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Innovative steps for Assam tea industry

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Abstract: In the world tea trade scenario, India stands as a leader. But Indian tea industry has to take great care in energy consumption patterns for rational utilization of the existing sources of energy as well as for future implementation of possible nonconventional energy sources. Through rational utilization of conventional energy alone, a potential savings up to 20% electrical energy and 40% heat energy can be accomplished. Technologies like Combined Heat and Power systems (cogeneration), waste heat utilization etc. help in achieving pollution control and energy efficiency. Use of nonconventional energy through solar dryers, biomass gasifiers, wind generator etc. will prove to be a boon to energy intensive industry like tea processing in future. Keeping this ground level scenario in mind, this project intends to present a case study, conducted at a Tea factory and Plantation, Dibrugarh, Assam, to reduce its input costs of energy in order to increase the overall productivity of the tea estate. The estate produces Cut-tear-curl (CTC) category of black tea. With sufficient understanding of concepts of optimization and modelling, systematic data can be collected from the tea estate, analyzed, modelled in a suitable way and a new improved model can be suggested with lower input costs and increased productivity. The patterns of energy consumption in the various subsystems in general, and withering and drying in particular can be analyzed and empirical relations are formulated by the application of EORT modelling. These models may be optimized and results can aim at striking a balance between withering and drying with a view to minimize energy input without a corresponding compromise in quality. The optimized model can be developed for each and all Tea Industry for better understanding of energy consumption and prediction of the tea production.

Keywords: CTC, Drier , EORT, Withering

I. INTRODUCTION

India, the largest producer and consumer of tea in the world, accounts for around 28 per cent of world production and 13 per cent of world trade. Tea is the prime beverage consumed in India, and private final consumption expenditure (PFCE) on tea, coffee and cocoa aggregated Rs.134.96 billion in FY2005, accounting for around 2% of India's PFCE on food, and 0.7% of India's PFCE. The latest available data indicates that tea accounts for 90.6% for India's consumption of stimulants (tea, coffee, and cocoa beans), followed by coffee (7.7%), and cocoa beans (1.7%). Robert Bruce in 1823 discovered tea plants growing wild in upper Brahmaputra valley. Tea industries in India are mainly located in rural hills and backward areas of north-eastern and southern states. Major tea growing areas of the country are concentrated in Assam, west Bengal, Tamil Nadu and Kerala. The other areas where tea is grown to a small extent are Karnataka, Tripura, Himachal Pradesh, Uttaranchal, Arunachal Pradesh, Manipur, Sikkim, Nagaland, Meghalaya, Mizoram, Bihar and Orissa. Unlike most other tea producing and exporting countries India has dual manufacturing base. India produces both CTC and orthodox teas in addition to green tea. The total turnover of the Indian tea Indian industry is in the vicinity of Rs.8000Crs. As on 31-12-2006 the Indian tea industry is having (a) 1655 registered tea manufacturers (b) 2008 registered tea exporters (c) 5418 number of registered tea buyers and (d) 9 tea auction centers.

However, the production as well as export of tea has shown a declining trend in the recent years of the current decade. Thus, while the production increased from 835.6 million kg in 1997-98 to 848 million kg in 2000-01, it started declining thereafter from 847 million kg in 2001-02 to 830 million kg in 2004-05 and further down to only 667 million kg in 2005-06. Exports of tea, on the other hand has shown a further deterioration from 211 million kg in 1997-98 to 189 million kg in 1999¬-2000 and from 204 million kg in 2000-01 to 183 million kg in 2003-04 and to just 101 million kg in 2005-06. In spite of almost stagnant rupee value in the period, the value of India's tea exports has come down from Rs.2192 crore in 1998-99 to Rs.1637 crore in 2003-04 and to less than RS.1000 crore in 2005-06. Thus our tea exports as proportion to production has declined from 24 percent in 1998¬99 to 15 percent in 2005-06, though it was 25 percent in the previous year.

In recent years, some quantity of tea is also imported for blending and re¬-exports. The quantity of such imports went up from just 9 million kg in 1998-99 to 32.5 million kg in 2004-05 and it declined to 8 million kg in 2005-06.

In terms of employment, the tea industry employs around 1.27 million people at tea plantations and 2 million people indirectly, of which 50% are women. The last fact is particularly important when we consider that tea industry, to a large extent, drives the economies of the regions where the tea gardens are concentrated, for example Assam.

Now if we boil down to the manufacturing counterpart of Indian tea industry then we will see that the sector is comparatively small. In fact, the tea as an agricultural output earns more money for the country than as a manufactured product. But this by no means indicates that tea manufacturing is a nascent concept in India. As we will see that the only player that has crossed the seven seas to promote branded tea in form of Polypacks etc. is Tata Tea. But the fact that there are no other major house which has promoted itself as a tea manufacturing house provides enough scope to the houses themselves to improve their status. But there are some intrinsic problems[1].

II. PROBLEMS IN THE INDIAN TEA INDUSTRY

The most serious ailment remains with low productivity and the low quality of made tea due to low investment on infrastructure and low managerial efficiency. The problems of high cost of production and stagnant productivity are to be solved in the first place for the modernization and development of the sector.

Even though India still produces 27 percent of global tea output, the quality of product is sadly doubted in the global market. It is a fact that the planters of major tea growing states, themselves were not careful enough about the deterioration of quality during heydays and their negligence gradually turned more than 30 per cent of tea bushes into infructuous plants. Also, the presence of large amount of pesticides which are possible carcinogenic in the tea manufactured mainly in Assam has forced the international customers to opt for tea from other regions. Studies confirm that the root cause of closure of a number of tea gardens in parts of the country was low productivity and lack of investment in plant development activities.

There is yet another paradox which the Indian Tea Industry faces. This could be explained in terms of the huge difference between the price received by producer and the price charged by dealers and retailers. The common consumer in the market is confused of the fact that while the producers are facing the crisis created by a market glut and decline of prices, often voiced by the corporate entities, the benefit of low price does not come to the common consumers. The reason perhaps lies in non-conformity with regulated market behavior of producers among whom many are found to be selling out their produce directly without routing it through auction centers.

III. ASSAM TEA

The major driving force behind the country's tea ¬sector growth is the prospect of eastern India's tea industry, particularly of Assam which produces around 53 percent of the country's total production. It also employs more than 10 percent of the state’s work force which is around 12 lakh people. However, the share of Assam in the country's tea production in course of last three-and-half decades has remained confined to a narrow range from 51 per cent in 1970-71 to 53 per cent in 2003¬-04 due to decline in per hectare productivity though the area under the plantation rose from 182 thousand hectares to 280 thousand hectares in the period with the number of tea estates rising from just 750 to as many as 32,000.

There is a sudden rise in the number of tea gardens of Assam and its area under tea (to around three lakh hectares), particularly since the latter half of 1990's due to the unemployed youths taking to small scale tea production as their profession. There are around 25,000 small tea gardens in Assam today adding to the State’s total production by more than 50 million kg. But, since they grow in small scale, they cannot go for factory manufacturing and, hence, have to sell out only green leaves to the large estates which often subject them to exploitation. The addition to tea hectares by around 50 thousand hectares in the latter half of 1990's was possible mainly through conversion of agricultural land with below 10 hectares being the cutoff point of land for small tea growers.

IV. PROBLEMS IN THE ASSAM TEA INDUSTRY

A considerable number of tea gardens of the State have gone sick over the period due to lack of infrastructure, modernization and efficient management. The Assam Tea Corporation, a state-level public sector enterprise, for example, is not functioning at all. The amount of goodwill that Assam tea had long been enjoying in the international market has now been eroded to a great extent. Though Assam tea is still earning around 50 per cent of the foreign exchange earned by India's tea industry, its demand is already in recession due to better quality-tea supplied by countries like Sri Lanka, Cuba etc. at comparatively lower prices.

V. STEPS TAKEN FOR THE DEVELOPMENT OF THE SECTOR

Some of the steps have been taken for the development of the sector which provide some hope for improvement of the sector:

i. Withdrawal of additional excise duty of Re 1.00 per kg on tea as announced in the Union Budget 2005-06.

ii. Sanctioning of two schemes viz. grant of subsidy for production of orthodox teas and assistance to the two Research and Development institutions, viz Tea Research Association at Tocklai (Assam) and United Planters' Association for Southern India Tea Research Foundation with an estimated outlay of Rs.93 crore for financing Planning Commission is very positive about finding a solution of the tea crisis which the industry has long been suffering from. The Union Commerce Ministry proposed to unveil a 15-year programme for massive replantation and rejuvenation of the tea industry.

iii. If the "Special Purpose Tea Fund", with a revolving corpus of Rs.1000 crore with a target of replantation in 1.7 lakh hectares over a period of 15 years to be created now will greatly benefit the tea growing states of Assam, West Bengal, Tamil Nadu, Kerala and Uttaranchal. The revival package for tea industry had already been assured of fiscal and tax incentives and of cost effectiveness for both domestic and export markets. The Union Commerce Minister also assured that it would provide a concrete support with special thrust on regeneration of old and replenish able tea bushes. The package which was proposed is also supposed to frame a marketing strategy to give the tea in the global market.

VI. TEA PRODUCTION METHOD IN A TEA INDUSTRY

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, therewill 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 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.

VII. STEPS IN TEA LEAF PROCESSING

1. **Plucking:** The tea leaves (top two leaves and the bud leaf) are first plucked (picked) from the end of the branchlet. Hence comes the term "*etikolidutipaat*" or "*Two leaves and a bud*". They are then brought to the tea factory where they undergo further processing.

2. **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. In the withering section, there are 18 troughs each with an area of 1400 sq. ft. However, loading on each trough is around 1.8 kg/sq. ft., exceeding which may result in the potential burning of tea leaves. There are large fans which are run through 5 HP motors. A movable hinged damper is placed next to the fans.The damper position determines whether the air has to be forced through the pile of leaves from beneath or from over the top.

3. **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:

a. The traditional or 'Orthodox' method involves the leaves being gently twisted and rolled. The resultant leaf is wiry or 'flakey' in appearance and gives subtle, light liquor.

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

4. **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. The fermentation is done on machines which have surfaces which are moving at a slow speed. The tea leaves from the CTC machine are spread on the surface. Hot air is passed through these tea leaves through the pores on the surfaces. The hot air is provided through ducts which bring in hot air.

5. **Drying:**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.

6. **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).

Tea manufacturing in a Tea Factory and Plantation is essentially the same method used all over Assam for "*Assam Tea*". The various **sub systems** therefore are:

1. Plucking
2. Withering
3. C.T.C
4. Fermentation
5. Drying
6. Sorting
7. Packaging

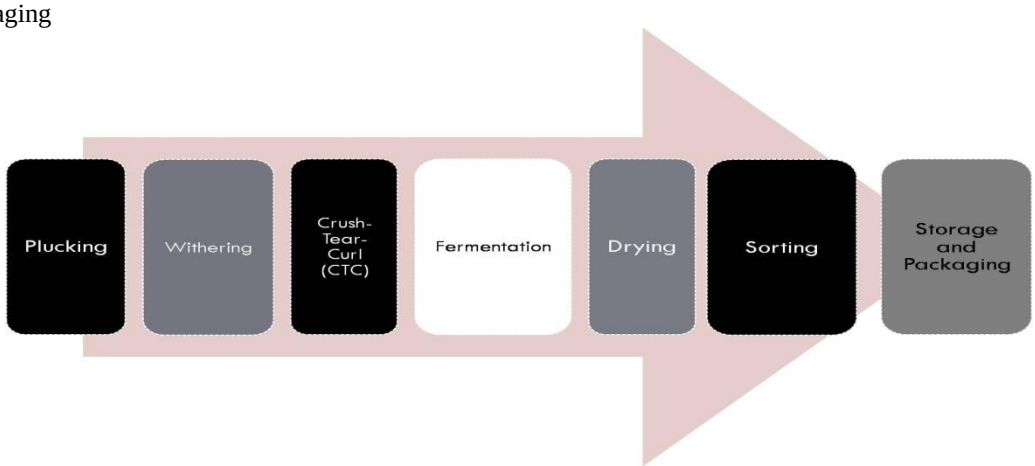

Fig1: Process flow diagram in a Tea Factory and Plantation.

VII. EVOLUTIONARY OPERATIONS RESEARCH MODELS FOR OPTIMIZATION

Evolutionary Operations Research Techniques (EORT) involves very systematic small changes in process variables during the operation of the process. The results of previous small changes may be used to suggest further changes, so as to approach the optimum operating conditions in a series of small steps.

EORT may be used to identify the combination of multiple variables to enhance the response of any operation, thereby improving the operational objectives and also the productivity of the complex system considerably. The basic concept is that a smooth response surface exists for a set of variables, which ultimately tend to converge at a single optimum. This is the principle of advanced control system (ACS) in which the impact of minor variations of process parameters is used to vary other parameters in order to maximize or minimize the objective function, for example, maximization of energy efficiency of the equipment of the total system. EORT models are based on actual process variables, which are dynamic in nature and fluctuate owing to exogenous or endogenous factors [2].

VIII. EORT MODELLING METHODOLOGY

The following steps are to be followed in order to develop a very reliable and valid model for the energy industry:

- Define the expected objective of the model.
- Outline the general process and data collection.
- Identify the manipulable and non manipulable variables by observed data, analytical data or a combination of both.
- Develop a basic model with the identified variables which affect the objective function and deleting the least effective variables
- Perform a sensitivity analysis and model validation by manipulating the variables and comparing the observed output with the model output
- Check model validity under observed conditions for a stipulated range of variables
- No validation will be deemed necessary if the deviations between observed and model outputs are within statistical limits

IX. ADVANTAGES OF EORT MODELLING

- Involves very systematic small changes in process variables during the operation of the process
- Maybe used to identify the combination of multiple variables to enhance the response surface of any system
- EORT generates a set of decision models based on LP /NLP algorithms and serve as a powerful, effective and result oriented Decision Support System
- EORT models are based on observed facts and figures unlike simulation models based on certain assumptions and hypotheses
- Facilitates efficient monitoring of a system as well as more precise and timely corrective actions

X. MODERN TECHNIQUES FOR ENERGY REDUCTIONIN WITHERING AND DRYING PROCESSES

The energy consumption in withering can also be reduced by adopting any of the modern techniques stated below.

1. DUAL SPEED WITHERING

The power consumption in withering can be reduced to 0.08 units/kg of made tea by using an aerofoil bladed adjustable pitch fan with a dual speed and dual rating energy efficient motor and suitable control panel. The usual amount of air required is 15 - 20 cfm/kg of green leaf. After the preset time, the airflow is automatically reduced, thereby reducing the power consumption by 50 - 60%.

2. WASTE HEAT RECOVERY

The waste heat available in tea factories are mainly from (i) flue gas and (ii) exhaust of tea dryer. Generally, sensible heat losses in the flue gases leaving the chimney is 35-55% of the heat input to the furnace. When the excess air and flue gas temperature are more, the waste heat available also will be more. The sensible heat in the flue gases can be recovered by either preheating combustion air or charge preheating. Preheating combustion air effects fuel savings. Heating devices used for this purpose are recuperator and regenerator. Also if the air is enriched with oxygen, combustion of the fuel is faster and more complete.

3. FLUIDIZED BED DRYER WITH BIOMASS GASIFIER

The Fluidized Bed Dryer can be supplied with hot air produced by the heater based on woody biomass down draught gasifier. The system, specially adapted for tea drying, uses conventional fired wood or any other woody biomass with density above 250 kg/mavailable at the factory location. The gasifiers have achieved up to 80% thermal efficiency in the conversion of solid biomass to gas and up to 33% of efficiency in electrical conversion. The calorific value of the combustible producer gas formed from biomass gasification is of the order of 3780 - 5040 kJ/mand is sufficient for thermal applications in tea drying. The units can deliver constant temperature air.

For a gasifier based tea drying system with a capacity of 300 kg of made tea per hour and hot air flow at 120°C of 11400 kg/hour, the specific fuel consumption is 0.4 kg wood/ kg of made tea and the wood consumption rate is 120 kg/hr. Before using this system, the level of consumption was 0.9-kg wood/ kg of made tea. Hence the rate of fuel wood consumption can be reduced by more than 50% by the use of gasifier based tea dryer.

The project cost per MW is about Rs. 3.5 crores. The cost of unit generation ranges from Rs. 1.50 to Rs. 2.20 per kWh[3].

4. COMBINATION TEA DRYER

For producing tea with brisk, strong liquors, Endless Chain Pressure / Fluidized Bed Dryer combination dryers can be used in which low temperature firing and gradual removal of moisture take place. Its energy requirement is 3.6 kWh/kg of made tea. It has got water evaporation capacity of 700 kWh whereas the conventional dryers have a capacity of only 380-kg/hr. power consumed is only 14 kW whereas Fluidized Bed Dryer consumes 37 kW. Drying cost/kg of made tea is also less in combination dryer - Rs. 0.65 against Rs. 1.11 in conventional dryer.

To set the desired drying time, a variable speed drive system is also provided. Fluidized Bed Dryer reduces the moisture of CTC dhool from 70% to 3% within 15 minutes whereas a conventional dryer takes 23 minutes.

Cyclones and dust collectors can be used to trap fly-off tea, which can be re-fired.

5. SOLAR HOT AIR SYSTEM

Solar energy can be used to heat ambient air to around 60-75°C. This air can be delivered by a fan to the indirect fired furnace to heat it to the temperature required for drying tea. On a clear sunny day, the saving on the fuel by use of solar energy is around 50% of the fuel-wood used for drying.

Solar air heating panels can be mounted on the roof of the tea factory. Ambient air drawn through the solar panels will get heated during daytime. One module of 10 msq. area can provide heat to the order of 2.1 MJ/year. Each sq. metre of solar collector can deliver 160 kg hot air at 75°C on a sunny day.

Approximate cost of the modular solar hot air system is Rs. 8.5 lakhs and the payback period is around 4 years.

The constraints in making use of solar panels in tea factories are difficulty in storage of heat, high initial cost and large area required for locating the solar collectors.

XI. CONCLUSION

The thermal energy consumption patterns in withering and drying processes can be studied in different Tea Industry of Assam and various unique empirical relations may be derived with the data available in these Tea Industry and optimization of the empirical relations can be utilized for the minimization of Thermal energy consumption and maximize the profit.

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