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Babcock and Wilcox

1972

WOOD WASTE
COMBUSTION IN
.6

STEAM

ITS GENERATION AND USE

AP42 Section 1.6
4/93
Reference 2

THE BABCOCK & WILCOX COMPANY
NEW YORK

loss and requires either extremely high stacks ... to obtain the required steam capacity from ... boilers. To alleviate these conditions a low-draft ... Stirling boiler, as shown in Fig. 7, was designed. ... vertical tube bank facilitates cleaning, and the ... baffle arrangement usually permits natural- ... operation to the required peak capacity at ... efficiencies in the order of 57%. In sugar ... with refineries, a higher efficiency is necessary ... reduce the amount of supplementary oil required. ... thermal efficiency of 65% may be obtained by the ... use of an air heater and an induced-draft fan, ... shown in Fig. 8.

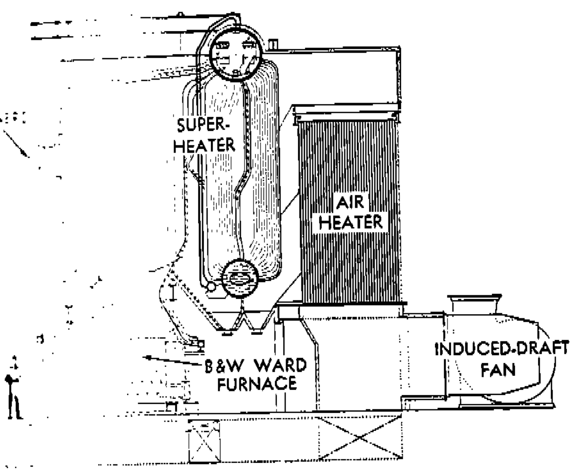


Fig. 8. *A Two-Drum Stirling boiler with air heater and water-cooled Ward furnace*

In recent years bagasse has been burned on stokers of the spreader type. This method of burning, however, requires bagasse with a high percentage of ... a moisture content not over 50%, and a more experienced operating personnel. Because of such limitations, the Ward furnace is considered the most ... reliable, flexible, and simple method of burning bagasse.

Wood Refuse

The burning of wood as a fuel for steam generation is generally confined to those industries or operations where wood refuse is available. Average sawmill practice shows that, in the cutting of lumber, ... half the total weight of a log appears as refuse—sawdust, chips, slab, and bark. The pulp-and-paper, furniture, and plywood industries are typical operations where such refuse appears in appreciable quantities.

All woods have substantially the same chemical analysis but may vary considerably in density and moisture content. Typical analyses of several kinds of wood are given on page 3-A3 of the Appendix.

Wood refuse available as a fuel may consist of large pieces, such as slabs, logs, and bark strips, and small pieces, such as sawdust and shavings. Furnaces for burning wood refuse are usually designed to handle chip size, in which case it becomes necessary to pass the large pieces through a hogger or chipper. Reducing the wood to chip size permits uniform continuous feeding, a more rapid burning of the small particles, and a more complete coverage of the grate.

Wood refuse from some processes contains 75% or more moisture. In order to obtain useful heat from the combustion of this type of fuel, it is necessary to reduce the moisture content to 60 or 65%. Mechanical presses are generally used for this purpose.

Wood-burning furnaces are not usually troubled with severe slagging conditions unless the wood is burned in combination with other fuels or unless the refuse comes from salt-water-borne logs. Ashes from two fuels often combine to form an ash of lower melting temperature than that of either ash taken separately. In some parts of the country, provision must be made for the removal of large amounts of sand and dirt which are dragged in with the logs. Such foreign material entrained in the combustion gases would cause the erosion of such surfaces as tubes, baffles, flues, and fans.

Grates for furnaces may be divided into air-cooled and water-cooled classes, or they may be a combination of the two. They should have about 30% free air space. For ash removal, grates may be of the rake-out, dumping, or moving type.

To design an efficient wood-burning furnace, the following steps in the combustion process must be considered: 1) drying, which proceeds rapidly on the surface but requires time to reach interior parts of large pieces, 2) distillation and burning of volatile matter, and 3) burning of fixed carbon. The temperature in the furnace must remain above the kindling point (between 750 and 1000 F), or the fire will go out. Furnace temperature depends upon the calorific value and the moisture content of the fuel, the weight of air flowing through the fuel bed, and the heat loss from flame and fuel bed by radiation. Furnaces designed for the burning of wood refuse fall into three types; pile, thin-bed, and cyclonic.

Pile Burning. The Dutch oven, or extension type of furnace with a flat grate, is the oldest design of furnace for burning wood refuse in a pile. Fig. 9 shows a modern version having water-cooled side walls, roof, and partial front wall. The hogged fuel is fed continually through a low roof and is permitted to pile up in a cone, the apex of which is directly under the feed hole in the roof. Most of the air for combustion enters through the grate around the edge of the pile and sweeps over the fuel, so that most of the burning takes place on the

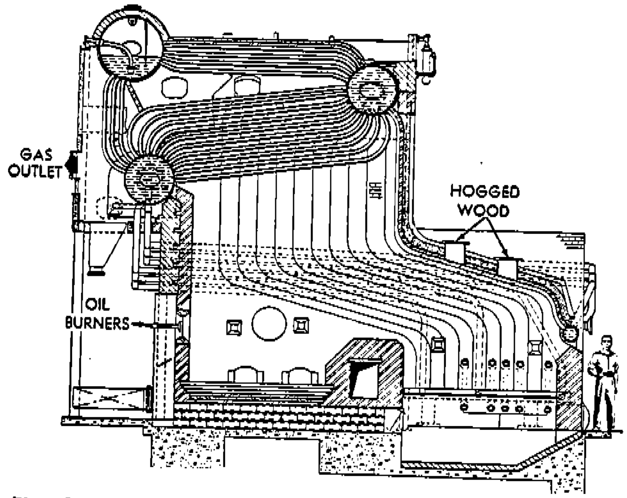


Fig. 9. A water-cooled extension furnace for burning hogged wood under a Type H Stirling boiler

surface of the pile. Some of the air is injected through the side walls toward the pile in order to obtain turbulence for completion of combustion.

The fuel supply cannot be closely regulated with this method of firing, and frequent manual adjustment is required for good operating results. Excess air at the boiler outlet is between 30 and 40%. Combustion rates of 125 lb per hr per sq ft of grate have been attained, burning wood having 45% moisture (as fired), using cold air. With hot air (300 to 350 F), the burning rate can be increased 25%. Above 45% moisture the combustion rate decreases rapidly. Ash is removed by rake-out or by dumping grates.

A small two-drum boiler unit designed to utilize

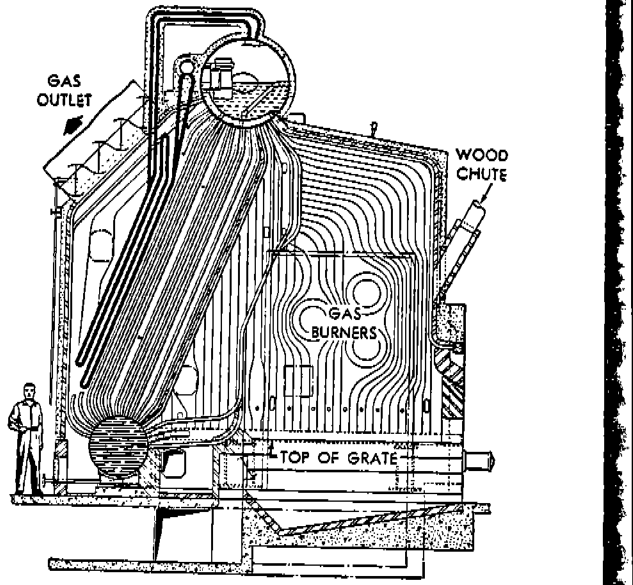
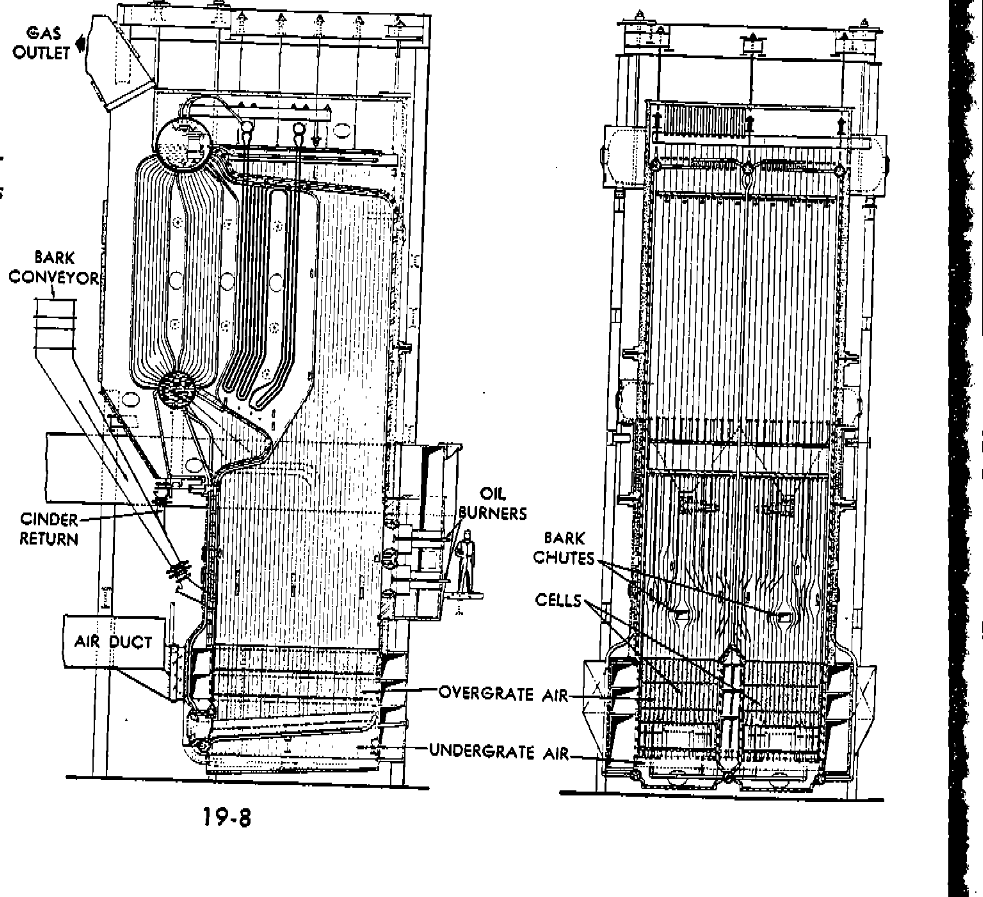


Fig. 10. An Integral-Furnace boiler with the furnace serving as a Dutch oven

the furnace as a Dutch oven is shown in Fig. 10. The wood drops by gravity into the furnace through circular chutes located in the upper front wall and falls into piles on top of dumping-type air-cooled grates.

A large two-drum single-pass boiler unit, in which the furnace acts as a Dutch oven, is illustrated by Fig. 11. In addition, provision has been made to burn oil in combination or alone. The furnace consists of two cells having water-cooled pinhole grates. Each cell is fed by its own air-swept chute through the

Fig. 11. A Two-Drum Stirling boiler with water-cooled furnace and cells for hogged-fuel burning



wall. Most of the 600 F air for combustion is forced through tuyères at three elevations around the sides of each cell. Some undergrate air is used to aid ignition, particularly when fuel is fed to the cell or when burning-down preparatory to removing ash. This unit is capable of burning fuel having 60 to 65% moisture at a rate of ... per hr per sq ft of grate with 30% excess air at boiler outlet. Ash is raked out every third day.

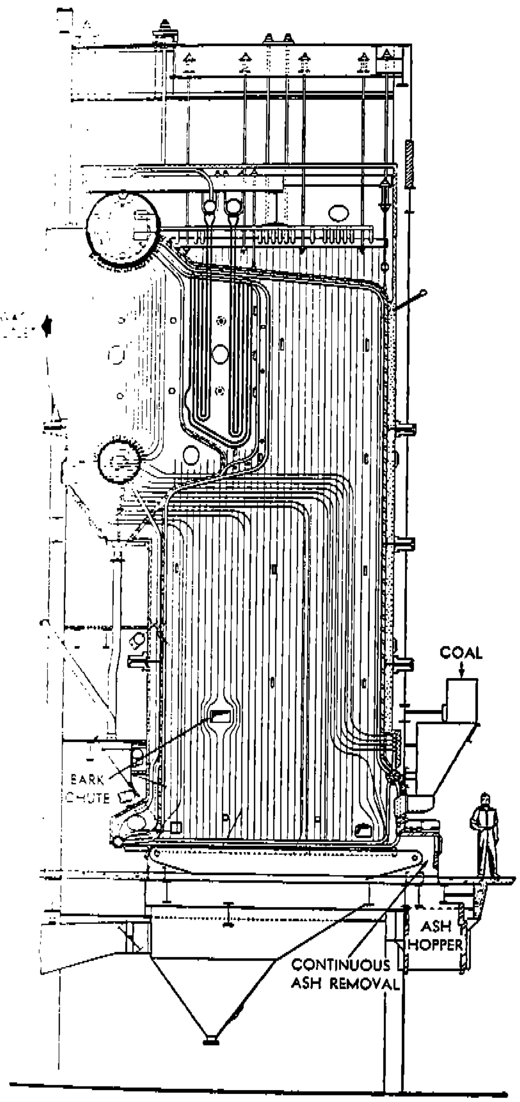


Fig. 12. A Two-Drum Stirling boiler with spreader stoker for coal and/or wood firing

...n-Bed Burning. Fig. 12 illustrates a two-drum ...-pass boiler equipped with a conventional ...ader stoker for coal firing and single chutes ...ugh each side wall for wood firing. With this ...ngement wood and coal can be burned separately or in combination. Introduction of the wood ... well above the grate permits the smaller particles to dry out and burn in suspension, while the remainder of the fuel continues in flight to the grate, where combustion is completed. Most of the air for combustion goes through the grate, a small portion being injected at high pressure (30 in. of water) through tuyères in the front and rear walls to promote turbulence. This type of unit is designed to burn refuse containing 45 to 60% moisture at rates up to 1,000,000 Btu/hr, sq ft, when supplied with 35 to 70% excess air at 400 F. Ash is continuously discharged from the moving grate.

Another variation of a two-drum single-pass boiler design for wood burning in combination with oil, gas, or pulverized coal is shown by Fig. 13. The air-swept wood chutes are located across the front wall. With this arrangement most of the wood burns in suspension. Oil burners are located in the bridge wall as shown.

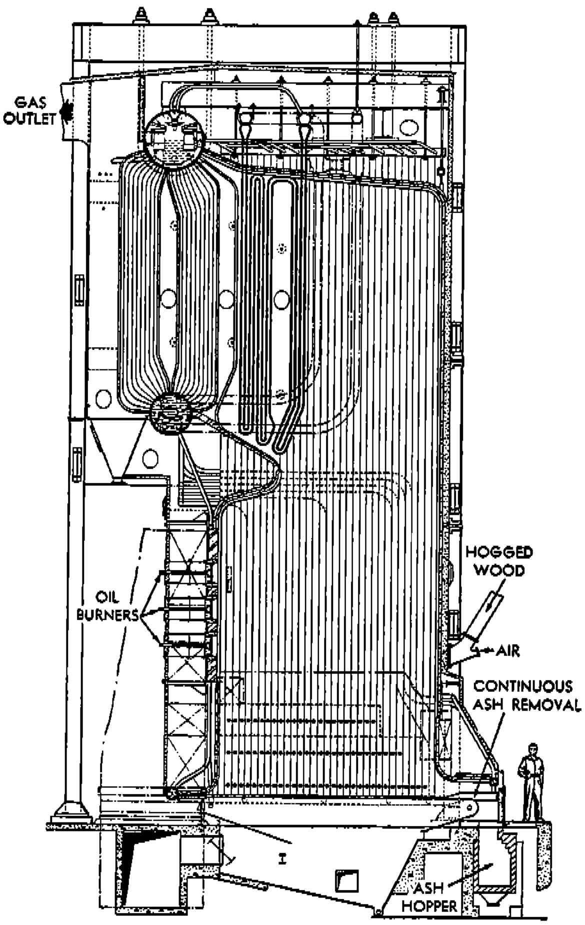


Fig. 13. A Two-Drum Stirling boiler with water-cooled furnace designed to burn wood with either oil, gas, or pulverized coal

Still another variation for a combination of wood and coal firing is that wherein the wood chute is located in the front wall directly above the coal flippers. The wood feed, consisting of unhogged refuse, passes through a rotating distributor that directs the flow sequentially through the chutes distributed across the furnace width. This permits the individual piles of wood partially to dry out before receiving the next feed fraction.

Cyclonic Burning. A furnace-boiler combination designed primarily for coal firing in a Cyclone Furnace is shown by Fig. 14. Provision has been made to burn some bark within the Cyclone Furnace in conjunction with coal. In order to accomplish this, however, it has been necessary to use double-screened hogged fuel for ease of handling and adequate control.

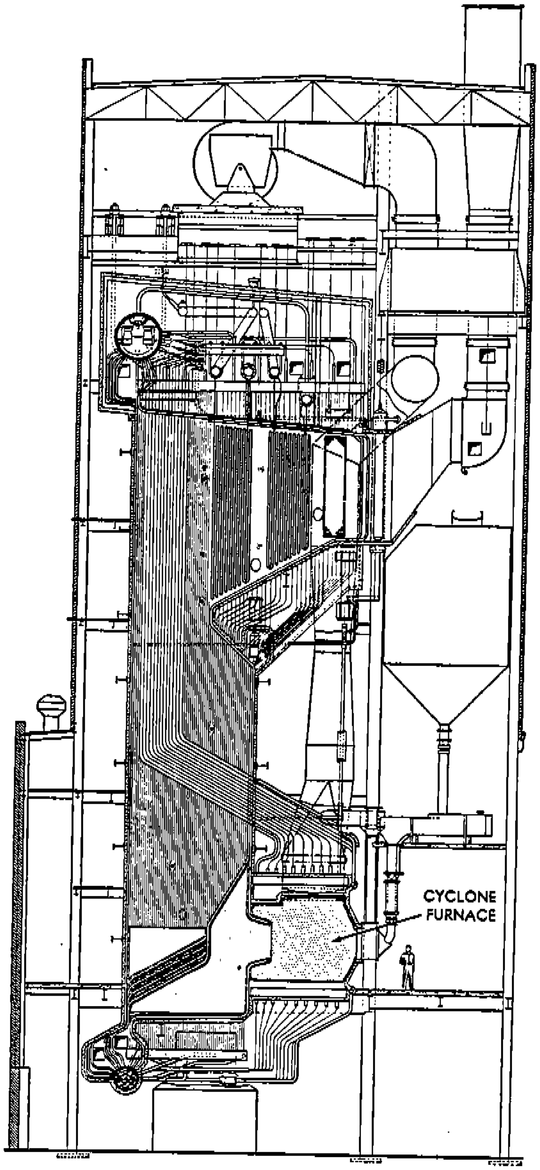


Fig. 14. A Radiant boiler with Cyclone Furnaces adapted to burn hogged fuel with coal

Coal Char

Coal char is a residue from the low-temperature (900-1000 F) carbonization of coal or lignite. The removal of gas and tar leaves a char which may be used as a fuel. Not until recently has there been any active interest in char as a boiler fuel.

Char varies in analysis, depending upon the source of the coal from which it is produced. In the carbonization process about half of the volatile matter is removed. This results in increased percentages of fixed carbon, ash, and sulfur, with a corresponding reduction in heating value of the char itself. The ash-softening temperature is quite close to that of the ash from the original coal, since the process does not change the nature of the ash. Grindability ranges from 41 to 150 (ASTM). A comparison of a typical char analysis with that of the original coal is shown in Table 1.

TABLE 1

Analyses of Coal and Coal Char

Fuel	Original Coal	Coal Char
Analyses (Dry Basis), % by wt		
Proximate		
Volatile matter	41.4	15.1
Fixed carbon	48.7	69.0
Ash	9.9	15.9
Sulfur	4.2	4.6
Heating value		
Btu/lb, dry	13,340	11,910
Btu/lb, moisture-and-ash free	14,810	14,160
Ash-fusion temperatures, F		
Reducing atmosphere		
Initial deformation	1960	1930
Softening	2100	2020
Fluid	2410	2500
Oxidizing atmosphere		
Initial deformation	2440	2360
Softening	2520	2490
Fluid	2670	2680

The char resulting from most of the present processes is of a sizing represented by the data of Table 2.

TABLE 2

Char Sizing (As-Received Basis)

Screen Size, No.	% Through
8	100
16	97.9
30	87.1
50	68.3
100	40.2
140	28.1
200	21.4

Apparently the volatile matter of *low* ignition temperature is driven off in the carbonization process, since char is more difficult to ignite than coal having the same percentage of volatile matter. Because of its sizing and high ignition temperature, most char is not well suited for burning on stokers. However,

Analyses of Wood and Wood Ash

Column No.*		1	2	3	4	5	6
Wood Analyses (Dry Basis), % by wt							
Proximate							
Volatile matter		72.9	76.0	74.7	74.3	69.6	72.6
Fixed carbon		24.2	18.7	23.3	24.0	26.6	27.0
Ash		2.9	5.3	2.0	1.7	3.8	0.4
Ultimate							
H_2	Hydrogen	5.6	5.4	5.7	5.8	5.7	5.1
C	Carbon	53.4	49.7	53.9	52.2	51.8	51.9
S	Sulfur	0.1	0.1	trace	trace	0.1	trace
N_2+O_2	Nitrogen + Oxygen	38.0	39.5	38.4	40.3	38.6	42.6
A	Ash	2.9	5.3	2.0	1.7	3.8	0.4
Heating value, Btu/lb		9030	8370	9120	8810	8740	8350
Ash Analyses, % by wt							
Silica	as SiO_2	—	—	—	1.7	32.0	14.3
Iron	as Fe_2O_3	—	—	—	3.2	6.4	3.5
Titanium	as TiO_2	—	—	—	0.0	0.8	0.3
Aluminum	as Al_2O_3	—	—	—	3.2	11.0	4.0
Manganese	as Mn_3O_4	—	—	—	3.9	1.5	0.1
Calcium	as CaO	—	—	—	60.8	25.3	6.0
Magnesium	as MgO	—	—	—	3.0	4.1	6.6
Alkalies	as Na_2O	—	—	—	10.4	10.4	25.0
Sulfate	as SO_3	—	—	—	3.0	2.1	7.4
Chloride	as Cl	—	—	—	0.4	trace	18.4
Carbonate	as CO_2	—	—	—	11.5	7.0	14.0
Undetermined		—	—	—	—	—	—
Ash-fusion temperatures		†	‡	—	—	—	—

*Col No.	Kind of Wood
1	Southern pine bark
2	Oak bark
3	Oregon wood, hogged
4	White-fir bark, salt-water stored
5	Spruce bark, salt-water stored
6	Redwood bark, salt-water stored

Ash-Fusion Temperatures, F

	Reducing		Oxidizing	
	†	‡	†	‡
Initial Deform.	2180	2690	2180	2680
Softening	2220	2720	2220	2730
Fluid	2340	2740	2470	2750

Analyses—Typical Bagasse, Coke Breeze, and Fluidized-Bed Char

Analyses (As Fired), % by wt		Bagasse	Coke Breeze	Fluidized-Bed Char
Proximate				
Moisture		52.0	7.3	0.7
Volatile matter		40.2	2.3	14.7
Fixed carbon		6.1	79.4	70.4
Ash		1.7	11.0	14.2
Ultimate				
H_2	Hydrogen	2.8	0.3	
C	Carbon	23.4	80.0	
S	Sulfur	trace	0.6	4.1
N_2+O_2	Nitrogen + Oxygen	20.1	0.8	
H_2O	Moisture	52.0	7.3	
A	Ash	1.7	11.0	
Heating value, Btu/lb		4000	11,670	12,100