

smaller classes, although the principle of operation is much the same. The overfeed spreader type stoker, (Figs. 2 and 3) is adaptable to a wide variety of coals and is being extensively used in capacities up to 1000 boiler horsepower.

Combustion Process

Due to the marked differences in design and operating characteristics of stokers and the widely different characteristics of stoker coals, it is difficult to generalize on the subject of combustion in automatic stokers.

In anthracite stokers of the small Class 1 overfeed type, burning takes place entirely within the stoker retort and tuyere. The ash and refuse of combustion spills over the edge of the tuyere into an ash pit or receptacle from which it may be removed either manually or automatically (Fig. 8).

The larger underfeed anthracite stokers operate on the same principle except that the retort is rectangular and the refuse spills over only one or two sides of the grate. Anthracite for stoker firing is usually supplied in the No. 1 buckwheat or No. 2 buckwheat size.

Since the majority of the smaller bituminous coal stokers operate on the underfeed principle, a general description of their operation will be given. When the coal is fed from the hopper or bin 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 non-combustible. 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 of the coal. 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 used. While some of the ash fuses into particles in 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 normally fuses into a clinker. The temperature attained in the fuel bed, the chemical composition and homogeneity of the ash, and the time of heating are factors which govern the degree of fusion.

Most bituminous coal stokers of Classes 1, 2 and 3 operate on the principle of the removal of the ash in this clinker form. Clinker tongs are provided to facilitate removal of the clinker on the smaller models.

There are a number of factors which materially affect the burning rate and the combustion results obtained with automatic stokers, the most important of these being the type and design of stoker, the characteristics of the fuel, and the manner in which the stoker is installed and operated.

Furnace Design

Due to the wide differences in stoker, boiler and furnace design, and fuel burning characteristics, it has not been found practical to establish fixed rules for the proportioning of furnaces for automatic coal stokers.

It is, therefore, essential that an experienced stoker installer give careful consideration to these factors when applying the equipment.

The *Stoker Manufacturers Association* has published standard recommendations on setting heights for stokers having capacities up to 1200 lb of coal per hour. Due to the variable conditions encountered, these data could not be prepared to apply to all equipment or fuels, but are intended merely as a guide for *average* minimum setting heights.

Combustion Adjustments

The coal feeding rate and air supply to the stoker should be regulated so as to maintain as nearly as possible an ideal balance between the load 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 problem of maintaining the correct proportions of air and fuel is of utmost importance. It is desirable to supply a minimum amount of air required to properly burn the fuel at the rate it is being fed to the furnace.

While there may be only slight variations in the specified rate at which the coal is being fed to the furnace, due to variations in the size or density of the coal being used, there may be wide variations in the rate of air supplied 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 of the bituminous stokers, even in the smaller domestic sizes, incorporate air controls which automatically compensate for these changes in resistance and maintain a constant air fuel ratio.

It is also 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. The efficiency of combustion may be determined by analyzing with an Orsat apparatus the gases formed by the combustion process. With this equipment the percentage by volume of carbon dioxide (CO_2), oxygen (O_2), and carbon monoxide (CO) in the flue gases may be obtained. The percentage of CO_2 indicates the amount of excess air supplied. The presence of CO indicates a loss due to incomplete combustion, as the result of a deficiency of air or the improper mixing of air in the gases of combustion.

Sizing Stokers and Stoker Ratings

The *Stoker Manufacturers Association* has adopted a uniform method of rating stokers which includes convenient tables and charts for selecting the size of stoker required².

Controls

The heat delivery from the stoker of the smallest household type to the largest industrial unit can be accurately regulated with fully automatic

²Uniform Stoker Rating Code. Copies of this standard may be obtained from the *Stoker Manufacturers Association*, 307 North Michigan Ave., Chicago, Ill.