

VIBRATING GRATE STOKERS FOR THE SUGAR INDUSTRY

TA GIAIER AND TR LOVSKA

Detroit Stoker Company, Monroe, Michigan 48161, United States of America

Abstract

Some 15 years ago in the United States, it became apparent that travelling 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. The 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 or 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.

Keywords: vibrating grate stoker, ash, co-generation

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 the 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 features and advantages of vibrating grate stokers, and includes an operating experience list.

Recent history

The use of refuse and by-product fuels for the generation of process steam and/or power is almost 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 travelling grate spreader stoker was developed to burn coal and quickly became the predominant firing equipment for industrial coal fired boilers.

In 1944, the first travelling 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 travelling grate spreader has accounted for the 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 used primarily to dispose 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 into this scenario that the vibrating grate stoker was introduced in the early 1980s.

The problem

The use of refuse and by-product waste as fuel has become important to industry because of unknown fuel costs and the benefits of 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 the two key issues of 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 is 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 tons per hour for practical purposes, although there are several installed that have larger capacities.

The travelling grate remains very efficient although 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 the mechanical limitations of the travelling 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:

- High availability to maximise operation time of the firing system.
- Low maintenance requirements to reduce down time and repair costs.
- High operating efficiency.
- Ability to follow plant load closely.
- Ability to handle large variations in fuel size, quality, ash content and moisture content.
- Complete compatibility with auxiliary or alternate fuels.
- Complete capability with conventional power boiler designs which are well proven and cost competitive.
- 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 travelling grate; however, unlike any existing travelling 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 consists 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 similar to that on conventional vibrating chip conveyors used in many industries (Figure 1).

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

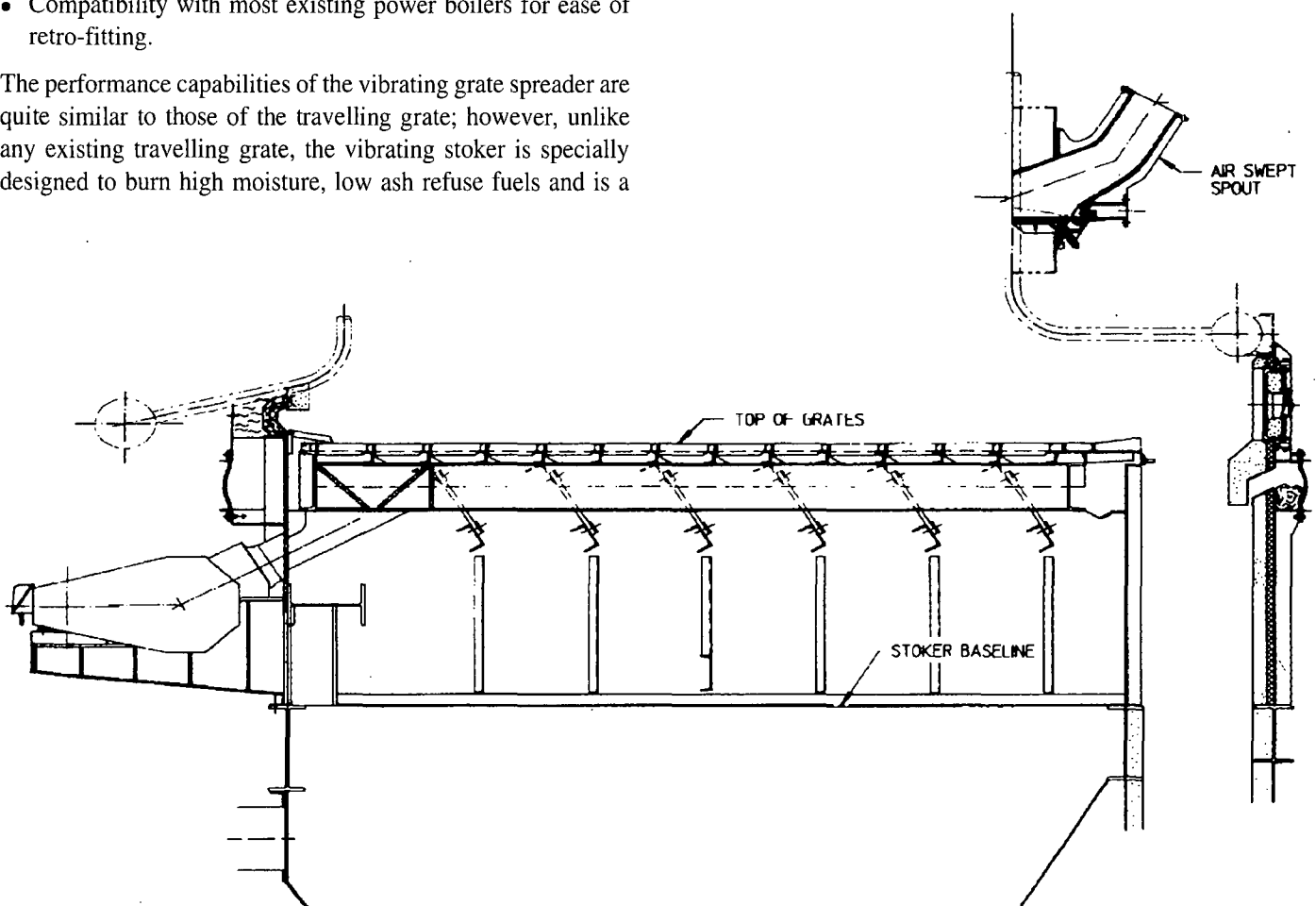


Figure 1. Air-cooled vibrating grate.

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 are derivatives of the air-cooled vibrating grate. The grate can be inclined 6° to augment further 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 (Figure 2).

Both the air-cooled and water-cooled vibrating grate systems 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 use of excess air to ensure sufficient air for combustion. The integrity of the vibrating grate stoker surface will be maintained over a long period, thereby ensuring 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 utilise 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 to 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 travelling grate

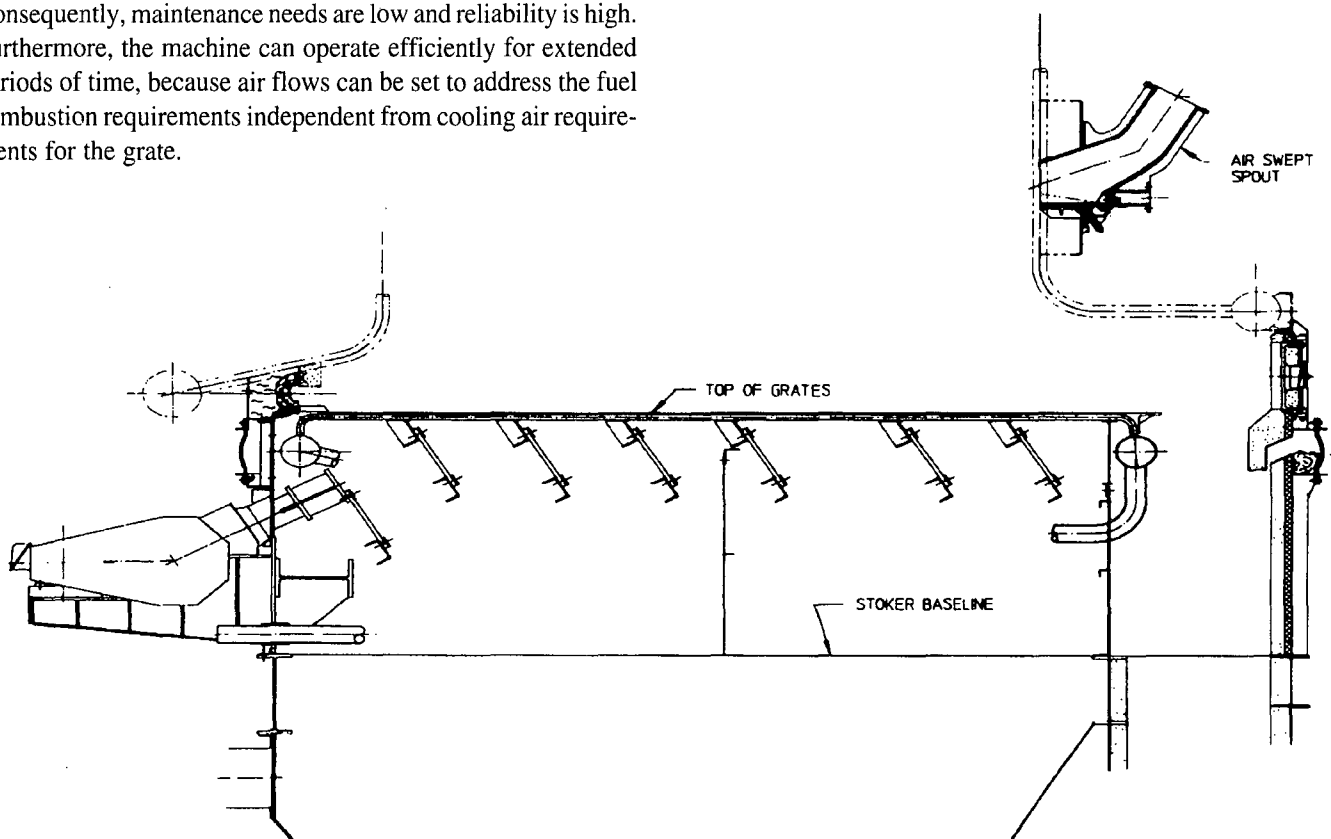


Figure 2. Water-cooled vibrating grate.

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 stokers 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 of 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. In the United States there are more than 100 air and water-cooled vibrating grate units firing coal and ranging in size from 25 to 50 t/h steam. Coal can be fired easily using either the existing fuel feed system, individual coal feeders, or with pulverised 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 travelling grates, pinhole grates, dumping grates, pulverised coal, suspension fired wood and, in many cases, oil or gas. Maximum possible heat releases are attainable, thereby maximising 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 pulverised fired units or converted black liquor boilers (Table 1).

Table 1
Grate heat release rates (MW/m²).

Travelling grate spreader	2,05 to 3,15
Pinhole grate	1,58 to 2,36
Water-cooled vibrating grate	2,52 to 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 steam capacity of over 4 800 tons/hour. The first unit started up in 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 (IPPs) and sugar mills. To date, 15 IPP plants and six boilers at sugar mills in the United States and Canada use the air-cooled or water-cooled vibrating grate (Table 2).

Conclusions

The use of air or water-cooled vibrating grates should be evaluated when considering a new combustion system or retro-fitting

Table 2
Air and water-cooled vibrating grates burning biomass.

Year	Location	t/h	Year	Location	t/h
1983	Wisconsin	36	1989	South Carolina	127
1984	Ohio	36		Georgia	159
1985	Minnesota	68		Quebec	94
	Oregon	2x79		British Columbia	239
	Arkansas	295		Chile	120
	Alabama	181		Arkansas	163
	Maryland	2x11		Alabama	68
	Ontario	32		British Columbia	159
	British Columbia	54		Washington	102
	Maine	70	1990	Alabama	68
1986	New Hampshire	63		Newfoundland	71
	Maine	63		British Columbia	136
	Michigan	63		Washington	91
	New Hampshire	64		Louisiana	227
	New Hampshire	73	1991	Alberta	210
	British Columbia	113		British Columbia	255
1987	Quebec	136		Alabama	91
	British Columbia	100		Vermont	86
	Maine	45		Brazil	100
	Mississippi	61	1993	California	54
1988	Newfoundland	23	1994	Tennessee	36
	Alberta	130		Florida	3x200
	British Columbia	159		Michigan	156
	Brazil	100		Florida	2x200
	Alabama	204	1995	Virginia	190
	British Columbia	113		New Brunswick	249
	Maine	82		Pennsylvania	68
	California	82		Argentina	35
1989	South Carolina	136	1996	Florida	159

an existing unit burning biomass and coal fuels. The sugar industry has several basic requirements to ensure a competitive position in the market place, such as high reliability, maximum efficiency, ease of operation with minimum attendant labour 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 such as coal, oil, gas etc
- Ability to operate continuously
- Compatibility with existing boiler designs
- Ability to fire a wide range of fuel moistures, sizes and ash content without detriment to efficiency and control
- Lowest possible emissions
- High steam generating capacity.

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