# *Research on Gas Supply and Demand Forecasting Model of Iron and Steel Enterprises and Comparative Analysis of Examples*

**Lianyong Wang[1], Yifan Yang[1,*] and Chao Liu[2]**

*[1]School of Metallurgy, Northeastern University, Shenyang, China*
*[2]Shenyang Aluminum & Magnesium Engineering & Research Institute Co., Ltd., China*
*a. yyfneu@126.com*
**Yifan Yang*

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***Abstract:*** Gases are important iron and steel enterprises secondary energy, while the study on the supply and demand forecasting method of the gas system in Iron and steel enterprises is the basis of achieving scientific scheduling on Gas Resources. It is of very important significance to reduce energy consumption per ton, to reduce gas emission and to improve the economic efficiency of enterprises with an effective means that can accurately predict gas resources and scientific control. The article takes an example for the generation of the blast furnace gas, combined with the historical production process data of an iron and steel enterprises, making a comparative analysis between the model established by causal analysis forecasting method and moving average forecasting method from time series prediction method. The analysis result points out that the prediction by our model can fit the requirement of warning of gas schedule well. Its prediction accuracy is high, and it is more suitable for practical production.

## 1. Introduction

Researchers at home and abroad have carried out researches to improve the energy-saving level of blast furnaces and proposed a series of new theories and new methods [1, 2, 3]. Some foreign scholars applied the second law of thermodynamics to analyze the energy conservation of the system, which played a guiding role in industrial production [4, 5, 6].

The steel manufacturing process is an irreversible process in which the two factors of process complexity and time evolve in the processing system [7]. Material flow and energy flow are independent and interconnected and restrict each other. Material flow is the main body of steel production, and energy flow promotes the flow and transformation of material flow. When product specifications and production are constant, they determine the resources and energy efficiency of the company [8].

Study the flow of energy, discover the migration patterns, and seek energy-saving measures. Academician Zhongwu Lu and Professor Jiuju Cai of China studied the interaction between material flow and energy flow in the whole process of steel production, pointing out that the energy consumption of tons of material is influenced by material flow and energy flow. In terms of material flow, any input of Fe-containing materials from the outside to an intermediate process will be conducive to energy conservation; any Fe-containing materials that are exported from the process to the environment, returned to the upstream process, and recycled within the process will increase energy consumption; In terms of energy flow, increasing energy by-products, waste heat and residual energy can reduce energy consumption. This method of studying the energy consumption of steel processes is called e-p analysis [9, 10].

The energy of the blast furnace is input by using coke, pulverized coal, and other materials as the carrier. After the complex reaction in the furnace, the iron and water, blast furnace gas and other substances are used as the carrier. The utilization of the output energy determines the level of energy recovery. Therefore, a predictive analysis of energy flow plays an important guiding role in actual production.

At present, the methods of energy flow prediction in iron and steel enterprises mainly include expert experience prediction method, time series prediction method, neural network prediction method and causality prediction method.

With the development trend of the steel industry in the direction of informatization and automation, the expert experience forecasting method will gradually be difficult to adapt to the actual production needs of modern steel enterprises and will be eliminated; Time series analysis and prediction based on historical data can only make reasonable predictions under normal working conditions. Once the working conditions change, the regularity is broken, which will produce a large prediction bias; The neural network method is too complicated and is not suitable for the development trend of informatization. The factors affecting the fluctuation of energy flow in the steel industry are numerous and complicated, and it is of great practical significance to realize the prediction of energy flow based on the change of material flow.

The so-called causality prediction method is a method of using the causal relationship of the development of things to speculate on the future development trend of things. This method uses the variables that need to be predicted as dependent variables, and analyzes the factors that affect it, to determine which variables to take as independent variables and to analyze how these factors work on the predictors. Then establish a first-off mathematical model and predict it by solving the mathematical model.

The so-called moving average prediction method is a simple smooth prediction technique. Its basic idea is: according to the time series data, item by item, the calculation of the sequence time average value containing a certain number of items to reflect the long-term trend. Therefore, when the value of the time sequence period due to the effects of random fluctuations and variations, undulating, difficult to show the development trend of events, using a moving average method can eliminate the influence of these factors, the direction of development and trends (i.e. trend line) show events. The long-term trend of the predicted sequence is then analyzed by the trend line.

In the following, taking the production of blast furnace gas as an example, combined with the historical data of a steel company's production process, the dynamic model of gas supply and demand forecast established by causality prediction method and moving average prediction method based on time series prediction method is compared and analyzed.

## 2. Comparative Analysis of the Generation of Blast Furnace Gas

Blast furnace iron making is an extremely important part of modern iron and steel complex. Its main raw materials are iron ore raw ore or sinter, as well as additional materials such as limestone. The main fuel is metallurgical coke. In addition to pig iron, a large amount of blast furnace gas will be produced in the process of blast furnace smelting. In the metallurgical process, since the carbon in the coke is burned in the furnace, and it is a layer of hot and thick coke, it begins to change from air excess to insufficient air combustion, resulting in blast furnace gas [11].

According to the blast furnace production conditions, its working conditions can be generally divided into four stages: normal production, wind reduction, blowing down and reblowing. The time for the blast furnace to reduce wind operation is generally several tens of minutes, and the operating hours of the blowing down and reblowing are relatively long. To make the data meaningful, but not to refine the time scale to make the model run complex and prolonged, this paper takes 5 minutes as a data prediction point. The gas production of the blast furnace of a certain enterprise under different working conditions is calibrated, and the prediction model based on the causality prediction method is as follows [12].

$$g_{out,\ BFG}(t)=\begin{cases}\bar{M}(t)Q_{\bar{M},\ BFG} \cdots\cdots\cdots\cdots\cdots\cdots t\in \text{normal production}\\ f_{reduction}(t)\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots t\in \text{wind reduction}\\ 0\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots t\in \text{blowing down}\\ f_{reblowing}(t)\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots t\in \text{reblowing}\end{cases} \quad (1)$$

In the formula (1), $\bar{M}(t)$ is the average productivity of molten iron at time t ($t\cdot h^{-1}$); $Q_{\bar{M},\ BFG}$ is the Corresponding gas generation quota when blast furnace productivity is $\bar{M}$ ($Nm^{3\cdot t-1}$); $f_{reduction}(t)$ is the blast furnace wind reduction function ($m^3\cdot h$) ; $f_{reblowing}(t)$ is the blast furnace reblowing function ($m^3\cdot h$).

$$f(t)=Kf[\bar{M}(t)] \quad (2)$$

In the formula (2), $K$ is the amount of blast furnace gas production per kilogram of coke (coal, crude oil, etc.) ($Nm^3\cdot kg^{-1}$); $f[\bar{M}(t)]$ is the yield-coke ratio (coal ratio, etc.) function; The unit of coke ratio is kilograms per ton.

According to the above model, the predicted and actual values of the blast furnace gas production in the blast furnace of a steel joint enterprise are shown in Figure 1 [13].

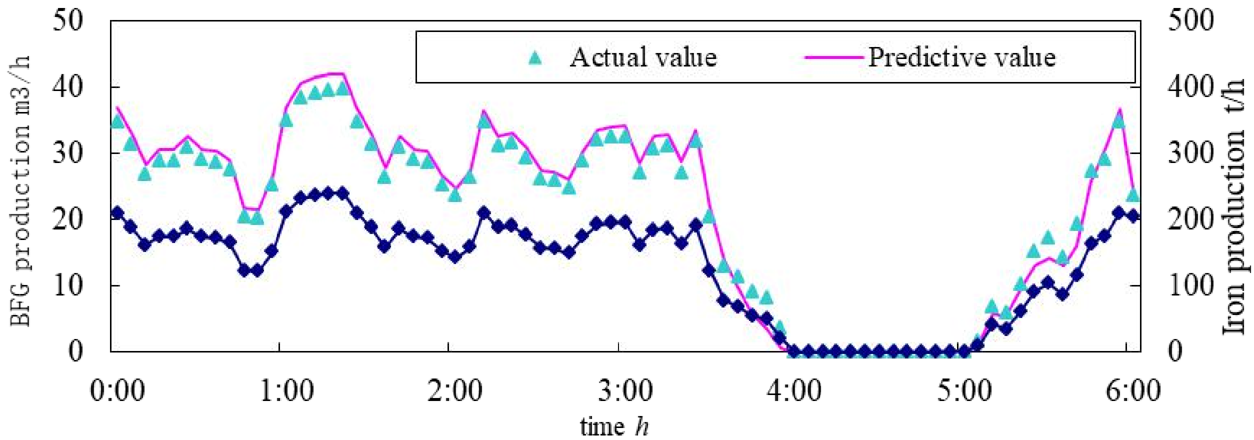


Figure 1: Real and predictive values of the generation of BFG.

It can be seen from the trend of the above graph that the dynamic prediction method based on data calibration agrees well with the actual value of the blast furnace gas generation in the blast furnace ironmaking process. Next, the gas supply and demand forecasting dynamic model based on the prediction model and the moving average prediction method is compared and calculated, and the predicted and actual values of the blast furnace gas generation in the high ironmaking process can be calculated. The calculation results are shown in Figure 2.

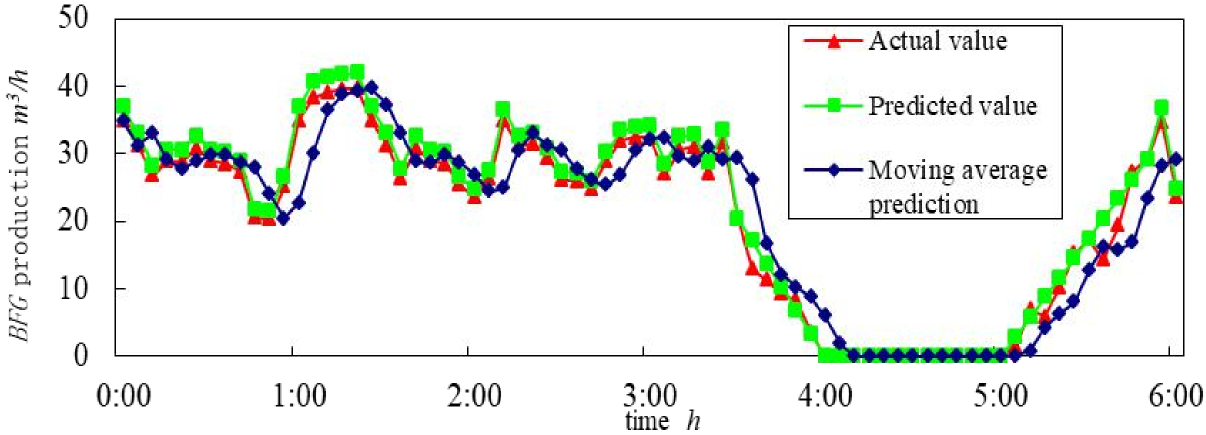


Figure 2: Real and predictive values by different ways of the generation of BFG.

According to the change of blast furnace production conditions (normal production, wind reduction, blowing down and reblowing four production conditions) in the blast furnace ironmaking process, the curve of the normal production stage and the start of the blast furnace ironmaking process in the above-mentioned Figure 2 is compared and analyzed, as shown in Figure 3 and Figure 4 respectively.

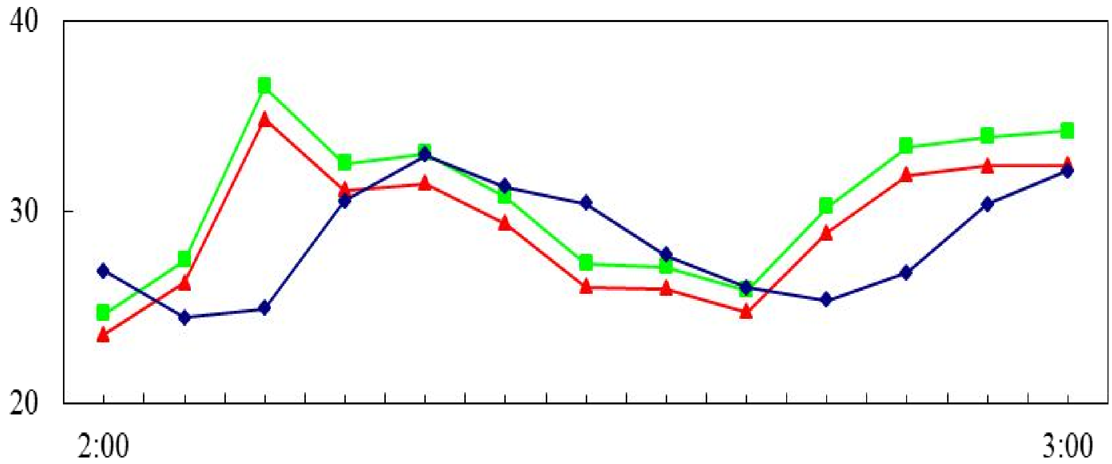


Figure 3: Real and predictive values by different ways of the

generation of BFG under the stage of normal production.

In the normal production stage, during the blast furnace ironmaking process calculated by the model, the maximum deviation between the predicted value and the actual value of the blast furnace gas generation is 5.5%, and the average deviation is about 4.7%, which can meet the requirements of gas dispatching warning. The maximum deviation between the predicted value and the actual value of the blast furnace gas generated by the moving average prediction method is 28.3%, and the average deviation is about 9.7%. Moreover, when the prediction is applied by the moving average prediction method, the predicted result of the calculated amount of blast furnace gas is significantly delayed in time.

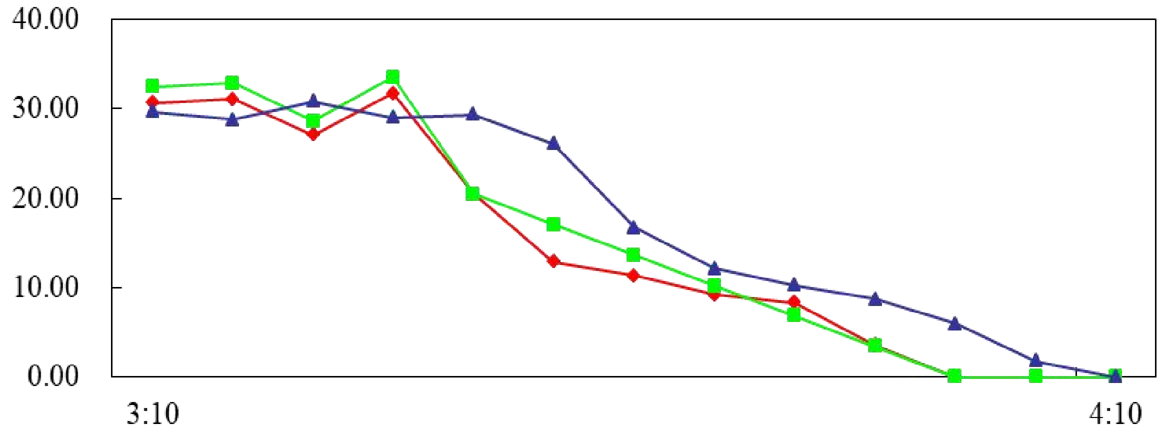


Figure 4: Real and predictive values by different ways of the

generation of BFG under the stage of abnormal production.

In the abnormal production stage (wind reduction, blowing down and reblowing), as shown in Figure 4, at the beginning of the blowing down, the maximum deviation between the predicted value and the actual value of the blast furnace gas generation is 14.2. %, the average deviation is about 6.3%, which can meet the requirements of gas dispatching warning. The maximum deviation between the predicted value and the actual value of the blast furnace gas generated by the moving average prediction method is 141%, and the average deviation is about 30.4%.Moreover, when the prediction is applied by the moving average prediction method, the predicted result of the calculated amount of blast furnace gas is also significantly delayed in time.

It can be seen from the above results that the moving average prediction method based on time series prediction method has obvious hysteresis in the application process and cannot meet the requirements of practical applications.

As with the process described above, in the steel industry, the amount and consumption of the remaining energy flows can be similarly analyzed and compared.

## 3. Conclusions

The main difficulty in the instantaneous flow forecast of by-product gas is that it is affected by random disturbance factors, the uncertainty is strong, and the regularity is not obvious. Besides, the non-stationary nature of the by-product gas instantaneous flow data series needs to be addressed.

In this paper, the dynamic model of gas supply and demand forecast established by the causality prediction method and moving average prediction method based on time series prediction method is compared and analyzed. The results indicate that the model built by the causality prediction method predicts the supply and demand of the gas system with high prediction accuracy under the specified time requirements. The prediction accuracy is higher, which is more suitable for guiding actual production, so that the prediction of consumption of the gas system is more scientific and reasonable, and thus provides effective guidance for real-time balanced dispatching of gas.

On a deeper level, the comparative analysis indicates that the dynamic prediction of energy flow should be combined with the change of material flow, and the dynamic operating conditions and equipment conditions should be fully considered, and the allowable state is divided into normal production state and abnormal production state. For abnormal production conditions, a dynamic prediction model based on data calibration should be established to obtain reasonable prediction results.

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