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# STEAM CONDENSERS AND THEIR APPLICATION IN SUGAR FACTORIES.

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In modern sugar factories steam condensers are practically essential. In modern power plants their adoption, although almost general, is dependent upon the profitable use of condensing water and the economical use of the steam; and in some cases, but seldom in large plants, condensers can be dispensed with. Not so, however, in a sugar factory, wherein there exists, in addition to the undoubted economy of steam, the most important physical condition that at high temperatures sugar decomposes or forms "Non-crystallizable Sugar." As it is beyond question that the temperature at which this action takes place in sugar solutions falls much below the boiling temperature at atmospheric pressure, it is practically essential that they should be evaporated "in vacuo." "Cool" boiling is the practice in almost every present day sugar factory, although the extent to which it is carried varies. There is no denying the fact, however, that between 28″ of vacuum and 15 lbs. gauge steam pressure, which is about the maximum it is customary to discharge the steam from the power units into the exhaust mains, there is a difference of 150° Fahr., and if the former figure, that is the high degree of vacuum, can be maintained on sugar factory evaporators, the best practicable condition will prevail.

From the foregoing remarks it will be gleaned that in sugar factories the application of condensers is in connection with the evaporating plant and not the power units. In a well-balanced factory the exhaust steam from the power plant is just about sufficient for the evaporation of the sugar juice to a density suitable for passing it on to the machinery for purging the sugar of the syrup, and connected with the evaporating apparatus condensers are required for dealing with the steam given off in the process. In Figure 1 is

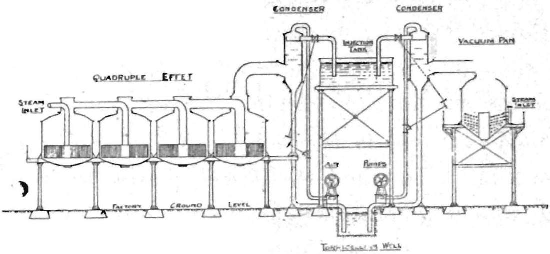


Fig. 1.

shown a diagrammatic sketch which illustrates a typical arrangement of jet condensers in conjunction with the effêt and vacuum pan evaporating vessels which are common to practically all modern factories, and it may here be said that, although the title of these notes probably suggests that condensers for sugar factories differ from those for ordinary steam condensing plants, this is not the case to any significant degree. The figure will, however, serve to familiarize Members with the purpose of condensers in sugar houses, and it may also elucidate any terms that are used, or any special features of the plant illustrated hereafter that might not, without this preliminary illustration, be quite clear.

The type of condenser most generally adopted in sugar factories is the "Jet," and the reasons therefor are principally :—

(1) Because the condensed water from the evaporators is unsuitable for boiler feed on account of the contamination of the steam by contact with the sugar solutions, which give off certain noxious gases, and thus renders it unnecessary to save the water.

(2) Cheapness in cost.

(3) High efficiency, especially the counter current type.

(4) Minimum of labour required for operation and maintenance.

(5) Lightness; thus facilitating the adoption of the barometric principle.

In the face of these reasons there does not seem to be much room for the adoption of surface condensers in sugar factories, even although they possess the advantage of requiring a minimum size of air pump. They have, however, been used to a limited extent in the past and are still occasionally applied, especially for central condensing systems. Fifteen years ago the Colonial Sugar Refining Co. installed a large surface condensing central system at one of their Queensland Mills. The condenser was of the ordinary circular form, 7′ 0″ in diameter, and containing 5000 sq. feet of cooling surface. To it were connected, by means of 42″ diameter valves, the steam pipes from two large pans and an effêt apparatus. It has since been replaced by independent jet condensers for each evaporator, the consensus of opinion up to the present time being in favour of such an arrangement, for in the process of sugar boiling the vacuum pans are alternately charged and discharged, consequently when "cutting in" a fresh pan to the condensing system, it must be obvious that the vacuum on the whole system will temporarily recede, which is undesirable from the sugar boiling point of view. Then again the difficulty of keeping the very large isolating valves tight is by no means a negligible item. Notwithstanding the disadvantages described, there is much in favour of a central system from the engineers' aspect, and it is frequently adopted. A very interesting example of a central system consisting of a large combined jet condenser and air circulating pumps is shown in the next Figure 2. The air pump works on the Edwards valveless suction principle, and surrounding the barrel is the large jet condensing chamber working counter current. The air pump is driven by an extension of a vertical engine piston rod. On an extension of the crank shaft, centrifugal pumps are fixed which respectively elevate the injection water and

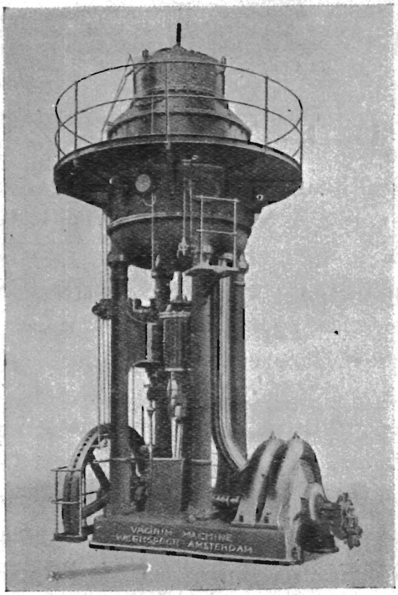


Fig. 2.

draw off the condensed water. The arrangement is by the "Werkspoor" Co. of Amsterdam, and as a means of economising floor space, elevating the condenser so as to possibly make use of the barometric column, and for grouping the whole of the condensing plant, there is a good deal to commend it. A sectional view of this plant is shown in Fig. 3. The writer cannot vouch for this being strictly correct, but from memory of a sectional drawing and from the outside view, he thinks it is nearly so.

Apart from jet and surface condensers, no other type has been adopted to anything like the same extent in sugar houses, although of recent years the "Ejector" condenser has been so perfected that it is being largely adopted for

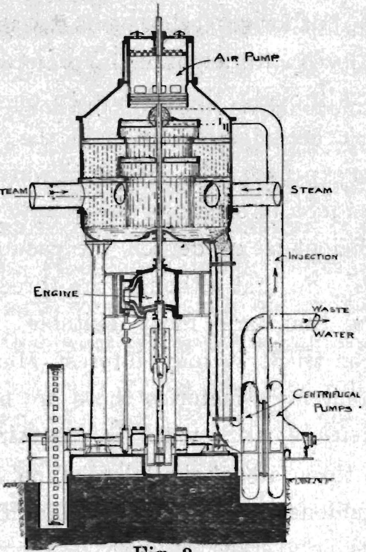


Fig. 3.

power plants. Some years ago the Colonial Sugar Refining Co tried an ejector condenser of the type depicted on the

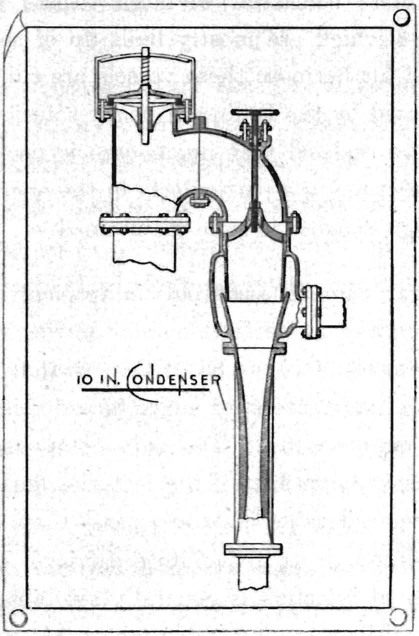


Fig. 4.

next Figure, 4, but for several reasons it was not sufficiently successful to justify its adoption in preference to the true "Jet" type. Although the advantage of dispensing with an air pump is considerable, it is in the writer's opinion obtained at tne expense of the amount of water required, and, unless this be much in excess of the quantity that would be used for an efficient jet condenser, the vacuum obtained will not be as high. So that although the three principal types of condensers that are most suitable for sugar factories have been tried, it may interest Members to know that in the Company's factories there are no less than 110 separate condensers, each with its own air pump, and of which all but three are of the "Jet" type. The largest of these has a condensing capacity of 30,000 lbs. of steam per hour, whilst their average capacity is about 20,000 lbs. of steam per hour. All of them are operating in connection with evaporators consisting of large vessels up to 15′ in diameter, and which are mostly built up of cast iron plate sections; and furthermore these vessels are subject to much vibration caused by the boiling of heavy solutions within, so that it will be realized that much care is necessary in the designing, erecting, and particularly in the operating of such plants if a high vacuum is to be maintained.

The sugar cane is essentially a tropical plant, and it reaches its maximum perfection in countries which have a mean temperature of 75° to 85° Fahr., so that at the outset the designer of condensers for sugar factories has to contend with hot injection water. The only compensating feature is that because the product of the factories has usually to be transported considerable distances, and they are therefore preferably placed so as to facilitate carriage by water, an ample supply of injection is generally available. Nevertheless, the conditions are not favourable for obtaining high vacua and the question of when the economical limit for sugar factory purposes is reached has been nearly as keenly contested as has been that of the profitable limit for marine installations. As has already been mentioned, there is no doubt as to the undesirability of high temperatures in sugar boiling, but it seems to be a difficult matter to determine the extent of the loss at different temperatures. There is no doubt, however, as to what it costs to obtain high vacua. The engineer knows that to obtain a 25″ vacuum with injection water at 80° Fahr., only 20 lbs. of water will be required, theoretically, per lb. of steam, whereas, if a 28″ vacuum is required with the same temperature of injection water, the ratio of water and steam will rise to 50 to 1, or an increase of no less than 150%. If the exact, or even the approximate amount of sugar destroyed at certain temperatures, was determinable, a comparative balance-sheet would soon set the matter at rest. However, with the knowledge that with every increase of temperature the loss of sugar is also increased, many factory owners set a high standard vacuum for the condensers of their evaporating plant. The Colonial Sugar Refining Co. does so for its numerous installations, and throughout the service, sometimes under the most trying conditions, the standard is almost invariably maintained. It must be remembered too that a sugar factory engineer has under his care a surprisingly diverse collection of plant; the order of a power house is necessarily absent, and the condensers ofttimes cannot receive the attention that high vacuum apparatus needs. To ensure the maintenance of the high standard set, systematic tests are made at stated periods, and it may interest members to see a copy of an actual test return from a factory, in this instance, Pyrmont Refinery. See Figure 5. It will be seen that the average

**VACUUM PAN TESTS.**

Pyrmont Refinery. Week ending Jan^y 6^th 1912

| Pan Number or Letter. | Vacuum obtained and held during 10 minutes test. | Loss of Vacuum in 10 minutes with pump stopped and water shut off. | Barometric Pressure. | Temperature on Pan Floor. | REMARKS. |
|---|---|---|---|---|---|
| 1 | 28" | 1" | 29·83 | 92° | |
| 2 | $28\frac{1}{2}$" | $1\frac{5}{8}$" | 29·83 | 89° | |
| 3 | $27\frac{1}{2}$" | 4" | 29·87 | 104° | |
| 4 | 28" | $1\frac{1}{2}$" | 30·08 | 80° | |
| 5 | 28" | $1\frac{3}{4}$" | 29·83 | 91° | |
| 6 | 28" | 2" | 30·08 | 90° | |
| 7 | $27\frac{3}{4}$" | $1\frac{1}{2}$" | 29·87 | 90° | |
| 8 | $29\frac{1}{4}$" | $\frac{1}{2}$" | 29·83 | 89° | |
| 2 eff | $27\frac{1}{2}$" | $1\frac{1}{2}$" | 29·91 | 104 | |

No 3 found leaky joint

NOTE.—The records of the weekly tests are to indicate the efficiency of the vacuum pans and pumps.

The second column will show primarily the result of the pump test, to be made, preferably, on a Saturday morning when the work of a pan is finished for the week. The pan should be steamed out, closed, and the pump started at normal revolutions, the injection water valve being opened to the extent obtaining when boiling down a charge.

In the third column, the degree of tightness of the pan and condenser will be revealed—including the tightness of the pump in cases where there is no valve in the air pipe separating the pan from the pump.

Fig. 5.

vacuum obtained under as near as practicable working conditions is 28 inches, while to indicate the tightness of the evaporators, condensers, pumps and connections, it will be noticed that the average drop in vacuum is 1.7 inches in ten minutes. A drop of $3\frac{1}{2}''$ in ten minutes is considered too much. Thus it will be seen that the large vessels must be kept very air tight, as the opportunities for leakage into the systems is vastly greater than in ordinary steam power plants.

Under the conditions described, it will not be difficult to understand that the general trend is towards the adoption of counter current barometric condensers, and this type is now installed by the C.S.R. Co. wherever possible. It is not, however, a general practice; many prominent makers still manufacture numbers of parallel current condensers working under the wet principle Such a condenser is illustrated in Figure 6, which shows the general arrangement of a vacuum pan

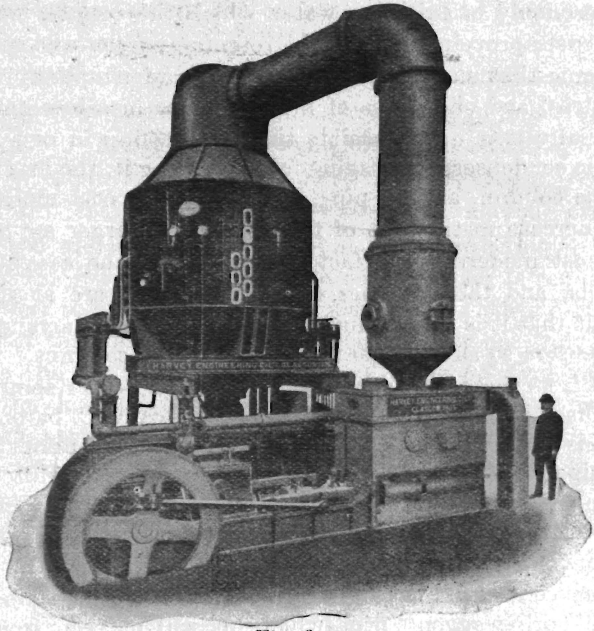


Fig. 6.

with its wet condenser and air pump, while the next Figure 7 shows a sectional view through a similar condenser of the same type. It is in effect the simple jet condenser that has hardly altered in any of its main features since Watt introduced it in his double acting engine. It was probably his most important invention, viz.: "The use of a separate condensing chamber into which a jet of condensing water played." The only construction that can be put upon the continued use of this type of condenser is, that as previously suggested, there are many sugar manufacturers who are content with a comparatively low vacuum, and under such circumstances there is not the same call for

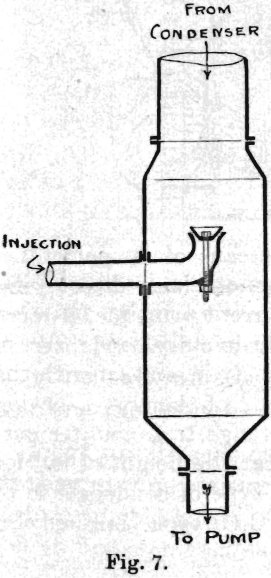


Fig. 7.

the economy of injection water which the counter current condenser provides. As to the retention of the wet system, it seems that such is entirely a matter of simplicity, compactness, and cheapness of first cost; for in a low building especially it is quite feasible that the roofing in of a barometric condenser, the staging for supporting it, the long barometric column, and air pipe, might together cost more than the increase in the cost of the necessarily larger air pump. In most modern sugar factories, however, the evaporating vessels, and the buildings containing them, are at such a height that it is really much more convenient to arrange the condensers so as to make use of barometric columns. Quite apart from these considerations, the C.S.R. Co. for some time past has almost entirely adopted the vertical C.C. barometric type as the most efficient in all respects, the exceptions being principally in the case of Refineries, wherein the limited distance between the floors of the buildings has rendered it almost compulsory to adopt a type of condenser requiring less height. In these instances one of the oldest forms of sugar factory condensers has been adopted, viz., what is called the "safe" or "waggon" type which, as will be seen from the next Figure, 8, is essentially a rectangular body, in which

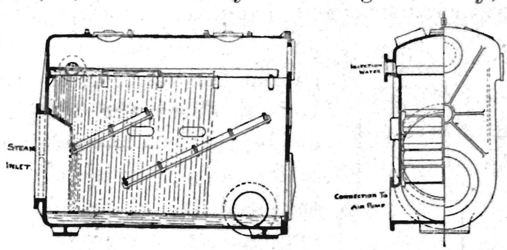


Fig. 8.

the injection water is dispersed by means of a perforated spray plate. Although this type cannot claim direct relationship to either the con or contra current principle, it more nearly approaches the latter, for the air in a dry condenser, in passing up to the outlet is brought closely in contact with the cold injection spray at the adjacent end of the tray. Owing to the fact that it is impossible to arrange true counter currents of water and steam, and also that the height of fall for the condensing water is limited, this type of condenser is to some extent inferior to the vertical C.C. type, but only in so far as the economy of water is concerned.

The baffles shown are of woven wire and their use as water breaks will be referred to later. They are arranged in the slanting manner shown with the object of trying to create upward currents of steam, practically simulating the C.C. action. Another feature which is worth attention is the series of weirs across the dispersion plate, these render it certain that the injection water will spread evenly across the width of the plate, and at times in the sugar boiling process, when only very little condensation is required, it is better to have a full width of shower for a portion of the length of the condenser than a longer shower not fully traversing the width. The "safe" or "waggon" type of jet condenser has not been extensively adopted outside sugar factories, partly no doubt for the reason of its unsuitability for C.C. action, but to show that this principle may be adopted to some extent therein, here is an instance, in Figure 9, of a

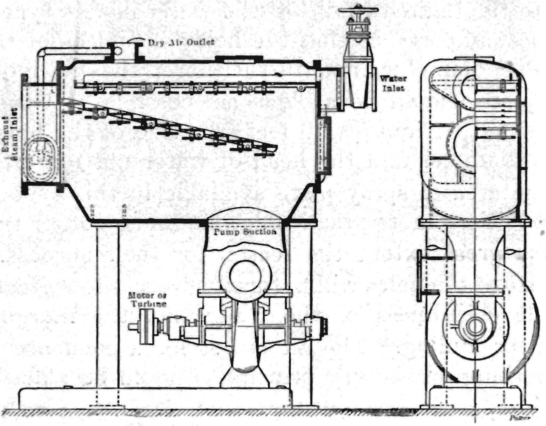


Fig. 9.

condenser, made by the Wheeler Condenser Co. of America, for which is claimed excellent results, even in water economy. The principal feature of this condenser lies in the method of dispersing the water by means of steps.

Good results have been obtained with "safe" condensers and they may be satisfactorily adopted, especially where the height available is too limited for the vertical types, and in such an instance as illustrated in the next Figure 10. The