

OVERFEED STOKERS OF THE INCLINED TYPE

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In this paper the author discusses the development and present construction, and method of operation, of the front- and side-feed types of inclined overfeed stokers. Three side-feed stokers are described, with an illustration of a Dutch-oven type of setting. It is stated that 200 per cent of boiler rating can be obtained with 0.3 in. to 0.5 in. draft loss through the fuel bed, and that when forced draft is applied, it should be done with proper regard to air circulation and the maintenance of suction above the fire. Three front-feed stokers are also described, with an illustration of a setting with ignition arch, and an explanation of combustion control by varying the stroke of the coal pusher and the angle of rotation of the bars. The effect of the flux content of ash in determining the fusion temperature is also discussed.

STOKERS of this type are of two general classes, the side-feed double-inclined or V-type, and the front-feed or single-inclined stoker. Development in this country was not hampered by an attempt to fit a square plug in a round hole, and as there were practically no space limitations, it was possible to get the needed combustion space. The early development of these stokers was along natural-draft lines, because that was the draft available and because it was possible to readily burn all the coal required to meet load conditions. As the steam plants have increased in size, the boilers and stokers have also increased in size until this type has apparently reached a limit in a stoker having a projected grate area of 100 to 110 sq. ft. in a single unit, capable of burning sufficient coal, under forced draft, to develop about 2000 b.h.p. as a maximum.

2 The double-inclined side-feed stoker was the first to make its appearance in this country, Thomas Murphy fathering this particular line of development, commencing about 1875. His first attempt was hand-operated and was apparently brought about in an attempt to overcome troubles due to cleaning fires and loss of

capacity during cleaning periods. It was placed in the firebox of a marine boiler and had inclined grates, every second grate being movable. It was provided with a revolving toothed cylinder or clinker grinder, extending from front to rear along the bottom of the V, for the removal of clinker and ash.

3 In 1879 Murphy moved this device forward into a Dutch oven, for use in connection with a return-tubular boiler, and added magazines and stoker boxes for feeding coal to the upper end of the grates. He placed a firebrick arch above the entire grate surface, with a second arch enclosing an air space above this arch and with provision for circulating air for combustion over the firebrick arch and through openings in the arch plates immediately above the fire, at the point where the volatile gases are distilled from the coal. About 1880 he provided an engine drive, placing a reciprocating bar across the front of the stoker, with arms and links to operate the stoker shafts which moved the stoker boxes back and forth, the rocker bars which raised and lowered the movable grates, and with a ratchet which rotated the clinker grinder. In all essential features this stoker is the stoker of this class of the present time, as represented by the Murphy, Detroit, and Model stokers, although there are many minor changes in the stokers as built today.

4 About 1885 the front-feed inclined stoker was developed, the Roney and Brightman stokers being brought out at that time. The Brightman stoker was apparently not a financial success and it gradually disappeared; a modified form of it, however, still remains in the Wetzel stoker. The Roney stoker was actively pushed by the Westinghouse interests and is being built by them today. The Wilkinson stoker was brought out by Alfred Wilkinson and was in rather extensive use from 1895 to 1905, particularly for anthracite coal. It has now largely disappeared.

5 Originally the grates in the side-feed stokers were set at an angle of 35 deg. with the horizontal. As the size of the stokers was increased this angle was increased to 40 deg., and later to 45 deg., which is the present standard. Grates at this angle are suitable for bituminous and semi-bituminous coals. With non-coking coals a much flatter grate is desirable, and when coals of this sort are to be burned it is advisable that the stokers be designed particularly for the coal in question. The grates in the Roney stoker are at an angle of 35 deg. with the horizontal, and this stoker will burn

anthracite and bituminous coal and lignite. The grates in the Wetzel stoker are also set at the same angle.

6 Where wood refuse or spent tanbark is used, this is usually burned in connection with bituminous coal, enough coal being burned to keep the grate surface covered. Wood refuse is spouted to the stoker through an opening in the stoker front, or dropped through openings in the arch directly onto the fuel bed. Tanbark is usually mixed with the coal and fed to the stoker in the regular way, that is, through the magazine or hopper. Spent tanbark will run about 60 per cent moisture, and when a half-and-half mixture is used about 85 per cent of the heat supplied to the boiler will be from the coal, the remainder from the tanbark.

SIDE-FEED DOUBLE-INCLINED STOKERS

7 The side-feed double-inclined stoker may have either a flush-front or Dutch-oven setting. The flush-front setting is limited to the smaller return-tubular boilers and horizontally-baffled water-tube boilers. On the larger return-tubular boilers, vertically baffled horizontal water-tube boilers, and boilers of other types it is advisable to place the stoker in a Dutch-oven setting. A Dutch-oven setting materially simplifies the matter of supplying coal to the stoker, and where desirable an eight or ten-hour supply of coal can be stored on top of the stoker. A typical Dutch-oven setting is shown in Figs. 1 and 2.

8 These stokers are made in various sizes, both as to width and depth, varying from a stoker with a grate surface 4 ft. wide and 3 ft. deep to one having a grate 12 ft. wide and 9 ft. deep. In the larger stokers 1 sq. ft. of projected grate area is provided for each $6\frac{1}{2}$ rated horsepower of the boiler, and in the smaller stokers 1 sq. ft. for about each 5 rated horsepower. Where the stokers are set with a Dutch oven they extend in front of the boiler about the depth of the grate surface of the stoker, this being varied to suit local conditions and the details of the boiler. The overall width of the stoker is roughly the width of the boiler setting. The head room required will vary with the width of the stoker. The boiler should be set sufficiently high so that the front header or the sill of the tube-door opening clears the top of the arch about 3 in. This would mean a height of about 6 ft. on a 100-hp. boiler, 7 ft. 9 in. to 8 ft. 3 in. on a 300-hp. boiler, and 11 ft. 3 in. on a 600-hp. boiler. Where vertical water-tube boilers are used, such as

Wickes, Rust, or Erie City vertical, it is advisable to place a combustion space between the rear of the stoker and the tube surface of the boiler. This can be made of somewhat greater cross-section than that of the stoker. The distance from the rear end of the grate surface to the tube surface should be 6 or 7 ft.

9 Stokers of this class are usually driven by a small steam engine operating the reciprocating bar through a chain of gearing,

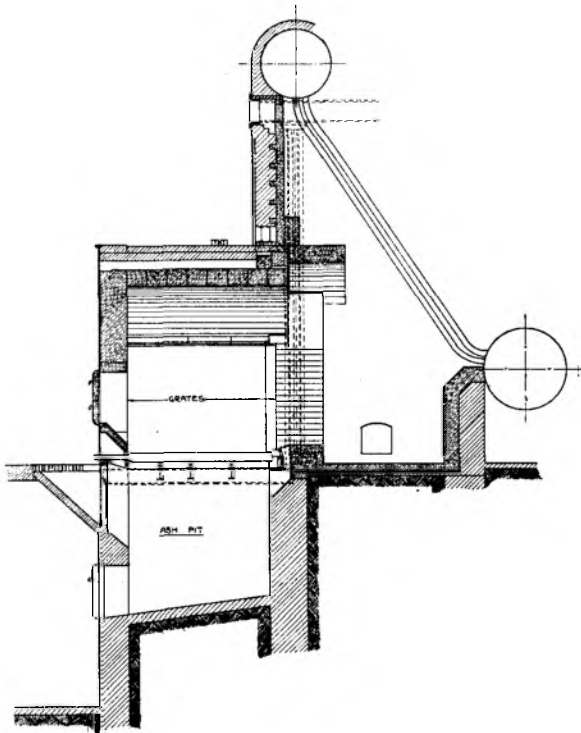


FIG. 1 TYPICAL DUTCH-OVEN SETTING FOR SIDE-FEED DOUBLE-INCLINED OVERFEED STOKER UNDER A 500-HP. STIRLING BOILER

the details of the gear reduction being arranged to suit the particular stoker. Where for any reason it is desirable to do so, a motor, either a.c. or d.c., can be used in place of the engine. The speed range of the motor, however, is liable to be considerably smaller than that of an engine: about 3 to 1 for the a.c., and 4 to 1 for the d.c. motor. An engine is preferable to a motor, as the exhaust steam which it supplies is useful under the clinker grinder.

10 As far as the author knows, the most convenient and effective means of chilling clinker so that it can be readily handled is by means of low-pressure steam. This was apparently first employed on a stoker of this class in 1895 and its use is covered by a patent issued to J. H. Nicholson. A pipe was cast in each of the side plates of the grate bearer and holes drilled through the side plate and pipe so that steam was discharged under the clinker grinder and also under the lower ends of the grates. Later on, when a sectional type of grate bearer was devel-

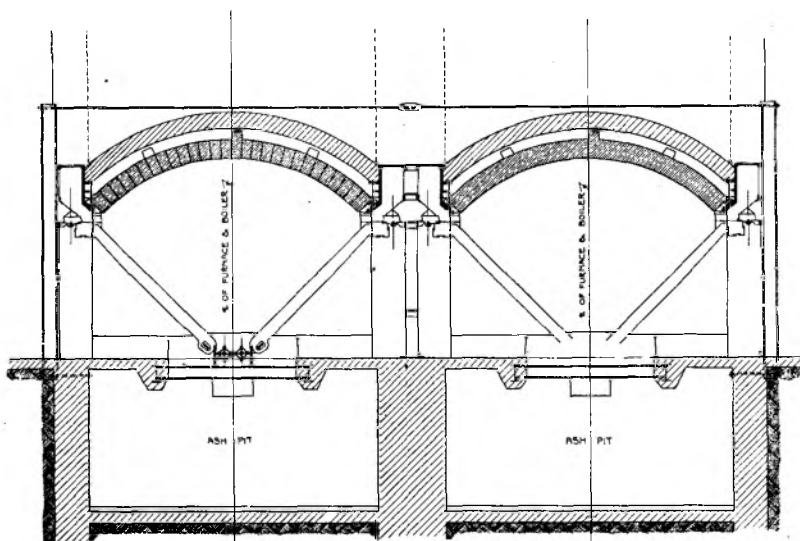


FIG. 2 TYPICAL DUTCH-OVEN SETTING FOR SIDE-FEED DOUBLE-INCLINED OVERFEED STOKER UNDER A 500-HP. STIRLING BOILER

oped, a single steam line was placed under the clinker grinder, as this was sufficient with most coals reaching the market ten or fifteen years ago. When the practice grew up of grinding mine dumps and selling the resulting product as high-grade West Virginia coal, the use of additional steam lines under the lower ends of the grates became desirable and these were rather generally used, the result being the equivalent of the earlier design, where steam was discharged under both the clinker grinder and the lower ends of the grates.

11 It is desirable that the fuel be fed as uniformly as pos-

sible to the stoker. The fuel bed is about 8 to 10 in. thick at the upper end of the grates, thinning down gradually toward the clinker grinder. The fuel bed over the lower end of the grates should be thin and active. Minor fluctuations in load should be taken care of by minor variations in the draft over the fire. Where the load changes into a decidedly higher or lower range, the coal feed should be increased or diminished to meet this range, the draft over the fire being regulated to take care of the immediate needs of the boiler.

12 The draft loss through the fuel bed will vary with the amount and kind of coal being burned, the high-volatile coals requiring less draft than the lower-volatile coals. The amount of draft required is also affected by the amount and kind of ash which the coal carries. Where proper draft is provided, stokers of this class will take care of various loads readily up to 200 or 225 per cent of boiler rating, although the draft available usually limits the capacity to 200 per cent of boiler rating or less. Where there is a shortage of draft it is possible to compensate for this in part by increasing the amount of "roasting" or hand manipulation of the fuel bed. At 200 per cent of boiler rating the draft loss through the fuel bed will vary from 0.3 to 0.5 in. water gage, depending on the kind of coal and the amount of roasting.

13 Where it is desired to obtain more capacity than can be obtained with the natural draft available, it is sometimes possible to do this by adding forced draft. Where forced draft is applied to a stoker of this class, it is advisable to see that all the necessary items for its proper installation are taken care of. The air should be admitted to the space beneath the grates, either at the front or the rear, in a line parallel with the clinker grinder; two inlets being used, placed symmetrically with reference to the center line of the stoker. Instances have been found where a blower has been placed through each side sheet, discharging air directly against the grates, and troubles have quickly resulted from such practice. Under natural-draft conditions the amount of air reaching the furnace through the openings in the arch plates increases as the capacity increases, and provision should be made so that this same condition holds good under forced-draft conditions.

14. From time to time small blowers have been applied to stokers of this class without paying any particular attention to the method of installation. The natural draft available is poor,

and the owner wants more capacity and is readily beguiled by a promise of more capacity at a low first cost. A typical case would be one in which there is a draft of about 0.15 in. over the fire under natural-draft conditions. Due to poor breeching design and a dirty boiler, the draft loss between the chimney and furnace is rather large, so that with a 5 or 10 per cent increase in capacity the draft over the fire is reduced to a point where the fire is blown out of the various openings. No attempt is made to insure proper air circulation. Usually these installations are made without referring the matter to the maker of the stokers.

15 The limit of capacity under forced-draft conditions will be that point where the draft over the fire is so reduced that fire is blown out of various openings. This will be when the draft over the fire is reduced below 0.10 in., probably to about 0.05 in. The same conditions hold good here that obtain with forced-draft stokers generally, and the paragraph placed in many contracts for forced-draft stokers requiring the purchaser to provide a draft of 0.1 in. over the fire at maximum rating should be considered to apply properly to installations of this class of stoker when equipped with forced draft.

16 With forced draft properly installed and skilful firing, it is possible under favorable conditions to get in the neighborhood of 300 per cent of boiler rating. The fires are rather thin for forced-draft work and it requires closer attention to the fuel bed to keep the grates covered than in the case of stokers using a much thicker fuel bed.

17 Where these stokers are operated under natural-draft conditions the proper method of regulating the air supply is by adjusting the damper at the outlet of the boiler. This can be done by hand where necessary, and if it is controlled by hand the damper should be connected to a quadrant near the front of the stoker so that it is within convenient reach of the fireman. Where it is controlled in this way the damper will be shifted slightly as the steam pressure rises or falls. There is no objection to using a damper regulator provided this regulator is of proper design. In other words, it should be a regulator which reproduces the action of a skilled fireman as closely as possible and shifts the damper slightly with varying steam pressure. A two-position damper regulator, or one which holds the damper in an open or closed position, depending upon the steam pressure, is worthless.

18 Various forms of automatic control for the draft and coal feed have been used, the favorite form being to vary both the coal feed and the draft as the steam pressure fluctuates. The writer has found no means of determining by the steam pressure whether more coal or less is needed in the stoker. This is a matter which needs the intelligence of a fireman. The automatic device is as apt to be wrong as right.

FRONT-FEED INCLINED STOKERS

19 Of the many forms of front-overfeed inclined stokers which have appeared, the Roney and Wetzel are still being built. The Roney is a natural-draft stoker only. It is not used in conjunction with forced-draft equipment. It is made up of an inclined grate with transverse bars. Each bar is supplied with sectional grate-bar tops so arranged that they allow a uniform distribution of air through the whole grate area. At the upper end of the furnace, flat fuel plates are provided on which the coal can coke, and this prevents sifting of the green coal until the coking process is well under way; by this time there is no further trouble with siftings. There is an agitation given to the grates by a rotary motion on the transverse bars. This motion feeds the refuse and fuel uniformly toward the lower end of the grates. At this point and immediately above the dump grates there is an agitator for the purpose of breaking up clinker that may form in this zone; it also serves the purpose of preventing the avalanching of the fuel bed down the grate while the dump grates are open and the fire is being cleaned. The dump grates are slotted, thus providing active fuel-burning surface in this zone.

20 The angle of rotation of the transverse bars can be varied from nothing to a maximum. The stroke of the coal pusher can also be varied. The ability to control these motions without changing the speed of the engine provides a very wide range of flexibility. It is customary practice to operate Roney-stoker driving units at constant speed, and take up the fluctuation in the rate of feeding coal by means of the variable adjustments on the stroke of the coal pusher and grates. Motors or reciprocating engines are usually supplied for driving Roney stokers. As a rule, constant speed drivers are supplied. The whole stoker-driving mechanism is extremely simple, as a multiplicity of stokers can be driven from one shaft which operates both the feed and grate motion.

Even with this type of drive, every stoker on a lineshaft can be driven at a different rate if so desired. In addition to driving the Roney stoker with an engine, it can also be operated to a limited extent by hand.

21 The thickness of the fuel bed on a Roney stoker is uniform for a given grade of coal and does not vary for different ratings. The best practice is to control the rating on the boiler as desired by means of the boiler damper and not by thickening

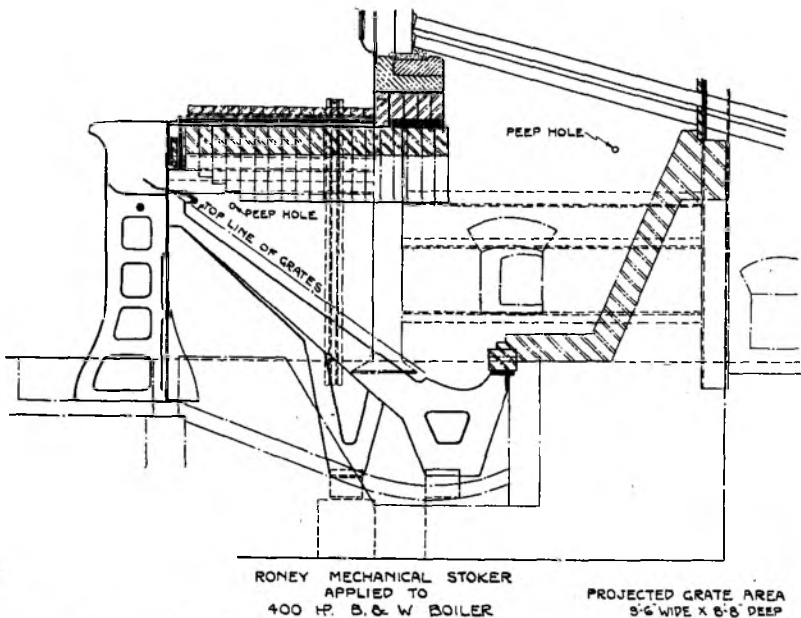


FIG. 3 FRONT-FEED OVERFEED STOKER WITH IGNITION ARCH UNDER A 400-HP. BABCOCK & WILCOX BOILER

or thinning the fuel bed. There are installations in service where there is automatic regulation controlled by steam pressure, but as a rule it has been found that hand regulation of the boiler damper is about the most reliable and effective method for this class of stoker.

22 The Roney stoker, a typical setting of which is shown in Fig. 3, is applicable to any type of boiler. It is set with an arch to ignite the incoming fuel and burn the volatile gases. This stoker is suitable for burning anthracite and bituminous coals and lignite.

For burning anthracite and lignite a slight change is made in the grate-bar tops so that they will overlap in any position and thus prevent the fuel from sifting through. There are a number of installations where hog fuel has been burned very successfully in conjunction with coal. This is done by using an extension furnace and cutting a hole through the arch so that the hog fuel can be dropped through the arch and on the fuel bed.

23 One of the outstanding features of the Roney stoker is the accessibility of all parts. There is practically nothing that can happen to this stoker that will put it out of service, and it can almost always be operated until it comes out of service for regular cleaning and repairs.

24 The Wetzel stoker is somewhat similar to the Roney, the principal difference being in the form of grate used. Instead of being made up of bars extending across the furnace and rocking, the grate is made up of a series of bars extending from front to rear. These bars are ribbed to prevent sifting, the upper end of the grate is supported on a short rocker arm so that it has a slight forward-and-back motion, and the lower end on an arm placed at a somewhat different angle, so that the motion of the lower end of the grate is practically at right angles to the grate surface.

25 The grates of the Wilkinson stoker were a series of hollow bars roughly rectangular in cross-section. They were stepped on the upper surface and air openings provided in the vertical surface of these steps. Air was supplied to these bars under pressure induced by a small steam jet. Coal was fed to the upper end of the bars and the bars had a slight forward-and-back motion. The bearing for the bars at the lower end was in the form of a box which took care of the accumulation of siftings and permitted their removal when necessary. The stoker was provided with an ignition arch at the upper end and a dump plate or ash pocket at the lower end. It made a rather satisfactory stoker for burning the smaller-sized anthracite coals under boilers of the sizes then in general use.

ASH

26 Most coal ash has a fireclay base with various kinds and amounts of foreign materials which act as fluxes, such as iron, lime, magnesia, and sodium and potassium oxides. An ash con-

taining 40 per cent of fluxes will melt at about 2000 deg. fahr. and one containing 5 per cent at about 3000 deg. fahr. If the percentages of fluxes are plotted in connection with the melting point of the ash, the points will be found to group around a straight line extending between the points mentioned above, the exact figure of course depending somewhat on the relative silica and alumina content of the ash. An ash low in fluxes is therefore desirable because it will be an ash of high fusing temperature and one which can be handled in a stoker more readily than an ash high in fluxes. An ash low in fluxes is also desirable when the maintenance of the stoker and boiler brickwork is considered, as small particles of ash impinge on the brickwork, and the iron, lime, etc., in the ash form an active flux for this firebrick at furnace temperatures.