tiple retort design. It is used in some of the largest industrial plants and central power stations. Zoned air control has been applied to these stokers, both longitudinally and transversely of the grate surface.

The overfeed flat grate stoker is represented by the various chain- or traveling-grate stokers.

Another distinct type of overfeed flat-grate stoker is the spreader type in which coal is distributed either by rotating paddles (Fig. 5) or by air over the entire grate surface (Fig. 6). This type of stoker is adapted to a wide range of fuels and has a wide application on small sized fuels, and on fuels such as lignites, high-ash coals, and coke breeze.

The overfeed inclined-grate stoker operates on the same general combustion principle as the flat-grate stoker, the main difference being that rocking grates, set on an incline, are provided in the former to advance the fuel during combustion.

Combustion Process

In anthracite stokers of the Class 1 underfeed type, burning takes place entirely within the stoker retort. The refuse of combustion spills over the edge of the retort into an ashpit or receptacle from which it may be removed either manually or automatically. Anthracite for stoker firing is usually pea, buckwheat, rice, or barley size (see Chapter 33 for a description of size).

Because the majority of the small bituminous coal stokers operate on the underfeed principle, a general description of their operation is given. When the coal is fed into the retort, it moves upward toward the zone of combustion and is heated by conduction and radiation from the burning fuel in the combustion zone. As the temperature of the coal rises, it gives off moisture and occluded gases, which are largely noncombustibles. When the temperature increases to around 700 or 800 F the coal particles become plastic, the degree of plasticity varying with the type of coal.

A rapid evolution of the combustible volatile matter occurs during and directly after the plastic stage. The distillation of volatile matter continues above the plastic zone where the coal is coked. The strength and porosity of the coke formed will vary according to the size and characteristics of the coal. While some of the ash fuses into particles on the surface of the coke as it is released, most of it remains on the hearth or grates and, as this ash layer becomes thicker with time, that portion exposed to the higher temperatures surrounding the retort fuses into a clinker. The temperature in the fuel bed, the chemical composition and homogeneity of the ash, and the time of heating govern the degree of fusion.

Most bituminous coal stokers of Classes 1, 2, and 3 require manual removal of the ash in clinker form.

In the underfeed side-cleaning stokers the fuel is introduced at the front of the furnace to one or more retorts, and is advanced away from the retort as combustion progresses,

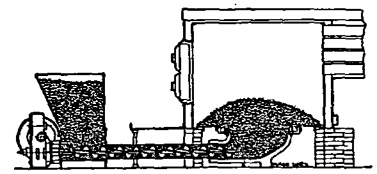


Fig. 3 .... Underfeed Screw Stoker, Hopper Type, Class 2 or 3

while finally the ash is disposed of at the sides. This type of stoker is suitable for all bituminous coals, while in the smaller sizes it is suitable for small sizes of anthracite. In this type of stoker the fuel is delivered to a retort beneath the fire and is raised into the fire. During this process the volatile gases are released, are mixed with air, and pass through the fire where they are burned. The ash may be continuously or periodically discharged at the sides.

The underfeed rear-cleaning stoker accomplishes combustion in much the same manner as the side-cleaning type, but consists of several retorts placed side by side and filling up the furnace width, while the ash disposal is at the rear. In principle, its operation is the same as the side-cleaning underfeed type.

Overfeed flat-grate stokers receive fuel at the front of the grate in a layer of uniform thickness and move it horizontally to the rear of the furnace. Air is supplied under the moving grate to carry on combustion at a sufficient rate to complete the burning of the coal near the rear of the furnace. The ash is carried over the back end of the stoker into an ashpit beneath. This type of stoker is suitable for small sizes of anthracite or coke breeze, and also for bituminous coals, the characteristics of which make it desirable to burn the fuel without disturbing it. This type of stoker requires an arch over the front of the fuel bed to maintain ignition of the incoming fuel, and frequently a rear combustion arch.

Overfeed inclined-grate stokers are provided with rocking grates and ash plates on which ash is accumulated and dumped periodically. This type of stoker is suitable for all types of coking fuels, but preferably for those of low volatile content. Its grate action keeps the fuel bed broken up, thereby allowing free passage of air. Because of its agitating effect on the fuel, it is not desirable for badly clinkering coals. It usually should be provided with a front arch to ignite the volatile gases.

Combustion Adjustments

The coal feeding rate and air supply to the stoker should be regulated so as to maintain a balance between the load

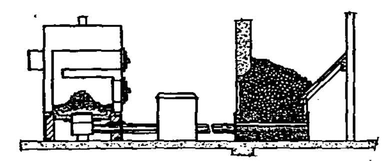


Fig. 2 .... Underfeed Stoker, Bin Feed Type, Class 1

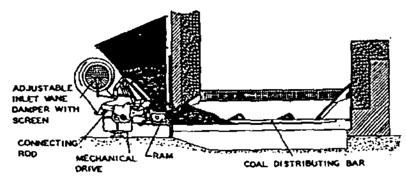


Fig. 4 .... Underfeed Side Cleaning Stoker

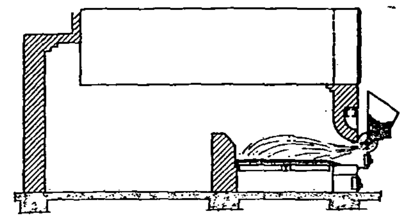


Fig. 5 .... Overfeed Spreader Stoker (Rotor Type)

demand and the heat liberated by the fuel. Under such conditions, no manual attention to the fuel bed should be required, other than the removal of clinker in stokers which operate on this principle of ash removal.

As in all combustion processes, the maintenance of the correct proportions of air and fuel is essential. It is desirable to supply the minimum amount of air required to properly burn the fuel at the rate of feed.

While there may be only slight variations in the rate at which the coal is being fed, due to variations in the size or density of the coal, there may be wide variations in the rate of air flow as the result of changes in fuel-bed resistance. These changes in resistance may be caused by changes in the porosity of the fuel bed due to variations in size or friability of the coal, ash and clinker accumulation, and variations in depth of the fuel bed. Because of this variable fuel bed resistance, many bituminous stokers, even in the smaller domestic sizes, incorporate air controls which automatically compensate for these changes in resistance and maintain a constant air-to-fuel ratio. The efficiency of combustion may be determined by analyzing the flue gases, as explained in Chapters 33 and 44.

It is desirable on most stoker installations to provide automatic draft regulation in order to reduce air infiltration and provide better control during the banking, or off, periods of the stoker. It is imperative that adequate combustion air be supplied and, therefore, it is usually necessary to provide a direct outdoor opening for this purpose. (See Chapter 33.)

Combustion Chamber Design

The Stoker Manufacturers Association has published standard recommendations on setting heights for stokers having capacities up to 1200 lb of coal per hour.[3]

The empirical formulas for determining these setting heights are:

For burning rates up to 100 lb coal per hour

$$H = 0.1125\,B + 15.75 \tag{1}$$

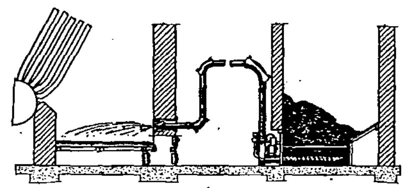


Fig. 6 .... Overfeed Spreader Stoker (Pneumatic Type)

For burning rates from 100 to 1200 lb coal per hour

$$H = 0.03\,B + 24 \tag{2}$$

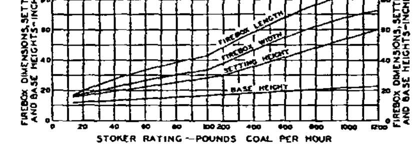
where

H = minimum setting height, inches, measured from dead plates to crown sheet for steel boilers. For cast-iron boilers height may be $\frac{7}{8}\,H$.

B = burning rate coal per hour, pounds.

Standards for minimum firebox dimensions and base heights have been formulated by the Stoker Manufacturers Association as shown in Fig. 7.[3]

In considering these recommendations, it should be understood that they show the average recommended minimum. There are many factors affecting the proper application of stokers to various types of boilers and furnaces, and, in certain instances, setting height or firebox dimensions shown in the standards may be modified without impairing performance. Such modification will depend upon the experience of



[a] For reference in selecting or designing boilers and furnaces for stoker firing Dimensions shown are for net inside clearance at grate level using coal with heating value of not less than 12,000 Btu per pound. Under certain conditions smaller fireboxes will permit satisfactory performance but these dimensions are preferred normal minimums.

Fig. 7 .... Suggested Minimum Firebox Dimensions and Base Heights[a]

the installer or designer with a particular stoker, the type of fuel used, and the construction of the boiler or furnace.

Installation of stokers (particularly smaller sizes) on the side of the boiler or furnace may facilitate clinker removal.

Rating and Sizing Stokers

The Stoker Manufacturers Association[2, 3] has suggested a method for rating solid fuel stokers as follows:

$$\frac{\text{Load (Btu per hour)}}{\text{Heating value of coal (Btu per pound)} \times \text{overall efficiency of stoker and boiler or furnace}} = \text{Stoker burning rate required (pounds of coal per hour)}$$

In determining the total load placed on a stoker-fired boiler by a steam or hot water heating system, a piping and pickup factor of 1.33 is commonly used in sizing the stoker, but should be increased when conditions are unusual.

Controls

The control of coal-fired equipment is discussed in the section Controls for Automatic Fuel-Burning Equipment.

DOMESTIC OIL BURNERS

An oil burner is a mechanical device for the oxidation of hydrocarbon liquids (fuel oil) and air under controlled con-