TIP SHEET

- Firetube boilers use radiant and convective forces to transfer heat from the burner to the water within the vessel
- An advanced heat transfer spiral tube increases heat transfer by as much as 85% compared to a traditional bare tube
- In today's optimized boilers, the heating surface is approximately three square feet per boiler horsepower versus five square feet

Firetube Boiler Design and Engineering Part II

There are different types of firetube boiler designs, including dryback and wetback ones with either an integral or gun burner. No matter the type, in a firetube boiler both radiant and convective forces work to transfer heat from the burner to the water within the vessel.

Radiant heat transfer occurs in the furnace and includes the surfaces that surround the flame. To maximize radiant heat transfer, it is imperative that the burner and the furnace be matched precisely so combustion can be fully completed. This ensures that there is very low to no CO and zero hydrocarbon and the heat is delivered within its confines to maximize radiant heat absorption conductively.

Convective heat transfer in the boiler is the amount of surface that does not see the flame, but is only exposed to the hot combustion gases. This is the area of design where the heat transfer engineer is looking very closely to maximize the Reynolds number, which is the ratio of inertia forces to viscous forces. To a large extent, this dynamic is dependent on the turbulent velocity of the gas passing through the heat transfer surfaces.

Engineers want to maximize the heat transfer coefficient, which is the proportionality between heat flow per unit area and the delta T from fireside to waterside.

It used to be that five square feet of heating surface in the boiler was required to maximize efficiency and extend the life of the pressure vessel. Some manufacturer designs and many specs continue to use this old, but still valid, engineering principle.

In today's optimized firetube boiler design, highly engineered spiral tubes are used instead of bare tubes. A bare tube only utilizes a portion of its diameter for heat transfer because the hot gas boundary layer that forms as the velocity slows during its travel through the tube reduces the heat transfer. As a result, more surface area is needed to exchange the heat of the gas before it exits the stack. On the other hand, an advanced heat transfer spiral tube uses its entire inner tube diameter surface, increasing the heat transfer by as much as 85% compared to a bare tube.

Due to this efficiency, fewer tubes and passes are required in today's newer design, thereby reducing the fan motor horsepower, which saves electrical energy. This also facilitates a more compact boiler design that has a smaller footprint and weighs less than the traditional firetube.

By optimizing the convective heat transfer surface of the spiral tube, engineers were afforded the space to geometrically optimize the size and shape of the furnace. Utilizing advanced computational fluid dynamics (CFD) modeling techniques, engineers also maximized the heat transfer in the radiant zone, achieving the overall optimum Reynolds number and heat transfer coefficients while significantly lowering the flue gas pressure drop through the unit.

In today's optimized boilers, the heating surface is approximately three square feet per boiler horsepower versus five square feet. This is due to the heat exchanger now more effectively extracting heat in both the radiant and convective sides.

Today's engineers use CFD and Finite Element Analysis to engineer and prove better firetube boiler packages. These analytical design techniques enable them to achieve optimal radiant and convective heat transfer outcomes and also properly match burner characteristics to the furnace to maximize efficiency and ensure a long asset life.

To learn more about firetube boiler design, watch the Firetube Boiler Design, Construction and Engineering webinar. To find an authorized Cleaver-Brooks representative near you, visit cleaverbrooks.com.