CONSIDERATIONS FOR REHABILITATING SPREADER STOKER-FIRED BOILERS

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ABSTRACT

Due to the rising costs of fuel, capital and new equipment, Power Plant Engineers are taking a closer look at upgrading existing plant equipment. This paper addresses areas of consideration for the rehabilitation and upgrading of existing spreader stoker-fired boilers, focusing primarily on the fuel burning equipment. This paper also addresses certain economic considerations associated with the work involved.

INTRODUCTION

Many power plants today have spreader stoker-fired boilers of one type or another. These units have either been mothballed because of their age or, for various other reasons, do not get the maintenance attention required to insure efficient operation. The plant's steam generation is usually provided by the more modern oil-and- gas fired boilers.

The unpredictable costs of these fuels and their reported dwindling reserves are prompting Power Plant Engineers to seriously consider refurbishing existing coal firing equipment. The upgrading and rehabilitation of this equipment could help reduce generating costs and also give the plant fuel flexibility.

There are many areas of a spreader stoker-fired boiler that need to be considered for rehabilitation, but none more important than the fuel burning equipment. The following discussion deals with the spreader stoker, associated equipment necessary for optimum performance and information to consider when developing material cost estimates.

BOILER INSPECTION

Unit efficiency, reliability and cost control or reduction are the major concerns of the Power Plant Engineer. A primary consideration to rehabilitate a spreader stoker fired boiler is to determine the present physical condition of the unit.

A comprehensive inspection of the unit will provide the Power Plant Engineer with the existing physical condition of the unit. It will also inform the Engineer of potential problems that may exist without his knowledge. The results of the inspection can determine whether the rehabilitation of the unit would or would not be cost

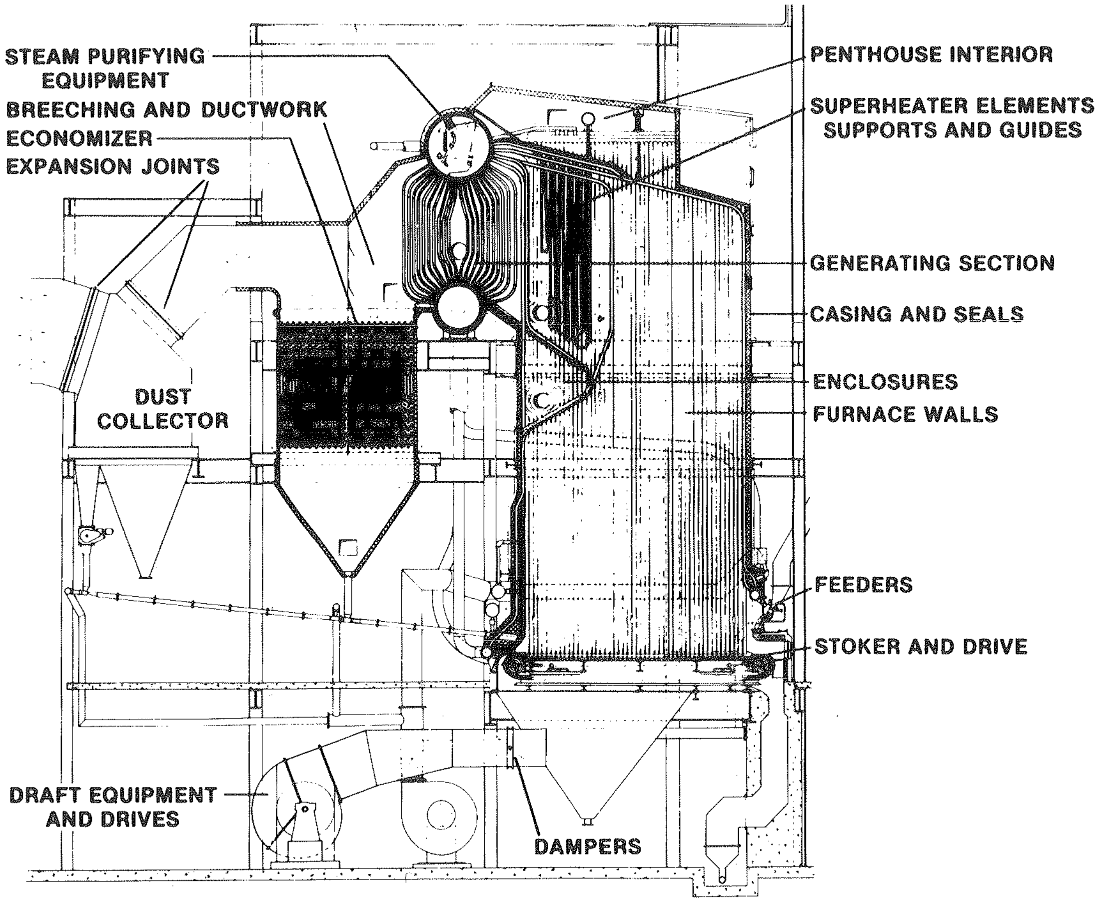


Figure 1

effective. Figure 1 illustrates the major areas of a unit which should be inspected. Proper use of the comprehensive inspection report can greatly assist the Power Plant Engineer in determining the scope of work required for the proper rehabilitation of the unit.

This type of customized unit inspection should be broken down into distinct categories, i.e. pressure parts, fuel burning equipment and auxiliaries. The inspection report should state the condition of the fuel burning equipment and recommendations may be made to upgrade the equipment to the latest standards. Depending on the extent of the inspection requested by the Power Plant Engineer, i.e. entire unit vs. fuel burning equipment only, pricing can vary from standard industry per diem rates for a Service Engineer and standard field service report to approximately $20,000, depending on size of the unit, for a comprehensive inspection report with recommendations.

STOKERS

Spreader stoker-fired boilers have been the workhorse of the industrial coal burning power plants. They are utilized on boilers that range in size from 40,000 pounds of steam per hour to 400,000 pounds of steam per hour. The spreader stoker can be adapted to oscillating grates, dump grates, or traveling grates. Discussions in this paper will be limited to the traveling grate spreader stoker.

Spreader stokers of the traveling grate type are probably the most popular stoker due to their relative simplicity, low maintenance and ability to respond to load variations. When upgrading or rehabilitating stoker equipment, the following areas should be closely investigated.

1. Grate/Grate Drive
2. Coal Feeder

GRATE/GRATE DRIVE

The grate is the surface on which the fuel is burned and which also allows combustion air to pass through. Due to overheating, the grate clips may have become distorted, cracked, missing or have air passages plugged, not allowing combustion air to pass through.

The grate clips should be constructed of high temperature alloy material to sustain longer life, control oxidation growth, maintain surface stability and minimize cracking. The grate clips could be subjected to temperatures as high as 1500F which the alloy material can survive.

The grate clips should also be self cleaning. The air passages should be designed and arranged to allow a uniform air flow for combustion and to eliminate plugging. The total surface of the clip should be exposed to cooling air to reduce distortion and overheating.

The grate support system is a very important part of the traveling grate spreader stoker. It should provide for the grate surface not to carry any load, therefore, providing longer life to the grate surface. It should also provide easy on line replacement of the grate clips.

The grate air seals should allow for uniform distribution of combustion air across the grate. These seals along with damper controlled air zones help regulate the combustion air in the direction of fuel travel.

Stoker grates are constantly being refined and or improved to provide better control, operation and dependability. Depending on the age and method used to protect the stoker when it was not in use, the stoker itself may require very little to place it back into peak operating condition. Work to refurbish the stoker might consist of as little as replacing a few grate clips and seals to as much as replacing the entire grate. One should also seriously consider any modifications or changes the manufacturer suggests, for these changes will provide cost savings via one or more of the above stated benefits.

The grate drive usually only requires a good cleaning to put it back to proper operating condition.

COAL FEEDER

Coal feeders of various types have been developed to provide positive and accurate metering of coal without avalanching, or overloading the distributor. The lateral and longitudinal distribution of coal over the grate surface is provided by the coal feeder. Figure 2 illustrates the most popular types of feeders used for firing coal on a traveling grate spreader stoker. The coal feeder is made up of two basic sections:

1. The fuel feeder in the upper section.
2. The fuel distributor in the lower section.

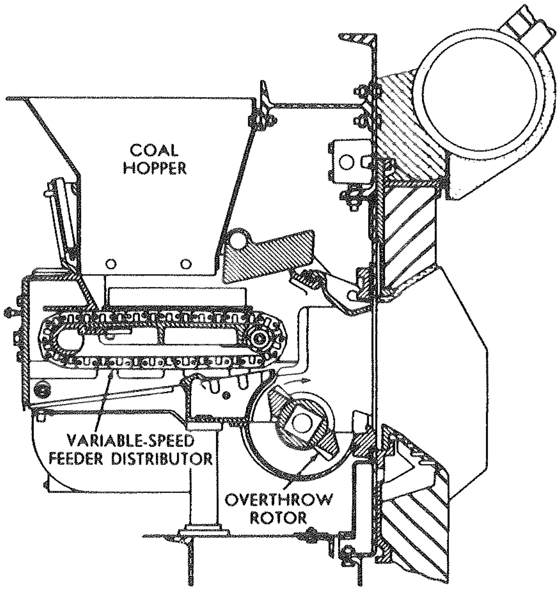
The fuel feeder should consist of an independently driven device which will volumetrically meter the fuel regardless of fuel size or moisture content. The independent drive allows for the feeder to be taken off line for short periods of time, should the need arise, without shutting down the boiler. An electric motor with a 2-stage speed reducer connected to a master control station provides proportional control to all feeders.

The fuel distributor should consist of multiple adjustable lateral distributor blades to insure uniform fuel distribution over the grate surface. Like the fuel feeder, it too should be individually driven and controlled so that one motor failure won't trip the unit. The speed of the distributor should be adjustable to achieve optimum fuel distribution.

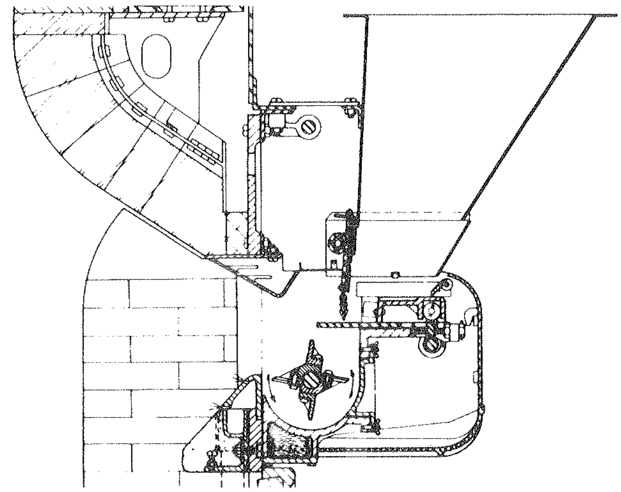
To provide better control, operation and dependability of existing coal feeders, consideration should be given to replacing the drives with individual drives for both the fuel feed and fuel distributor sections.

If the age and condition of the coal feeder is such that incorporating modifications will not provide for better control, operation or dependability, only replacement of wear parts and routine maintenance may have to be performed.

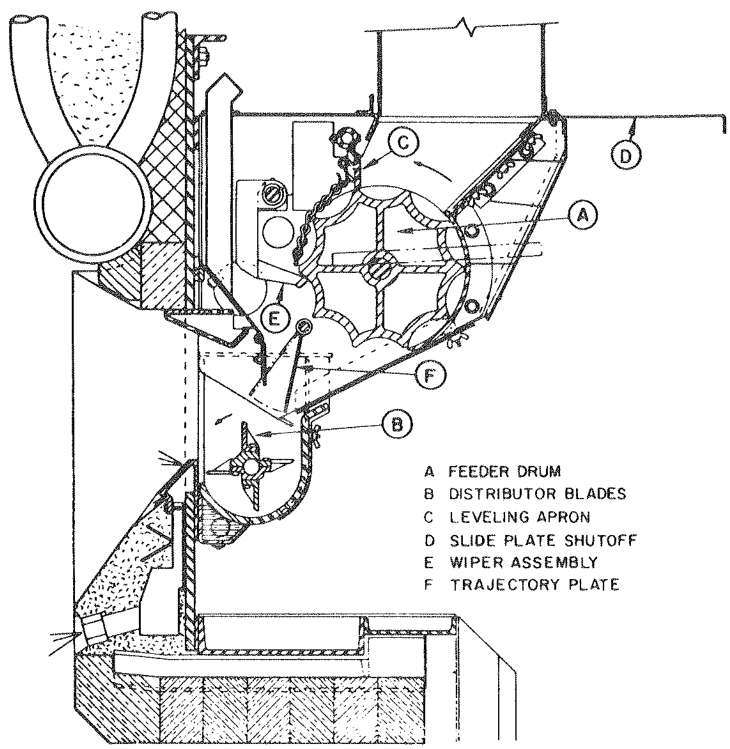
Should it be appropriate to replace the entire feeder with a later model, this can usually be done with little difficulty. This would entail the modification or replacement of the stoker front plate, modifications to the feeder openings and addition of necessary controls.



Variable Speed Chain Type Feeder



Riley Model "B" Feeder



Riley Model "F" Feeder

Figure 2

FUEL

The traveling grate spreader stoker is designed to handle a wide range of coals that are presently available. Bituminous, sub-bituminous and lignite coals are suitable for spreader stoker firing. The present coal supply at a plant has most likely changed from that which the unit was originally designed.

A key consideration regarding coal firing is the fuel and ash analysis, a sample of which is shown in Figure 3. From this information, the fouling and slagging characteristics of the coal ash can be determined. These characteristics are used to determine if the furnace and convection sections of the boiler are properly sized for that particular coal. The fouling and slagging characteristics are not a major factor in spreader stoker fired boilers until lower grade coals are considered for burning.

Coal sizing is important in order to assure even distribution of the coal over the entire grate by the feeders. The coal as received should have a top size of 1″ down to not more than 50% less than 1/4″ and not washed or screened more than once. The coal should be delivered to the feeder without size segregation.

The larger sizes will distribute readily throughout the grate surface and support ignition. The finer particles will burn in suspension allowing rapid ignition response. A heavy concentration of fines, however, will interfere with uniform coal distribution, increase handling difficulties caused by additional moisture and may increase suspension burning and particulate carry over. Figure 4 shows the typical coal size range for spreader stokers.

The sulfur content of the fuel can cause major problems with the heat recovery equipment. If the flue gases are cooled near the dew point of the flue gas, the sulfur in the coal creates the possibility of corrosion. Most spreader stoker fired boilers are equipped with an economizer. Typically 250F feedwater is adequate for economizer protection for spreader stoker firing. However, the boiler designer must evaluate the fuel sulfur versus feedwater temperature.

FLYASH REINJECTION

Spreader stokers are associated with high particulate emissions. When subjected to high heat release rates, carryover of unburned carbon from stokers increases. The amount of carbon carried out of the furnace represents a carbon loss and thus reduces boiler efficiency. In order to recover some of that carbon loss, an effective flyash reinjection system is required to obtain optimum efficiency.

This reinjection system should provide the return of flyash to the furnace for reburning from the boiler soot hoppers and economizer soot hoppers. This will account for 30-50 percent total flyash reinjection. Figure 5 shows industry accepted carbon loss predictions for spreader stokers with or without flyash reinjection.

Flyash reinjection increases dust loading and requires suitable dust collecting devices to maintain low stack emissions. Carbon loss is a major factor in the efficiency of a spreader stoker fired boiler. Consideration of carbon loss becomes an economic evaluation of efficiency gain verses pollution control equipment required.

Ash reinjection systems usually work on the pneumatic principal with air required usually taken from the overfire air fan. A separate fan to provide air can also be used. A cast material is used to reduce the erosive action of the ash on piping and elbows. Depending on the configuration and size of the unit, the ash reinjection system can become a costly item. This cost is usually offset by the efficiency gain of the unit.

OVERFIRE AIR SYSTEM

In older spreader stoker-fired boilers, the overfire air system is probably inadequate as compared to current standards. The combustion of coal requires special measures to assure a continuous supply of oxygen to be in contact with the unburned carbon particles. This intimate mixing of air with the coal particles is best achieved in a turbulent furnace to help remove combustion products as they form. This furnace turbulence results in quicker and more complete combustion.

An overfire air system is a custom designed feature of strategically located air nozzles. These nozzles carry high pressure air into the furnace promoting increased combustion efficiency. Figure 6 shows an overfire air

TYPICAL FUEL ANALYSIS

1. PROXIMATE ANALYSIS—% (As Received)	
a. Moisture	14.00
b. Volatile Matter	31.16
c. Fixed Carbon	43.83
d. Ash	11.16
e. Higher Heating Value, BTU/LB	11,048
2. ULTIMATE ANALYSIS—% (As Received)	
a. Moisture	14.00
b. Carbon	61.18
c. Hydrogen	4.21
d. Nitrogen	1.24
e. Chlorine	.15
f. Sulfur	2.95
g. Ash	11.16
h. Oxygen (By Difference)	5.11
3. MINERAL ANALYSIS OF ASH—%	
a. Phosphate Pentoxide, P_2O_5	0.25
b. Silica, SiO_2	39.43
c. Alumina, Al_2O_3	15.63
d. Titania, TiO_2	0.83
e. Ferric Oxide, Fe_2O_3	28.95
f. Lime, CaO	10.99
g. Magnesia, MgO	0.68
h. Potassium Oxide, Ka_2O	1.99
i. Sodium Oxide, Na_2O	0.64
j. Undetermined	0.61
4. ASH FUSION TEMPERATURE:	
a. Reducing Atmosphere:	
(1) Initial Defermation (ID)	1980
(2) Softening (H = W)	2080
(3) Softening (H = ½W)	2120
(4) Fluid Temperature (FT)	2230
b. Oxidizing Atmosphere:	
(1) Initial Defermation (ID)	2240
(2) Softening (H = W)	2400
(3) Softening (H = ½W)	2430
(4) Fluid Temperature (FT)	2520
(5) T250	2180
5. GRINDABILITY—HARDGROVE INDEX	64.7

6. SIZE: 100% through 1¼″ ID ring.

7. AVERAGE DENSITY: 45 LBS/CU. FT.

Figure 3

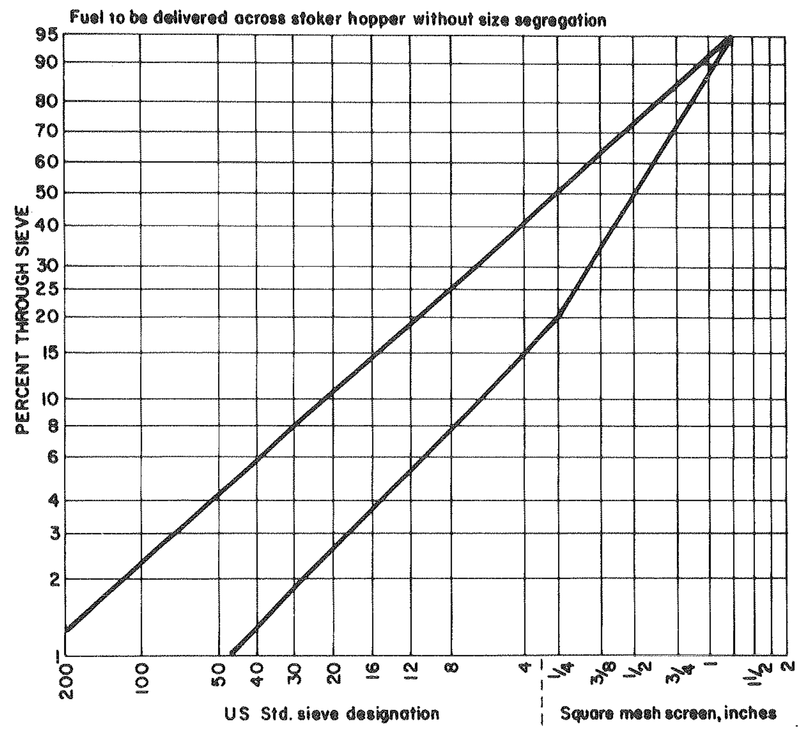


Figure 4   Coal Size Distribution Range

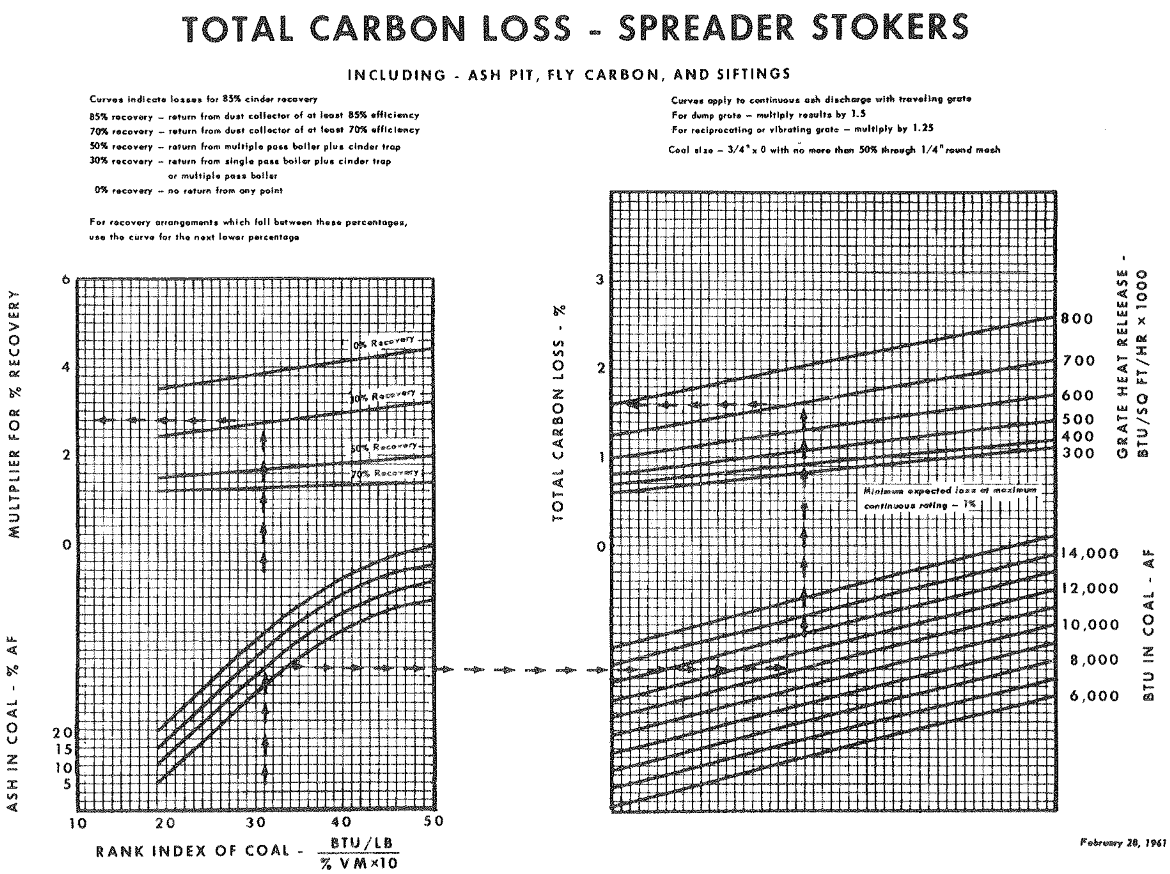


Figure 5

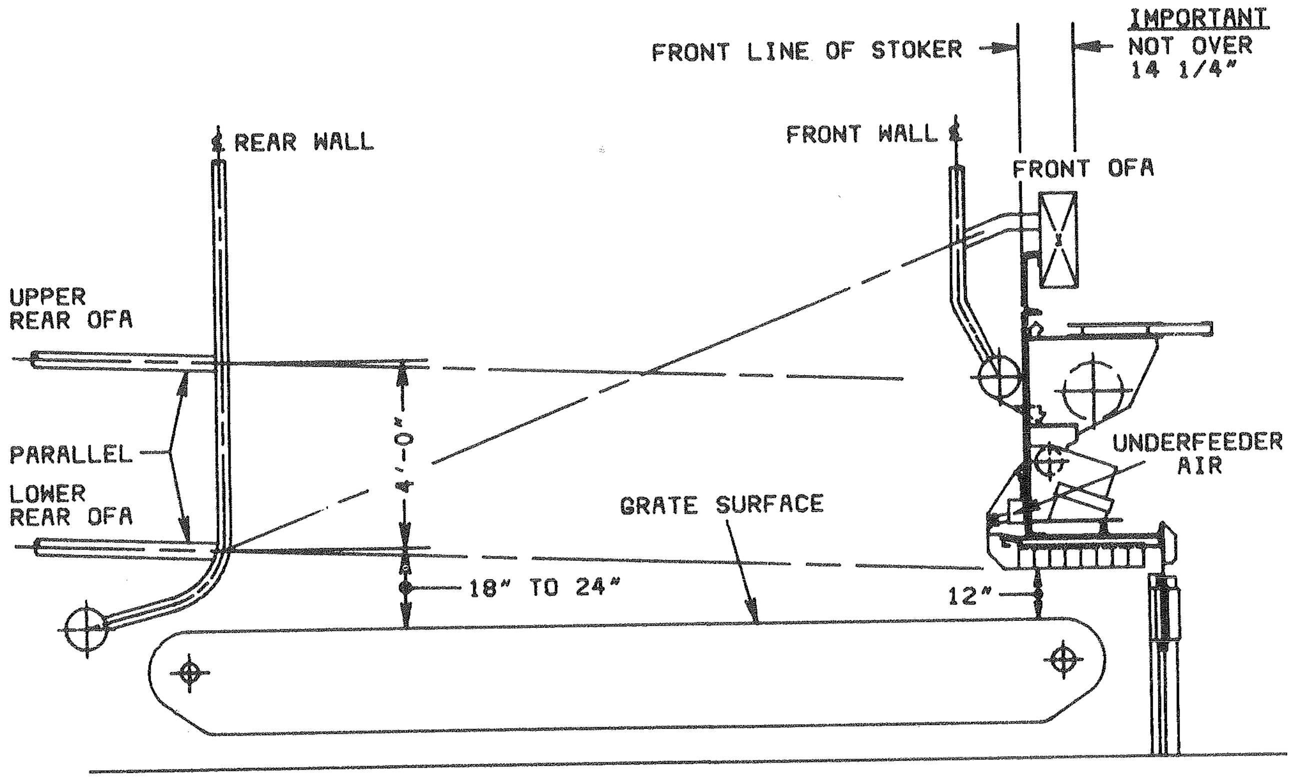


Figure 6   Overfire Air System for Traveling Grate Spreader-stoker Coal Firing

system for a traveling grate spreader stoker application. Properly sized overfire air equipment can reduce excess air required for complete combustion, reduce cinder carry over and eliminate smoke.

A review of the overfire air system should be performed to determine the adequacy of the existing equipment. Modifications to the existing system usually consist of replacing the fan, ducting and the relocation or addition of air nozzles.

Start-up services for testing and fine tuning the new or refurbished equipment should be considered by the Plant Engineer as part of the overall cost of the project. If the unit or other units in the plant have not been operated on coal for a substantial period of time, present personnel might not have the experience for properly operating the coal burning equipment. It may be advisable to include a training program as part of the rehabilitation project.

SUMMARY

The present condition of the fuel burning equipment must be considered when planning to rehabilitate or upgrade an existing spreader stoker-fired boiler. The grate, grate drive and coal feeders must be in such condition so as to promote dependable operation.

Fuel analysis and coal sizing play a key role when firing coal. It not only affects fuel distribution on the grate but also other areas of the boiler. These areas include heat recovery and pollution control equipment. To achieve optimum fuel efficiency, proper design and arrangement of overfire air and flyash reinjection systems is necessary.

We have discussed a subject with a great amount of variables and covered them with general statements. Depending on prior use, present condition of the equipment and scope of work determined by the plant engineer, the economics of rehabilitation will vary considerably with each installation. At the very least, we hope we have given the reader a starting point from which to develop plans and apply to his particular needs.

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