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NOTES ON THE EQUIPMENT AND WORKING OF
AN INSTALLATION OF 20 BOILERS IN A SUGAR
REFINERY.

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COAL HANDLING AND STORING.

The coal is brought to the Refinery by colliers and can be unloaded therefrom at a rate of 50 tons per hour, and to provide for continuous work there are two weighing machines, each having a capacity of 24 cwts. They are filled alternately and are discharged into a receiving hopper, in the bottom of which is fitted a mechanical revolving device, with four pockets, and this is driven by a sprocket wheel and chain so that it feeds the coal evenly to the elevator. The latter is of the ordinary scraping type, it is 80ft. long and is inclined at an angle of 45deg. The coal is discharged from the elevator on to a horizontal conveyor of the same type as the elevator, and it is about 360ft. long, and divided into two sections. The advantage of such an arrangement is that one section only of the conveyor need be worked when coal is being discharged into the nearer end of the storage bin. Twenty discharge openings are provided in the bottom of the conveyor trough so that the coal may be dropped into the bin at any point required. Shoots convey the coal from the bottom of the bin to the feeding hoppers of the mechanical stokers. The coal bin has a storage capacity of 2,500 tons, and it is constructed of timber. The coal elevator and conveyors are driven by electric motors, the power required when they are handling 28 tons per hour being 15.5 horse power, the elevator requiring 5.5, the first section of the conveyor 5.5, and the second section of the conveyor 4.5 horse power.

MECHANICAL STOKERS.

The stokers in use are of the Underfeed type, and of two classes, viz., "B" and "E." The "B" class is fitted to the Cornish boilers and the "E" class to the Babcock

and Wilcox and the Stirling boilers. In the "B" class the coal is fed to the furnace by means of a revolving spiral screw, and the rate of feed is regulated by the adjustment of a shield over the circumference of a ratchet wheel, whilst in the "E" class, which feeds the coal to the fire by means of a pusher or ram, the rate of feed is controlled by the regulating valve "E" shown in Plate XXV., Figs. 1, 2, and 3. The important feature of the steam cylinder of this stoker is the means employed for controlling the movement of the main valve. By controlling this valve the duration of the period of rest can be varied at each end of the stroke of the piston. The arrangement of the main valve "B," and auxiliary valve "C" is like that commonly employed on direct-acting single cylinder steam pumps, and it is by the addition of the water cylinder "D" that the main valve "B" is controlled. The action is as follows:—Steam enters the cylinder at "F" and fills chamber "G." In the position shown, the main piston has just completed its return stroke, and by means of a tappet (not shown) attached to the crosshead, the auxiliary valve "C" has been moved to the end of its stroke. In this position the auxiliary valve "C" admits steam to the chamber "J," and thus forces the main valve "B" in the direction of the arrow. The valve would shift instantly were it not for the water cylinder "D." The water in this cylinder is obtained by the condensation of steam in the pipe "KK" and being connected to the steam supply, the water in "D" is always under steam pressure. The area of "J" being greater than the area of "D", steam in "J" forces the water in "D" into the pipe "K". But at the end of the feed stroke, when the auxiliary valve "C" opens the chamber "J" to the exhaust, the pipe "K" being under steam pressure the water re-enters "D" and forces the valve "B" back to its former position. It will be seen that during the time between the cutting off of the port "H" and the opening of the port "H" the main piston will remain at rest. Hence, the period of rest may be varied by regulating the rapidity of flow of water to and from the cylinder "D" by means of the regulating valve "E". The plunger of water cylinder "D" is kept tight by the composition cup "M."

The stoker is first a feeder and a thorough coker, then it distributes the fuel perfectly, and is self cleaning. The sliding bottom is actuated by the steam motor already described, the number of strokes of which may be varied from one in three minutes to fifteen in one minute, and as each stroke carries into the furnace 6lbs. of coal, it will be seen that the rate of feed can be varied between very considerable limits. The movement of the piston of Cylinder "C" is transmitted directly through the piston rod to the cross-head "D", which is bolted to the sliding bottom "E". This sliding bottom extends the full length of the trough. The block "B" has the same movement as "D" and "E"; thus the coal is fed by block "B" from the bottom of the hopper "A" on the sliding bottom "E", which not only carries it to the back end of the furnace, but forces it to rise the full length of the trough. As the coal rises in the trough, or coking retort, it is forced on to the bars "F", which are alternately moving and fixed ones. The moving bars work transversely to the trough, and the extent of the movement is about lin. On the bottom of each moving bar are cast two lugs, which engage with the bulb of the longitudinal rocking bars "H".

One of the most important features of this stoker is with regard to the distribution of the air, which enters the stoker through the aperture "N", covered by the windgate "Q". This windgate is adjustable by the crank "P" at the outer end of the furnace. The air upon entering the windbox "Q" passes upwards along each side of the trough, or retort, and is discharged, partly through the holes "R", into the retort. The surplus air passes through the bar "F", which, it will be observed, is made hollow. This bar, however, has no opening in its top surface, and no air can find its way into the fire above until it has passed through the aperture "S" at the bottom end of the bar, from which aperture it is discharged into the ash-pit "T". From the ash-pit "T" the air rises and passes through the small spaces between the bars into the coked fuel.

It will be seen that the action of the air, in passing through the bars, is to keep them cool, thus preventing

their burning out. The heat taken off the bars in this way raises the temperature of the air in the ashpit "T" up to about 400deg. F. When the clinker and ashes have accumulated on the dumping bars "K", a catch is knocked out, which allows the bars to fall down and the ashes to drop therefrom into the pit. This operation takes but a few seconds, and during this time it is not found necessary to close the windgate.

FANS AND ENGINES.

The necessary forced draught for the stokers is supplied by two fans, each of which has an impeller 8ft. in diameter, by 3ft. wide, and they are each driven by a 10in. by 12in. quick revolution engine of the enclosed type. Each fan is capable of discharging about 35,000 cubic feet of air per minute, and maintaining a water gauge pressure of 2in. at the discharge outlet when running at 240 revolutions per minute. The No. 2 fan supplies air at 1½in. pressure to the water tube boilers, and it is large enough to provide for an increase of the boiler plant. Provision has been made in the arrangement of the air ducts for each fan to temporarily supply air to the whole of the boilers should either of them break down. Both the engines and the fans were built in the Pymont workshop.

BOILER STATION.

The plant consists of 17 boilers of the eccentric flue Cornish type, one Babcock and Wilcox, and two of the Stirling type.

Here are the particulars of each of the Cornish boilers:—

Working pressure, 65lbs. per sq. inch.

Dia. of shell, 7ft. 3in.

Length of shell, 25ft. 6in.

Dia. of flue, 4ft.

Area of heating surface, 588 sq. feet.

Area of firegrate, 23 sq. feet.

and the water tube boilers are as follows:—

BABCOCK & WILCOX BOILER.

Working pressure, 165lbs. per sq. inch.

Heating surface, 3,610 sq. feet.

Firegrate, 68 sq. feet.

STIRLING BOILERS.

Working pressure, 165lbs. per sq. inch.

Heating surface, 2,380 sq. feet.

Firegrate, 39 sq. feet.

The total heating surface of the twenty boilers is 18,370 square feet.

ECONOMISERS.

These are arranged in two groups, the one through which the gases from the Cornish boilers pass consists of 800 pipes, as shown in Plate XXVI., Fig. 1. The second group is placed behind the water tube boilers and consists of 400 pipes, the total heating surface of both groups being 12,000 square feet.

The feed water supplied to the boilers is drawn from one of the city mains into an exhaust steam heater of tubular construction, containing 1,000 square feet of heating surface. In this heater the feed is raised from an average temperature of 60deg. Fahr. to 90deg. Fahr. From the heater, which is supplied with exhaust steam, the feed water is drawn by the pumps and forced through the group of economiser pipes behind the Cornish boilers, in passing through which it is raised from an average temp. of 90deg. Fahr. to about 280deg. Fahr., at which temperature it enters the Cornish boilers. The feed water for the water tube boilers is drawn from the first group of economiser pipes at a temperature of about 280deg. Fahr., and it is then pumped by a feed pump with a plunger of special design (and which is described later) through the second group of economiser pipes, where it is raised to an average temperature of 344deg. Fahr. It will be noted that the feed water enters the Cornish boilers at 312deg. — 280 deg. equals 32deg. Fahr. below the temperature corresponding with the steam pressure, and in the water tube boilers, the feed water enters at 370 deg. — 344deg. equals 26deg. Fahr. below the temperature of the steam. It occasionally occurs that the temperature of the feed water in the economiser tubes is slightly higher than in the boilers. This condition, of course, if not quickly attended to, would cause the formation of steam in the economiser tubes.

The leading fireman has control of the economiser, and by means of a thalpotasimeter placed near to No. 1 boiler, which is close to the feed pump station, he can readily ascertain the temperature of the feed water leaving the economisers, and if he observes that it approaches that in the boilers the feed pumps are immediately speeded up, or the check valves on the boilers slightly closed in order to increase the pressure in economiser pipes.

MAIN FEED PUMPS.

There are four of these, of the duplex type, each having 12in. diameter steam cylinders, $7\frac{1}{2}$ in. diameter water ends, and a stroke of 12in. Two of them are used for pumping the whole of the feed water through the first group of economisers, the third one then draws a portion of feed from the first group and pumps it through the second group into the water tube boilers. The fourth pump is a spare one.

Considerable trouble was experienced with the plungers of these pumps when handling water at such high temperatures, and several kinds of metal packing rings were tried, amongst which were brass, phosphor bronze, cast iron, patent metal, lignum vitae, and several kinds of high grade water packings. None of these were found satisfactory, and they seldom lasted more than 40 to 50 hours. After many trials and failures, Mr. Edgar Perdriau suggested a special type of vulcanised rubber packing ring, and this proved entirely satisfactory, the average working life of the rings being about six months. This type of packing ring has been used for pumps handling hot liquids, containing grit and sand; it has worked satisfactorily and with very little wear and tear.

It has been found advisable when pumping hot water, and other hot liquids, to keep the piston speed at about 30 or 40 feet per minute.

PRELIMINARY EXHAUST STEAM HEATER.

The duty of this heater is twofold. It utilises any surplus exhaust steam from the factory for heating the feed water, and it also raises the feed temperature to what may be called the critical point, for it is found that economisers fed with water below a temperature of 90deg. Fahr. are

liable to external sweating of the pipes, which produces active corrosion and causes the soot to cling to the surface of the pipes, and thereby reducing the efficiency.

DRAUGHT GAUGE.

The draught gauge used is one that was designed for ascertaining draughts with great accuracy, and it can be read to one-hundredth part of an inch. It is fitted with a spirit level on the top for setting it, and one end of the glass tube is raised one inch in twenty inches, so that to indicate one inch of draught, the water would have to move half way along the glass tube, which distance is equal to 10ins. It will readily be seen that for fine readings this type of gauge is most suitable.

BRICKWORK.

The leakage of air through the brickwork of a boiler station is often considerable, and is often due to the movement of the boilers when expanding and contracting. This is a condition that requires the constant attention of the engineer. Much trouble has been experienced in the station under review, owing to the seventeen (17) Cornish boilers being set in one continuous range. One of the above boilers has been fitted with adjustable covers and boiler blocks. These are so arranged that any movement of the boiler is taken up by a packing, between the boiler and brickwork, which consists of slag wool, and the result has been most satisfactory. When an inspection of the outside of the boiler shell is required, the whole of the covering blocks can be removed and replaced in a few hours.

FIRE BRICK LINING FOR FURNACE WORK.

The wear and tear of the furnace lining of boilers is a matter requiring much consideration, and it is very necessary to obtain a class of brick specially suited for the conditions to which it is to be subjected.

As the result of some experiments made to ascertain the right kind of brick for the boiler furnaces of the installation herein referred to, the most satisfactory results were obtained from a locally manufactured brick, and the repairs

that were necessary after twelve months' work cost but a few shillings.

A trial was made with a fire brick composed of 98 per cent. of silicate, and it was found to stand the high temperature well, but after being allowed to cool down several times it failed by cracking and crumbled away.

In mixing fire-clay for furnace work, the writer finds that two buckets of flue dust to one bucket of fire-clay, and to which is added a quart of Portland cement (salt water being used for mixing), makes a satisfactory mixture.

CLASS OF COAL.

The coal used is a mixture of Southern slack, the evaporative value of which may be gathered from the following analysis:—

| | |
|------------------------|-----------------|
| Water | 1.36 per cent |
| Vol. Hyd. Carbons | 23.3 per cent. |
| Fixed. Hyd. Carbons .. | 58.84 per cent. |
| Ash | 16.50 per cent. |
| Sulphur | .34 per cent. |

Evaporative value, 12.4lbs. water per lb. of coal.

The author has carried out a number of evaporative tests with the Cornish boilers, and with both types of water-tube boilers the results showing that an average evaporation of 10lbs. of water per lb. of coal, from and at 212deg. Fahr., has been obtained. Working with slack as fuel, it must be admitted that this is a high figure, but it can be accounted for by the special constitution of, and conditions under which the plant works, as follows:—

Economisers of ample surface, enabling the feed water to be introduced into the boilers almost at boiler temperature, with a consequent reduction of the temperature of flue gases to nearly the minimum feasible.

Continuous feeding of the fuel and the provision of forced draught, thus admitting of only a slight excess of air necessary for combustion.

Clean boilers surfaces due to the use of Sydney water.

Co₂ recorders and temperature indicators.

The author regrets being unable to give full particulars of the results of the evaporative trials referred to, but

these were made for the purpose of factory records only, and they were not verified or checked by any uninterested engineer. During these tests the feed was measured by a Glenfield Kennedy hot water meter, which was carefully checked before and after the tests, there being an error of 1 per cent., which was allowed for. The temperature of the gasses leaving the boiler, and the percentage of CO₂ was recorded by a Uehling Gas Composimeter. The action of the gas composimeter is based on the law governing the flow of gas through two small apertures. This law may be illustrated by a simple diagram (Plate XXVI., Fig. 2) representing two chambers C and C, which are in communication with each other through the aperture B, and with the source of gas through the aperture A. G is connected with an aspirator D as shown. The monometers P and Q indicate the gas tension within the respective chambers. The aspirator set in action, a vacuum is created in chamber C, the gas will flow from the chamber C through aperture B to chamber C, creating a vacuum in C which will cause gas to enter through aperture A., thus establishing a continuous flow of gas through both apertures. If a constant vacuum of, say, 48in. of water be maintained in chamber C and the two apertures A and B are of the same size, and are maintained at the same temperature, monometer P will show about one half the vacuum maintained in C due to the fact that the apertures oppose equal resistance to the passage of the gas. This relation will be maintained as long as the same volume of gas flows through B that enters at A. If, however, a constituent of gas be continuously taken away or absorbed from the gas in passing through chamber C, the vacuum therein will be correspondingly increased. This increase of vacuum in C, shown by the monometer P therefore correctly indicates the volume of gas absorbed, and in the gas composimeter is utilised to indicate the percentage of the constituent of the gas to be determined.

GENERAL REMARKS.

The boiler installation, when worked at its normal rate, consumes 540 tons of coal per week.

The economisers are blown down and washed out at each week end. The bottom boxes act as collectors and

prevent the sediment reaching the boilers. As an evidence of this action, the boilers can be run for a period of 6 to 8 weeks without opening the blow off cock, and when they are opened out for cleaning, the amount of red mud collected from the internal surface would not fill a quart pot. The inside surfaces of the boilers are practically free from any sign of corrosion, but where there is any indication of rusting or wasting, the surfaces are cleaned with a wire brush, and then receive a coating of white zinc mixed with turpentine.