

# Analysis on Effects of Energy Efficiency Standards of Industry Boiler in China

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**ABSTRACT:** China industry boilers have characteristics that huge total amount, wide distribution, high energy consumption and heavy pollution. Since the Chinese government revised the energy conservation law in 2007, boiler and other high energy consuming special equipment energy conservation supervision was more and more concerned, and in 2014 the Chinese government has enacted the new revision “atmospheric pollution prevention and control law” in which boiler emissions management requirement was increased. But because of boiler energy conservation and environmental protection work started late in China, relevant working basis is weak and the indicators for boiler efficiency, emissions are not perfect, to a certain extent, it restricted the progress of boiler energy conservation and environmental protection work in China. In this paper, we analysis on the effect of energy efficiency standards of industry boiler in China, and give a suggestion to promote China industry boilers to more energy saving.

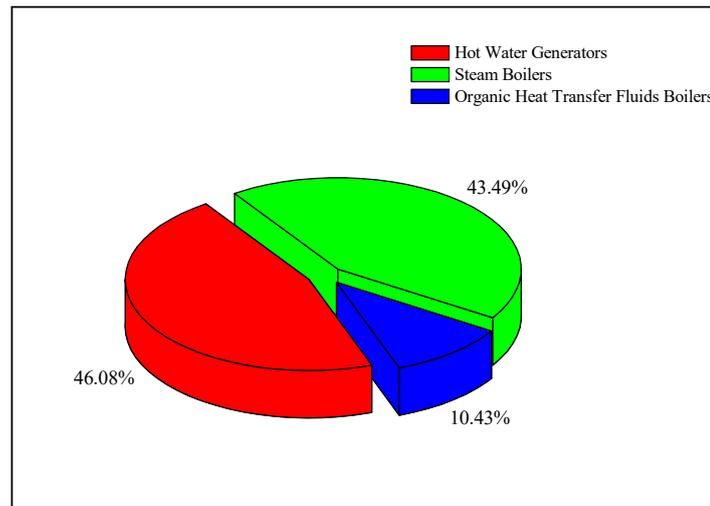
## 1 INTRODUCTION

Due to China’s industrial boiler huge total amount, wide distribution, high energy consumption and heavy pollution, since the Chinese government revised the energy conservation law in 2007, boiler and other high energy consuming special equipment energy conservation supervision was more and more concerned, and in 2014 the Chinese government has enacted the new revision “atmospheric pollution prevention and control law” in which boiler emissions management requirement was increased[1,2]. But because of boiler energy conservation and environmental protection work started late in China, relevant working basis is weak and the indicators for boiler efficiency, emissions are not perfect, to a certain extent, it restricted the progress of boiler energy conservation and environmental protection work

in China. Current energy efficiency conditions of industrial boilers after the execution of the latest energy efficiency standard in China, in this paper, we listed the basic condition of China industry boilers, and analysis barriers of industry boilers energy efficiency from the market side and manufacture side. Base on that, we got the conclusion which will give the clue to analysis the effect of China industry boilers energy efficiency.

## 2 BASIC CONDITIONS OF INDUSTRIAL BOILERS IN CHINA

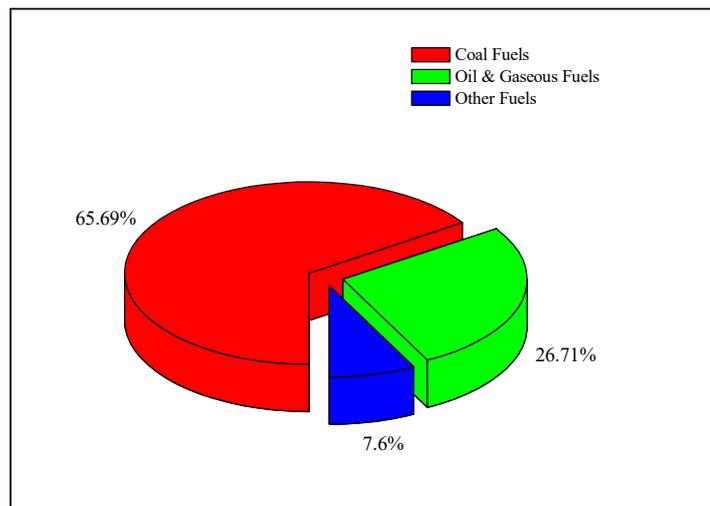
According to different media output by the boilers, they are mainly divided into three types: steam boiler, hot water boiler and organic heat carrier boiler[3], of which the quantities are distributed as shown in Fig. 1.



**Figure 1.** Distribution of Quantities of Media Output by Industrial Boilers

In China, industrial boilers cover a vast range and are mainly coal-fired. In the total quantity of industrial boiler, coal-fired industrial boilers occupy over 65%, oil/gas

fired boilers over 25% and electric boilers about 1%, and other boilers mainly use the fuels of marsh gas, black liquor, biomass and so on[4], as distributed in Fig. 2.



**Figure 2.** Fuel Classification and Quantity Distribution of Industrial Boilers

In China, industrial boilers have small average capacity and the boilers with capacity less than 35 t/h approximately occupy over 90% in total quantity of industrial boilers, of which 2 ~ 10t/h boilers occupy about 70% (it decreases gradually as the state gradually implements the policy of eliminating the coal-fired boilers less than 10t/h in recent years), and the average capacity of the boilers is less than 4t/h[5].

From the conditions of coal consumption, the coal consumption of the boilers less than 10t/h occupies 50% of total coal consumption and that of the boilers above 10t/h approximately occupies 50% of total coal consumption of industrial boilers for their single capacity is great. As for oil/gas fired industrial boilers, annual

consumption of standard oil by about 50,000 oil/gas industrial boilers is about 22 million tons[6]. As energy conservation and environmental protection have been concerned increasingly in China, more and more boilers with the fuel of biomass are used as well.

### 3 CONDITIONS OF BOILER MANUFACTURING AND SALE

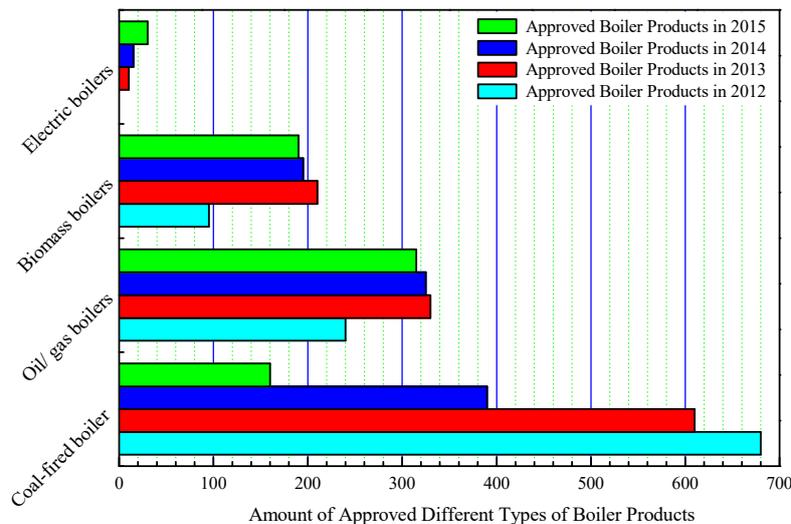
According to the statistical data of the General Administration of Quality Supervision, Inspection and Quarantine, 968 domestic boiler manufacturers and 103 foreign boiler manufacturers have obtained the boiler

manufacturing licenses as registered in the General Administration of Quality Supervision, Inspection and Quarantine by the end of 2015[7-11]. Along with economic development, the quantity of boilers in use has been going up in recent years in China. But, into 2015, increasing quantity of boilers has decreased in recent two years due to economic impact and national policy of eliminating coal-fired boilers less than 10t/h.

### 3.1 Energy Efficiency Conditions Of New Boiler Products

#### 3.1.1 Basic energy efficiency conditions of new boiler products

Since China implemented energy efficiency test system and indicators for approved boiler products in 2011, newly-designed boilers of the boiler manufacturers can be put into mass production after passing the test. The test conditions of approved boiler products in 2012-2015 are compared according to fuel classification as shown in Fig.3:

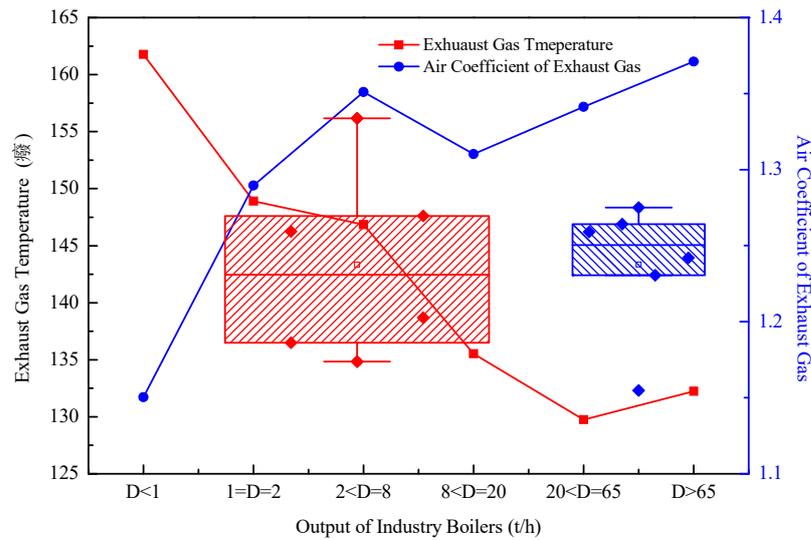


**Figure 3.** Comparison of Test Conditions of Approved Boiler Products in 2012-2015 as per Fuel Classification

It can be seen from the above figure that, in the test of approved products in four years, the tested quantity of approved coal-fired boiler products was decreasing year by year; a greater amplitude was seen in oil / gas boilers and biomass boilers in 2013 and tended to be stable afterwards; the number of electric boilers was small. The reason for the above change is that China has proposed the policy of “eliminating small coal-fired boilers, developing high-efficient boilers and implementing “coal-to-gas” for industrial boilers in energy conservation and environmental production of industrial boilers in China in recent years[7,8]. The coal-fired boilers with small capacity are difficult to meet the requirements in energy conservation and environmental protection performances. In particular, the *Action Plan on Prevention and Control of Air Pollution* (GF [2013] 37) clearly proposes various measures for comprehensively renovating small coal-fired boilers and specifies that the coal-fired boilers (10 steam tons / h or less) should be substantially eliminated in built-up areas in prefecture-level and high-level cities up to 2017, except for necessary conservation, and it is forbidden to newly produce coal-fired boilers with 20 steam tons / h.

By studying boiler energy efficiency indicators of USA, European Union and Japan, it can be seen that the assessment standard for boiler energy efficiency are not merely based on boiler thermal efficiency in foreign countries, especially in Japan, where main indicators are emission temperature and excess air factor of the boiler. At present, current Chinese energy efficiency standard does not mention the energy efficiency indicators other than thermal efficiency. In order to assess the feasibility of foreign methods in China, thee thermal efficiencies, emission temperatures, excess air coefficients and other data of boilers with different outputs have been summarized according to the test conditions of approved boiler products at the end of 2015: for the approved boiler products with various fuels in 2015, the arithmetic mean of boiler thermal efficiency is 87.62% with weighted mean of 87.67%; the arithmetic mean of emission temperature is 146.60°C with weighted mean of 135.18°C; the mean of excess air coefficient is 1.29.

#### 3.1.2 Data analysis on excess air coefficient and exhaust gas temperature of new boiler products



**Figure 4.** Statistical Chart for Some Parameters of New Industrial Boiler Products

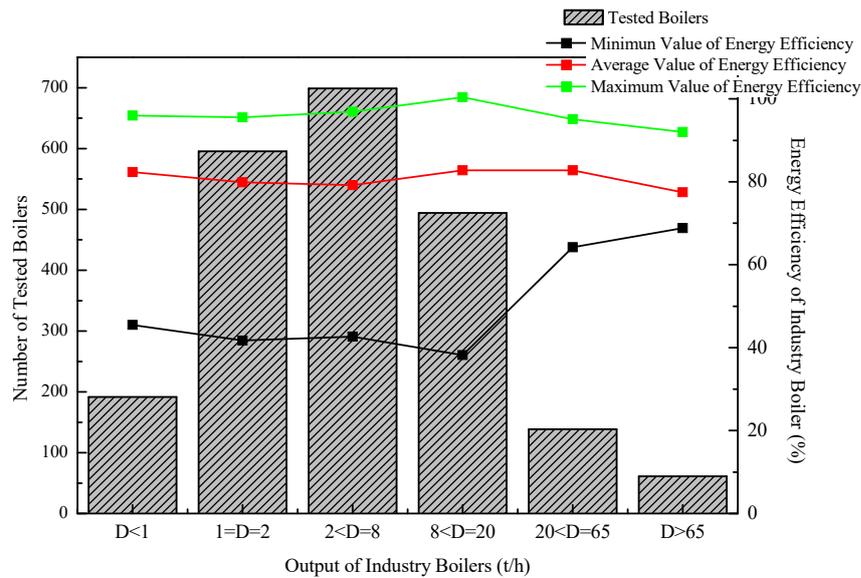
From figure 4, it can be known that when the boiler output is less than 1t/h, the average exhaust gas temperature of the boiler is up to 161.73°C, however, with the increase of the boiler output, the exhaust gas temperature of the boiler decreases gradually. It indicated that since TSG G0002-2010 *Supervision Regulation on Saving Energy Technology for Boiler* has been issued, the new products of industrial boiler manufacturing enterprises have been designed completely according to the requirements of the regulation, adopting the relevant energy-saving technology for decreasing the exhaust gas temperature. When the boiler output is less than 1t/h, the average exhaust gas temperature of the industrial boiler is significantly higher than other boilers; since flue gas loss is one of the major heat losses among the boiler heat loss, generally the flue gas loss increases 1% and energy consumption increases 1.4% with exhaust gas temperature exceeding 15°C; according to the overall analysis of steam boiler of which boiler rating is less than 1t/h and the application of the current energy-saving technology, energy-saving technology can be adopted for the steam boiler of which boiler rating is less than 1t/h to

reduce exhaust gas temperature and flue gas loss appropriately, and there is still some space for improving boiler thermal efficiency.

### 3.2 Energy Efficiency Of Industrial Boiler In Use

#### 3.2.1 Basic energy efficiency of industrial boiler in use

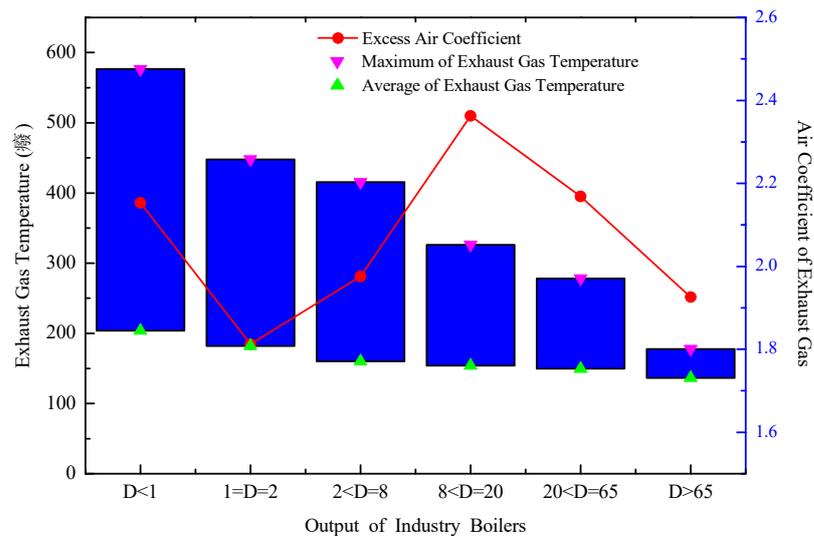
The industrial boiler in use follows the specifications of *Supervision Administration Regulation on Energy Conservation Technology for Boiler*; the inspection institution of special equipment and the energy-saving service institution with qualification are subject to the plan and arrangement of local quality and technical supervision bureau; efficiency test is carried out once every 2 year combining with safety periodic inspection, and energy-saving transformation should be carried out for those failing to reach the limits of thermal efficiency. See Figure 5 for statistical analysis on thermal efficiency of industrial boiler in use.



**Figure 5.** Statistical Chart for Thermal Efficiency of Energy Efficiency Test of Industrial Boiler in Use

### 3.2.2 Data analysis on excess air coefficient and

*exhaust gas temperature of industrial boiler in use*



**Figure 6.** Statistical chart for flue gas parameters of energy efficiency test of Industrial Boiler in Use

From fig 5 and fig 6 above, it can be known that the overall thermal efficiency, exhaust gas temperature and excess air coefficient of industrial boiler in use all decreased compared with the test data of new industrial boiler products with the same capacity, and there are main two reasons: one is that the load varies a lot during boiler operation, and it operates under low load in most cases, which affects the thermal efficiency of the boiler; the second is that the automatic control level of the old boiler is low, while the operation level of operators operating the boiler daily cannot make sure that the boiler is under the optimal operation; the third is that the boiler operation conditions cannot be met, such as in adaptation between fuel and boiler model, etc.

## 4 ANALYSIS ON INDUSTRIAL BOILERS IN CHINA

### 4.1 Energy Efficiency of Chinese Industrial Boiler

Since the boiler energy-saving supervision has been carried out by General Administration of Quality Supervision, the system of energy efficiency test was implemented on industrial boiler; the execution of such system improved the energy efficiency of new boiler products effectively, especially in 2016, General

Administration of Quality Supervision issued *Supervision Regulation on Saving Energy Technology for Boiler* (Revision 1), greatly improving the energy efficiency of small coal-fired boiler, circulating fluidized bed boiler and oil (gas)-fired boiler according to the national policy; in future, the thermal efficiency of Chinese new industrial boiler products will be higher than 80%, which is good for improving using efficiency of boiler, guiding users to use new energy-saving products.

Although certain progresses and achievements have been obtained, there are still the following problems for Chinese boiler:

1. A lot of manufacturers with small scale and low market occupancy.

Chinese boiler manufacturing is established and developed after the founding of People's Republic of China, and the boiler manufacturing in our country has made great progress with the booming of national economy since the reform and opening-up. Licensing system is implemented on Chinese boiler manufacturing enterprise; the boiler manufacturing has been standardized and expanded since the implementation of license on boiler manufacturing enterprise; the production capacity of some boiler manufacturing enterprise has been improved continuously, but the industry is developed extremely unevenly; there are many manufacturing enterprises but less personalized products, and the production capacity of the enterprise is ordinary.

2. The energy efficiency level of the boiler in use is low with a large gap between the design energy efficiency.

There has been the phenomenon of so called "excess capacity" in our national industrial boiler for a long time, that is to say, most of boilers are under low-load operation, on the one hand, it is due to a certain allowance for the selected data during boiler design, which seems relatively conservative; on the other hand, the capacity and number of the boiler selected often exceed the actual demand a lot when the design institute and users select the boiler, considering the development demand in future and other factors; what's more, limited by the production, the load of the boiler during the actual operation usually fluctuates greatly within a wide range along with the steam and heat load variation, causing a lot of boilers operating under low load for a long time. At present, the capacity and number of boiler selected by industrial boiler operation units throughout the country usually exceed the actual demand a lot, and the daily average operation load is only about 50%~60% of rating load, which causes the actual operation efficiency is actually 10~15 percent lower than the design thermal efficiency of the boiler, resulting in serious waste of primary energy.

3. There are many hot-water boilers with single purpose, and the step utilization is not considered.

In recent years, the demand for hot-water boiler with large capacity is increasing year by year driven by rapid development of real estate market all over China and the requirements of policy for central heating, and the proportion of hot-water boiler occupying the total

demand for industrial boiler is increased. The hot-water boilers of 70MW, 91MW and 116MW even 168MW are used. Although gradually replacing coal-fired industry, business and domestic boiler having small capacity and low parameters as well as large quantity and wide range with boilers of large capacity and high parameters can comply with social industrialization, population urbanization and life quality development of our country, it does not comply with the new direction of energy step utilization due to single purpose of hot-water boiler and about 4 months of operation in heating supply season of each year.

## 4.2 Energy Efficiency & Environmental Indicator Of Industrial Boilers In China

1. The energy efficiency indicator of industrial boiler product is out of line with the actual operation

At present, the boiler efficiency indicator is established on basis of rated load conditions of boiler, while boilers are generally under non-rated loads conditions during the actual operation, as the average load rate of industrial boilers in China is between 50% ~ 70%, taking transient boiler thermal efficiency as the unique indicator of industrial boilers without consideration of the impacts of boiler load change, fuel change, management factors and operation factors on the boiler operating energy efficiency is adverse to the boiler users to know the position of operating efficiency level of boiler in the same industry and within the same region, or to the government to grasp the operating efficiency level of industrial boilers among different industries and region, which is required to urge the sub-standard enterprises for rectification. In addition, the above-mentioned two standards are the energy efficiency standards of boiler body, and cannot be used to evaluate the energy consumption of the boiler system.

2. Energy efficiency indicators of industrial boiler are incomplete, and the market is full of boilers with high energy consumption and low efficiency.

At present, the energy efficiency indicators of biomass boiler, pulverized coal industrial boiler, blast furnace / coke oven gas boiler and electro-thermal boiler products are not available, and those of natural gas boiler and coal-fired boiler have not been revised for many years. Many boilers with high energy consumption and low energy efficiency enter the market at low prices, and the thermal efficiency indicator of some boilers is only between 60 % ~70%.

3. It is unscientific to evaluate the efficiency indicators of in-service boiler only with transient thermal efficiency due to the lack of system energy efficiency indicators.

Due to the scope of safety supervision on boilers in China, most efforts made by the boiler manufacturers, inspection & test organization and users on the safety, energy conservation and environmental protection are only for the boiler body, and they fail to establish indicators from the perspective of boiler system to regulate the management and operation conditions. In consideration of the low automatic control level of China

in industrial boilers, especially industrial coal-fired boiler, it is impossible for the boiler operating efficiency to reach the economical operation indicators by adjusting the boiler operation parameters based on the operator's experiences due to the different technical quality of operators and lack of energy conservation awareness and technical level of management and operation personnel.

4. Low heat value is used for thermal efficiency calculation, and is not suitable for condensing natural gas-fired boiler.

As it is customary to adopt low heat value of fuel for thermodynamic calculation during the boiler design and manufacturing in China, low heat value is also adopted for thermal efficiency calculation in the existing energy efficiency test method. At present, the domestic boiler manufacturing enterprises and users are attaching greater importance to energy conservation and environmental protection performance of boilers, using natural gas-fired boiler equipped with flue gas recovery unit is becoming increasingly common, and the thermal efficiency of some natural gas-fired boiler calculated according to the existing standards after exhaust temperature reduction exceeds 100%, which seems unscientific and adverse to comparison between condensing boiler and non-condensing boiler.

## 5 CONCLUSION

Based on study above, China energy efficiency standards for industry boilers are really give a great promote on industry boilers energy efficiency, and highly energy saving technology, but we should try hard to improve energy efficiency indicator to promote industry boilers energy efficiency, further, the system evaluation method of industry boilers should be developed, as the amount of energy saving is greater than product of industry boilers. Another, industry boiler law and regulation should be speed up to formulate the produce of industry boilers to enhance the system of supervise on the energy consumption of industry boiler.

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