

Comparative Analysis of the Efficiency of Cast Iron Boilers at Power Plants

M A Nefedova¹, E A Biryuzova¹, S D Pestich¹, A S Aleksandrov⁴

¹Saint-Petersburg State University of Architecture and Civil Engineering, 2-ya Krasnoarmeyskaya street, 4, city St. Petersburg, 190005, Russia

E-mail: ssgasu@mail.ru

Abstract. Currently, in most regions of the Russian Federation low-capacity heating boiler rooms are being in use. They are equipped with domestic cast-iron boilers which service life exceed 25 years. As a result, the used burner equipment and automatics are morally and physically obsolete and not responding the modern requirements of the Federal Law "On Heat Supply" adopted on 10th August 2017 to reform the thermal power industry with the aim of enhancing the energy, ecologic and economic performance of equipment. In conditions of active search for reserves of fuel and energy economy resources research connected with the use of cast iron boilers of low power is essential. Low-capacity boiler rooms are widely used as a source of thermal energy for industrial enterprises and residential sector, as well as for reconstruction of historic areas of major cities. The current direction of the research is benchmarking of all characteristics of the operation of cast-iron heating boilers of domestic production after technical re-equipment using modern equipment and instrumentation with foreign production which is widely used in our country. The result of the research work is the development of recommendations for improving the energy efficiency of low-capacity boiler rooms.

1. Introduction

Cast iron heating boilers are being used for over 150 years. Cast iron boilers are in high demand even nowadays because of their benefits above their direct competitors – steel boilers.

Advantages of cast iron boilers are:

– cast iron boilers consist of sections. Boiler can be easily collected and disassembled on sections, moved and repaired if needed.

– cast iron has high corrosive resistance. During the exploitation walls of cast iron boiler are covering with the layer of «dry rust», which does not allow corrosion to permeate deep into material. At mostly, electrochemical and wet corrosion destroy those parts of boiler, at which temperature of the boilers wall can be below temperature of dewpoint temperature.

Most often, such corrosion occurs in the furnace of the boiler when condensate falls out on the walls, which is formed by the interaction of flue gases with the wall of the boiler, the temperature of which is below the temperature of the gases while condensate contains various aggressive salts and acids.

Disadvantages of cast iron boilers:

– large mass of the boiler as compared to a steel boiler of the same capacity.



–the need for competent personnel who operates precisely with cast iron boilers that have many conditions and limitations which must be observed. otherwise it will damage or rupture the boiler. For example, you can not fill in cast iron boilers with cold water.

–the difficulty of performing a technically competent passport piping of the boiler.

– low boiler efficiency.

Despite the difficulties in the operation of cast-iron boilers they are still widely used in heat power engineering of various levels. This is also a small heat power engineering aimed at preparing low-power thermal energy for private consumers and heat-and-power engineering related to the provision of thermal power for entire cities from CHP and TPP.

2. The possibility of using cast iron boiler with a large service life

The source of heat supply in small regional cities and urban-type settlements is the thermal power station and boiler houses in which sectional cast-iron boilers with low efficiency are used to generate heat carrier for heating purposes.

It is possible to increase the efficiency of cast-iron boilers by studying and identifying the boiler operation schedule at maximum power and identifying the efficiency that corresponds to these operating modes. Such an increase in the efficiency of work can only be achieved by solving organizational problems even without additional capital investments. Another way to improve the efficiency of the boiler equipment is connected with the replacement of morally and physically obsolete burner equipment and automation of the boiler unit with modern equipment which meet all modern requirements of reliability and durability of work. This method requires significant financial investments which can not always be provided by owners of small heating boilers.

The solution of the problem of increasing the efficiency of cast iron sectional boilers without their replacement can be achieved by inexpensive but effective technical re-equipment of the burner equipment, which is reduced to the use of the domestic development of the modernized design of a horizontal low-pressure (low-pressure) burner with forced air supply and complex automatic control and security. [7]. Such a solution will allow to operate domestic cast iron sectional boilers for a long time without their replacement and to increase the efficiency of the boiler in the long-term industrial mode by 15-16%, therefore, it is up-to-date and meeting the modern requirements of the Federal Law "On Heat Supply", adopted on the 10th August 2017 aimed at reforming of power engineering with the purpose of increasing energy efficiency, ecological compatibility and economic efficiency of equipment.

The conducted studies of the performance indicators of cast-iron boilers that passed the proposed modernization revealed high energy efficiency, fuel efficiency and compliance with environmental requirements (Table 1, 2).

3. Application of modern cast-iron heating boilers.

Modern cast-iron heating boilers of domestic and foreign manufacturers equipped with modern gas-burning devices already have high efficiency about 91% and a wide range of sizes which allows using this equipment for various groups of consumers. It is also possible to use not only natural gas but also liquefied as well as diesel fuel. It is obviously an advantage. Having carried out research as well as reviews of operating organizations on the performance of cast iron boilers of domestic and foreign production the following peculiarities were revealed: the impossibility of launching a foreign-made boiler at low air temperatures (not provided according to the technical certificate), the complexity of repair and its high cost. At the same time, boilers of domestic manufacturers are designed for climatic features of Russia, are easier to set up and maintain, are durable and maintainable. However, the choice of a manufacturer should be based on the characteristics of the equipment and the operating conditions.

The cost of boiler equipment of foreign manufacturers is **150-200 %** higher than the cost of similar domestic equipment. Currently, this indicator is decisive.

Table 1. Results of the studying the operation of cast iron sectional heating boilers before and after the replacement of equipment..

| Indicators before replacement of equipment | | | Indicators after replacement of equipment | | |
|--|-------------------------------------|--|---|-------------------------------------|--|
| Efficiency of the boiler plant, % | coefficient of excess air, α | concentration of nitrogen oxides, mg / m^3 | Efficiency of the boiler plant, % | coefficient of excess air, α | concentration of nitrogen oxides, mg / m^3 |
| 1 | 2 | 3 | 4 | 5 | 6 |
| 75 | 1,35-1,75 | 110-135 | 91-92 | 1,10-1,15 | 90-135 |

Table 2. Indicators of economic efficiency proposed upgrading of equipment.

| Energy Saving Proposal | Savings of natural gas on the average boiler | | Saving of natural gas | The cost of replacing equipment, thousand roubles | Payback period |
|---|--|---|-----------------------|---|----------------|
| | hour, m^3 / h | annual for the heating season, thousand of m^3 | | | |
| 1 | 2 | 3 | 4 | 5 | |
| Modernization of gas-burning equipment with modern means of automation ³ | 12-15 | 60 | more than 10% | 150. | 3 years |

4. Conclusion

The conducted studies clearly demonstrate the possibility of further use of cast-iron heating boilers that have been in operation for a long time after a low-cost upgrade of gas-burning equipment and a complex of automation. In addition, the performance of modern domestic cast iron boilers is not inferior to foreign ones and are quite competitive.

References

- [1] Roddatis K F, 1977 *Boiler plants* (Moscow: Energiya) 432 p
- [2] Esterkin R I, 1989 *Boiler plants* (Leningrad: Energoatomizdat) 280 p
- [3] *Handbook of boiler plants of low productivity* / edited by K F Roddatis 1989 (Moscow: Energoatomizdat) 488 p
- [4] Biryuzova E A, 2004 *Improving the burning of natural gas for heating cast iron sectional boilers with horizontally-slotted (bottom) burners: the dissertation for the degree of PhD of Technical Sciences* (St. Petersburg: SPSUACE) 265 p
- [5] Staskevich N L, Severinec G N and Vigdorchik D YA 1990 *Handbook on supply and use of gas* (Leningrad: Nedra) 762 p
- [6] Volikov A N, 2006 *Thermal calculation of steam and hot-water boilers* (St. Petersburg: SPSUACE) 130 p
- [7] Severinec G N, Lomakina E A and Bezrukih V Yu 2003 *Outdoor (bottom) burner: the patent for the invention №2211403, Russian Federation; IPC 7F23D 14/22 / publ. 27.08.2003, Bulletin № 24 5 p*
- [8] Delyagin G I, Lebedev V I and Permyakov B A 1986 *Heat-Generating plants* (Moscow: Energoatomizdat) 586 p
- [9] Nefedova M A, 2017 *Energy-Saving technologies in the operation of small-capacity boilers: the dissertation for the degree of PhD of Technical Sciences* (St. Petersburg: SPSUACE) 168 p

- [10] Pamfilova K D, 2002 *Methodical guidelines for determining fuel, electricity and water consumption for heat generation by heating boiler houses of municipal heat and power plants* (Moscow) 51 p
- [11] Basniev K C, 1994 *Encyclopedia of the gas industry* (Moscow) 884 p
- [12] Chepel V M, Shur I A, 1980 *Combustion of gases in furnaces of boilers and furnaces and maintenance of gas facilities of enterprises* (Moscow) 591 p
- [13] Kuznecov N V, Mitor V V, Dubovski I E, Karasina E S, Rubin M M, Bloh A G, Marshak U L, Petrosyn R A, Lokshin V A, Mochan S I, Kendis P N, 1973 *Thermal calculation of boiler units* 296 p
- [14] SR 89.1330.2012 *Boiler installations. Updated version* (Moscow) 93 p
- [15] Sidelkovski L N, Urenev V N, 2009 *Boiler installations of industrial enterprises* (Moscow) 528 p
- [16] Sergeev A V, 2012 *Handbook for staff boilers: thermal mechanical equipment of boiler* (Moscow) 256 p
- [17] SR 12–529–03 *Safety rules for gas distribution systems and gas consumption* (Moscow) 72 p
- [18] Palei E L, 2010 *Boiler rooms. Normative requirements and practical recommendations in the design: reference and practical guide* (Saint–Petersburg) 119 p
- [19] Nefedova M A, 2014 *Energy–ecological advantage of using gaseous fuels in industrial heat–and–power engineering* (Saint–Petersburg) 222–225 p
- [20] Nefedova M A, Biryuzova E A, 2015 *Working out of working methods and increase of energy efficiency of gas boiler houses of small capacity* (Saint–Petersburg) 100 p
- [21] Kyazimov K G, 2014 *Gas equipment of industrial enterprises. Device and operation: reference book* (Moscow) 240 p
- [22] D B Solovev, A E Merkusheva 2016 Novel active current transducers for diesel power stations *International Journal of Power Electronics and Drive Systems* Vol. 7 (1) pp. 152-158. [Online]. Available: <http://dx.doi.org/10.11591/ijpeds.v7.i1>.