio of waste heat and energy

The energy consumed by iron and steel enterprises is the primary energy and secondary energy, the primary energy mainly includes coal, purchased power and industrial water, the secondary energy is produced by companies mainly includes gas, from power generation, waste heat steam, recycling water, and so on\(^6\).

The coke and coal (coke iron integrated) volume of the BaoGang Group in the ironing process was large, from Table 1, we can see that the coke and coal volume was higher than the average volume of the other major domestic steel enterprise 47kg/t, calculating in accordance with the current production of 5.3 million tons iron, it could consume 25 million tons of coke every year. The emission rate of the blast furnace gas and coke oven gas were higher than the average level of major steel 10 percentage points and 5.27 percentage points respectively, the emission volume of this two kinds of the gas was \(1.63 \times 10^9\) m\(^3\) and \(5.74 \times 10^7\) m\(^3\) respective, a total of 0.235 million tons of standard coal equivalent. Converter gas recovery amount is significantly lower. These made a lot of valuable gas resources were wasted and environment was polluted. The fresh water consumption per ton of steel up to 16.6 m\(^3\) of the enterprise, higher than the average volume of the other major domestic steel enterprise 5.5 m\(^3\), the enterprise consumed nearly 30 million m\(^3\) more than the other major domestic steel enterprise yearly.

2.3. Low Eco-efficiency, and environmental pollution is serious

Before 2005, because of the large energy consumption, low recovery ratio of the second energy, the BaoGang Group had a high production cost, at same time, the enterprise put out a lot of industrial waste, wastewater and three kinds of gas; these not only wasted a lot of energy, but also throat the environment around the enterprise.

So, the enterprise formed a consensus that they must increase energy efficiency and energy-saving and ejection-decreasing efforts, it is an important measure of cost-reduction and efficiency-increasing.

3. The energy utilization of ecological model of the BaoGang Group and analysis of the BaoGang Group’s benefits in energy-saving and ejection-decreasing

3.1. The energy utilization of ecological of the BaoGang Group
Since “The 11th Five”, the BaoGang Group effectively implemented the energy utilization of ecological model and earnestly implemented the “three dries, and three utilizations” advanced technology that popularized and applied by iron and steel industry, and the BaoGang Group actively arranges the ecological model of energy utilization projects.

Table 2 shows the steel production and the important technical and economic indexes from 2000 to 2009. We can see from the table, during nine years, energy conservation reached 2.71 million tons standard coal, annual mean energy saving is 0.301 million tons standard coal, steel production increased 2.66 times, the total consumption of energy only increased 1.71 times. This indicates the BaoGang Group has a qualitative leap in energy utilization of ecological model.

Table 2 the important technical and economic indexes of the BaoGang Group during 10th five years

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel production (million tons)</td>
<td>3.78</td>
<td>3.909</td>
<td>4.816</td>
<td>5.251</td>
<td>5.431</td>
<td>7.015</td>
<td>7.485</td>
<td>8.839</td>
<td>9.839</td>
<td>10.07</td>
</tr>
<tr>
<td>Energy consumption of per ton (kge/t)</td>
<td>1115</td>
<td>1072</td>
<td>1068</td>
<td>1019</td>
<td>972</td>
<td>892</td>
<td>779</td>
<td>769</td>
<td>737</td>
<td>717</td>
</tr>
<tr>
<td>Freshwater consumption for producing per ton of steel (m3/t)</td>
<td>28.7</td>
<td>27.8</td>
<td>23.6</td>
<td>19.75</td>
<td>14.9</td>
<td>9.8</td>
<td>7.95</td>
<td>7.45</td>
<td>6.95</td>
<td>6.72</td>
</tr>
<tr>
<td>Quantity of spontaneous electric power (billion kwh)</td>
<td>0.22</td>
<td>0.366</td>
<td>0.608</td>
<td>0.612</td>
<td>0.655</td>
<td>0.739</td>
<td>1.1</td>
<td>1.348</td>
<td>1.87</td>
<td>2.911</td>
</tr>
<tr>
<td>Irradiation of blast furnace gas (%)</td>
<td>7.2</td>
<td>8.3</td>
<td>14.5</td>
<td>16.82</td>
<td>8.5</td>
<td>12.6</td>
<td>6.9</td>
<td>11.7</td>
<td>5.9</td>
<td>2.9</td>
</tr>
<tr>
<td>Total recovery of converter gas (m3/t)</td>
<td>11.8</td>
<td>13.1</td>
<td>13.6</td>
<td>28</td>
<td>38.5</td>
<td>40.6</td>
<td>49.7</td>
<td>54.4</td>
<td>46.1</td>
<td>82.2</td>
</tr>
</tbody>
</table>

3.2. The implementation of three dries technology

(1) From April 2006 to the second quarter of 2007, dry dedusting technology of six blast furnaces of the BaoGang Group had successive ploughed into use. Compared with the original wet dedusting, the six blast furnaces cloud save turbid circulating water 57.25 million tons and reduce the supplement of new water 2.8 million tons. After the dry dedusting technology increases the temperature of gas, corresponding electric energy production increased 40%, which cloud save electric power cost 50 million Yuan annually.

(2) Since 2005, the BaoGang Group has built three sets of CDQ-Coke Dry projects already that can realize the stable production power at present. It can recycle 80% of 1000 Celsius red coke heat to product steam and generate electricity; this would reduce energy consumption of coking process and enhance quality of coke. The achievement of dry dedusting technology will reduce coke ratio of a blast furnace 2% to 5% and improve the capabilities of production of blast furnace about 1%, in terms of blast furnace process the extension of benefits can be achieved about 30 million Yuan every year. In 2009, generated electricity 247 million KWH, solved environmental pollution which made by wet dedusting technology, the focus has obvious economic benefits and social benefits.

(3) In 2006, two 100 tons converters’ converter gas recovery project and dry dedusting project and afterheat recovery project of the first steelworks, two 210-ton converters’ converter gas recovery project and dry dedusting project and afterheat recovery project of the second steelworks were completed. The effect is very significant.
3.3. The implementation of “three utilization”

(1) Make full use of three kinds of gas, reduce the rate of radiation.

In October 2005 and April 2006, the newly completed two 130-ton boiler that can clean burn gas and their assorted two generators can generate electricity 33 million KWH, they can burn blast furnace gas 0.24 million m3, reduce the radiation rate of blast furnace gas effectively, the direct economic benefits is about 4.342 million Yuan.

In recent years, thermal power plant transformed coal-burning boiler into pure blast furnace gas-burning boiler, the implementation of this project would reduce BFG radiation rate by more than 0.6 million m3 per hour, reduce outsourcing steam coal by 1.114 million. The indirect economic benefits is about 450 million Yuan.

CCPP (Gas-Gas-Steam combined cycle power units) was put into use in 2008, it fully utilized surplus operation, cut BFG radiation rate and coke oven gas radiation rate sharply, in 2008, BFG radiation rate and coke oven gas radiation rate were respectively reduced to 2.78% and 5.92%, compared with 2007, respectively reduced by 5.78 and 1.1 percentage point.

In 2009, the BaoGang Group’s recovery of converter gas reached 0.826 billion m3. Compared with the number in 2008, the recovery of converter gas increased by 0.373 billion m3. Ton of the converter gas 82.2 m3 cubic metres, compared with that in 2008, it has increased by 36.2 m3. It’s the first time that realized all of converters energy saving steelmaking.

(2) Efficiency of water-saving has increased year by year.

From 2000 to 2009 the BaoGang Group’s steel production growth is 166%, but fresh water consumption steel per ton has been down from 28.73 tons to 6.72 tons, reduced by 76.6%, the fact realizing water saving and production increasing, was ahead of pace to meet the goal that fresh water consumption per steel ton went by 8 tons by 2010 which request by national steel industry policy. Industrial water reuses reached 94.46%.

General water circulation of the enterprise has been optimized. The BaoGang Group has invested 160 million Yuan, by 2003, the enterprise has completed the total sewage treatment project, and this projection can treat 6000 tons wastewater every hour, make water resource management change from simple end treatment to overall process cantonment. This not only reduces the quantity of water from the Yellow River and out-emission amount of wastewater which reaches the standard, but also greatly improves the recycling ratio of recycling water.

(3)The comprehensive utilization of coal and coal slurry in by-products resources.

In order to reduce the production cost, and reduce the environment pollution, at the same time of the thermal power plant boiler increasing usage amount of blast furnace gas, coal ratio and coal slurry ratio can reach 20%. From 2001 to 2009, the amount of middings and coal slurry which used by admixing reached 1.215 million tons, reduced the purchasing of power coal, and cut the total cost nearly 119 million Yuan.

3.4. The implementation of the Environmental governance

In 2007, the enterprise invested 767 million Yuan in 26 items important environment comprehensive treatment of important polluted area included iron works, steel works, coal-oven plant, and concentrating mill and so on, and regional environmental conditions improved obviously, total emission was controlled. The discharge of sulphur dioxide was about 5000 tons and the discharge of COD was about 1500 tons year round.

On the aspect of comprehensive utilization of dump, the BaoGang Group successfully built 7 brick making production lines, and they can consume steel slag 0.17 million tons. The blast furnace slag can become cement material through water treatment. The super-fine steel slag powder projection which was
already put into use can consume steel slag 0.8 million tons, and can form a new building materials industries that with steel slag as the main materials and with ash as the auxiliary materials. The change that transforms coal-burning to gas-burning of thermal power plant boiler and steel works lime kiln, this is not only realizes coal recourse saving, polluted emissions reducing, but also effectively uses the gas resources, reduces production cost, reduces sulfur dioxide emissions 7500 tons. The investment and utilization of CCPP makes the quantity of sulphur dioxide reduce 4250 tons, it has more obvious effect in the utilization of water resources aspect and the emission of pollution aspect, as mentioned above.

4 Conclusion

Although the BaoGang Group has taken the ecological model that could use energy synthetically and obtained considerable economic benefits and social benefits in energy conservation and emission reduction during “the 10th Five”, both home and abroad, and some advanced large iron and steel enterprises, are still relatively backward. This will need to further learn from advanced enterprise, continue to improve the energy management system for energy conservation and emission reduction, make the long-term strategic objectives, optimize production process, improve the technical level, implement the new technology and new technology of energy conservation and emission reduction, improve the second energy utilization ratio, and reduce environmental pollution in order to really realize resource conservation and environment friendly enterprise.

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Du Yongwei (1961), male, associate professor, master tutor, Research direction is economic management and resource management, (Inner Mongolia Autonomous Region of Higher School Science Research Project, Project Numbers NJSY08078), (Ministry of Education ChunHui Project, Project Numbers S2009-1-01002)

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