

# Exergy analysis on industrial boiler energy conservation and emission evaluation applications

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**Abstract.** Industrial boiler is one of the most energy-consuming equipments in china, the annual consumption of energy accounts for about one-third of the national energy consumption. Industrial boilers in service at present have several severe problems such as small capacity, low efficiency, high energy consumption and causing severe pollution on environment. In recent years, our country in the big scope, long time serious fog weather, with coal-fired industrial boilers is closely related to the regional characteristics of high strength and low emissions [1]. The energy-efficient and emission-reducing of industry boiler is of great significance to improve China's energy usage efficiency and environmental protection. Difference in thermal equilibrium theory is widely used in boiler design, exergy analysis method is established on the basis of the first law and second law of thermodynamics, by studying the cycle of the effect of energy conversion and utilization, to analyze its influencing factors, to reveal the exergy loss of location, distribution and size, find out the weak links, and a method of mining system of the boiler energy saving potential. Exergy analysis method is used for layer combustion boiler efficiency and pollutant emission characteristics analysis and evaluation, and can more objectively and accurately the energy conserving potential of the mining system of the boiler, find out the weak link of energy consumption, and improve equipment performance to improve the industrial boiler environmental friendliness.

## 1. Description in Brief of Exergy Analysis

Characterization of material how much calories, one of the state parameter of enthalpy and enthalpy only expressed the unit mass material amount of calories, but did not show the merits of the heat quality. The quality of the energy is not the same, the same heat energy, its ability to effectively work is not the same. For example, although the quantity of the boiler flue gas is very big, but the heat is hard to use. Exergy is a quality material availability of calories, in the absence of other sources of heat, the steady flow of working medium from the initial state through reversible process changes to and environment medium in thermal equilibrium can be one of the biggest useful work, known as the working medium in the initial state of thermodynamic exergy. Thermodynamic exergy is one of the working medium state parameter, it corresponds to a certain temperature value is a single. In the process of actual heat, the sum of the entropy of the system of material is increasing, but the system is the sum of exergy is less. The exergy analysis for industrial boiler efficiency analysis, so as to improve the energy efficiency of industrial boiler is very timely and necessary [2].



Exergy analysis method is based on the first law of thermodynamics and the second law of exergy balance of thought, on the basis of the concept of its exergy balance for the tool, by studying the cycle of the effect of energy conversion and utilization, to analyze its influencing factors, to reveal exergy damage location, distribution and size, find out the weak links, and explore ways to improve the effect of energy conversion and utilization.

### *1.1. Exergy balance and exergy loss*

Conservation of energy may be the most basic rule that scientists have yet discovered concerning the universe. Exergy energy use can be part of, it is not balance of payments, the actual transformation process, the part of the available can, will be transformed into unavailable exergy will reduce, called the exergy loss. This is not in violation of the law of conservation of energy and exergy balance is the sum of exergy and exergy loss in balance.

Exergy balance considering the number of energy, also take into account the power quality. exergy balance, the key is to write down all the exergy loss is needed to keep balance. Among them, the internal irreversible exergy loss of heat balance does not reflect. Two methods of analysis has a qualitative difference. Both and save the inner relationship between each other, exergy balance is based thermal equilibrium.

### *1.2. Exergy analysis and exergy efficiency*

Usually heat balance and energy conversion efficiency and can't reflect the exergy utilization degree, we introduce the concept of exergy efficiency. exergy efficiency and the energy conversion efficiency is defined by a similar, the difference is that the exergy efficiency is income pay exergy and exergy ratio [3]. There is the concept of exergy efficiency, we can for a thermal system to establish exergy balance equation, and carries on the exergy analysis. Exergy analysis to quantitative calculation and loss of exergy balance, energy utilization. Balance is the foundation of energy flow to include relating to income and various losses, the allocation proportion can distinguish between the primary and secondary. Exergy analysis efficiency can be calculated, determine the degree of effect and the effective utilization of energy conversion. Exergy analysis can analyze the energy use of rationality, analysis of all kinds of damage and influence factors, puts forward improvement possibility and improving ways, and predict the improved energy saving effects.

## **2. Optimization and Application of Exergy Analysis**

Exergy analysis of the development of the optimization can be divided into three levels: thermodynamic optimization; optimization of thermal economics; the combination of thermal economics and ecology. Thermodynamic analysis can only calculate the exergy loss and exergy loss, engineering decisions still need to consider factors such as investment, economic and environmental impact.

### *2.1. Thermodynamic optimization*

The irreversible loss in the process of industrial boiler work with external loss of exergy analysis belongs to the thermodynamic optimization, it evaluated the combustion process in the effective measure of the fuel is converted to heat, corresponding combustion model and mathematical model is established, finish the calculation of exergy efficiency program, finally using numerical analysis has been influencing exergy efficiency in the working process of the main influencing factors.

### *2.2. Optimization of thermal economics*

In recent years, with the method of exergy analysis and thermal economics are widely used in the energy and petrochemical industry in our country, energy conversion in the process of production, transfer, use, and damage are analyzed, reveals how much energy of each part, cause and position of the energy loss, to improve equipment, improve the energy utilization method and so on to find out.

Industrial boiler thermal system for the diagnosis and analysis of the main equipment of the system and thermodynamics of link integrity, point out the weak link in the system, and with the use of traditional heat balance method, the results were compared, for power plant operation optimization and energy-saving technological transformation provides a scientific basis [4].

### *2.3. The combination of thermal economics and ecology*

When the further development of exergy analysis and thermal economics, combined with ecology gradually, it makes industrial system design and planning stage is considering the ecological environment protection, avoid environmental pollution in the process of production in the future.

Due to improve the boiler efficiency and reduce the effects of pollutants on the environment are interconnected, the boiler efficiency, improve the efficiency of combustion and heat transfer process, in particular, the effective use of resources and environment sustainable development will also bring new improvement. Reduce pollutants discharge, reducing the loss of the high grade energy, which improves the efficiency of the boiler. The combined realization of coal-fired boiler thermal efficiency and environmental protection will be the future boiler energy-saving reform of the economic operation and development trend

## **3. The Application of Exergy Analysis in Industrial Boiler**

Industrial boilers in service at present have several severe problems such as small capacity, low efficiency, high energy consumption and causing severe pollution on environment. exergy analysis method for boiler equipment efficiency and pollutant emission characteristics of a detailed analysis and study is to establish a comprehensive consideration of the important methods for the evaluation system of the boiler thermal efficiency and environmental protection.

### *3.1. Exergy analysis in the application of boiler economic evaluation*

By the exergy analysis, we can realize more profoundly the weak links of using energy systems and manage more rationally the energy process used. exergy analysis can get input materials such as boiler fuel and effective utilization and the balance of the relationship between the loss rate, so as to analyze the rationality of energy utilization. Furthermore, the method of exergy analysis may perfectly analyse the status of using energy of all kinds of boiler surface.

Boiler and heat transfer heat transfer process during burning process exergy efficiency and the exergy analysis can be concluded that fossil fuel energy use efficiency is equal to the loss and the ratio of input, so the efficiency of the boiler combustion is endowed with practical significance. the results show that the main loss process in the boiler for combustion and heat transfer process, the combustion process to reduce the power loss coefficient of air conditioning and inlet air temperature. Boiler exergy loss occurs mainly in the process of combustion chamber of a stove or furnace, this may be due to incomplete combustion, heat insulation effect is poorer, and the entropy production is bigger, rather than the calculation results show that the condenser heat loss is the main equipment, reveals the importance of exergy analysis from different angles [5].

In recent years, domestic scholars boiler parts a lot of calculation and analysis on modification of equipment and device, such as how to improve the feed temperature, at the same time in the boiler exhaust smoke under the premise of constant temperature appropriate increase secondary air temperature, etc. through the exergy analysis of boiler efficiency calculation and performance analysis it is concluded that the exergy efficiency of the boiler and its various parts, and the size of the exergy loss of each process, and the results with the boiler heat balance analysis results were compared, found that exergy loss mainly includes the combustion process of boiler exergy loss and exergy loss of heat transfer process, it is pointed out the direction of the in order to further improve the efficiency of the boiler. In combustion, heat transfer process as the breakthrough point, through oxygen-enriched combustion, improving steam initial parameter method to reduce the coal consumption of the boiler.

### 3.2. *The application of exergy analysis in boiler pollutant emission characteristics*

Exergy analysis can be used to improve the sustainable development of the society and nature, exergy is to explain the energy into the environmental impact of the best tools, exergy and the sustainable development of economy, and environment factors are closely linked. Energy due to the internal irreversibility, exergy loss may occur, so should try to reduce the loss to achieve sustainable development. Environmental impact and the relationship between the emissions and resource depletion can be created according to the physics principle based on the exergy of expression [6].

Many of the existing boiler emissions evaluation index, mostly for a number of pollutants are compared, and a single comprehensive evaluation of quantitative index of the performance of the boiler is less. For example, to calculate the desulfurization denitration, dust removal system, such as energy consumption and waste quantitative influence on the environment. exergy is measuring system suitable relationship between the loss and environmental loss, exergy analysis, for boiler can be caused by the pollutants into the environment influence quantitative evaluation analysis. Boiler system exergy magnitude depends on the state of the system and environment, only when the system and the environment balance, loss to zero.

Establish system discharge of wastes and waste heat exergy calculation model for description of the environmental pollution, In the boiler system, waste exergy is mainly refers to from the flue gas, solid waste burning, wastewater, and left in waste heat boiler of exergy when into the environment [7]. When calculating the overall boiler pollutants fire unavailable, need to consider different pollutant degree of damage to the environment, exergy of the potential difference is the measurement of environmental damage.

## 4. Conclusion

Exergy analysis to explain the reason of the loss of energy consumption, for the future energy efficiency are more accurate and scientific evaluation and prediction, will be important for the sustainable development of assessment tools. the exergy theory is applied to the actual boiler calculation of the ultimate goal is to draw a perfect unity of quantitative evaluation method of energy saving and emission reduction to find the lowest parts of the equipment or utilization in the process of running, and put forward concrete can reasonable transformation method. exergy calculation analysis of pollutant control device can further reveal the side of the boiler energy conservation and environmental protection work. exergy analysis to the boiler thermal efficiency and environmental protection of the establishment of a comprehensive quantitative evaluation method will play an important role.

Coal-fired boiler drawing surface and pollution control equipment system flow diagram, and calculating exergy analysis, establish the unity of the boiler economic performance and environmental performance evaluation index system, determine the best working condition of boiler operation, to avoid problems such as inefficient high emissions, industrial boiler is the urgent need of theoretical research and engineering application in the future. Based on the theory of exergy comprehensive consideration of economy and environmental protection, map corresponding with table, fire with fire, it is concluded that the two best integration performance. The establishment of the integrated model is of great significance for energy conservation and emissions reduction, and will become the evaluation of power plant boiler performance good or bad, to guide the actual modification, the importance of fault diagnosis and optimizing operation methods and indicators.

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