STEAM HEATING OF AIR FOR TEA DRYING MACHINES*

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Since the writer published an article in *The Tea Quarterly* under the heading "The Use of Steam in Tea Factories," Volume VIII Part III, November, 1935, pages 147 to 151, he has been responsible for the installation of the "all-steam" system of operation in seven tea factories in North-East India where there are now a total of 27 dryers working on the steam-heating system, and the results obtained are of sufficient interest and importance to the Ceylon Tea Industry to warrant a further article.

Many readers of this article will have seen the small steam-heated dryer used for experimental work in St. Coombs Factory, and will have appreciated the cleanliness and ease of control. That installation works on live steam, whereas the large scale commercial plants work mainly on low pressure steam at from 5 lbs. to 7 lbs. (gauge) pressure exhausted from a steam engine, which provides the power for driving the factory.

The steam is used in suitable radiators to heat the air for the dryers, and does not come into direct contact with the leaf.

Low pressure steam alone is sufficient for drying temperatures of up to 200°F. but above this temperature it is necessary to arrange to work the last section of the radiators on steam at boiler pressure, usually 120 lbs. gauge.

This system can be used with advantage anywhere in the world even if the water available for the boiler is scarce and of poor quality, as once the boiler has been filled the same water is continually recirculated and the boiler therefore works under almost ideal conditions with distilled water, as the quantity of fresh water required is only that needed to compensate for any loss by leakage which should be a very small amount.

* The Institute does not necessarily endorse the views expressed in papers contributed by others than members of the staff.

The first factory in which steam-heating of air for the tea dryers was tried out, using mainly exhaust steam from the steam power plant, was partially converted to this system in 1937 and very quickly showed that the scheme was simple to operate, thoroughly reliable and highly economical. The simplicity of operation is specially emphasised because it not infrequently happens that increased fuel economy can only be obtained by increased complication and, in such cases, some of the saving in fuel is offset by a need for more expensive supervision, whereas, with the steam-heated dryers, the system is extremely simple and the drying temperature is maintained constant within very close limits.

The existing drying equipment in this first factory to be converted consisted of a 6 ft. "Empire," two "Paragon," and three "Down Draft" dryers, and it was decided, in the first instance, to try out the scheme by converting the 6 ft. "Empire," and one of the "Paragon" dryers, to the steam heating. About two-thirds of the crop could be handled by these two dryers alone, using the "Empire" for first firing and the "Paragon" for second firing. The total coal used for power and drying for the previous season, 1936, had been 2.06 lbs. of coal per lb. of tea and, by using steam heating for two-thirds of the crop, the total coal for power and drying was reduced to 1.4 lbs. of coal per lb. of tea on a crop of 954,400 lbs.

For the 1938 season, it was decided to convert the second "Paragon," this enabled about seven-eighths of the crop to be handled by the Steam-Heated dryers leaving the three "Down Draft" dryers unconverted, for use on very heavy "rush" days. This factory has now been worked in this manner for two seasons, 1938 and 1939, and the total fuel consumption was reduced to 1.07 lbs. of coal per lb. of tea for power and drying on a crop of 1,028,800 lbs. in 1938 and 1,009,440 lbs. in 1939.

Very careful watch was kept on the quality of the tea, and it was the unanimous opinion of all concerned that the effect of steam heating had been towards improving the quality, as was only to be expected, by reason of the constant drying temperature. It is also very satisfactory to be able to record that the original equipment has now worked for three seasons with no expenditure whatever on maintenance of the steam-heating plant.

The Steam Heating system having proved so very simple, reliable, and economical in operation, it was decided by the same Managing Agents to convert fully three other factories to this system, and another managing agency converted one factory of a group in Upper Assam to the "All Steam" system of operation for the

available, and by the courtesy of the Managing Agents concerned, are presented herewith.

Table showing amount of coal used with the "All Steam" system for power and drying, as compared with drying only.

District	Drying only. Average 1936/7/8.			Power and Drying "All Steam" System 1939.	
	Number of Gardens	Total crop lbs.	Lbs. of coal per lb. of tea Drying only	Crop lbs.	Lbs. of coal per lb. of tea Power and Drying
Assam	24	8,484,800	1.2	Garden A 1,003,840	1.27
Dooars	11	6,452,400	1.29	Garden B 1,053,520	1.65
Sylhet	15	7,632,240	1.05	Garden C 1,009,440	1.07
Cachar	5	1,196,160	1.6	Garden D 538,000	1.39

Table showing saving actually realised by the "All Steam" system of operation.

District	Crop made lbs.	Saving in lbs. of coal per lb. of tea.	Remarks
Assam	Garden A 1,003,840	(.5) See footnote *	Previously used :—Old engine for power and coal for drying.
Dooars	Garden B 1,053,520	.61	Previously used :—Separate coal fired steam plant for power and coal for drying.
Sylhet	Garden C 1,009,440	.94	do do Has now worked for 3 seasons.
Cachar	Garden D 538,000	(1.14) See footnote.*	Previously used :- Oil engine for power and oil fuel for drying.

* For the purpose of providing a satisfactory basis of comparison a figure is shown in brackets representing in terms of coal the total saving in fuel actually realised on the Estates concerned, *e.g.*, a total saving of 0.94 cent per lb. of tea, with coal costing 0.78 cent per lb. delivered on the Estate, would be represented by 1.2 lbs. of coal per lb. of tea.

The savings indicated in the preceding tables are exclusive of any allowance for elimination of stove, and chimney renewals.

In the first table figures are given for fuel consumption for drying only for 1936, 1937 and 1938, representing the average of a stated number of estates in each district and it will be seen that, with the "All Steam" system, the fuel required for power and drying is only very slightly in excess of the amount required for drying only in the normal manner.

On some estates, particularly in the Dooars, a certain amount of wood has been used in the dryers and, in such cases, any wood used has been converted to a "coal equivalent" by taking 3 lbs. of wood as equivalent to 1 lb. of coal. This is, if anything, rather unfair to the wood, so that the average coal consumption figures given for drying only, especially in the Dooars, should, if anything, be increased somewhat, but this does not apply to the figures stated for the estates using steam heating as, on these estates, coal only has been used.

The main item in the cost of fuel on a tea garden is the transport which frequently costs more than the coal at pit-head, or oil fuel at the refinery, and transport costs vary greatly with the situation of the garden, not only in regard to length of the route, but also in regard to local communication with the nearest railway station.

It has therefore been thought better not to show the actual cash saving realised by the "All Steam" system in the different districts, but to show the amount of coal that is represented by the cash saving on the estate concerned, and this has the further advantage that an estate which formerly used oil engines for power and/or oil fuel for drying can be brought on to the same basis of comparison.

It will be seen from the tables that, in all cases, a very substantial saving has been effected in fuel costs by converting to the "All-Steam" system.

Assam.—Garden "A," where an oil engine for power and coal for drying were previously used was converted to the "All-Steam" system for the 1939 season and returns a total figure for power and drying of 1.27 lbs. of coal per lb. of tea, as against a district average for the three preceding years, on 24 other estates, of 1.2 lbs. for drying only. The saving on this estate, compared with 1938, is equivalent to the cost of .5 lb. of coal per lb. of tea, on a crop of 1,003,840 lbs. of tea excluding any allowance for the elimination of stove and chimney renewals, and lower maintenance costs of steam plant, as compared with an oil engine.

Dooars.—Garden "B," where a separate coal fired steam plant for power and coal for drying was used formerly, was converted to the "All Steam" system in 1939 and returns a total figure for power and drying of 1.65 lbs. of coal per lb. of tea. The season started with unusually small crops for the first three months and, up to the end of July, only 356,000 lbs. of tea had been made, with an expenditure of 2.07 lbs. of coal per lb. of tea. From August to November inclusive, 659,200 lbs. of tea were made with a total fuel expenditure of 1.4 lbs. of coal per lb. of tea. It is, therefore, reasonable to suppose that, in a more normal season, the fuel consumption would not exceed 1.5 lbs. per lb. of tea and would probably be better than this when more experience had been gained in working the plant. This same factory, in 1936, used a total of 2.64 lbs. of coal per lb. of tea for power and drying and it will be observed that the average of eleven other gardens for drying only for the previous three years — 1936, 1937, and 1938 — is 1.29 lbs. of coal per lb. of tea (and, as mentioned above, on account of the larger amount of wood used in the Dooars, this figure should probably be increased). The saving achieved, compared with with 1938, on a crop of 1,053,520 lbs. is equivalent to .61 lb. of coal per lb. of tea, excluding any allowance for elimination of stove and chimney renewals.

[Up to the end of August, 1940, the date of the latest available figures, garden "B" made 682,000 lbs. of tea with a coal consumption of 1.61 lbs. per lb. of tea, whereas, to the end of August, 1939, 580,000 lbs. had been made with 1.78 lbs. of coal per lb. of tea.

Moreover, another estate in the Dooars converted for the 1940 season returns a total coal figure up to the end of August, 1940, of 1.28 lbs. of coal per lb. of tea.]

Sylhet.—Garden "C" is the one referred to in the opening paragraphs where a steam heating plant was first installed in 1937, and the staff have had three years' experience in working the plant, which replaced a separate steam plant for power and coal for drying. It is interesting to record that, for both the 1938 and 1939 seasons, the same total coal consumption figure, *i.e.*, 1.07 lbs. of coal per lb. of tea for power and drying, is returned, whereas the average of fifteen other gardens for the previous three years is 1.05 lbs. of coal per lb. of tea for drying only, so that this factory has achieved the remarkable result of obtaining power and drying for only 2 per cent more fuel than the other factories have used for drying only and, compared with 1936, when the total coal consumption for power and drying was 2.06 lbs. of coal per lb. of tea, there has been a saving of 48 per cent. The saving achieved in comparison with 1936, on a crop of 1,009,440 lbs. is equivalent to .94 lb. of coal per lb. of tea, excluding any allowance for elimination of stove and chimney renewals.

[This factory up to the end of August, 1940 has made 592,320 lbs. of tea with a coal consumption of .91 lb. per lb. of tea.]

Cachar.—Garden "D" was converted to the "All-Steam" system in 1939. This estate previously used an oil engine for power and oil fuel for drying, and it is surprising to find that, using the new system with coal only, the total figure for power and drying is 1.39 lbs. of coal per lb. of tea, which is less than the average of five other estates for drying only. The saving realised on this estate compared with 1938, on a crop of 538,000 lbs. is equal to the cost of 1.14 lbs. of coal per lb. of tea, exclusive of any allowance for elimination of stove and chimney renewals.

It therefore appears reasonable to expect, that, by installing the "All-Steam" system, the total fuel for power and drying will not be more than 20 per cent above the amount normally used for drying only, whether it be wood, coal, or oil, and is likely to be less than this, so that in a factory using modern dryers which can show a figure for drying only as low as .5 lb. of coal per lb. of tea on the season's working, it should be possible to get down to about .6 lb. of coal per lb. of tea for power and drying with the "All Steam" system.

In addition to the saving in fuel, there are the great advantages of drying at a constant temperature, of having steam available for sterilising rollers and sifters, etc., and of the elimination of stove and chimney renewals. In large factories, there is likely to be a reduction in the number of stokers required.

Where stoves are in existence, they may be retained and the steam heater arranged above, or adjacent to, the stoves, with suitable air ducts and valves, so that either the stove or steam heater can be used as required; but, seventeen of the twenty Steam Heated dryers working during 1939 had the stoves removed, and a further seven dryers converted for the 1940 season are also without stoves.

It should be emphasized that the great economy achieved by the "All-Steam" system is due to making full use of the heat in the exhaust steam and it is perhaps not generally realised that a steam engine utilizes not more than 10 per cent of the total heat in the steam, the remaining 90 per cent being wasted in the exhaust, all of which in the new system is utilized for heating the air for the dryers.

There is a further considerable saving due to the elimination of the fuel used for lighting up the dryers, as the amount of fuel required for keeping the boiler plant banked at night is very con-

siderably less than normally used for lighting up the dryers. The saving from this source is so considerable that it is worth while considering the desirability, where oil engines are comparatively new and in good condition, of installing the necessary boiler plant and steam heaters, to be worked on live steam until the oil engines need replacing, when steam plant would be installed to enable the maximum economy to be achieved. It is interesting to record that several large factories in Kenya use live steam heating for the dryers, and have found that it is more economical than direct firing in the normal manner.

There is nothing about the situation or arrangement of any of of the factories from which these figures have been obtained, which makes them in any way peculiarly suited to the use of steam heating for drying. The economies indicated may be confidently expected from the application of this system to any factory, by using in the boiler plant the same fuel, whether wood, coal, or oil, that would normally be used in the dryers. There are, moreover, several advantages, the value of which cannot be directly measured in cash, these are: cleanliness, owing to dirt and dust from fuel being confined to the boiler room, convenience, especially the convenience of being able to start up any dryer without having to light up a stove and wait for the dryer to be warmed up — and, above all, absolute control of temperature, adjustable, but, when set, automatic in its action.

There is no reason why the results obtained in North-East India should not apply in Ceylon, so that by installing the "All Steam" system the total fuel consumption for power and drying in a Ceylon factory should not exceed that used for drying only by more than 20 per cent, and is likely to be less than this. The additional fuel used for providing warm air for withering should remain approximately the same.