Study of energy efficiency assessment technology of steam system in iron and steel enterprise

Jihui Chen[a], Tao Zhou[b] and Maolin Dong[c]

CISDI R & D Co., Ltd., Chongqing, China

[a]jihui.chen@cisdi.com.cn, [b]tao.zhou@cisdi.com.cn, [c]maolin.dong@cisdi.com.cn

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Abstract. Steam system is one of the key aspects of energy saving and consumption reduction in iron and steel enterprise. On the basis of analysis the utilization status and utilization potential of steam system in iron and steel enterprises, this paper establishes a steam system energy utilizing efficiency assessment regulation which can be applicable for all production units in the whole iron and steel plant based on the fundamental principles of energy loss and energy utilization efficiency. Furthermore, evaluation model software is also developed, and the results can provide technical support for the further research and optimization of steam system in steel iron and steel enterprises.

Introduction

Iron and steel industry is the basic industry of the national economy, and it is also a key industry of energy consumption and pollution emission. Through technological development to strengthens energy-saving and emission-reduction, improves all kinds of primary energy and secondary energy utilization efficiency, optimizes energy controlling technology is the urgent request of energy utilization and the development for iron and steel industry in the present and future.

The concern of energy medium in iron and steel enterprises is in the background of the sharp decline of the profits of steel rolling products and the gradually increasing need of reduction the cost of running through the context of the gradual expansion of the operating costs. Due to the problem of the measurement, the beginning of the energy saving and emission reduction had focused on two aspects of combustible-gas and water, and then began to intervene in the optimizing utilization of steam system. Although each enterprise have own steam pipe network system, steam generating device and using device, but it is not clear that how about the situation of steam system. Besides, there not only has not related specifications and documents, but also has not feasible assessment method of steam system which is effective for each production unit of the iron and steel enterprises [1,2]. In the present work, the utilizing situation and the utilizing potential of the steam system in the iron and steel enterprises is analyzed, and the steam system energy utilizing assessment regulation is also researched. Furthermore, evaluation model software is also developed and the relevant results can provide technical support for the further steam system optimization in steel iron and steel enterprise.

Analysis of the utilization status of steam system in iron and steel enterprises

Steam system has an irreplaceable role in iron and steel production. On the one hand, it can be directly used in production and life. On the other hand, it is the intermediate link in the energy conversion process. For a long time, there has been the lack of systematically research about iron and steel enterprises steam utilization efficiency evaluation. Though many scholars have putted forward to the point of “the good energy utilization is taken into the energy quality level", but there still did not form an effective and scientific evaluation method which can support the iron and steel enterprises for steam system energy efficiency assessment [3].

S. Liu of Lanzhou Petrochemical Company analyzed the evaluation method of a typical steam network system [4]. G. Zhang of Northeastern University produces the energy conservation analysis of steam system towards a object of the energy utilizing process general model [5]. The above work is

mainly based on the theoretical analysis, and the problem on the specific production aspects should be studied in the further. N.N. Xu [6] and W. Song [7] of Shandong University, Q. Zhang [8] of Northeastern University respectively studied the assessment method of typical steam generating system, and developed evaluation software, but the research results still could not be effectively applied in steam utilization evaluation for complex production units in iron and steel industry.

According to the analysis result of the domestic steel industry energy utilization, we can find that although people have paid much more attention to the utilization of various waste heat and waste energy, but there are still a lot of wastes of resource. The reason not only lies in the backward technology and equipment, but also lies in the Solution thinking. In the past, people's focus on energy consumption in iron and steel industry mainly concern on the energy flow conversion which based on the energy balance theory of the first law of thermodynamics. But the further energy saving potential can't be found through the traditional balance method. And there is less attention on the energy efficiency of the second law of thermodynamics, which resulting in poor performance and energy level matching.

The domestic steam utilization in iron and steel enterprises generally exist the serious devaluation of grade, imbalance supply and demand in winter and summer, low recovery rate of waste heat steam, low recovery rate of condensate water, reasonable mode of steam supply, incomplete settings of measurement instrument. Whether operation workman or the engineering design personnel, they all can not accurately grasp the characteristics of the steam production and utilization on each process unit in the iron and steel enterprises. The energy level difference of steam from the production to the utilization is also not been fully considered. People can't realize "the good energy utilization is taken into the energy quality level" and the solving methods of the above problems are basically rely on experience, which resulting in low efficiency of steam utilization.

Analysis of the potential of waste heat steam in iron and steel enterprises

During the course of recovering and utilizing of waste heat steam, we should do our best to realize energy level matching, temperature counterpart and cascade utilization between supply and demand according to the steam quantity and quality. In accordance with the requirements of technical and economic conditions, we can choose more suitable energy systems and equipments, so that the waste heat steam can play the greatest economic and environmental benefits.

In this paper, the generation amount of steam in different production processes of iron and steel enterprises is collected in Table 1. It can be seen from Table 1 that there exists certain difference on the steam recovery level of domestic iron and steel enterprises. At the same time, there are also significant distance compared with foreign advanced iron and steel enterprises.

Table 1. Recovery status of steam in different processes of iron and steel enterprises

	coking (kg/t coke)	sintering (kg/t sinter ore)	convertor (kg/t steel)	heating furnace (kg/tsteel)
steam production	400-5800	60-100	80-120	25-50
domestic benchmark value	583	82	110	/
foreign advanced value	580-600	100-120	100-120	80-110

Based on the second law of thermodynamics, the recovery potential calculation results of flue gas sensible heat of coking, sintering, converter, heating furnace is shown in Table 2.

Table 2. recovery potential of waste heat in iron and steel enterprises

process	type	energy description			average recovery of steam	potential of process waste heat (%)
		heat (GJ/t)	useful energy (GJ/t)	energy levels		
coking	sensible heat of coke	1.4	1.2	0.85	1.0	17
sintering	sensible heat of sinter ore	0.62	0.32	0.52	0.22	31
converto r	sensible heat of gas	0.8	0.6	0.75	0.4	34
steel rolling	sensible heat of gas	0.32	0.18	0.56	0.12	30

From Table 2 we can find that although the recovering proportion of waste heat steam of each process is not great, but the quantity of waste heat resources in iron and steel enterprises of is very large and the recycling utilizing potential of waste heat steam is also great (exceeding 17%). Therefore, how to better use the waste heat steam of the iron and steel enterprises will be an important direction in future.

Research on energy efficiency evaluation technology of steam system in iron and steel enterprise

In order to evaluate availably the utilizing effect of the existing steam system in iron and steel enterprises, and provide technical support for the further optimization of steam system, this paper carries out a study on the steam system energy efficiency evaluation.

(1) Research on energy efficiency evaluation criteria of steam system in iron and steel enterprise

In order to evaluate the effect of steam utilization, the evaluation criterion should be established firstly. In this study, an evaluation criterion of the steam utilizing effect for steel and iron enterprises is developed.

Through the analysis of the first law and the second law of thermodynamics, it can be found that the essence of the energy utilization effect is how much heat is used and how much is wasted.

Based on the principle of minimum energy loss between the steam source and the steam user' point (i.e. matching rate), this paper developed an Energy Efficiency evaluation criterion of the steam utilizing system of the iron and steel enterprise, which can be expressed in the following equation:

$$P_{S1}=E_{X1}/E_{X2} \quad (1)$$

Where E_{X1} and E_{X2} represent the steam heat of user and the steam heat of source, respectively. P_{s1} represents the matching rate of steam utilization. E_{X1} and E_{X2} can be calculated by the equation of H-373*S=69.893, where H and S represent the enthalpy of steam and the entropy of steam, respectively.

The Calculated result of Eq.1 is the matching rate of steam utilizing system of a single user. We can gain the matching rate of all steam users in one process unit through calculate their useful energy values and flow rate, which can be expressed in the following equation:

$$P_s = \frac{\sum_{i=1}^{n} P_{si} * Q_i}{\sum_{i=1}^{n} Q_i} \quad (2)$$

Where P_{si} and Q_i represent the matching rate of each steam users in one process unit and steam flow rate of each user in one process. P_s represents the matching rate of all steam users in one process unit.

Finally, we can obtain the comprehensive matching rate of an iron and steel enterprise through calculate all the matching rates of each process unit.

In this study, the logic relation of steam utilization system of iron and steel enterprise is shown in Fig. 1.

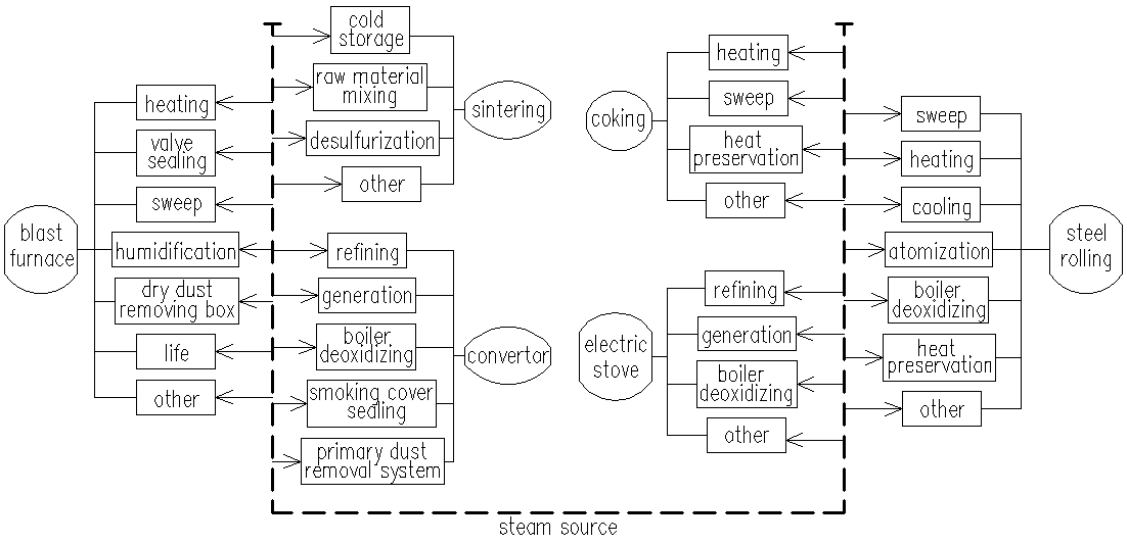

Fig. 1 The logic relation diagram of steam source and steam user in iron and steel enterprise

(2) Development of steam energy efficiency evaluation software in iron and steel enterprise

Based on the above steam utilization evaluation criteria, the basic computing steps of the evaluation software are shown as follows: Entering the steam parameters of the steam user and steam resource of a process, such as temperature, pressure and flow rate; Finding the enthalpy value and entropy value of the steam according to the thermodynamic parameters, and calculating the useful energy values through the equation of H-373*S=69.893; Calculating the matching rate of the steam user and steam resource; Calculating the matching rate of all steam users in one process unit through calculate their useful energy values and flow rate; Calculating the comprehensive matching rate of an iron and steel enterprise through calculate all the matching rates of each process unit.

According to the above ideas, we developed an evaluation software of steam utilization in iron and steel enterprises with VBA software, and the software interface is shown in Fig. 2.

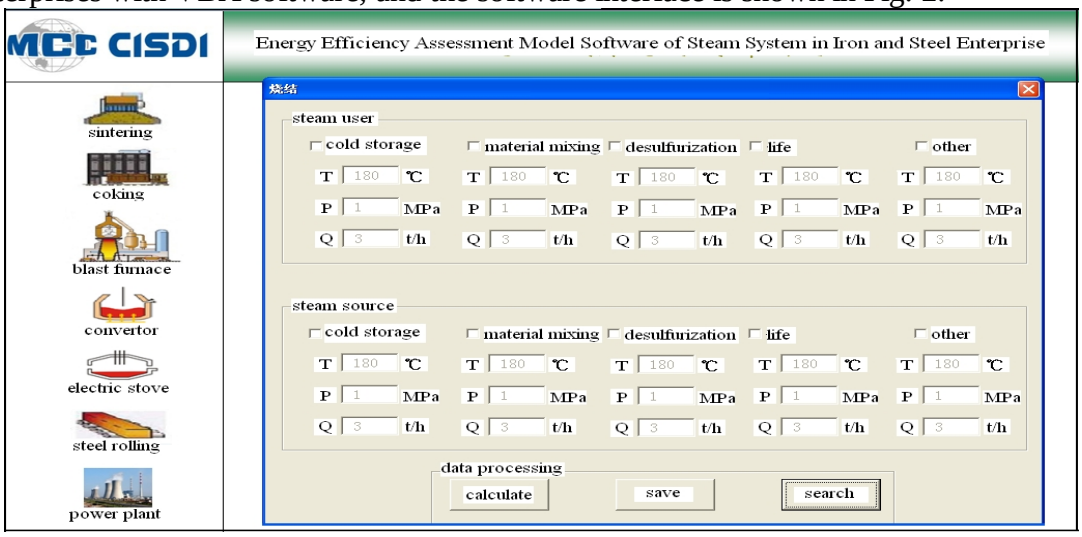

Fig. 2 Steam energy efficiency evaluation software interface of the iron and steel enterprise

Conclusions

(1) The utilization potential of steam system in iron and steel enterprises is great, and the recovery proportion of all production units are at least 17%.

(2) Based on the fundamental principles of energy loss and energy utilization efficiency, this paper established a steam system energy utilizing efficiency assessment regulation and model software which can be applicable for all production units in the whole iron and steel plant, and the relevant results can provide technical support for the further steam system optimization in steel iron and steel enterprises.

Acknowledgements

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