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Co-Firing Biomass With Coal Utilizing Water Cooled Vibrating Grate Technology

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Co-firing biomass with coal has been implemented successfully for many years using conventional combustion grate technology for use in the pulp and paper industry for systems ranging in size up to 70 MW.

With the application of water cooled vibrating grates, biomass co-firing can be applied for larger utility size systems. This paper discusses benefits both with new boiler installations and issues for retrofit applications.

1. INTRODUCTION

By the year 2040, the total population on earth is expected to double to about 10 billion people. With the continued industrialization of Asia, Africa, and the Americas, the world energy consumption is projected to triple. At the present rate of consumption, the world's known oil and natural gas supply will be depleted in about 100 years. While coal reserves could sustain some of the world appetite for energy for several centuries, the problems associated with mining and the environmental pollution produced by coal fired power plants would only aggravate an already precarious ecological balance.

Co-firing is a proven technology for power generation. Utilities and industry have co-fired biomass and coal which has:

- Reduced emissions
- Reduced fuel costs
- Reduced wood waste
- Extended life of existing boilers
- Provided economic activity in rural regions

These benefits provide good reasons for utilities and industry to co-fire coal and biomass in combination.

This paper will give a brief history of co-firing technology using pulverized coal (PC) along with specific information on the application of water cooled vibrating grates.

2. HISTORY

Industrial boilers have been co-firing biomass and coal for many years. Several methods have included pulverized coal (PC) and stoker firing in some combination.

Generally, units larger than 250,000 lb/hr steam have employed PC above a conventional spreader fired stoker system. Table 1 describes some design parameters for the differing firing methods. Units below 250,000 lb/hr steam capacity co-fire biomass in combination with coal using a spreader fired grate with both fuels being spread onto the grate. The simplicity and flexibility of the stoker boiler makes this one of the most adaptable types to co-fire biomass. The biomass and coal is pneumatically or mechanically distributed over a moving grate. The stoker types include traveling grates that move the fuel from rear to front and water cooled vibrating grates used in more modern facilities.

Table 1
Different Firing Methods

Fuel	Type Of Combustion System	Heat Release Rate	Excess Air
Bagasse	Spreader Fired Grate	1×10^6 BTU/ft^2/hr	25 - 30
Wood Waste	Spreader Fired Grate	1×10^6 BTU/ft^2/hr	25 - 30
Municipal Solid Waste (MSW)	Mass Fired Reciprocating Grate	3×10^5 BTU/ft^2/hr	80 - 100
	Spreader Fired Travel Grate	7.5×10^5 BTU/ft^2/hr	50 - 80
Bituminous Coal	Pulverized (PC)	------	15 - 20
	Spreader Fired Grate	7.5×10^5 BTU/ft^2/hr	25 - 30
	Underfeed Grate	3×10^5 BTU/ft^2/hr	40 - 50

3. RETROFIT REQUIREMENTS

There are several issues that must be evaluated with a retro-fit application.

Fuel handling systems are required that include truck scales which weigh and unload the biomass. Processing equipment such as disc screens and hammer mills may be required to size the biomass fuel. Also, storage and reclaim systems with fuel metering equipment are required. All the fuel handling systems must be connected by conveyors.

The air pollution control (APC) system originally designed for coal firing may create problems depending on the type of gas treatment system. Most employ an electrostatic precipitator (ESP) which can lose some efficiency with the additional flue gas volume which occurs from biomass co-firing. Depending on the coal ash characteristics, the fly ash resistivity of the coal/biomass could also reduce the efficiency.

Excess air requirements tend to be higher with the biomass fuel which is also associated with the higher fuel moisture. This will produce an increase in the flue gas flow rates which will lead to increased pressure losses. The induced draft fan will be affected by this and possible modification will be required.

Boiler retro-fit requirements differ by boiler design. There are three categories of boiler technologies that are most prevalent in the market place; stokers, pulverized coal, and fluid beds. Each technology has specific design features which determine the retro-fit considerations for co-firing.

4. STOKER TECHNOLOGY

The predominant stoker fired technology in the industrial market is the spreader fired traveling grate (Figure 1). This technology incorporates a moving grate that travels from the rear to the front with the solid fuel being mechanically or pneumatically distributed from the front over the grate surface. The fuel burning on the grate sustains combustion with larger particles while the smaller particles are burned in suspension. The ash bed on the grate protects the grate from the elevated temperature of the suspension fired flame with cooling also occurring from the combustion air flowing through the grate. This technology can be designed for many different solid fuels with the use of different fuel distributors (Figures 2a, 2b, and 2c).

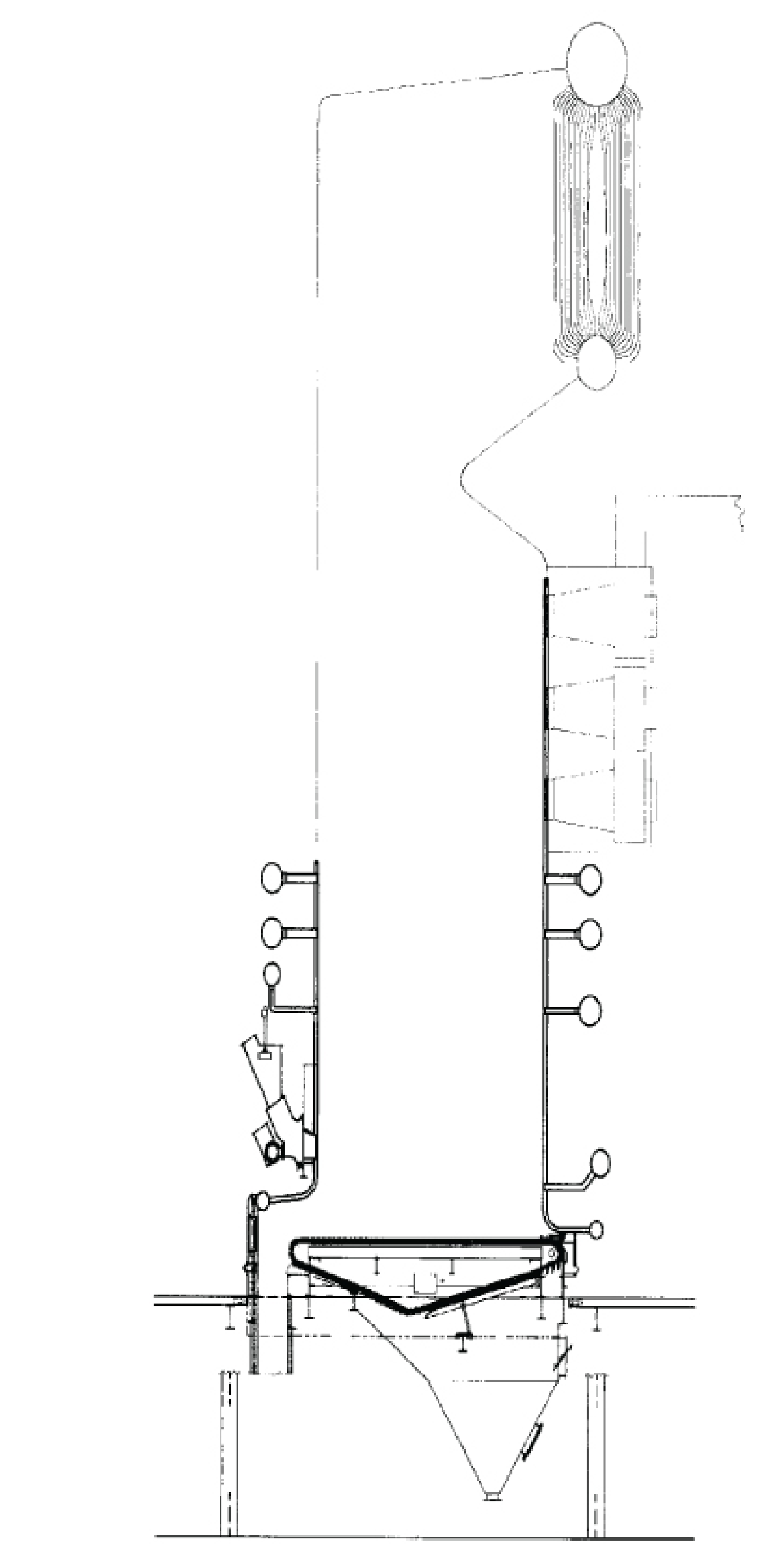

Figure 1. Detroit RotoGrate® Boiler Side View With Spouts

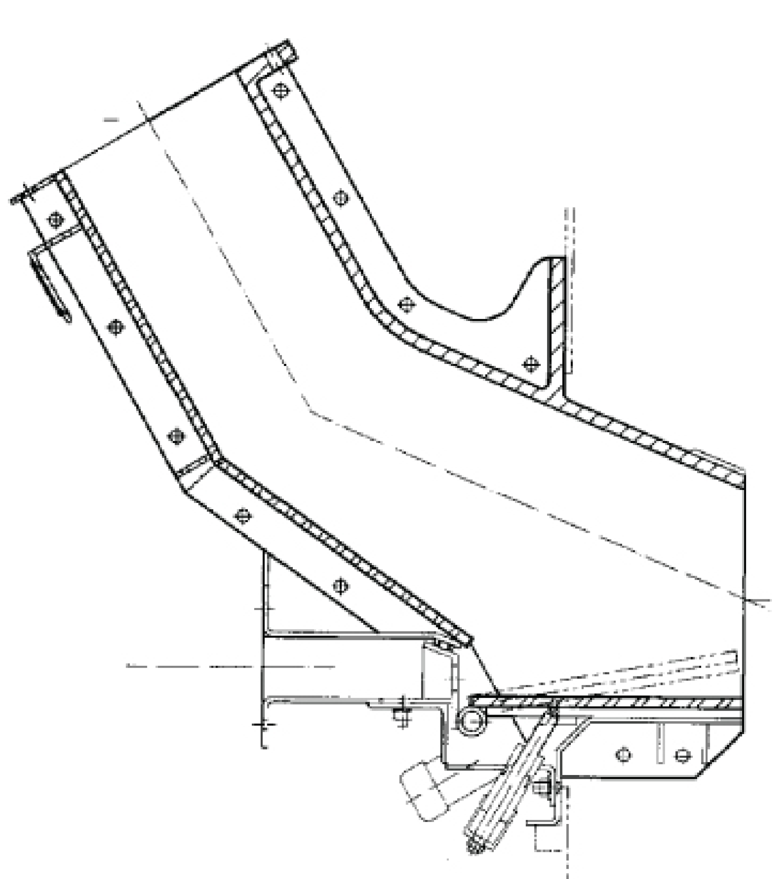

Figure 2a. Side View Air Swept Spout

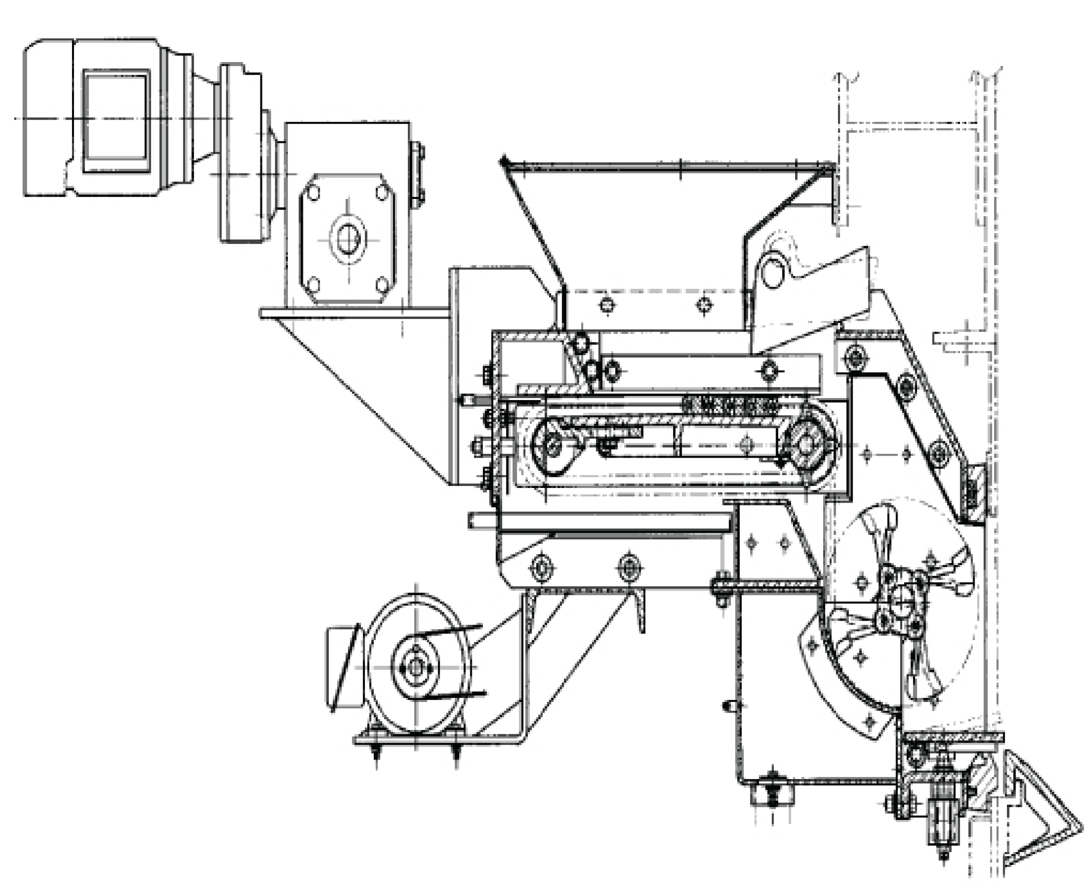

Figure 2b. Side View Underthrow Feeder

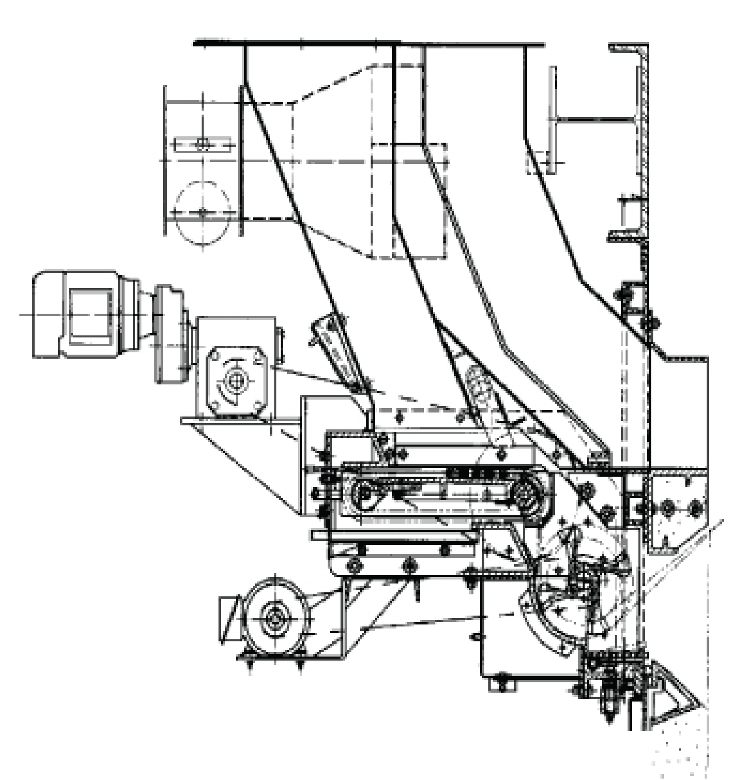

Fig 2c. Side View Combination Feeder

Each distributing device is arranged depending on fuel and particle sizing, fuel density, and fuel feed rates (Figures 3 and 4).

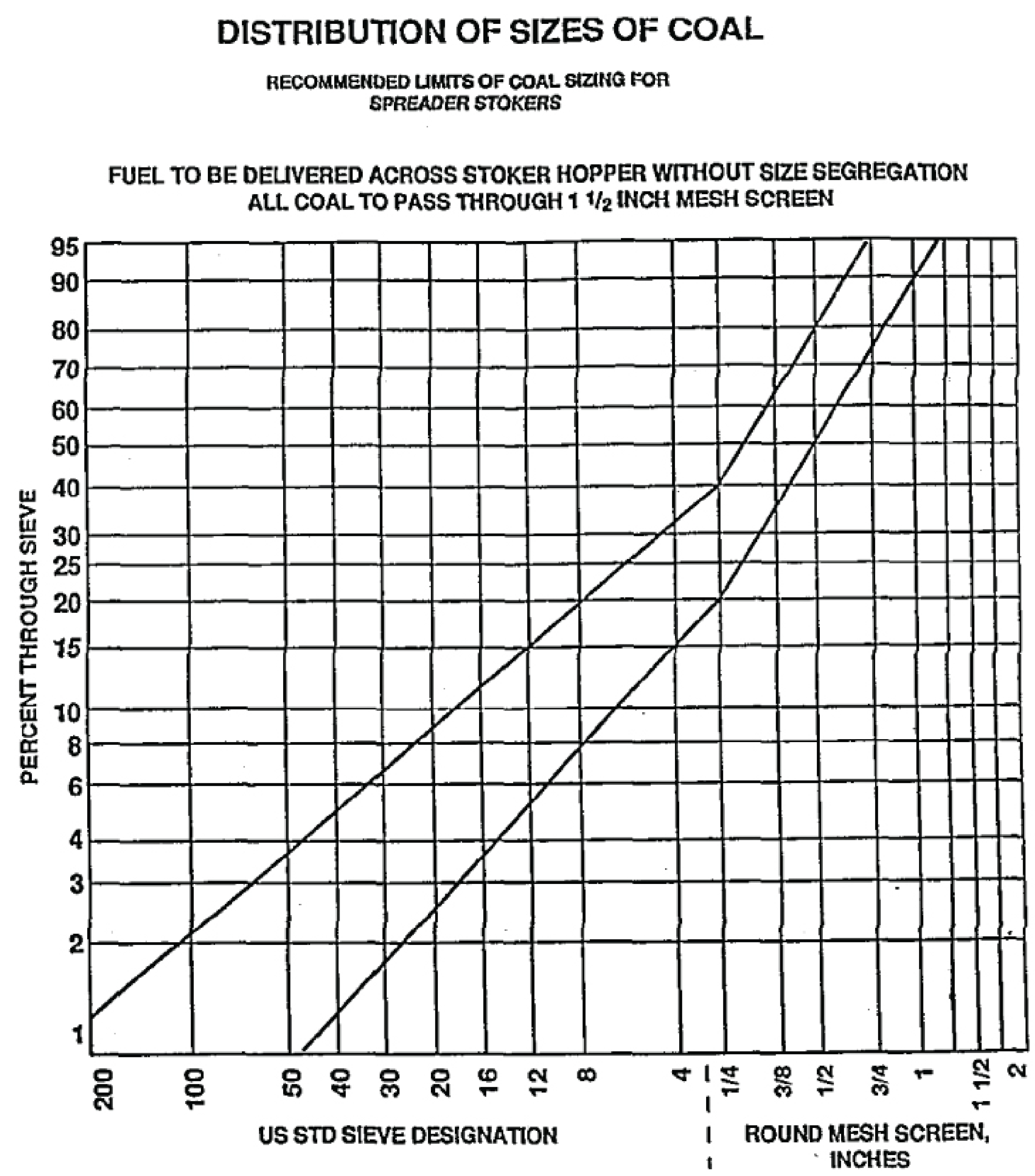

Figure 3. Hog Fuel Distribution Curve

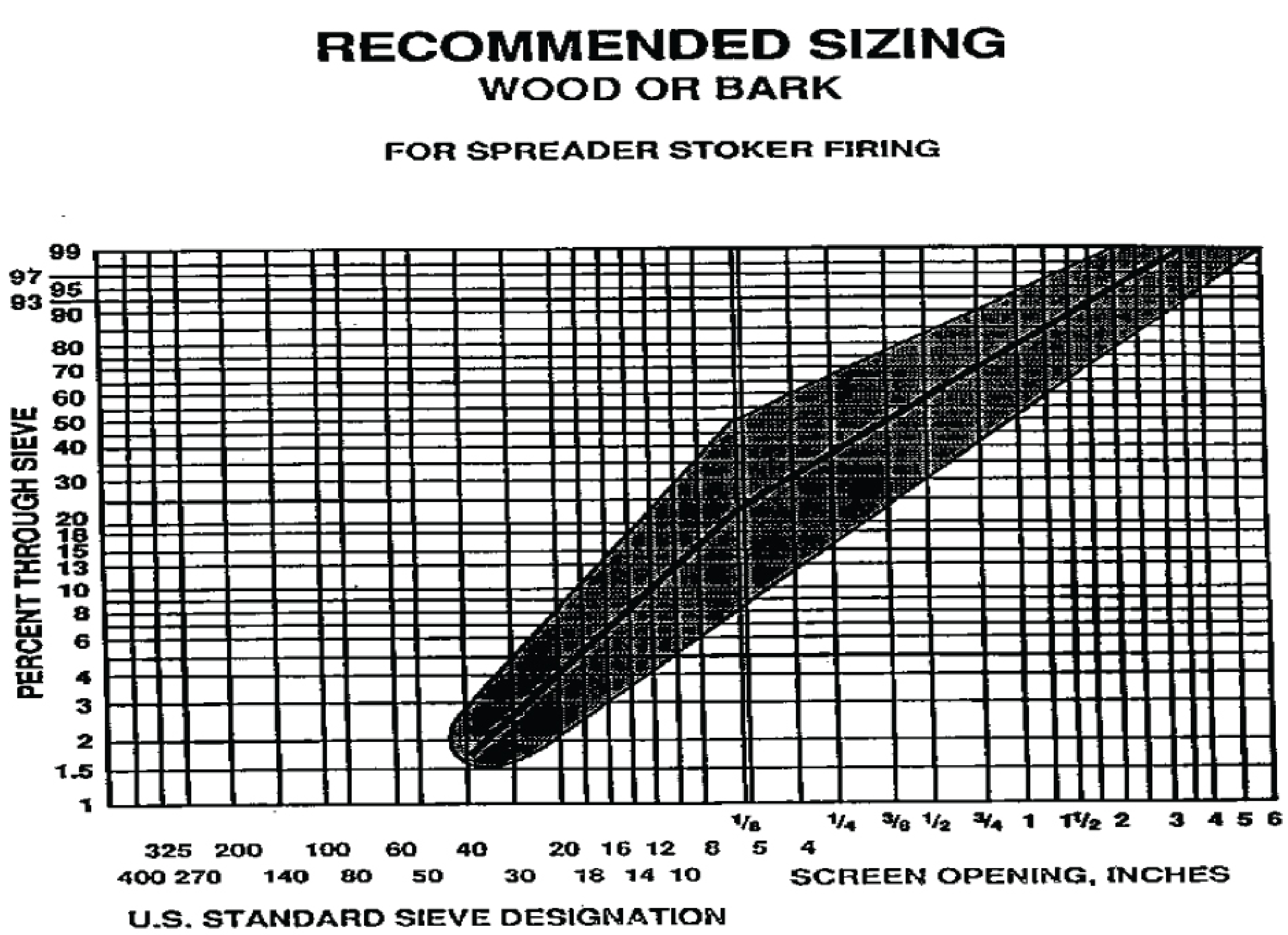

Figure 4. Coal Distribution Curve

Over the past 15 years, there has been a greater application of water cooled vibrating grates for stoker firing biomass. This is due to of the increase in boiler sizes which are limited to approximately 500,000 lb/hr steam with traveling grates and the use of higher preheated combustion air temperatures needed for the combustion of higher moisture biomass. These conditions required more equipment durability which can be accomplished with a water cooled vibrating grate. This technology uses a water cooled grid which supports the fuel with preheated combustion air flow through the fuel promoting combustion. The fuel is distributed from the front with the fine particles burning in suspension over the grate. The water cooled grid is set on flex straps which allow for a small vibration to be imparted on the grate producing a conveying action for automatic ash removal.

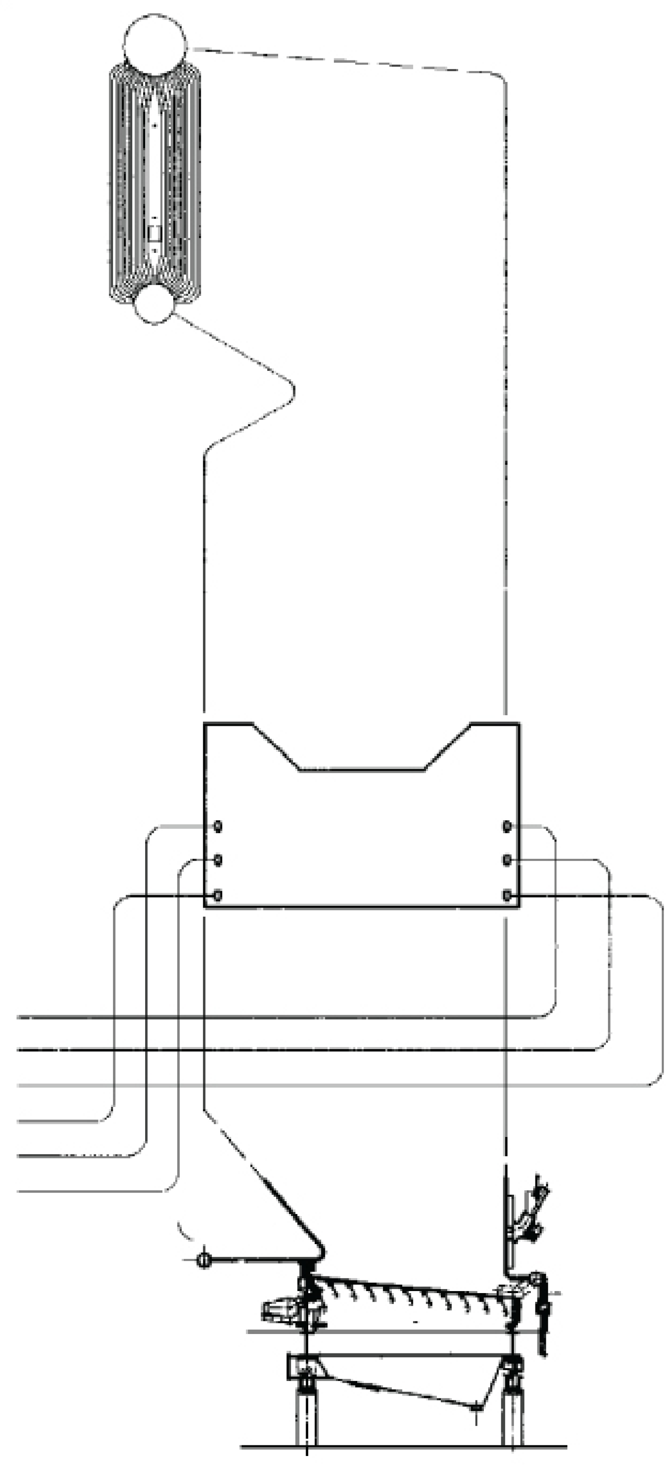

Figure 5. Pulverized Coal With Water Cooled Vibrating Grate (Detroit Hydrograte®)

With a water cooled vibrating grate, PC combustion can be introduced above the grate up to 100% load with the grate design also sized for 100% load (Figure 5). The design of the grate allows for combustion of the PC without concern for overheating and damage from radiant heat. Cooling requirements of the grate are minimized because of the water cooling. Stoker firing of the biomass minimizes the amount of fuel processing and sizing of the fuel particles than is required with PC firing.

5. PULVERIZED COAL

The PC boiler comprises the largest percentage of boilers in the utility market. The technical and financial requirements for retro-fitting PC boilers can be substantially higher than stoker fired boilers. The PC boiler can be retro-fitted for biomass co-firing with the addition of biomass injection ports in or near the existing PC burners. This suspension firing method requires that the fuel particle size be less than 1/4". Particles larger than this can not burn completely in suspension and fall to the furnace bottom. If the existing PC boiler does not have the proper furnace bottom with additional combustion air, incomplete burn-out occurs. Also, this method of firing can be problematic with fuel moistures above approximately 15%. Fuel drying equipment is then required.

6. EMISSIONS

Important environmental benefits can be obtained by co-firing with biomass. Biomass has less than .03% sulfur content which can off-set the SO_X emissions produced from the coal firing. NO_x reductions have been obtained by several facilities running co-firing tests but the levels of reductions depend on many factors. It can be said that biomass fuels have lower fuel-bound nitrogen (FBN) levels than coal (e.g. <0.2%). Additionally, the higher volatility and lower ignition temperature of biomass can contribute to more rapid ignition of the biomass fuel input which can promote a staged combustion process. This explains the NO_x reduction results.

Particulate emissions become even more difficult to predict with biomass co-firing. The ash content of biomass can be variable (wood can have <1% ash, agricultural waste >15% ash). Ash composition for biomass can also vary because of inherent inert material in the plant matter and inert material from harvesting techniques. All these factors contribute to the difficulty in predicting particulate emissions.

Finally, the environmental benefits associated with biomass firing displacing coal is clearinly recognized. The carbon dioxide (CO_2) generated from biomass co-firing is considered as recycled carbon within the biosphere instead of carbon added to the biosphere. Most of today's wood harvested for paper and allied products are replenished by planting. Therefore, there is a direct replacement affect regarding CO_2 emissions.

7. CONCLUSION

Co-firing biomass with coal has many advantages from emissions to renewable fuel usage. The retro-fitting to stoker firing tends to have the least complex of the various options. Retro-fitting a water cooled vibrating grate can be a cost effective solution for larger boiler designs which use conventional technology. The technology is proven with this type of technology being in use for many years.

REFERENCES

1. Adams, P.J. (1996). Modern Industrial Boilers - A Comparison of Firing Systems. ASME International Joint Power Generation Conference, Houston, TX.
2. Adams, P.J. and I.G. Lutes (1982). Developments in Steam Generator Design For Combustion of Hog Fuel and Coal. American Power Conference, Chicago, IL.
3. Tillman, D.A., E. Hughes, and S. Plasynski (1992). Co-Firing Bio-Fuels in Coal Fired Boilers. Summary of test experiment.