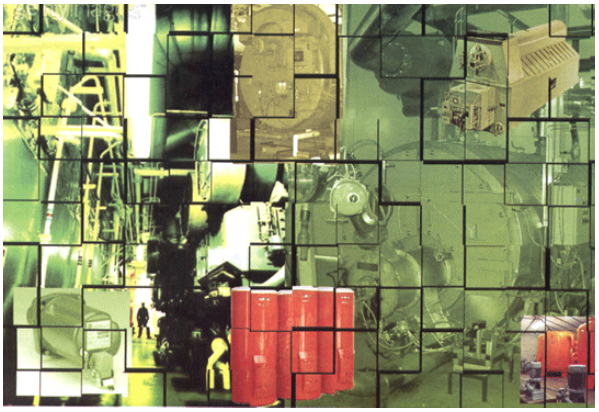
Types of Boilers

A wide range of options



Boiler systems are classified in a variety of ways. They can be classified according to the end use, such as foe heating, power generation or process requirements. Or they can be classified according to pressure, materials of construction, size tube contents (for example, waterside or fireside), firing, heat source or circulation. Boilers are also distinguished by their method of fabrication. Accordingly, a boiler can be pack aged or field erected. Sometimes boilers are classified by their heat source. For example, they are often referred to as oil-fired, gas-fired, coal-fired, or solid fuel –fired boilers.

Let us take a look at some typical types of boilers.

Firetube boilers

Firetube boilers consist of a series of straight tubes that are housed inside a water-filled outer shell. The tubes are arranged so that hot combustion gases flow through the tubes. As the hot gases flow through the tubes, they heat the water surrounding the tubes. The water is confined by the outer shell of boiler. To avoid the need for a thick outer shell firetube boilers are used for lower pressure applications. Generally, the heat input capacities for firetube boilers are limited to 50 mbtu per hour or less, but in recent years the size of firetube boilers has increased.

Firetube boilers are subdivided into three groups. Horizontal return tubular (HRT) boilers typically have horizontal, self-contained firetubes with a separate combustion chamber. Scotch, Scotch marine, or shell boilers have the firetubes and combustion chamber housed within the same shell. Firebox boilers have a water-jacketed firebox and employ at most three passes of combustion gases.

Most modern firetube boilers have cylindrical outer shells with a small round combustion chamber located inside the bottom of the shell. Depending on the construction details, these boilers have tubes configured in either one, two, three, or four pass arrangements. Because the design of firetube boilers is simple, they are easy to construct in a shop and can be shipped fully assembled as a package unit.

These boilers contain long steel tubes through which the hot gases from the furnace pass and around which the hot gases from the furnace pass and around which the water circulates. Firetube boilers typically have a lower initial cost, are more fuel efficient and are easier to operate, but they are limited generally to capacities of 25 tonnes per hour and pressures of 17.5 kg per cm^2.

Watertube boilers

Watertube boilers are designed to circulate hot combustion gases around the outside of a large number of water filled tubes. The tubes extend between an upper header, called a steam drum, and one or more lower headers or drums. In the older designs, the tubes were either straight or bent into simple shapes. Newer boilers have tubes with complex and diverse bends. Because the pressure is confined inside the tubes, watertube boilers can be fabricated in larger sizes and used for higher-pressure applications.

Small watertube boilers, which have one and sometimes two burners, are generally fabricated and supplied as packaged units. Because of their size and weight, large watertube boilers are often fabricated in pieces and assembled in the field. In watertube or "water in tube" boilers, the conditions are reversed with the water passing through the tubes and the hot gases passing outside the tubes. These boilers can be of a single- or multiple-drum type. They can be built to any steam capacity and pressures, and have higher efficiencies than firetube boilers.

Almost any solid, liquid or gaseous fuel can be burnt in a watertube boiler. The common fuels are coal, oil, natural gas, biomass and solid fuels such as municipal solid waste (MSW), tire-derived fuel (TDF) and RDF. Designs of watertube boilers that burn these fuels can be significantly different.

Coal-fired watertube boilers are classified into three major categories: stoker fired units, PC fired units and FBC boilers.

Package watertube boilers come in three basic designs: A, D and O type. The names are derived from the general shapes of the tube and drum arrangements. All have steam drums for the separation of the steam from the water, and one or more mud drums for the removal of sludge. Fuel oil-fired and natural gas-fired watertube package boilers are subdivided into three classes based on the geometry of the tubes.

The "A" design has two small lower drums and a larger upper drum for steam-water separation. In the "D" design, which is the most common, the unit has two drums and a large-volume combustion chamber. The orientation of the tubes in a "D" boiler creates either a left or right-handed configuration. For the "O" design, the boiler tube configuration exposes the least amount of tube surface to radiant heat. Rental units are often "O" boilers because their symmetry is a benefit in transportation.

"D" Type boilers

"D" type boilers have the most flexible design. They have a single steam drum and a single mud drum, vertically aligned. The boiler tubes extend to one side of each drum. "D" type boilers generally have more tube surface exposed to the radiant heat than do other designs. "Package boilers" as opposed to "field-erected" units generally have significantly shorter fireboxes and frequently have very high heat transfer rates (250,000 btu per hour per sq foot). For this reason it is important to ensure high-quality boiler feedwater and to chemically treat the systems properly. Maintenance of burners and diffuser plates to minimize the potential for flame impingement is critical.

"A" type boilers

This design is more susceptible to tube starvation if bottom blows are not performed properly because "A" type boilers have two mud drums symmetrically below the steam drum. Drums are each smaller than the single mud drums of the "D" or "O" type boilers. Bottom blows should not be undertaken at more than 80 per cent of the rated steam load in these boilers. Bottom blow refers to the required regular blowdown from the boiler mud drums to remove sludge and suspended solids.

“O” types boilers

“O” design boilers have a single steam drum and a single mud drum. The drums are directly aligned vertically with each other, and have a roughly symmetrical arrangement of riser tubes. Circulation is more easily controlled, and the larger mud drum design renders the boilers less prone to starvation due to flow blockage, although burner alignment and other factors can impact circulation.

Electric boilers

Electric boilers can use electric resistance heating coils immersed in water and are normally very low-capacity units. Other types of electric boilers are electrode-type units that generate saturated steam by conducting current through the water itself. Boiler water conductivity must be monitored and controlled. If the conductivity is too low, the boiler will not reach full operating capacity. When the conductivity is too high, over-current protection will normally shut off the power.

Proper conductivity and high-quality water as well as effective water treatment is required. Solids from the saturated steam tend to accumulate slowly on the insulators supporting the electrodes from the grounded shell. The unit must be shut down periodically so that the insulators can be washed off to prevent arcing. Finally, voltages of up to 16 kV may be used. Protection is needed for ground faults, over-current and, for three-phase systems, loss of phase. The main electrical disconnect switch must be locked out before performing maintenance on the boiler.

Other boiler classifications

Cast Iron boilers

Cast iron boilers are fabricated from a number of cast iron sections that are bolted together. The design of each section includes integral water and combustion gas passages. When fully assembled, the interconnecting passage create chambers where heat is transferred from the hot combustion gases to the water. These boilers generally produce low-pressure steam (15 psig) or hot water (30 psig) and burn either oil or natural gas.

Because of their construction, cast iron boilers are limited to smaller sizes. Because the components of these boilers are relatively small and easy to transport, they can be assembled inside a room with a conventional size doorway. This feature means that cast iron boilers are often used as replacement units, which eliminate the need for temporary wall removal to provide access for larger package units. They consist simply of a firebox surrounded by a water chamber for heat to be transferred directly from the firebox to the boiling water or to tube-type water heaters, while there are no boiler tubes. There is minimal need for feedwater, and the boiler water does not concentrate.

Tubeless boilers

Another boiler type that is sometimes used to produced steam or hot water is the tubeless boiler. The design of tubeless boilers incorporates nested pressure vessels with water located between the shells. Combustion gases are fired into the inner vessel where heat is transferred to water located between the outside surface of the inner shell and the inside surface of the outer shell. For oil-fired and natural gas-fired vertical tubeless boilers, the burner is typically located at the bottom of the boiler.

Some special applications of boilers require specific designs and operating procedures. These include waste to steam (trash to steam), waste heat recovery and heat recovery steam generators (HRSG).

Trash to steam

Trash to steam boilers use trash (paper, plant material, plastics, etc.) as fuel. The steam is used for electrical power generation or central plant steam delivery. The main consideration is that the fuel has a widely varying heat value. Temperatures and heat fluxes can very significantly over time. Water flows and the effects on chemical treatments can also very widely. These units need more exhaustive monitoring and control. Fireside fouling is frequently a problem.

Waste heat recovery

If the waste heat stream is at 600^{o}F or higher, a boiler can be used cost effectively to generate steam by recovering the heat value in the stream. Such boilers can be of either watertube or firetube design. These types of systems are common in the process industries.

HRSG systems

Heat recovery steam generators (combined cycle) are typically used in combined cycle electric power generation. Waste heat from gas turbine exhaust is used to generate steam. The low temperature of the exhaust gases compared to direct fired units puts less stress on he boiler tubes. These units are typically constructed of lighter grade materials. One common design is a three-drum configuration. The low-pressure (LP) drum is used as a deaerating feedwater heater. The intermediate pressure (IP) drum is used to generate steam for injection into the gas turbine. The high pressure (HP) drum is used to generate turbine steam for electrical power generation. Some units are configuration with duct burners to produce additional power. This can result in higher heat transfer and boiler system problems.

HRSGs require high-purity water because of the use of the IP drum steam for turbine injection. Dissolved solids must be kept to a bare minimum in these units. Because many units are in a cycling mode, start-up, shutdown and lay-up procedures are even more important in these systems.

In a typical HRSG unit, the LP drum is treated with amines and oxygen scavengers, the HP drum is treated with a coordinated phosphate programme, and the IP drum uses blowdown from the HP drum for some of the feedwater.

Packaged boilers

Boilers are occasionally distinguished by their method of fabrication. Packaged boilers are assembled in a factory, mounted on a skid, and transported to the site as one package, ready for hookup to auxiliary piping. Shop assembled boilers are built up from a number of individual pieces or subassemblies. After these parts are aligned, connected, and tested, the entire unit is shipped to the site in one piece. Field erected boilers are too large to be transported as an entire assembly. They are constructed at the site from a series of individual components. Sometimes these components require special transportation and lifting considerations because of their size and weight.

The packaged boiler is so called because it comes as a complete package. Once delivered to the site, it requires only the steam, water pipe work, fuel supply and electrical connections to be made for it to become operational. Packaged boilers are generally of shell type with fire tube design so as to achieve high heat transfer rates by both radiation and convection.

The features of packaged boilers are:

* Small combustion space and high heat release rate resulting in faster evaporation.
- Large number of small diameter tubes leading to good convective heat transfer.
- Forced or induced draft systems resulting in good combustion efficiency.
- A number of passes resulting in better overall heat transfer.
- Higher thermal efficiency levels compared with other boilers.

Owning to the evolution of boiler technology over time, it may be said with near surety that the types of boilers will grow over time. And many of these classifications may very well be overlapping.

But whatever the case may be, this only increases the choice for the final customer.

Reference Book:
Power Line
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