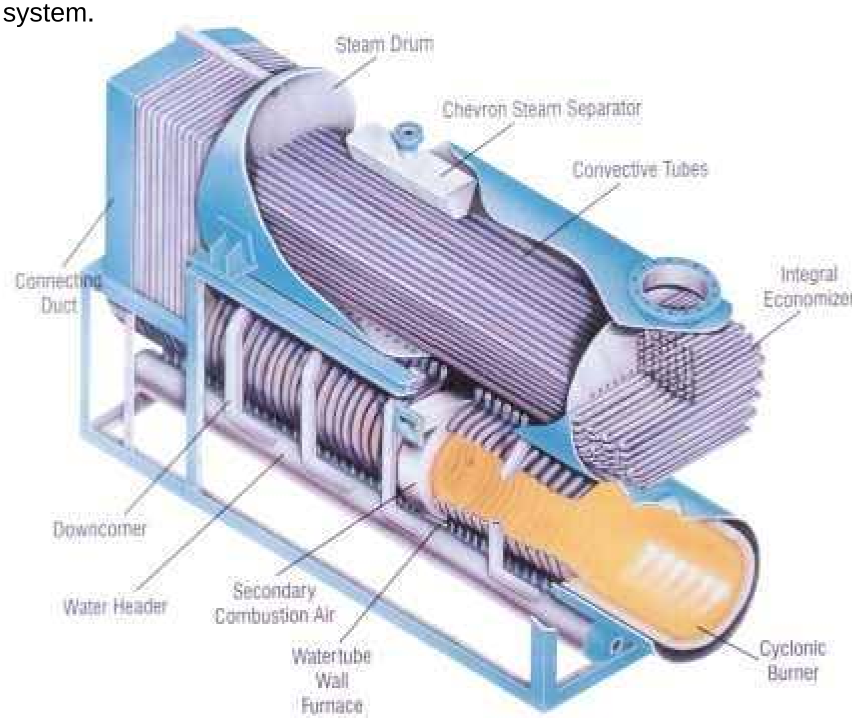
Turbo Fire XL Boiler

The TurboFireXL boiler combines watertube and firetube designs with a cyclonic burner and staged combustion system.



Cyclonic Combustion

Staged cyclonic combustion is executed in a cylindrical refractory burner section by injecting primary combustion air and fuel tangentially at high velocity through nozzle ports. The primary zone of the staged cyclonic burner is fired fuel rich in a combustion process characterized by intense swirl combustion flow and high internal recirculation. Combustion is completed by injecting secondary air through ports in a refractory ring in the waterwall section. The air staging of cyclonic combustion contributes to reducing NOx emissions in the boiler. Theoretically, fuel rich combustion of well-mixed air and fuel prevents the formation of NOx in the primary zone, since all the oxygen in the air is burned in the combustion of the fuel. Thus no oxygen is available to react with the nitrogen in the air to form nitrogen oxides. Since fuel rich combustion occurs at reduced flame temperature, the primary combustion temperatures are reduced in the staged combustion. The primary zone reduced gas temperature assists in minimizing the NOx formation in the secondary stage. In the primary zone burner, combustion air and fuel are mixed using a cross flow nozzle. The mixing is further improved by the enhanced recirculation induced by the refractory target orifice located at the secondary air injection ring. By injecting secondary air into the target orifice, good mixing of secondary air with the primary zone gases is accomplished. Low CO emissions and low excess air over a high turndown range (10:1) can be realized due to the proper mixing in the staged cyclonic burner. The turndown is the ratio between full load output and minimum load output. Having a high turndown reduces the frequency of on/off cycling. NOx formation is further reduced by the steam injection system (up to 80% possible reduction) located in the staged cyclonic burner. The steam is injected with natural gas into the primary zone of the burner and causes a lower local flame temperature. The injection of a small amount of steam (less than 0.05 lb of steam per ft3 of fuel flow) achieves NOx emissions < 25 ppm and slightly reduces the boiler efficiency (typically—3-10%). For oil firing, steam is injected through the swirler and annulus area of the oil gun. Other industry methods of NOx reduction are low excess air (natural gas fuel only—5-10% reduction), flue gas recirculation (60-70% reduction), and selective catalytic reduction (SCR—up to 90%).

The cyclonic combustion has a significant convective heat transfer component resulting from the swirling cyclonic flow, which increases the heat transfer. This increased heat flux reduces the surface area needed to generate the required steam.

Watertube Wall Boiler

The waterwall boiler section is a cylindrically shaped container. It contains 2-inch-diameter waterwall tubes on 3-inch center-to-centers. A gas-tight design for the high-pressure operation and containment of flue gases is achieved by waterwall tubes continuously seal-welded to a fin membrane. The watertubes form a wishbone configuration with one outlet connection for steam/water mixture to a steam drum and two inlet connections for water from a bottom water header. The wishbone configuration promotes circulation of the steam/water mixture in the membrane tubes to the steam drum. The bottom water header is protected from the flame impingement by removable cast refractory blocks.

The refractory burner section is flanged to the watertube wall. The secondary air section is seal-welded to the watertube wall. The target orifice in the waterwall is attached in the secondary air section. A turning box with watertube side walls and end walls connects the watertube boiler section and the firetube section in the steam drum. The turning box waterwall tubes also have a wishbone configuration with an outlet to a top header that connects with the steam drum and two water inlets from the bottom water header. A man-way to access the watertube boiler section is located at the end wall of the turning box. In addition, there are two viewing ports; one port gives a view of the flame from the burner and the other provides a view of the furnace and flame from the rear turning box.

Turning Box and Economizer

The watertube wall design of the sides of the turning box between the waterwall section and the steam drum provides additional heat transfer surfaces from the flue gas to the water-steam mixture (which increases boiler efficiency) and reduces refractory.

Standard and optional economizers are available based on site requirements. The standard economizer is a finned tube integral design, incorporating several parallel serpentine coils, connected to common top and bottom headers. The inlet and outlet of each coil are welded to a curved plate, and the plate is fitted onto the shell. Spacers that provide additional support and maintain spacing for the flue gas are welded between the elbows of each economizer coil. The flue gas is prevented from bypassing the economizer by flow diverters. A superheater, consisting of a compact serpentine tube array, is located in the turning box. The superheater is optional but helps produce higher overall steam generation efficiencies.

Burner and Steam Drum

The burner chamber has 10 to 14 air ports depending on the boiler size. The cyclonic burner has a cross-flow nozzle mixing design. Ports for the pilot, flame scanner, and optional oil-firing nozzle are in the burner front cover. The secondary air ports are located in the target orifice and the ports are tangential to the inner diameter of the orifice.

The internal components of the steam drum include a steam separator and convective tubes with option for a chemical feed and surface blowoff system. The convective tube bank further heats the steam/water mixture before releasing it to the steam outlet through the steam separator at the top of the drum. The separator is installed against the crown of the steam drum to provide maximum water/steam disengagement height. Typically, the internal surface of the convection tubes is ribbed to promote heat transfer. The diameter of the tubes is 2.5 inches for 30,000 lb/hr and 3 inches for 65,000 lb/hr and 100,000 lb/hr boiler units.

Reference:

http://www.pnl.gov/TechReview/boiler/boiler.html