Detroit Stoker Company

"Our Opportunities Are Always Growing"™

Vibrating Grate Stokers for the Sugar Industry

Thomas A. Giaier and Timothy R. Loviska
Detroit Stoker Company
Monroe, Michigan 48161 USA

Abstract

Some 15 years ago in the United States, it became apparent that traveling grate and water-cooled pinhole grate stokers were no longer able to cope with the increasing demands of the biomass burning industry, particularly pulp and paper. These demands included lower excess air firing for efficiency and emission control, higher boiler capacities, and greater availability to the plant.

These demands were met in part by the air-cooled vibrating grate stoker and more importantly, the newly developed water-cooled automatic ash discharge grate. This machine allows high efficiency firing at lowest possible emission rates, and prolonged operation without shutdown for maintenance for grate cleaning. The demands of the sugar industry are growing in the same direction and vibrating grate stokers are well suited to answer the challenge for highly reliable firing of bagasse and coal in the new evolution of co-generating power plants.

Introduction

The global sugar industry has many future challenges which will require innovation in both manpower and equipment. These innovations will include continuous automated systems, simplified equipment designs and reduced, non-redundant production equipment. The steam generating equipment of the future will follow these same requirements to help increase productivity and further meet the demands of higher efficiencies, environmental restrictions, co-generating power needs and maximum availability.

This paper describes in detail the features and advantages of vibrating grate stokers, including an operating experience list.

Recent History

The use of the refuse and by-product fuels for the generation of process steam and/or power is nearly as old as the industries producing these products. Early on in the development of the sugar, pulp and paper, and wood products industries, all of which produced large quantities of combustible by-product wastes, using wastes for process steam generation became common practice. As these industries grew, so did their needs for efficient, reliable, refuse burning equipment. Equipment varied widely in concept and operation from refractory cells to stationary grate spreader stokers to stokers primarily designed to burn coal.

In 1938, in the United States, the traveling grate spreader stoker was developed to burn coal and quickly became the predominant firing equipment for industrial coal fired boilers.

In 1944, the first traveling grate spreader was installed to burn bark and wood waste for the pulp and paper industry. As was the case with coal, this type of machine quickly became the most popular, larger size, wood burning stoker. The traveling grate spreader has accounted for the vast majority of the installed wood burning capacity in the United States in the past 50 years.

Until the drastic change in the world energy picture in the early 1970s, many refuse burning systems were primarily used to dispose of the refuse of by-product wastes. The generation of steam was often a secondary consideration and combustion efficiency was not a matter of great concern. By the same token, reliability of equipment was of lesser importance since loss of wood burning capacity was usually not critical. Emphasis changed when refuse by-products became far less expensive than alternative fuels such as oil and gas and to some extent, coal. It quickly became important to have more efficient and reliable equipment to burn refuse fuels. It was this scenario into which the vibrating grate stoker was introduced in the early 1980s.

The Problem

The use of refuse and by-product waste for fuel has become important to industry because of unknown fuel costs and the benefits to generating electricity for the local utility. The common goal of every application is to reduce the amount of fossil fuels burned for the production of steam. Many applications require the complete elimination of expensive fuels and therefore require the refuse burning system to be load responsive as well as efficient and reliable.

In order to generate the maximum quantity of steam and power from a refuse fired boiler, the design of the firing system must address two key issues: availability and efficiency. Until the introduction of the vibrating grate spreader stoker, no single firing system could completely address both of these issues with a wide variety of refuse fuels.

The water-cooled stationary grate spreader is reliable, but availability is reduced by grate cleaning requirements and efficiency drops with ash build-up between cleaning cycles. Ash is removed in batches similar to the method employed on dump grates. A series of steam jets are actuated to propel the ash along the grate into an ash hopper located at the front of the boiler. This machine is also limited in size to about 80 tph for practical purposes, although there are a number installed in larger capacities.

The traveling grate remains very efficient but in many cases maintenance requirements hamper availability. Because the grate must be air-cooled, the operating procedures necessary for maximum efficiency are often detrimental to grate life. Length and width are limited because of mechanical limitations of the traveling grate's components..

A Solution

The vibrating grate spreader stoker was developed to address the needs of the refuse burning industry which are perceived to be the following:

1. High availability to maximize operation time of the firing system.
2. Low maintenance requirements to reduce downtime and repair costs.
3. High operating efficiency.
4. Ability to closely follow plant load.
5. Ability to handle large variations in fuel size, quality, ash content and moisture content.
6. Complete compatibility with auxiliary or alternate fuels.
7. Complete capability with conventional power boiler designs which are well proven and cost competitive.
8. Compatibility with most existing power boilers for ease of retro-fitting.

The performance capabilities of the vibrating grate spreader are quite similar to those of the traveling grate; however, unlike any existing traveling grate, the vibrating stoker is specially designed to burn high moisture, low ash refuse fuels and is a derivative of a coal firing design. That is not to say that the design is entirely new in all respects. It is rather a hybrid machine which has its roots well established by extensive experience in the design of water-cooled vibrating grates for deep fuel bed coal burners and air-cooled vibrating grate spreaders for coal.

Design

Air-Cooled Vibrating Grate

The machine incorporates a horizontal grate surface which consist of individual air-cooled grate castings attached to a single moving frame, supported by steel flexing straps. The grate surface is intermittently vibrated using an eccentric drive at the rear of the unit. This intermittent vibration provides the necessary conveying action to the fuel bed and discharges the fuel ash off the front of the grate in a continuous manner. The mechanism is not unlike that used on conventional vibrating chip conveyors used in many industries. (Refer to figure 1)

The features of the air-cooled vibrating grate incorporates the continuous ash discharge capability with the vibrating grate simplicity. The design allows for extended periods of operation without ash protection, minimizing grate air flow without damage.

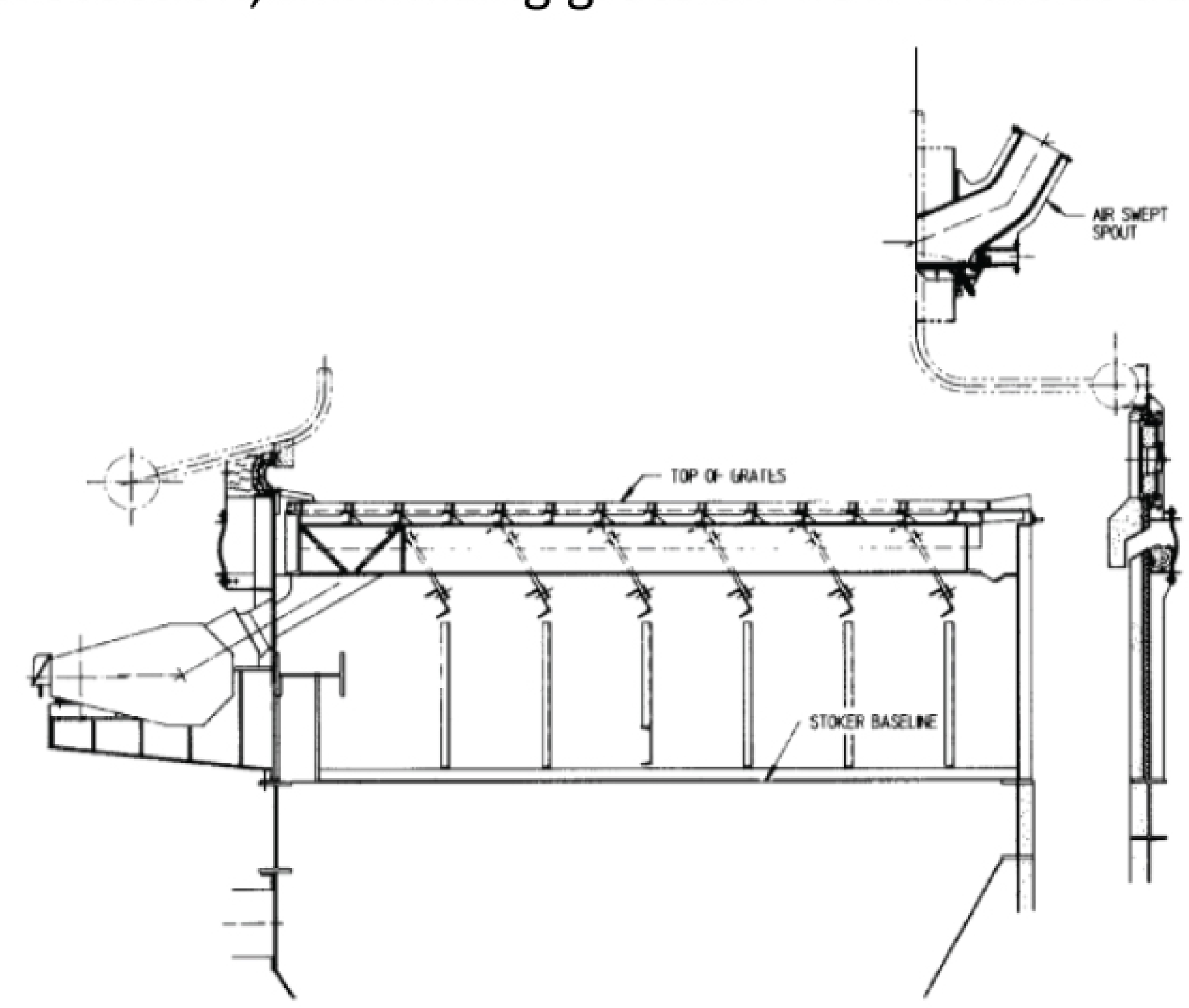

Figure 1: A general arrangement of an air-cooled vibrating grate

Water-Cooled Vibrating Grate

The water-cooled vibrating grate is a machine that combines the technology of the air-cooled vibrating grate with a water cooling capability of the grate surface. The grate support system, flexing straps and vibration generator is a derivative of the air-cooled vibrating grate. The grate can be inclined 6º to further augment the conveying capability and provide a degree of natural circulation of the cooling water, allowing it to be placed in the boiler circuit if desired. (Refer to figure 2)

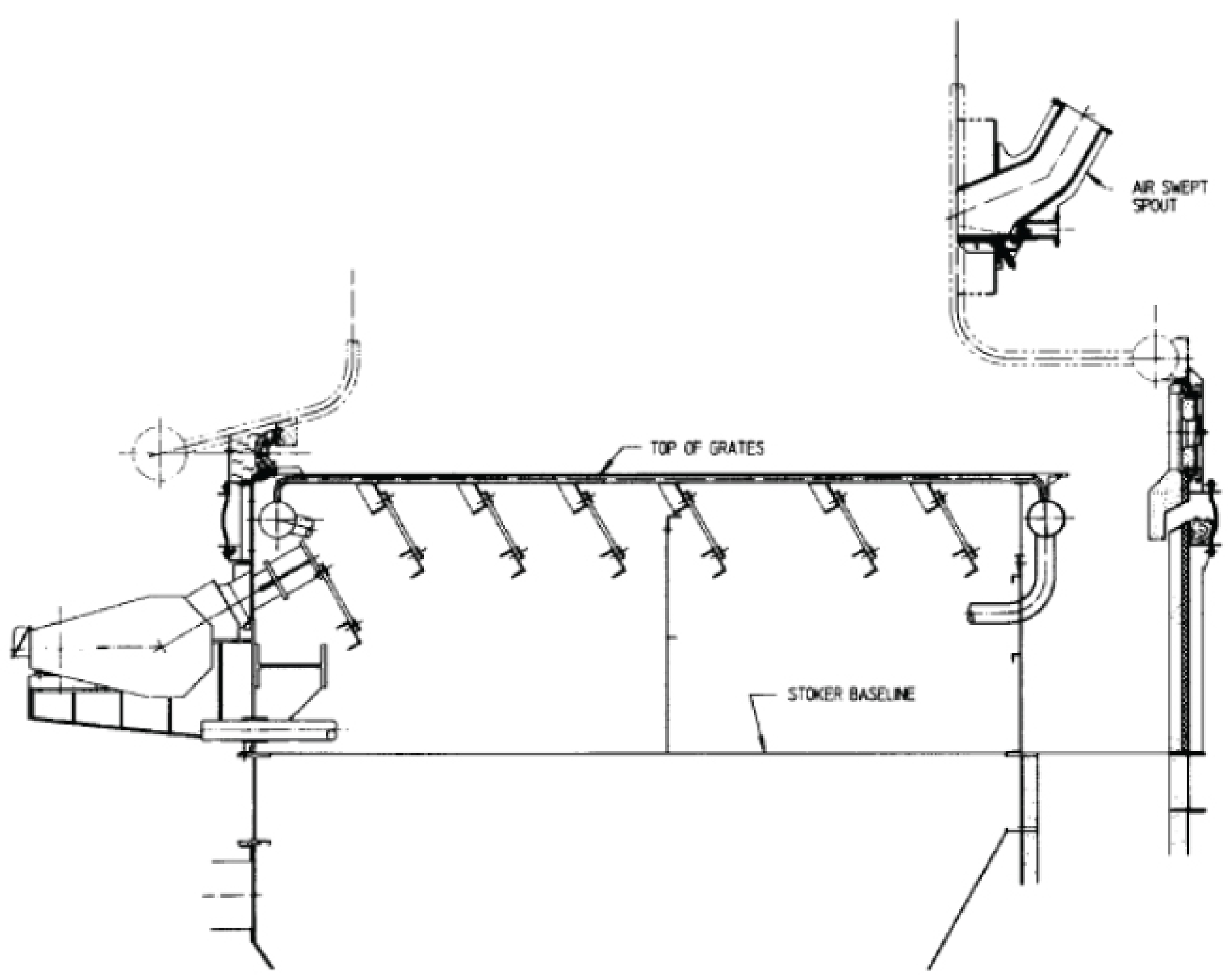

Figure 2: A general arrangement of an water-cooled vibrating grate

Both the air-cooled and water-cooled vibrating grate system offer a number of advantages.

- High air resistant grate design; thoroughly proven to be effective in spreader firing.
- Positive, automatic ash discharge; necessary for continuous operation without shutdowns or auxiliary fuel firing to clean grates.
- Reduced grate maintenance.
- Increased reliability
- No bearings or lubrication required in hot zones.
- Shop assembled modular design reduces installation time.

The unique feature of the water-cooled vibrating grate stoker which sets it apart from all other refuse burning stokers is the grate itself. The machine represents the first workable marriage between the water-cooled grate and the automatic ash discharge spreader concept. The use of a water-cooled grate drastically reduces the risk of heat damage to the component parts. Consequently, maintenance needs are low and reliability is high. Furthermore, the machine can operate efficiently for extended periods of time, because air flows can be set to address the fuel combustion requirements independent from cooling air requirements for the grate.

The water cooling feature also prevents grates from becoming warped, and gaps from occurring between the grate bars or keys. Gaps eventually lead to a higher usage of excess air to assure sufficient air for combustion. The integrity of the vibrating grate stoker surface will be maintained over a long period of time thereby assuring proper air distribution to the fuel.

The water cooling system provides the additional benefit of obviating the need for grate cooling air when no refuse fuel is being burned as could be the case when the fuel handling system is out of service. If the boiler is capable of firing additional fuels, they can be burned without regard to protection for the stoker grate.

Due to the simple grate surface design, both technologies can utilize a more sophisticated overfire air system. A more extensive overfire air system eliminates the concern of overheating the grate with high combustion air temperatures or reducing air flows, thereby using combustion air for combustion, not for cooling.

Although there are practical limitations for the size of waste fired boilers, neither water-cooled nor air-cooled vibrating grate stokers have such limitations. The length of the grate is limited by the ability of the distribution system to throw the fuel to the rear of the unit, otherwise the grate structure is limitless.

The grate sections are built in modules, each with its own drive, therefore as many modules as necessary can be installed in the furnace. Until now the practical upper limit for a traveling grate fired refuse burner has been about 225 t/h steam, but no such limit applies to the vibrating grate stokers.

Since so many of the component systems which make up the water-cooled and air-cooled vibrating grate stoker have substantial track records of their own, the machine cannot be considered revolutionary. The vibrating grate stoker firing system has evolved as a response to the need for a machine with its capabilities.

Since the vibrating grate stoker was developed primarily for firing waste fuels, the emphasis to date has been on the primary users of this type equipment, namely the wood products and pulp and paper industries. Other users of the machine include pulp mills, co-generation plants, coffee plants and institutional plants fired by biomass.

As indicated earlier, both the water-cooled and air-cooled vibrating grate technologies evolved from coal firing technology, and in fact these systems are fully capable of firing coal. There are more than 100 air and water-cooled vibrating grate units firing coal in the United States ranging in size from 25 tph to 50 tph steam. Coal can be fired easily using either the existing fuel feed system, individual coal feeders, or with pulverized coal burners above the grate.

The design of the grate system is such that it can be retro-fitted in existing boilers presently fired by traveling grates, pinhole grates, dumping grates, pulverized coal, suspension fired wood, and in many cases, oil or gas. Maximum possible heat releases are attainable thereby maximizing heat input for a given furnace plan area and often the grate will produce more heat than can be used or tolerated by the existing boiler. It is, therefore, likely that a boiler retro-fitted with the vibrating grate stoker will not be grate limited. Notable exceptions could be large pulverized fired units or converted black liquor boilers. Refer to Table 1.

Table 1

Grate Heat Release Rates (MWt/m2)	
Traveling grate spreader	2.05 - 3.15
Pinholegrate	1.58 - 2.36
Water cooled vibrating grate	2.52 - 4.41

Operating Experience

There are presently 40 water-cooled vibrating grate stokers in service in pulp and paper mills in the United States, Canada and South America with a combined steaming capacity of over 4,800 t/h. The first unit was started up October 1983, the second unit has been in operation since November 1984 and the third since October 1985. The extremely reliable performance led quickly to the use of this machine in wood fired Independent Power Producers (IPP) and sugar mills. To date, 15 IPP plants and 6 boilers at sugar mills in the United States and Canada use the air-cooled or water-cooled vibrating grate. Refer to Table 2.

Table 2
Air-Cooled and Water-Cooled
Vibrating Grates Burning Biomass

1983	Wisconsin	36t/h
1984	Ohio	36t/h
1985	Minnesota	68t/h
1985	Oregon	2 X 79t/h
1985	Arkansas	295t/h
1985	Alabama	181t/h
1985	Maryland	2 X 11t/h
1985	Ontario	32t/h
1985	British Columbia	54t/h
1985	Maine	70t/h
1986	New Hampshire	63t/h
1986	Maine	63t/h
1986	Michigan	63t/h
1986	New Hampshire	64t/h
1986	New Hampshire	73t/h
1986	British Columbia	113t/h
1987	Quebec	136t/h
1987	British Columbia	100t/h
1987	Maine	45t/h
1987	Mississippi	61t/h
1988	Newfoundland	23t/h
1988	Alberta	130t/h
1988	British Columbia	159t/h
1988	Brazil	100t/h
1988	Alabama	204t/h
1988	British Columbia	113t/h
1988	Maine	82t/h
1988	California	82t/h
1989	South Carolina	136t/h
1989	South Carolina	127t/h
1989	Georgia	159t/h
1989	Quebec	94t/h
1989	British Columbia	239t/h
1989	Chile	120t/h
1989	Arkansas	163t/h
1989	Alabama	68t/h
1989	British Columbia	159t/h
1989	Washington	102t/h
1989	Alabama	68t/h
1990	Newfoundland	71t/h
1990	British Columbia	136t/h
1990	Washington	91t/h
1990	Louisiana	227t/h
1991	Alberta	210t/h
1991	British Columbia	255t/h

1991	Alabama	91t/h
1991	Vermont	86t/h
1991	Brazil	100t/h
1993	California	54t/h
1994	Tennessee	36t/h
1994	Florida	3 X 200t/h
1994	Michigan	156t/h
1994	Florida	2 X 200t/h
1994	Virginia	190t/h
1995	New Brunswick	249t/h
1995	Pennsylvania	68t/h
1995	Argentina	35t/h
1996	Florida	159t/h

Conclusion

The use of air-cooled or water-cooled vibrating grates should be evaluated when considering a new combustion system or retrofitting an existing unit burning biomass and coal fuels. The sugar industry has several basic requirements to insure a competitive position in the market place such as:
high reliability, maximum efficiency, ease of operation with minimum attendant labor, and low maintenance.

These requirements are met with the following capabilities of the air-cooled and water-cooled vibrating grate stokers.

- Automatic ash discharge for high load continuous operation
- Load following capability
- Compatibility with other fuels: coal, oil, gas, etc.
- Ability to operate continuously
- Compatibility with existing boiler designs
- Ability to fire a wide range of fuel moistures, sizes, ash content without detriment to efficiency and control
- Lowest possible emissions
- High steam generating capacity

Bibliography

Eleniewski, M., Conversion of a Black Liquor Recovery Boiler to Wood Firing, Case History. CIBO Alternative Fuels IV, February 1994.

McBurney, F.B., Large Scale Biomass Plant - NW Energy Corp. ABMA Technical Conference, May 1994.

Zarraluqui, L., President's Message Twenty-Sixth Annual, American Society of Sugar Cane Technologists, June 1995.