ISSN : 0974 - 7435 Volume 10 Issue 6

BioTechnology
An Indian Journal

FULL PAPER

BTAIJ, 10(6), 2014 [1621-1625]

Iron and steel enterprise energy optimization model for the minimum energy procurement

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ABSTRACT

In order to solve consumer issues about purchasing raw materials in Iron and steel enterprises, byproduct gas - steam - electric energy optimization model is proposed. The model is mainly for the steel companies on transformation between byproduct gas energy, steam energy, and electrical energy, so that the recovery energy can meet the demand for process and electricity, get optimal utilization in gas and steam, and achieve the minimum value of raw materials Procurement in enterprise. Finally, by programmed and software emulation to obtain optimal efficiency and minimum value in consumption. The model is based on the rational allocation of secondary energy, so that Iron and steel enterprises can purchase necessary energy reasonably.

KEYWORDS

Energy optimization;
The minimum energy procurement;
Optimization model;
Gas-steam-electric.

INTRODUCTION

At present, tough market conditions, the problem of resources, energy and environmental constraints are increasingly severe; China's key steel enterprises in the sintering, coking and other important processes have a gap energy consumption compared with the international advanced level, secondary energy recycling efficiency is not highly, energy management system still needs improvement[1-3]. How to make full use of iron and steel enterprises surplus energy[4], for example: gas, thermal[5], electricity, power and steam, is the direction of social as well as the national concerning. So much rich energy, on the basis of meeting supply and demand balance, play their nature, make the entire energy value of the minimum, achieve the target constrained in production run, improve the utilization of secondary energy[6], at the same time, meet the business production plan, for companies to reduce the purchase of consumer.

IRONS AND STEEL ENTERPRISES ENERGY

Steel companies have many processes with complex, rich in resource, roughly divided in: sintering process, coking process, blast process, and the converter process and so on. System is mainly composed of: iron making, steelmaking, casting, rolling, etc.[7]. As technology improved, utilization of steam is broadening, in the northern region, winter is also the time to take advantage of it as the primary purpose of heating; summer will be converted to electricity generation as refrigera-

tion systems. Therefore, from the perspective of energy use analysis, Iron and steel enterprises is not only a large number of surplus gas can be stored according to the gas tank, and may be make the limited gas resources allocating to the corresponding buffer steps reasonable, or supplied directly to the outside, access to natural gas, liquid gas, electricity, etc., and Convert economic interests. In the steel industry complex process, a lot of heat generated, including waste heat, intermediate products or product sensible heat and latent heat, also a lot of steam generation, as one of the important secondary energy, and extensive use of steam, across various production systems in enterprises. Therefore, if closely contact and analysis the individual energy, can known that can be converted between each other, so that you can fully mobilize all secondary energy. This conversion can make more than the energy to do its duty, fully display their strengths, improving secondary energy utilization, and improve the economic efficiency of enterprises.

ENERGY ANALYSES

Secondary energy

Iron and steel enterprises purchased energy mainly make of coal, electricity, gas, etc. Other energy come from transformation, its energy system consists of: coal, gas, electricity, water, and steam, and several other subsystems. As one of the necessary energy for the media in iron and steel enterprise production, steam acts as an important role, about 10%. Of these, about 70% of recyclable waste heat steam. Similarly, by-product gas as an important secondary energy, accounting for about 40% of total energy consumption in enterprises, and today is the existence of a common phenomenon is the amount of gas produced is always greater than the consumption of production processes, accurate adjustment of gas consumption, avoid un-buffered, dissipate a lot of wasted energy situation. As another important steel heat energy, accounting for about 37% of energy consumption, to waste gas, waste products and other forms of heat consumption.

Byproduct gas

Iron and steel enterprises about 70% make of the coal, and about 30% of feed produced through the reaction of work as the blast furnace gas (BFG), converter gas (COG), coke oven gas (LDG) and other byproduct gas[8], the synthesis gas is a clean energy is also an important chemical raw material. Coke oven gas and blast furnace gas is the calorific value of the gas[9], can be used as fuel for civilian. It mainly components of carbon monoxide methane hydrogen oxygen carbon dioxide unsaturated hydrocarbon nitrogen small amount of hydrogen sulfide tar and phenol water. In fact, the generation of product gas is not stable, most need to long-distance transportation, when the device is started or stopped burning, can lead to Vice coal airway network pressure fluctuations. Thus, the efficient use of by-product gas is a challenge[10,11].

Steam

The use of steam is in an important position in the iron and steel enterprises, and mainly generated through high temperature by flue gas waste heat boiler, the heat from sintering and coking process, after internal heating boiler production remaining steam, as well as power generation by steam power generators after the backpressure steam, and other recycling, etc.. Steam

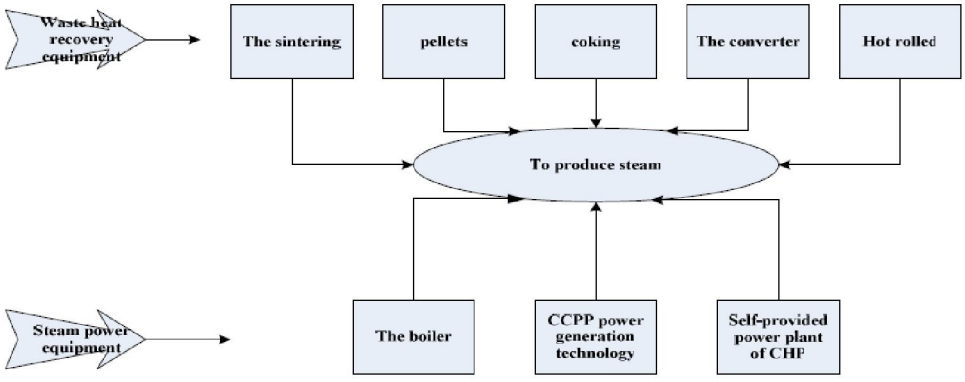

Figure 1 : Steam generator subsystem flowcharts

is mainly carried out in accordance with the role of dynamic action and thermal properties of the two use their own ways. In the steel industry, the steam is equivalent to a very important system. It mainly constituted by three subsystems: generating subsystem, conversion transport subsystem, and the user subsystem[12]. Steam system structure diagram is as follows:

Produce waste heat recovery equipment subsystems into power generation and steam generating equipment, the flow chart for it:

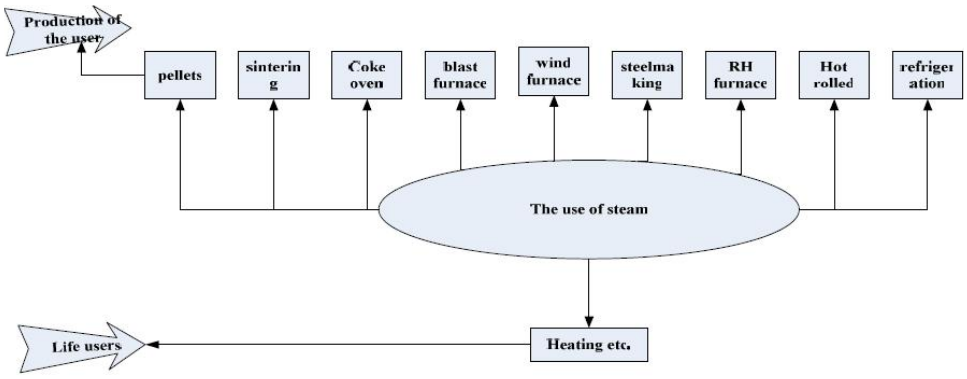

Figure 2 : Ways to use steam flow chart

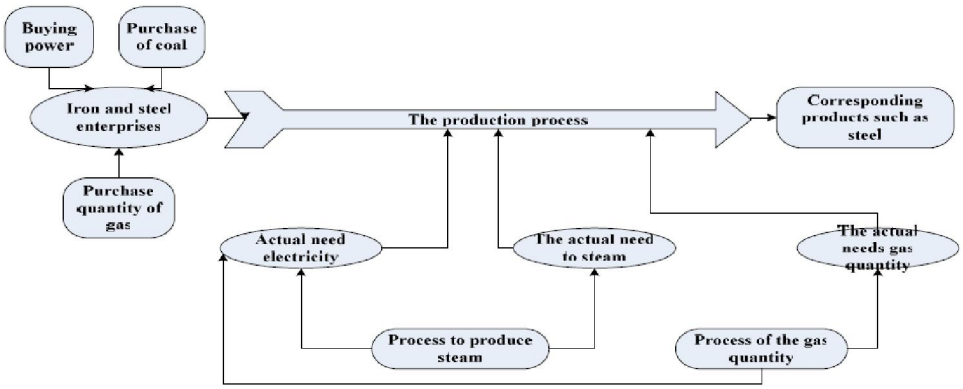

Figure 3 : Research in energy system flow chart

Vapor collection needs arising converted transport subsystem accumulator pressure reducer and other after the steam network supply subsystems. Therefore, the use of steam and living way into production user use[13,14], the flow chart as follows:

The establishment of energy optimization model

From the above analysis, the steel internal complexity, involving extensive range of secondary energy, fully schedule of the energy, is a top priority in energy conservation. Under the overall consideration based on the ideal of steel, research byproduct gas, steam and electric energy as the main target, in the iron and steel enterprises, the main part of the need to purchase listed as electricity, coal, gas volume three raw materials, after the step of using the product to produce the corresponding products of steel, etc., under the production process will generate a lot of use of byproduct gas, steam. Actual production process may be produced in the same part of the corresponding need to consume energy, that part gas, and part of the steam production processes need to return to the secondary use, if not all that is required under the circumstances, the remaining gas and steam through the use of various technologies, such as power generation, to meet the electricity demand in production processes.

According to the study flowchart is:

According to the flowchart, energy optimization model is:

Objective function:

$$\min Y = M \times y_m + Q_D \times y_d + Q_V \times y_g \quad (1)$$

The objective function represents the enterprise value of the purchase or consumption of raw materials in a minimum.

Among: Y-represents the total value of the purchase price, Yuan; M-represents the amount of purchasing

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coal, t; Q_D-represents the amount of purchasing electricity, KWh; Q_V-represents the purchases of gas, m^3;

y_m,y_d,y_g-represent the purchase of coal, electricity, gas single value,t/Yuan, KWh/Yuan, m^3/Yuan;

On the basis of the conditions of the process equipment is working properly and establishes the constraints:

The constraints for gas energy:

$$\mathbf{a:}\ Q_{gas} \le Q_V + Q_{g1} \times \alpha \quad (2)$$

Among: Represents the sum of the purchase and the amount of gas recovered part of the production process to meet the demand for gas; Q_{gas}-expressed enterprises byproduct gas demand, m^3; Q_{g1}-represents the amount of gas generated in business processes, m^3;

α- representation byproduct gas usage for process requirements, %;

$$\mathbf{b:}\ Q_{g1} \le \eta_1 \times M + \lambda_1 \times Q_D \quad (3)$$

Among: Said production step, the electricity consumption of coal and the amount of gas that can be produced to meet the conditions; η_1- represents coal consumption rate,%; λ_1- means power consumption,%;

$$\mathbf{c:}\ Q_{g1} \times \alpha \le Q_{1,c} \quad (4)$$

Among: Recover part of the gas used in the gas to meet the storage cabinet; $Q_{1,c}$-means that the storage capacity of the gas tank, m^3; the energy of the steam constraints:

$$\mathbf{a:}\ Q_{zh} \le Q_{z1} \times \beta \quad (5)$$

Among: Said part of the recovery process steam to meet the demand for steam; Q_{zh}-expressed demand for business process steam, kg; β- Said demand for its own processes using recycled utilization rate%; Q_{z1}-enterprise represents the amount of steam generated in the step, kg;

$$\mathbf{b:}\ Q_{z1} \le \eta_2 \times M + \lambda_2 \times Q_D \quad (6)$$

Among: Said production process, the amount of coal and steam consumption of electricity can be generated to satisfy the condition;

$$\mathbf{c:}\ Q_{z1} \times \beta \le Q_{1,s} \quad (7)$$

Among: Said vapor recovery storage capacity needed to meet; $Q_{1,s}$- means steam storage; The electric power constraints:

$$Q_{di} \le Q_D + (1-\alpha) \times Q_{g1} \times \mu_1 + (1-\beta) \times Q_{z1} \times \mu_2 \quad (8)$$

Among: Said power need to meet conditions; μ_1-said the conversion rate of product gas as converted to electricity,%; μ_2-said the conversion rate of steam as converted to electricity,%;

For the conversion rate constraints:

$$\mathbf{a:}\ 0 \le \alpha \le 1$$

$$\mathbf{b:}\ 0 \le \beta \le 1 \quad (9)$$

For non-negative constraints:

$$M, Q_D, Q_V, Q_{g1}, Q_{1,c}, Q_{zh}, Q_{z1}, Q_{1,s}, Q_{di} \ge 0 \quad (10)$$

THE MODEL RESULTS ANALYSIS

Select an iron and steel enterprises to use energy optimization model analysis[6]; ideally set byproduct gas demand is 70, the amount of gas produced is 80, the demand of steam energy is 60, generation of steam energy itself is 80, power demand in enterprise is 200, for the purchase of raw materials coal is 80 tons. On the current situation, the coal price is set to 2,000 Yuan, The price of electrical energy is set to 0.53 Yuan, and the gas purchase price is set at 2.31 Yuan.

Programming and simulation in MATLAB software

TABLE 1 : Set a variable's value

Name	Set the value
The gas consumption values	70
Steam consumption value	60
Power consumption value	200
The gas generated values	80
The steam produced value	80

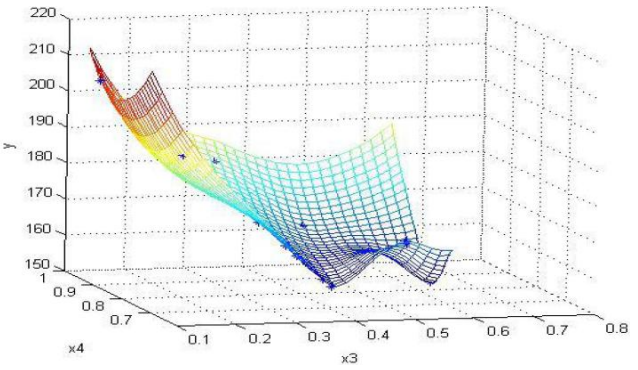

Figure 4 : The simulation diagram

TABLE 2 : Set a variable's value

Name	Set the value
The gas consumption values	100
Steam consumption value	100
Power consumption value	200
The gas generated values	80
The steam produced value	120

to get the results of the research target value and effect of the graph is:

Model is the optimal corporate minimum consumption is 160,000 +152.122Yuan. The value of the gas used in the production process is 65.52%, the steam value used in the production process is 80.9%, and last is used to generate electricity.

Or in another setting is as followed:

So, such a case, do not need to purchase power, all gas for power generation, and 41.39% of the steam for process use, The rest can be used to generate electricity. And at this time, what to obtain the value of raw material purchase is the minimum.

CONCLUSIONS

The establishment of the multi-energy optimization model, making the minimum consumption of steel companies, rational use of energy, rational distribution of energy usage, play model advantages in energy saving targets in complex processes. Based on the iron and steel enterprises throughout the ideal system, modeling. The shortcomings of this model is a static model in consideration, using classification process in a matter of time and energy production cascade is the main research goals for future, making the product gas in blast furnace gas, converter gas usage and various coke oven gas to get precise conversion rate, the steam in high-pressure steam, medium pressure steam, low pressure steam and other categories of energy, on the basis of this model, get accurate conversion rate, making iron and steel enterprises to a new level in energy saving.

ACKNOWLEDGEMENTS

This work was supported by key deployment project of Chinese Academy of Sciences (KGZD-EW-302), Liaoning Provincial Office of Fund (2012219001) and Liaoning Provincial Office of Education Fund (L2013157).

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