

is carried through the hollow arch where it may become heated and from which it is delivered into the combustion chamber through a series of openings along the bottom or rear side of the arch.

By aid of the smokeless arch, high volatile coals can be burned with practically no smoke at moderate rates of combustion.

The *down-draft* furnace (originally known as the Hawley down-draft furnace) consists of an upper grate of water tubes located above the usual rocking grate. The draft draws down through the upper grate and up through the lower grate. Coal is fired above the fuel bed on the upper grate and after the ash and some coke have been worked down on the lower grate a lively fire is maintained on both grates. The volatile gases pass down through the upper fuel bed and become highly heated as they meet in the combustion chamber between the grates, with the heated excess air from the lower fuel bed.

This type of furnace has proved successful for burning bituminous coal with high efficiency and without smoke.

MECHANICAL STOKER FIRING

Mechanical stokers have long been considered essential standard equipment for all major heating installations. They make it possible to burn coal at a high efficiency without smoke. Within recent years the smaller sizes of mechanical stokers have been developed to a remarkable extent, and it is now possible to achieve results with the small sizes which are comparable to those obtained in the large plants.

Advantages of Stoker Firing

With mechanical stoker firing there are a number of advantages over hand firing for burning bituminous coal. A good mechanical stoker installation will result in a saving of from 15 to 35 per cent of the fuel cost. It may save labor cost. Stokers will burn nut, pea and slack screenings, which are difficult if not impracticable for hand firing, and which can be purchased generally at a lower price than the coarser sizes of coal usually required for hand firing. The stoker, feeding coal continuously, without the uncontrolled blasts of excess air inherent to hand firing, will give more uniform combustion results than will hand firing, and will provide smokeless operation. For this reason alone, to abate the smoke nuisance, stokers are being specified for heating plants in many of the larger cities by smoke controlling departments. With mechanical stokers, automatic control is provided to give uniform steam pressure or temperature, the work and attention of the fireman is reduced and usually he can direct more attention to other duties. Frequently with old plants a lower capital charge and a higher return can be secured by installing stokers to increase the output of the old boilers rather than to purchase additional hand-fired boilers.

Types of Stokers

Stokers may be classified roughly as of the overfeed type and the underfeed type.

The *overfeed stoker* principally is used with natural draft. Although it feeds the coal automatically and continuously and gives improved results

over hand firing, it requires heat-storing masonry arches to give proper combustion and must have large combustion space and good draft to draw the air through the fuel bed. There is some evidence that the natural draft overfeed type of stoker is less flexible and adaptable in heating boilers than the forced draft underfeed stoker.

The *underfeed stoker*, as the name implies, feeds the coal underneath the fuel bed. The hot fire is on top of the bed and the fresh fuel as it is pushed up underneath the fire is ignited thoroughly.

The gases from the igniting coal, being forced through the hot fire above the coal, have all volatile matter burned completely and no unburned carbon leaves the furnace. In heating boilers the combustion chamber often is water jacketed and this directly exposed surface plays a very important part in the heat transfer to the boiler, so that the underfeed stoker, with its hot coals on top of the fuel bed, is particularly well suited to heating boilers.

With this type of stoker a forced draft fan is used for driving the air through the fuel bed, and the chimney is required only to draw the gases through the boiler.

With an underfeed stoker, due to thorough ignition, the gases burn with a short flame and it is possible to achieve smokeless combustion even where the combustion space is limited.

Underfeed stokers are made with multiple retorts and with single retorts. The *multiple retort*, rear cleaning types are used in large plants where great quantities of coal are burned. Smaller boilers up to about 30,000 sq. ft. rating in size, generally are best adapted to the *single retort type*. The coal is fed into the single retort stoker either by a screw conveyor or by a reciprocating ram.

The screw type of conveyor is very old in stoker practice but has been revived recently and gives good results for small retorts.

The larger retorts using a screw conveyor, experience some difficulty in getting uniform distribution of the coal sideways and longitudinally. With a reciprocating ram, however, equal distribution may be obtained to both sides of the furnace. A distributing moving bar in the bottom of the retort of a ram type stoker makes it possible to control the distribution of the fuel longitudinally.

It is obvious that uniform distribution of the fuel is essential in any underfeed stoker.

Single retort stokers are made in the dead plate type and in the side dumping grate type. With the *dead plate* arrangement the hot ashes must be pulled out through the fire door, whereas with the *dumping grate* type the ashes are dropped into the ashpit and may be removed at the convenience of the fireman. This arrangement makes it possible to clean the fires much more quickly and easily than with the dead plate type and dust and hot gases in the boiler room may be reduced.

Single retort underfeed stokers are furnished complete with forced draft fan, electric motor and air duct all built-in as a unit as shown in Fig. 3. This makes a compact and economical arrangement which is particularly well suited for heating plants. Each boiler is a self-contained independent unit. In plants of two or more boilers there is a saving in electric power