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HEAT BALANCE OF STEAM BOILERS

Siddikov Rasuljon Uktamovich
Doctor of Philosophy in Engineering Sciences (PhD)
Khusanova Sarvinoz Alisher kizi
Kokand branch of Tashkent State Technical University, Student
Bakhriddinova Dilnora Sharifjon kizi
Kokand branch of Tashkent State Technical University, Student
Mirzayev Islambek Umarali ugli
Kokand branch of Tashkent State Technical University, Student

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Abstract:
This article, we will discuss the heat balance of steam boilers, including the various components involved, the importance of maintaining a proper heat balance, and the methods used to achieve this.

Keywords: Boiler efficiency Heat transfer in steam boilers, Combustion efficiency in boilers, Types of fuel for steam boilers, Economizers for steam boilers, Water level control in steam boilers, Steam trap maintenance for boilers, Boiler blowdown procedures, Steam pressure control in boilers, Importance of boiler insulation, Boiler safety and maintenance, Diagnosis and repair of steam boiler issues.

INTRODUCTION: Steam boilers are a critical part of many industrial processes and serve as the primary source of energy for generating power and heat. They are widely used in various industries such as chemical, refineries, paper, and food processing. To ensure the efficient and safe operation of steam boilers, it is essential to maintain the heat balance. The heat balance of a steam boiler refers to the amount of heat supplied to the boiler versus the amount of heat lost from the boiler. The heat supplied to the boiler is expressed in terms of fuel energy and is typically provided by burning coal, oil, or natural gas. The heat lost from the boiler is due to various factors such as incomplete combustion, flue gas loss, radiation loss, and blow down losses. Maintaining the heat balance in steam boilers is critical for several reasons. Firstly, an imbalance in the heat balance can result in reduced efficiency, increased fuel consumption, and increased operating costs. Secondly, an unbalanced heat balance can also result in equipment failures, safety risks, and environmental issues. Therefore, it is essential to regularly assess and adjust the boiler's heat balance to ensure optimal performance
and reduce the risk of potential hazards.

HEAT BALANCE OF STEAM BOILERS

The heat balance of a steam boiler refers to the amount of heat energy supplied to the boiler and the amount of heat energy that is lost through various physical processes. In other words, heat balance is the accounting of all the heat that flows into and out of the boiler and controls the flow of steam and water in the boiler.
The heat balance equation for a steam boiler can be expressed as follows:
Q = Q1 + Q2 + Q3 + Q4 + Q5 + Q6
Where:
Q = Total heat energy supplied to the boiler
Q1 = Heat energy supplied by the fuel
Q2 = Heat energy lost through flue gases
Q3 = Heat energy lost through radiation and convection from the boiler shell
Q4 = Heat energy lost through blowdown and leakage
Q5 = Heat energy lost through incomplete combustion
Q6 = Heat energy lost through moisture in fuel and combustion air
To maximize the efficiency of a steam boiler, it is important to minimize the amount of heat losses. This can be achieved by optimizing the boiler design, improving the combustion process, and maintaining the boiler regularly.

OPTIMIZING THE BOILER DESIGN

The design of a steam boiler has an important role in maintaining the heat balance of the boiler. A poorly designed boiler can result in significant heat losses and poor steam quality. Therefore, it is essential to select the appropriate boiler design for specific applications. For example, a fire tube boiler is ideal for low-pressure applications where compact design and low maintenance cost are important considerations. On the other hand, a water tube boiler is suitable for high-pressure applications such as power generation, where steam quality is critical.

IMPROVING THE COMBUSTION PROCESS

The combustion process in the boiler generates heat energy that is transferred to the water/steam system. However, if the combustion process is not optimized, it can result in significant heat losses. The key to optimizing the combustion process is to maintain the right fuel-to- air ratio. If the fuel-to- air ratio is too high, the flame temperature increases, resulting in more heat loss through the flue gases. On the other hand, if the fuel-to- air ratio is too low, incomplete combustion occurs, resulting in additional heat loss through unburned fuel. Therefore, it is essential to maintain the fuel-to-air ratio within the recommended range by adjusting the combustion air/fuel ratio and monitoring the flue gas composition.

MAINTAINING THE BOILER REGULARLY

The heat balance of a steam boiler can be significantly affected by boiler scale, corrosion, and fouling of heat transfer surfaces. Therefore, it is important to maintain the boiler regularly to prevent these problems. Regular maintenance includes descaling and cleaning the inside of the boiler, checking the combustion process, and inspecting the heat transfer surfaces for signs of corrosion or fouling.

The heat balance of a steam boiler is essential to maintain the efficient operation of the boiler. The heat loss in the combustion process, as well as through the physical process of water/steam transfer, can significantly affect the boiler's performance. By optimizing the boiler design, improving the combustion process, and maintaining the boiler regularly, it is possible to improve the heat balance of the boiler and maximize its efficiency.

COMPONENTS OF HEAT BALANCE:

The heat balance of steam boilers consists of the following components:

1. Fuel- The amount of heat generated by the fuel is the main source of heat for the boiler. It is measured in British Thermal Units (BTUs) or Megajoules (MJ). The fuel can be a solid, liquid or gaseous form.
2. Combustion Efficiency - The combustion efficiency is the percentage of fuel that is burned and converted to useful heat. It is affected by a number of factors including the fuel type, combustion temperature, and the size and shape of the combustion chamber.
3. Heat Loss- A considerable amount of heat is lost from the boiler in the form of radiation, convection, and dry flue gases. The heat loss can be minimized by using insulation around the boiler, reducing gaseous formation and by proper maintenance and cleaning.
4. Steam Generation- The amount of steam generated by the boiler is another important component of the heat balance. It is measured in pounds per hour (lb/hr) or kilograms per hour (kg/hr).
5. Steam Pressure and Temperature- The pressure and temperature of the steam generated by the boiler are also essential components of the heat balance. They have a direct impact on the efficiency and economy of the steam generation process.
6. Feedwater Heating- Feedwater heating is the process of heating the water that is used to generate steam. The heat for feedwater can be obtained from either the flue gas or steam that has been condensed back into water.
7. Boiler Blowdown- The blowdown of the boiler is the process of removing the water that has been heated and has become too concentrated with dissolved solids. This is important to prevent the build-up of harmful minerals in the boiler.

METHODS TO IMPROVE HEAT BALANCE:

To improve the heat balance of steam boilers, the following methods can be used:

1. Reduction of Heat Loss- A comprehensive insulation system should be installed around the boiler to minimize heat loss. Additionally, air infiltration should be minimized to reduce the amount of heat lost.
2. Combustion Efficiency- Combustion efficiency can be improved by using proper combustion techniques, such as proper fuel mixture, and preventing fuel burners from clogging.
3. Steam Generation- Steam generation can be improved by increasing the size of the boiler and improving steam turbine efficiency.
4. Feedwater Heating- High-pressure feedwater pumps and heat exchangers can be used to increase the temperature of the feedwater before it enters the boiler.
5. Boiler Blowdown- Blowdown can be minimized by using an automatic feedwater control system, which automatically modulates the amount of feedwater to compensate for changes in steam demand.

CONCLUSION:

The heat balance of steam boilers is essential to ensure optimal performance and energy efficiency. The heat balance consists of fuel, combustion efficiency, heat loss, steam generation, steam temperature and pressure, feedwater heating and boiler blowdown. By optimizing these components, the heat balance of steam boilers can be improved, increasing the efficiency of the steam generation process and reducing energy costs. Proper maintenance and adherence to industry standards and regulations are essential to maintain safe and efficient operation of steam boilers.

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