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Technical Publication

Modern Trends in the Design of Central Station Boilers

by

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Presented at
20th Annual Rural
Electric Generating Conference
June 2-5, 1969
Denver, Colorado

MODERN TRENDS IN THE DESIGN OF CENTRAL STATION BOILERS

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The ever increasing demand for electricity throughout the country has prompted steam generating plants to increase in size to meet this challenge. One of the obvious signs to keep up with demand is the trend of more and more steam capacity per unit. Central station units sold by Riley Stoker Corporation in 1963 averaged 725,000 lbs of steam per hour. This average capacity was up to 1,150,000 lbs in 1965 and increased to 1,300,000 lbs in 1967. Most of those boilers were natural circulation units. Only a few years ago natural circulation boilers having a drum pressure of more than 2400 lbs were considered to be unusual. Today those pressures are up to 2750 lbs corresponding to turbine throttle pressures of 2500 lbs. Some years ago units operating at supercritical pressure were considered to be exceptional units. This is not so any more. We at Riley Stoker Corporation are building supercritical as well as natural circulation steam generators.

The design of a steam generator is governed by a variety of considerations. The most important one is that it has to adhere to the performance dictated by the plant requirements. Some of those important points are boiler efficiency, final reheat and superheat steam temperatures, fluid pressure drop and many more, all of which in some way or another affect the net station heat rate. In order to achieve this goal, proper selection of boiler components and equipment are very important considerations. From the operator's point of view a minimum of maintenance is expected from a steam generator. Last but not least is the question of economics. In today's highly competitive market is it imperative to reduce cost.

Keeping all of this in mind the engineer has to come up with a design which not only will perform well but is also most economical. As you all know the type of fuel being fired in a unit determines the shape of the furnace to a certain degree. Solid fuel fired furnaces have to be large in order to prevent slagging and plugging of heating surfaces. In those furnaces a heat release of 80,000 to 90,000 Btu/sq ft/hr is about the maximum one can allow and no trend away from this is evident, Figure 1. In oil and gas-fired units there has been a general acceptance of higher heat releases. A few years ago a gas-fired unit with a heat re-

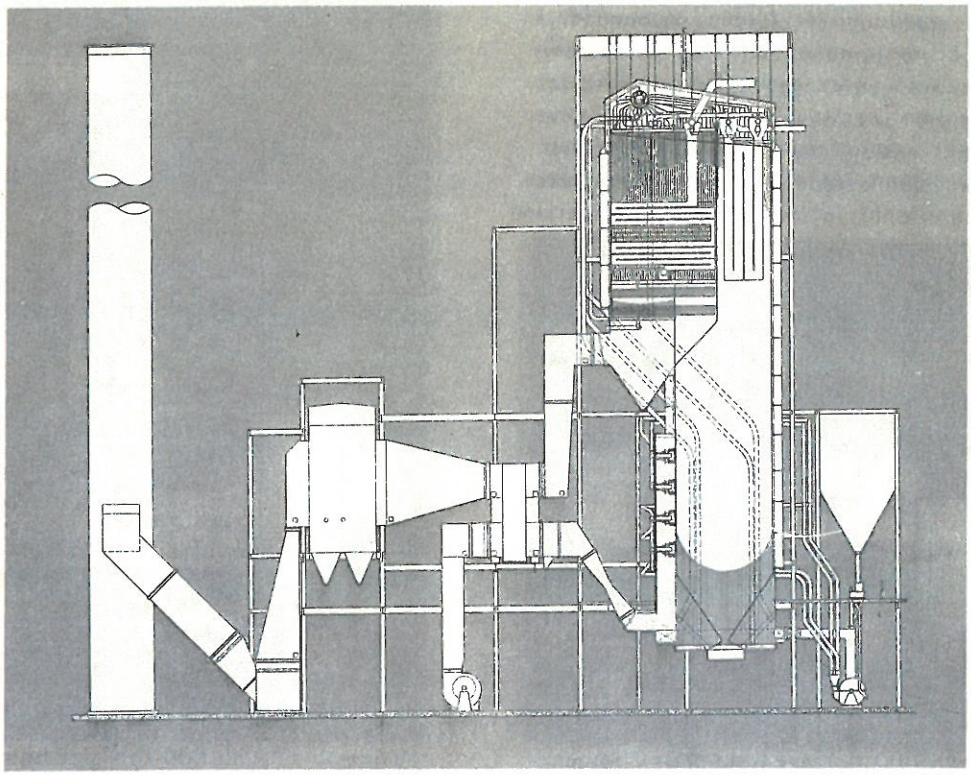

Figure 1. 2,000,000 lbs per hour Riley Steam Generator Damper Control of Reheat

lease of 150,000 Btu/sq ft of furnace envelope was considered to be highly loaded. Today 200,000 Btu/sq ft/hr is not unusual for oil and in natural gas firing 300,000 Btu/sq ft/hr is being used with increasing frequency, Figure 2. High heat release rates combined with high operating pressure (2200 lbs and up) make it mandatory that in certain furnace areas alloy tubing be installed.

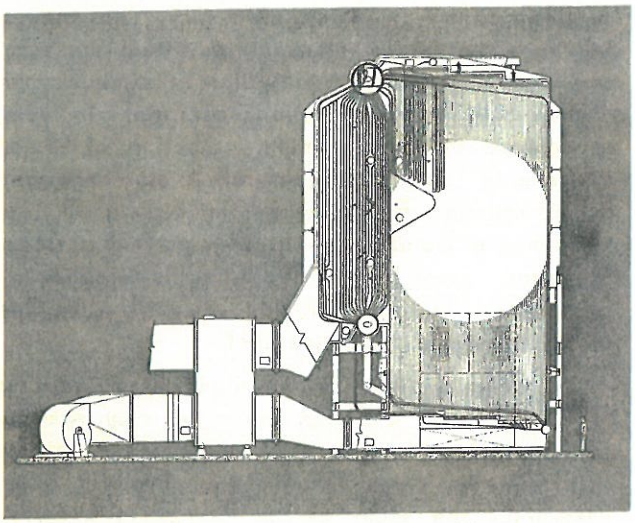

Figure 2. 700,000 lbs per hour Riley Steam Generator Gas & Oil-fired

The accompanying cross sectional side views of steam generators we have sold or recently offered illustrate the trend in superheater. The radiant superheaters are made up of platens suspended in the upper part of the furnace and are appreciably larger than they were years ago. The superheaters with three separate sections, a low temperature section, a radiant section and a high temperature section has now been replaced with superheaters having two sections only, a low temperature section and a radiant section, Figure 3. The finishing section or high temperature section is now an integral part of radiant superheater platens. It is obvious that with higher pressure and temperature alloy tubing is required. Due to the advancement of metallurgy some of the more expensive chrome molybdenum alloy has been replaced by carbon molybdenum steel.

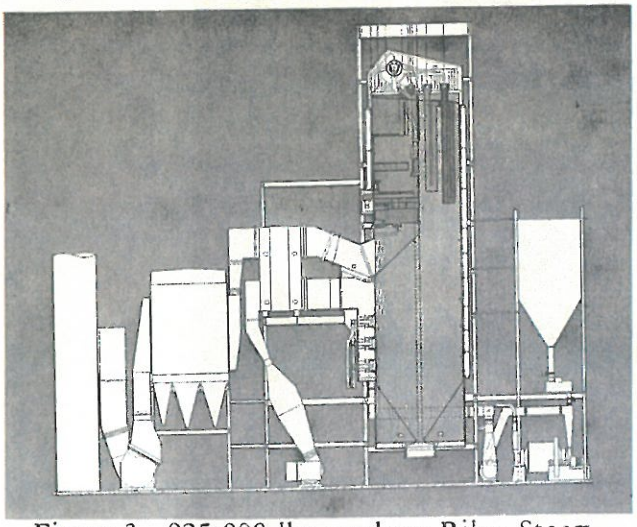

Figure 3. 925,000 lbs per hour Riley Steam Generator Damper Control of Reheat

Flue gas velocities in convection heating surfaces were usually limited to about 3600 ft per minute regardless of type of fuel being fired. Except for solid fuel fired units some of the specifications have pushed that limit up to 6000 ft per minute maximum. Reasonable increases in fan power and operating costs are acceptable when balanced against the resultant decrease in capital investment. This appears to be an outgrowth of the higher interest rates we are now experiencing.

Several years ago there was a reluctance on the part of some customers to accept a spray water type of control on steam temperature. After a number of successful installations the opposition vanished and today spray water control of primary steam superheater is widely accepted. We seem to be passing through a similar period on reheat/steam temperature spray control. Final reheat steam temperature control was mostly accomplished by

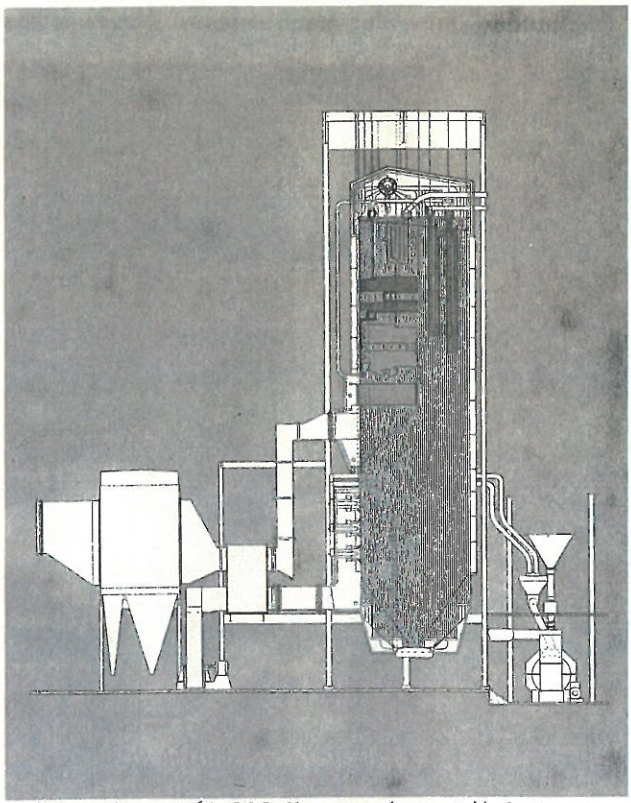

Figure 4. 1,160,000 lbs per hour Riley Steam Generator Excess Air Control of Reheat

other means and spray water in the reheater was used only in emergency or for overriding conditions. In many of today's steam generators spray water is used extensively for control of final superheat and reheat temperatures. As for the future we expect this to remain.

We also think that the use of excess air as a means of controlling temperature will be employed more frequently, Figure 4. It seems to us that acceptance of excess air is growing very fast. This type of steam temperature control is extremely simple. When the unit is operated at loads less than 100% output the normal tendency for steam temperature to fall off is counteracted by increasing the flue gas flow over the superheater and reheater surfaces by gradual and slight increase in excess air. This means that when the unit is operated at lower loads the efficiency is reduced. However, with today's capital charges and high interest rates it is easy to accept slightly higher fuel quantities at part load, particularly if the new unit will be operated at or near full load over the evaluation period.

AIR POLLUTION

It has been established that operation at low excess air in the magnitude of 1% or 2% reduces oxides of nitrogen and sulfuric acid formation when firing oil. On the other hand, the equipment needed for very careful metering of both fuel and air to each and every burner makes an installation quite expensive. The trend today is to use moderately low excess air in the order of 5% or 6% and to supplement this with fuel additives for chemical control of the flue gases.

The campaign against air pollution is continuing unabated. Electrostatic precipitators are frequently selected for 99% particulate removal when a few years ago 96% efficiency was acceptable and many pulverized coal-fired units has mechanical collectors guaranteeing 80% collection but delivering 70% collection. An increase in precipitator collection efficiency from 96 to 99% is far more impressive than these two figures appear because it means that the flyash in the stack has been reduced from 4% to 1% which is a reduction in the air polluting quantities of 75%.

There is a definite trend in the addition of equipment to remove sulphur gases from the flue gas. The application of gas scrubbers is proving to be expensive both from initial investment and also from the horsepower required for operation. Nevertheless the trend is certainly clear that steam generating units in the future will have equipment to remove sulphur from the flue gas.

Directly related to air and water pollution is the problem of waste removal. We anticipate that in years to come large incinerators will be installed throughout the country to burn mostly municipal refuse but it will also be only a matter of time that the available heat is used in connection with the generation of electricity in steam power plants and/or for heating swimming pools in municipalities or for process steam not unlike what is accomplished today with industrial type boilers.

As mentioned in the beginning unit sizes are steadily increasing. What also seems to be indicated is that many utilities find themselves having too many units in their system operating at supercritical pressure. Besides the many advantages of operating at supercritical pressure there is one decisive disadvantage in that there is not much of a storage capability available to compensate for some load swings. Careful considerations have to be given as to size of unit and especially to type of operation, supercritical or natural circulation, to forestall any major breakdown in the system network. With units

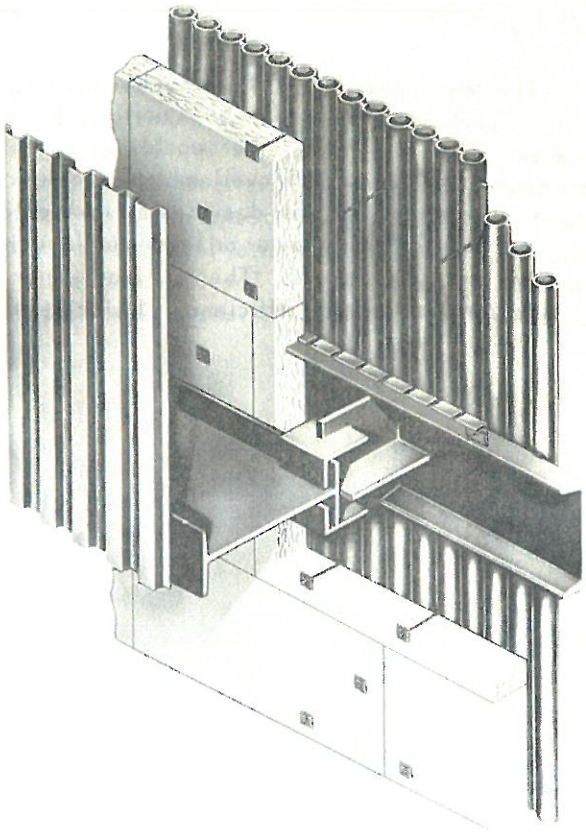

Figure 5. Riley Fire-Wall Construction

500 megawatts and larger we feel that there is an advantage in having these made up of two independent boilers serving one turbine. Twin boiler units add greatly to reliablity, availability and flexibility.

With still larger steam generators to come it becomes more and more important to cut down on erection time if at all possible. The tendency to ship large shop fabricated sub-assemblies is continuing. Furnace water walls are universally made of welded panel construction for both pressure and suction operated furnaces, Figure 5. It is now more common to have one regenerative air heater rather than two on a steam generating unit. This results in an appreciable saving in duct work and dampers. There is also a small saving in the regenerative air heater leakage with one heater rather than two. But the main reason perhaps for a single air heater per boiler is the attempt to reduce investment charges.

Some of the very large steam generating units today have two fans rather than one. The reason for this is not a search for more reliability if a fan outage occurs. Instead, the reason is that we have reached the point where if we try to use one fan per boiler we find that the fan wheel exceeds the limits of transportation dimensions.

PEAKING UNITS

The term "peaking unit" has a new meaning today. A peaking unit used to be a unit with built in excess capacity, a unit that would operate for short periods at 33% or 50% overload. Now a peaking unit is an individual unit designed for low yearly hourly service (25% load factor or less) and for daily shutdown and quick starts. The low load factor dictates low cost and low efficiency. Quick starts

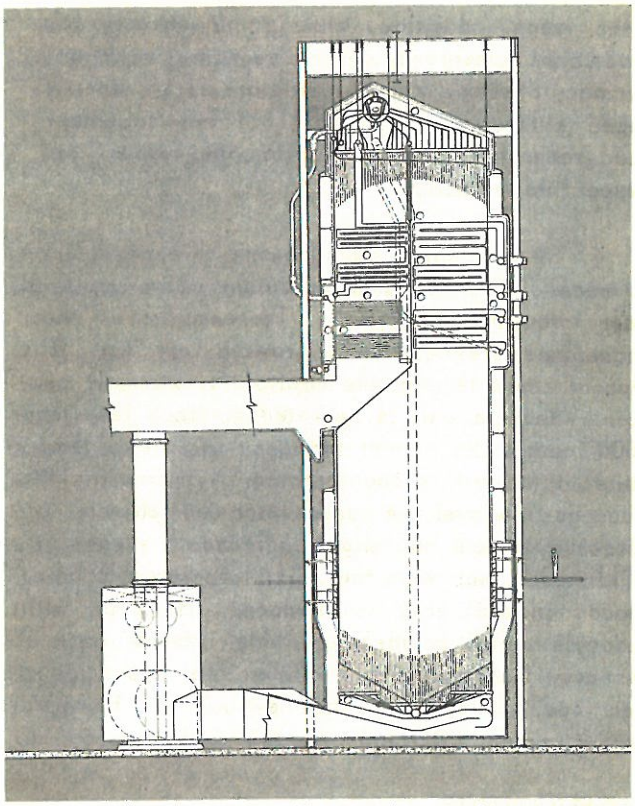

Figure 6. 1,150,000 lbs per hour Riley Steam Generator Gas Recirculation Control of Reheat

call for oil or gas fuel rather than coal and fully drainable superheaters. Certainly peaking units are more numerous than they were a few years ago.

CONCLUSION

Finally I would like to point out that a trend in thinking all steam generation will soon be by nuclear power has reversed itself. There are many who now think fossil fired units will be around for a long, long time. Thank you.