

Energy cost reduction study in a tea industry

This paper presents a case study on detailed Energy Cost Reduction Study at the various tea gardens of the Williamson & Magor Group, in Assam

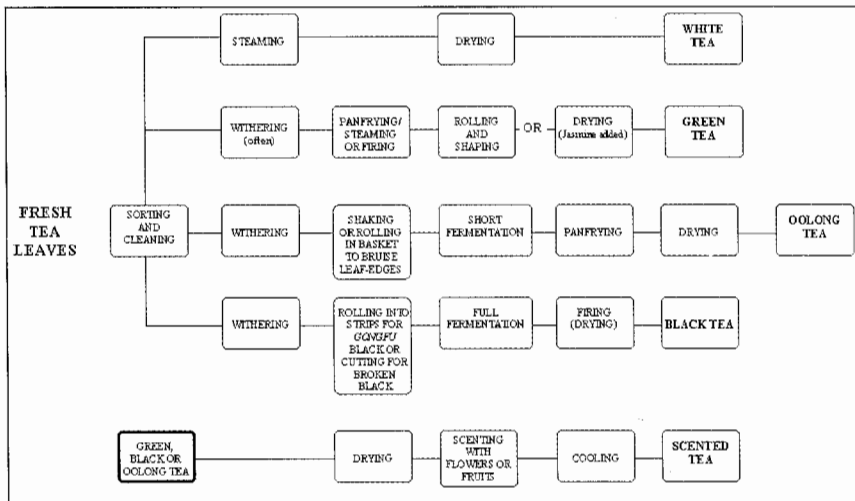
Tea Leaves Processing

Processing of black tea, which is normally preferred in India, is an art in itself. In tea industry they say that the best quality tea leaf should “curl like the dewlap of a bull, crease like the leather boots of a Tartar horseman, unfold like mist rising over a ravine, and soften as gently as fine earth swept by rain.” Tea is processed and grown in a variety of ways, depending on the type of tea desired.

As a result of these methods, maximum amounts of polyphenols and antioxidants are retained. The growing conditions can be broken down into two basic types - those grown in the sun and those grown under the shade.

The tea plants are grown in rows that are pruned to produce shoots in a regular manner, and are generally harvested three times per year. The first flush takes place in late April to early May. The second harvest usually takes place from June through July, and the third picking takes place in late July to early August. Sometimes, there will also be a fourth harvest. It is the first flush in the spring, which brings the best quality leaves, with higher prices to match

Processed tea is stored under low humidity refrigeration in 30 or 60 kg paper bags at 0-5 °C (32-41 °F). These are yet to be refined at this stage, with a final firing/drying taking place before



The flowchart of the tea making process is highlighted here

blending, selection, and packaging takes place. The leaves in this state will be re-fired throughout the year as they are needed; giving the green tea leaves a longer shelf life and better flavor. The first flush tea of May will readily be stored in this fashion until the next year's harvest. After this re-drying process, each crude tea will be sifted and graded according to size. Finally, each lot will be blended according to the blend order by the tasters and packed for sale.

Steps in tea leaf processing

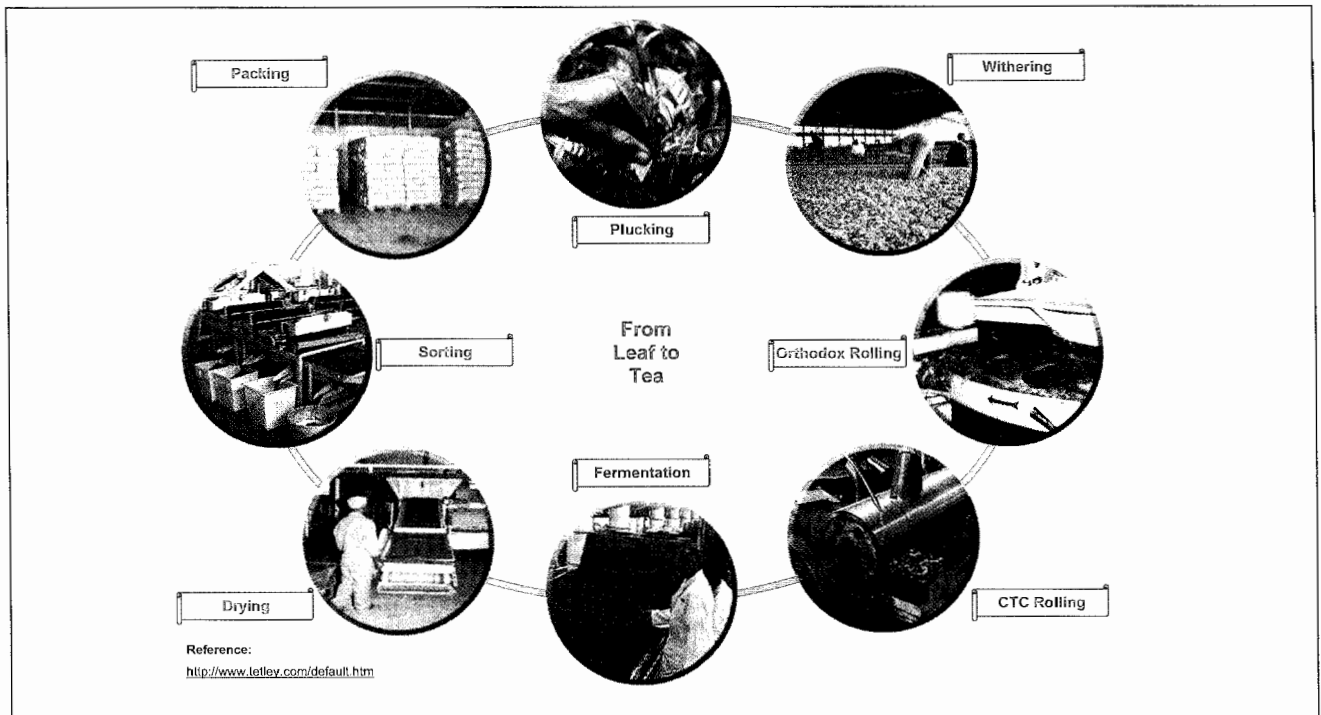
■ **Plucking:** The tea leaves (top two leaves and the bud leaf) are first plucked (picked) from the end of the branchlet. They are then brought to the tea factory where they undergo further processing.

■ **Withering:** The leaves are uniformly spread to wither either naturally (where the climate is suitable) or by means of heated air forced over the withering racks. The object is to evaporate as much of the tea leaf's water content so that the leaf becomes pliable like soft leather gloves. The plucked leaves are placed on a withering (drying) rack.

This first stage of withering may take 10 to 20 hours and its purpose is to bring down the internal moisture of the leaf to somewhere (depending upon the variety) between 60% and 70% of the original (at time of pluck) moisture. This reduction of moisture makes the leaf pliable and more amenable to the next step.

■ **Rolling and roll bearing (CTC):** From the withering-racks the soft, green leaf passes to the rolling machinery where it is twisted and rolled to break up the leaf cells and release the juices which give the tea its flavor. The first important chemical change starts here when the juices that remain on the leaf are exposed to the air and development of the essential oil begins. From the roller the tea emerges as twisted lumps which are broken up by coarse mesh sieves or roll-breakers. The fine leaves which fall through are taken to the fermenting rooms, while the coarse leaf is returned for further rolling. There are two distinct rolling methods:

○ The traditional or 'Orthodox' method involves the leaves being gently twisted and rolled as in the picture on the left. The resultant leaf is wiry or 'flakey' in



appearance and gives a subtle, light liquor.

○ CTC (Cut, Tear and Curl) involves the leaf being pressed through three sets of serrated rollers. This results in a more spherical leaf which brews more quickly, often giving a deeper, redder brew.

■ Fermentation: The leaves are treated so that the enzymes inside the cell are exposed to further development as a result of coming into contact with oxygen. This is called oxidation. The leaves begin to turn a bright copper penny color and 2 or 3 hours is generally sufficient time to accomplish this.

■ After this phase the tea goes into the drying operation. Tea is dried (removes the balance internal moisture until it is down to somewhere between 2% and 7% by weight) for between 30 minutes to several hours. The drying operation is exceptionally important in that this is the process that "seals in" the entire flavor and can represent one of the major differences between a mediocre tea and a superb tea even though they may come from the same estate. The purpose of drying is to arrest further oxidation and to dry the leaf evenly and thoroughly without scorching it. The

automatic tea drier consists of a large iron box inside which the leaves are spread on trays. The trays travel slowly from top to bottom while a continuous blast of hot dry air is forced into the box. Careful regulation of the temperature and of the speed at which the trays move is the main factor in successful firing.

■ Sorting & Packing: Sorting is done to remove the fibres and stalks and to separate the dried leaf into the different sizes or leaf grades. The tea, which was plucked the previous day is now stored in bins ready for packing and is now ready to be sold or blended).

Background

This paper concentrates on a few energy conservation measures identified during the course of energy audit in the tea gardens of Williamson Magor where the Kilburn dryers of FF models are in operation. Williamson Magor has already taken up a project in connection with energy cost reduction to install coal-fired boiler and use the steam for heating the air,

instead of using oil to heat the air, which is then used for leaf drying. At two of their tea estates, the plants are already installed with boilers and 6 more boilers have been ordered for installation in other tea estates.

Withering Section

In the withering section, the leaves are spread uniformly on longitudinal trays over meshes. The trays are divided into two parts longitudinally, as can be seen from the Figure 1. Fans are provided at one end which force the air into the tray (or sometimes induced draft fans). A movable hinged damper is placed next to the fans as can be seen. The damper position determines whether the air has to be forced through the pile of leaves from beneath or from over the top. As shown in Figure 1, the damper

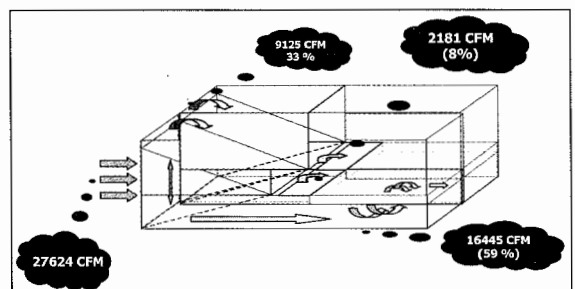


Figure 1: Double fan operation

position is such that the air will pass through the leaves from beneath the mesh, and then pass out from the other end, opposite to the fan side.

Blocking Air Leakages

The green arrows in Figure 1 indicate the total air flow being delivered by the fans as measured with the help of anemometer. The pink ones show the actual air being delivered for the withering process. The rest of the air, which constitutes around 41% of the total air being supplied, gets leaked (shown with red arrows) from the leaking joints as shown.

The first leaking point is where the damper is connected on the fan side. The movable damper top should ideally rest without leaving any gap on the fan side. But due to this gap, air passes through the top side, without actually doing the intended work of withering the leaves from beneath. Same is the case when the damper moves down, in which case air leaks through the bottom instead of going through the top of the leaves for withering. This was the case with all the trays.

The second leakage point was found where the damper is hinged with the tray section. The point where this hinged arrangement is there, some gap was observed in all the trays. Due to all these leakages, the average effective air being utilized for the purpose of withering was only 59%. Due to such leakages, the overall operating time for achieving the desired withering process was more and that meant wastage of energy. All leakage ends were attended to and the leakages were brought down to only 2-3%, which meant an annual energy savings worth Rs. 13 lacs for one tea garden on average.

Single Fan Operation

Sometimes, depending upon the required tea quality and shortage of leaves, single fan withering is also done, wherein out of the two fans provided in the withering tray, only one is operated and the other is kept off.

However, it was observed that during the single fan operation, the fan that has been kept off, starts to rotate in reverse direction and acts as an air exhaust system, which means that the fan sucking the air into the tray needs to deliver more air flow to achieve the withering process completely. This results in higher power consumption by the fan, which is nothing but unwanted energy wastage.

As can be seen from Figure 2, out of the total air flow of 36171 CFM developed by single fan, there is a leakage of 6925 CFM, which is about 19% of the total flow and the actual air being utilized for withering purposes is only 29245 CFM, which is 81% of the total flow.

It was observed that the suctions of these fans were not provided with individual dampers. Providing dampers at the suction of these fans will avoid the air being exhausted when single fan is in operation, thus helping to save electrical energy being wasted. This measure alone helped save electrical energy worth Rs. 3 lacs for one tea garden on average.

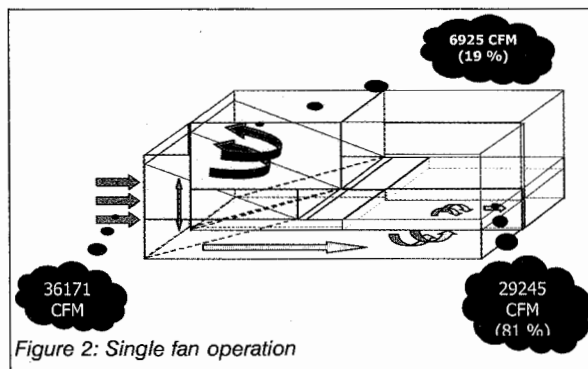


Figure 2: Single fan operation

Leaf Drying System

The existing FF model dryer consists of two fans for catering the hot air as well as the cold air. A heat exchanger has been placed in the suction of the hot air blower that heats the air to a level of 130 °C. Previously, the dryer had individual fuel burning system (TD oil fired). Figure 3 illustrates this.

Observations:

Following losses are observed in the existing system:

- As the air is heated in the suction of the hot air blower, the air density decreases by 25% resulting in increase in volume by 25%. The power consumption of fans and blowers are determined by three basic parameters namely flow (volume of air), head and the efficiency of the fan/blower system. Hence, the increase of air volume due to increase in temperature results in higher power consumption in the blower.

- Already, both the blowers (hot air and cold air), having extra capacity, makes the operator to partially close the dampers to regulate the flow. This

is introducing additional pressure drop across the dampers and in turn results in wastage of power.

Recommendation

The following recommendations can address the above mentioned losses.

- It is recommend to

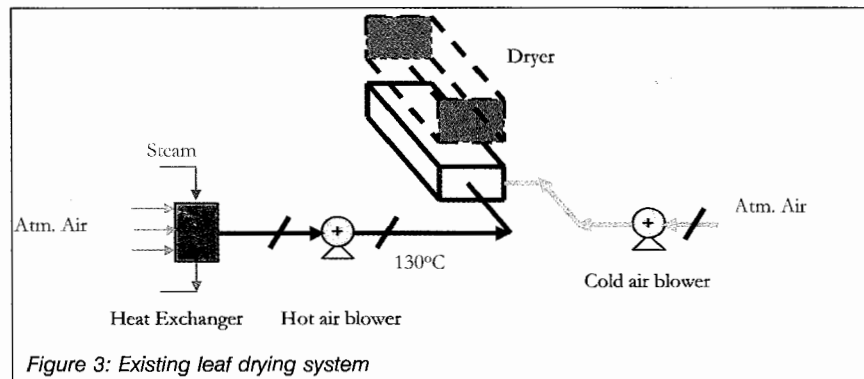


Figure 3: Existing leaf drying system

relocate the heat exchanger to discharge side of the hot air blower from the suction side of the blower. The schematic diagram of the proposed system is shown in Figure 4. By relocating the heat exchanger, the air volume handled by the blower will come down that will result in power savings.

■ To address the pressure drop across the damper, it is recommended

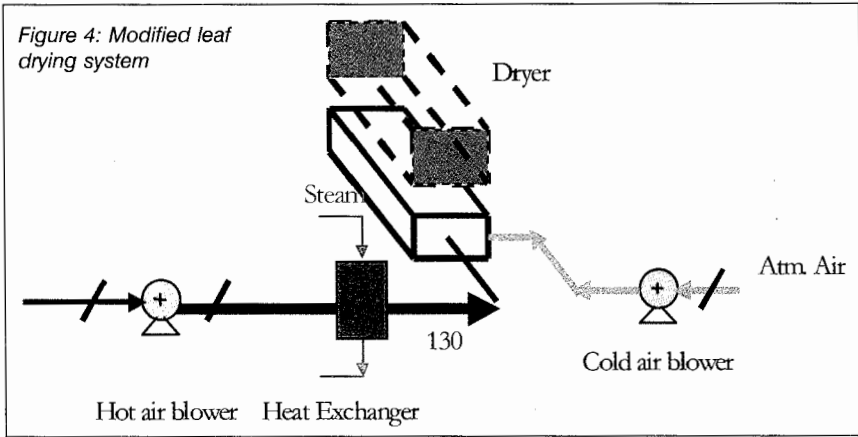
four beds will be in use and this means that the bed which is not loaded, the air through it will pass out of the openings, resulting in energy loss.

In order to avoid this, the individual bed air supply can be segregated and the supply line can be provided with a shutter. The operator can be asked to open the shutter of only that particular bed over which leaves have been placed for fermentation and shutters of

closed, the system pressure will rise and signal will be given to the VFD that the flow must be reduced in proportion to the desired pressure in the system. The VFD will reduce the fan speed, lower the power consumption and avoid the energy wastage. The proposed system is highlighted in Figure 6.

This measure is helped save Rs. 0.5 lacs per tea garden, with as much investment, hence giving a very attractive return of 100%.

Miscellaneous Measures
Other basic energy conservation measures, like lighting retrofits, waste heat recovery from continuous operated DG sets, fan and pump efficiency improvements were also identified. However, such measures are very basic to be considered under the purview of this article.

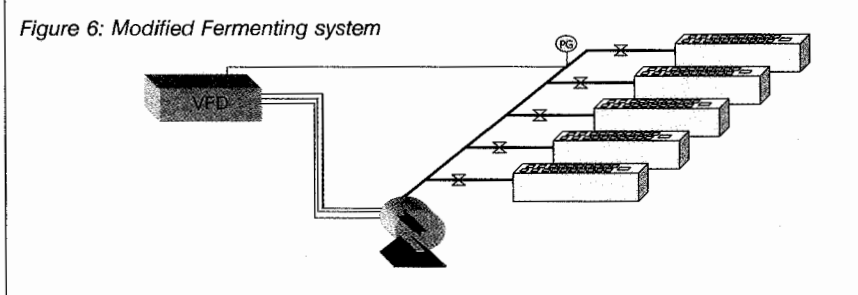
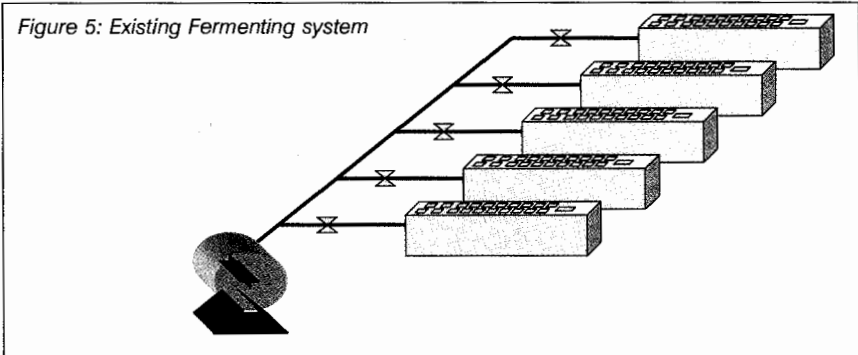


to install variable frequency drive (VFD) that can be used to regulate the flow by means of speed regulation. These two measures helped save electrical energy worth Rs. 3.5 lacs with an investment of about Rs. 2 lacs.

Fermenting System

In the fermentation section, the processed tea leaves are allowed to get oxidized. The leaves are kept in pots, which have minute opening at the bottom. These pots are then placed over circular or rectangular opening over a bed, through which air is passed with the help of a forced draft fan. The fan or blower forces the air through the hollow bed, which has openings only at the top over which the fermentation pots are placed. Sufficient time is allowed for the leaves to come in contact with the air and get conditioned.

A typical fermentation section, where a blower supplies air through 5 beds, is shown in Figure 5. However, all of these five beds will not be in use most of times. Normally only three or



all the beds over which there is no load must be kept shut. A VFD can be provided, which will regulate the fan air flow according to the signal from a pressure transducer. Once a shutter is

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