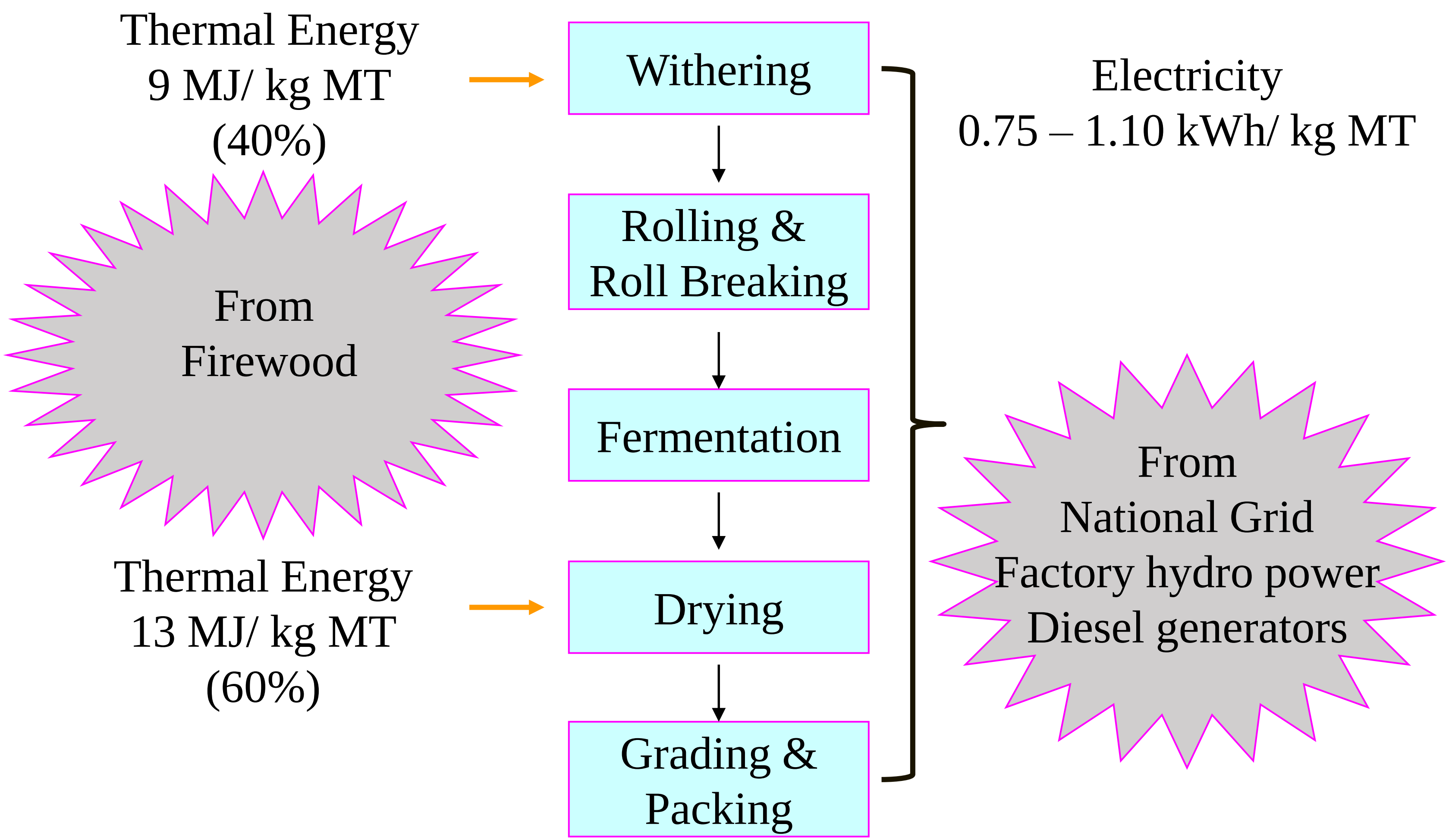
Energy saving in tea processing

W M S Weerawardena

Process Technology Division

Tea Research Institute of Sri Lanka

Energy Consumption in Tea Manufacturing Processes



Energy Losses in Tea Manufacture

- Avoidable losses
- Unavoidable losses

Focus should be to,

- Concentrate on avoidable losses
- Quantify the losses
- Identify ways and means of reducing losses
- Implementation

Energy Saving Opportunities

- Switch off unnecessary bulbs
- Avoid common switches in different sections – Introduce individual switches to bulbs
- Use of energy saving bulbs appropriately – CFL bulbs, LED Bulbs
- Maximum use of day light for lighting
  – clean glass windows, remove items blocking the glass windows, Transparent roof to obtain day light

Energy Saving Opportunities contd.

- Use of low current consuming bulbs appropriately
- Relocate the bulbs for direct lighting the tea processing areas
- Light colour paintings for machinery and factory
  – light reflecting effect

Energy Saving Opportunities contd.

Machinery maintenance to avoid,

unnecessary current load to machines

– loose V-Belts, poor alignment of power transmission systems, poor lubrication to machine parts, damaged parts in machinery, etc.

Unnecessary heat losses

– scale in the air heater parts, damaged fire bars, hot air leaks, etc.

Delay in tea processing

– damaged machinery, breakdown of machinery

Unnecessary breakdown of machinery and reduction in its performance

- rewound motors may not perform better.

Energy Saving Opportunities contd.

- Switch off machineries when not in use
- Switch on machineries one by one after a power failure and avoid common switches for machinery
- Check and ensure the function of the capacitor bank
  - power factor maintained at 0.99 with automated system
- Conveyors for proper feeding of teas into different machineries
  - machinery operating time is reduced.
- Reciting machinery for easy tea processing
  - machine idling time is reduced, delay in tea processing is avoided
- Replacing poor performing motors with low current consuming motors
  - rewound motors may consume more current

Energy Saving Opportunities contd.

Inadequate number of V-Belts

Poor alignment of machinery

Machinery recited properly

Energy Saving Opportunities contd.

Correct Sizing of Motors

- oversized motors operate continuously in a plant consumes much energy especially when the load factor is below 30%.

  Load Factor= (power input x Efficiency)/ (0.746 x motor HP)

  If the power input is 3.8kW and the efficiency is 80% of a 15 Hp motor, then the load factor is 27%. This is an over-sized motor and consumes much energy.

- Occasional operation of existing oversized motor will not add that much to the cost. To handle an uncertainty, for safety factor and future expansion like this might be ok.

Energy Saving Opportunities contd.

How to identify an oversized motor

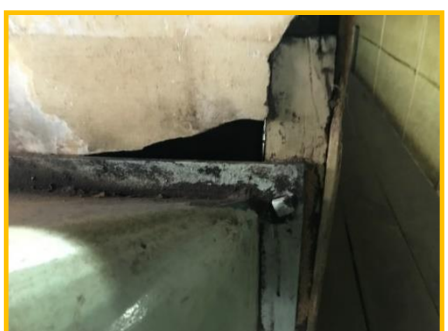
- Name plate data gives the output power of 7.5 kW, with efficiency of 85 %.
- using the above, the rated input should be, 7.5 kW/0.85=8.8 kW,
- Measure the actual input power and compare it with 8.8 k W.

  Lower input power indicates that the motor is over-sized.

Energy Saving Opportunities contd.

Withering Process

- Proper loading, loosening and turning operations in trough withering
- Avoiding under loading of leaf on the troughs
- Monitoring efficient use of hot air for withering
  – hygrometers, hot air damper adjustment
- Avoid air leaks in the chambers and transformation ducts



Energy Saving Opportunities contd.

- Avoid blowholes

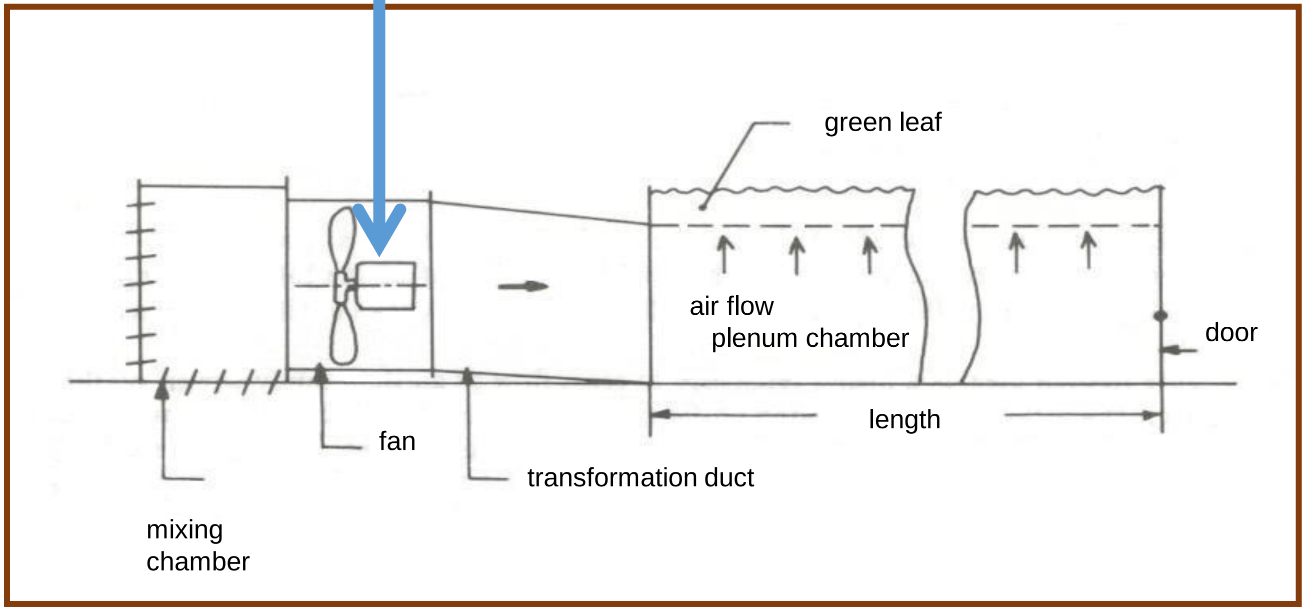
Avoid air escaping through the hygrometer box

- Maintain air control dampers to adjust required amount of ambient air and hot air.

- Sloped side plates of leaf loading section to avoid air leaks

Energy Saving Opportunities contd.

VSD



Use of VSD

- 40% saving on electricity
- 0.18 kWh/ kg MT

Varying speed → Varying airflow

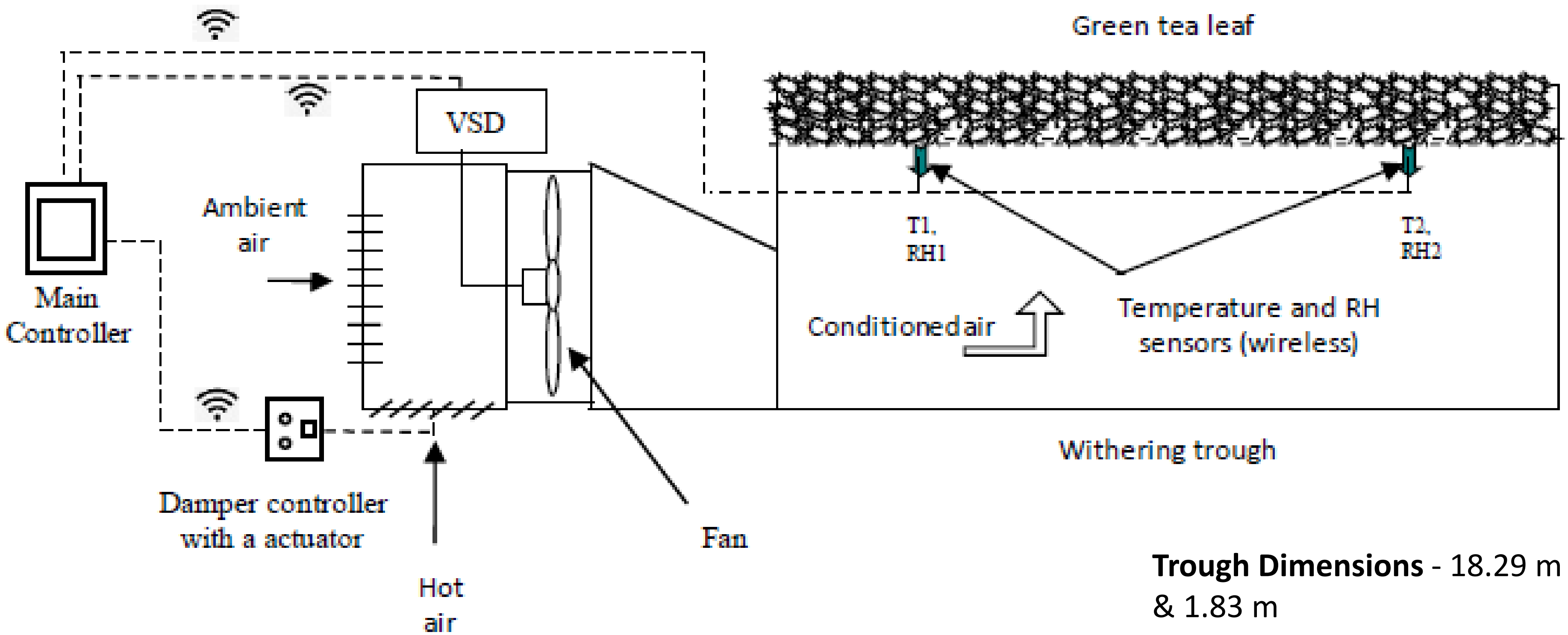
Reduced speed → Reduced airflow → Electricity saving

Energy Saving Opportunities contd.

TRI Developments for energy saving

- Semi – Automated withering control system

Semi–Automated Withering Control System



Trough Dimensions - 18.29 m x & 1.83 m

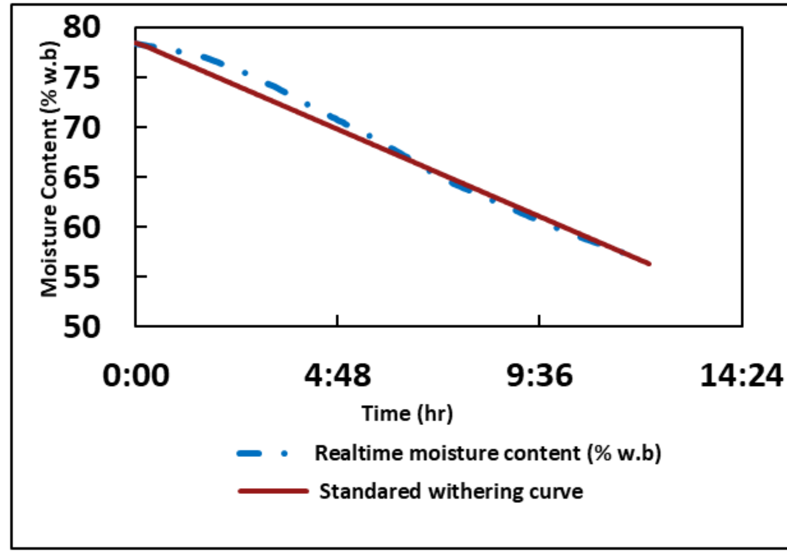
Schematic diagram the semi–automated withering control system

System Architecture

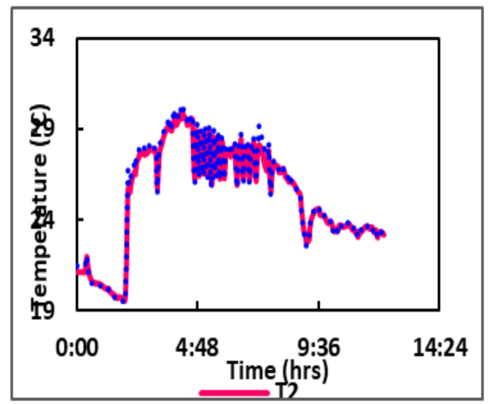
Input data
Leaf temperature
Green leaf weight
Withering period
Initial moisture
content

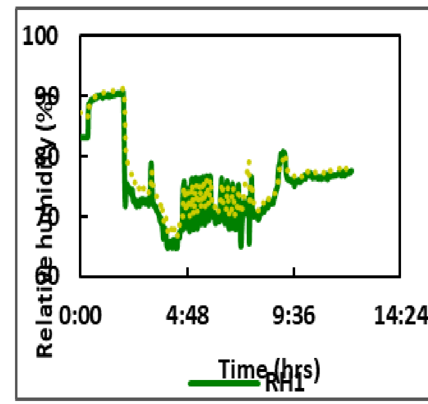
Software Program

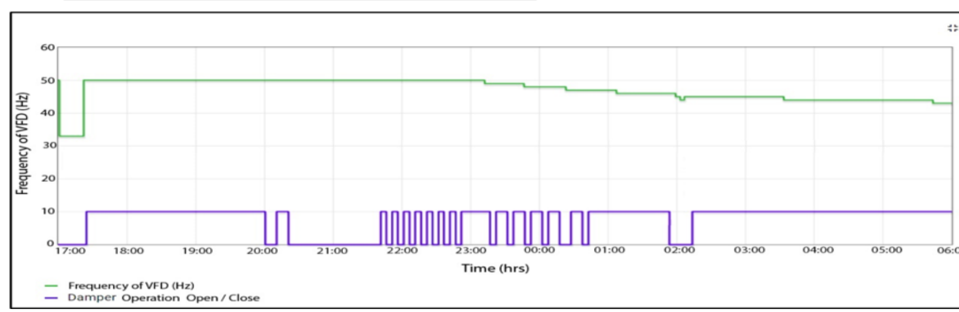
Relative Humidity
Temperature



Real time moisture content







Semi–Automated Withering Control System contd..

- Electrical energy saving of 34%.
- Specific electricity consumption was 0.16 – 0.18 kWh/kg of MT.
- Moisture removal rate maintained at 10 - 12 kg moisture/ kWh.

Benefits of the control system

- Achieving even & required wither in set time
- Web interface to view historical & real time data
- Optional manual mode facilitates uninterrupted withering process whenever the system cannot be operated in auto mode
- Reduces supervision by the factory staff.
- Remote monitoring & controlling
- Low cost energy saving measure
- Fabrication & installation service available in Sri Lanka

Energy Saving Opportunities contd.

Rolling Process

Improved rolling programme

Identifying required machinery – delay in manufacture could be avoided

Avoiding using additional machinery – idling of machinery could be avoided

Avoiding over-loading of machinery – high electricity consumption

Energy Saving Opportunities contd.

Drying Process

Use of Drier with suitable capacity as required

- Machinery in the rolling room and grading room are not under-charged
- Facilitate to increase the productivity.
- Re-firing could be done in the same drier and
- heating up of another drier could be avoided

Energy Saving Opportunities contd.

A Typical tea factory:

Made tea production – 1750 kg/ day
Drier rated capacity – 300 kg/ hr

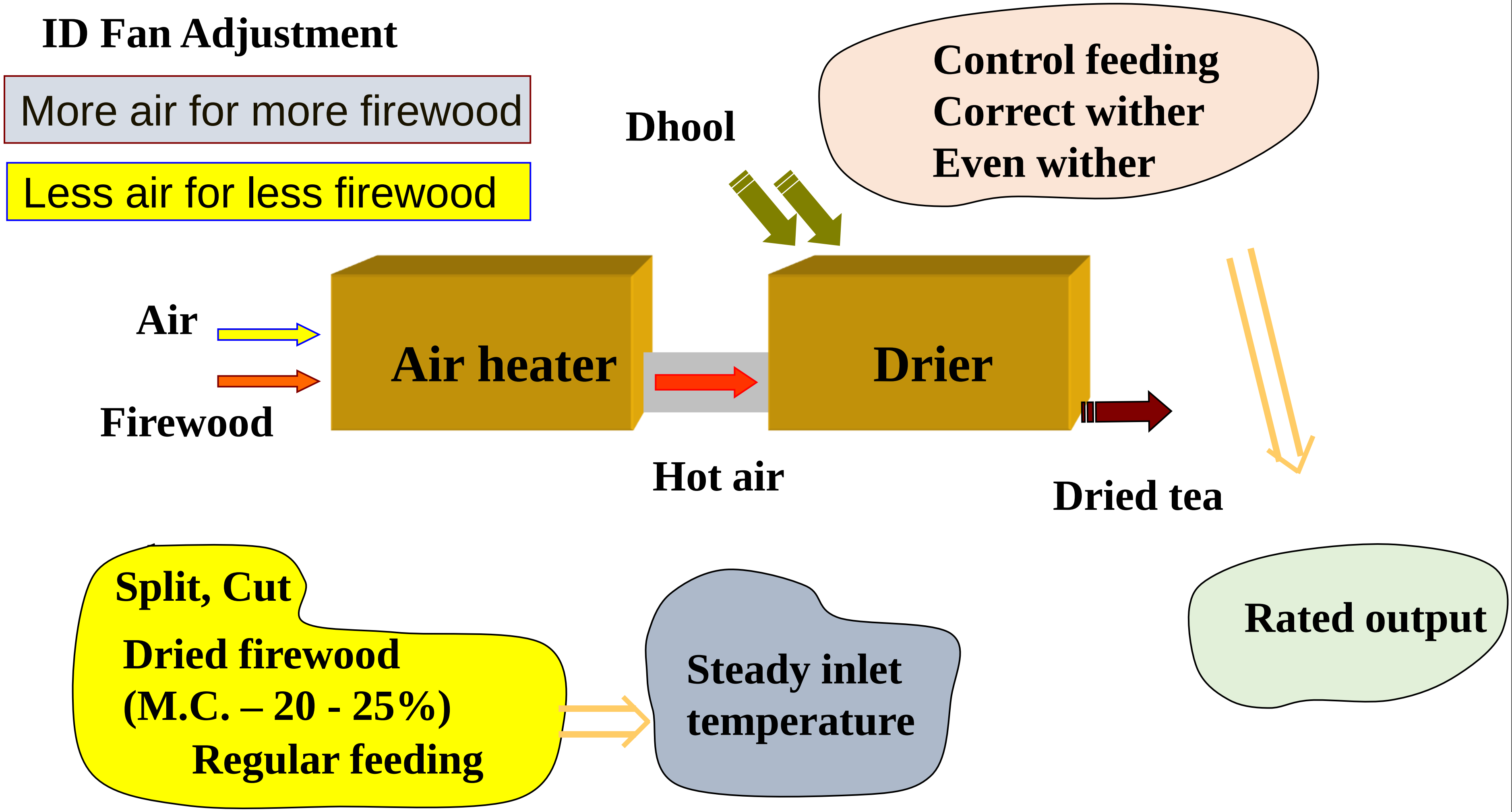
Operating drier with rated capacity:

Drier output - 250 → 300 kg/ hr

Drying time = 7 → 5hours & 50 minutes

Withering trough operating hours also could be reduced

Energy Saving Opportunities contd.



Energy Saving Opportunities contd.

Regular feeding of firewood into the air heater

Drier output – 250 kg/ hr
Assumed firewood consumption – 250 kg/ hr
Quantity of firewood to be fed at a time – 250/5 = 50kg
Feeding interval – after half of the lot (50kg) is burned

Feeding must be done within a short period to avoid
- cooling the flame &
- live flame entering tubes.

Keep firewood near to the air heater

Required firewood
Good burning

Overloaded firewood
Poor burning

Energy Saving Opportunities contd.

Supplying only required amount of air for combustion

Ash pit door adjustment to regulate air for combustion

ID Fan damper adjustment by checking smoke at chimney

Ash pit door Properly placed

Flue Gas - Observed Data

Oxygen %	Excess air %
15	163
8	40

More air leading to energy loss

Firewood saving – 7%

Energy Saving Opportunities contd.

Use of dry firewood

Firewood M.C (%)	Sp. firewood cons. (kg/ kg MT)
17	0.73
19.6	1.05
21.3	1.13
35.4	1.51

Moisture condensed in the flue gas line

Drying of firewood in firewood sheds

Energy Saving Opportunities contd.

Avoid accumulation of ash in the ash pit
– to avoid interruption to supply of air for combustion

Avoid accumulation of ash in the air path
– for smooth flow of burned air & heat transfer

Avoid operating air heater with sealed tubes
- to prevent damages to other tubes.

Energy Saving Opportunities contd.

Calibrating the drier thermometers at regular interval as required – To operate the drier at the optimum condition and to avoid energy losses

Temperature (°F)	
Drier inlet thermometer	Standard thermometer
260	280

Actual temperature – 280 °F
(20 °F more than the required temperature)

Energy Saving Opportunities contd.

Use of better/ efficient Air Heaters as required to reduce firewood Consumption.

Examples: 5-pass air heaters – efficiency is about 70%
Hot water generators – efficiency is about 70%

Use air heaters matching the drier capacity

– to achieve rated output of the drier

- to reduce unnecessary breakdowns and delay in manufacture

Energy Saving Opportunities contd.

A typical tea factory - Made tea production – 500,000 kg/ Yr

Specific Firewood consumption for drying (kg/ kg MT)		Annual Firewood Saving (cu.m.)	Annual Saving (Rs.)
Present Air heater	Better/ Efficient air heater		
1.5	0.75	1500	6,000,000.00
1.4	0.75	1300	5,200,000.00

Firewood price is taken as Rs.4,000.00 / cu.m.

Very old and small size air heaters could be replaced with Better/ Efficient air heaters

Cost benefit analysis – capital investment, saving on electricity, reduced cost on staff's and Workers' overtime, etc.

Energy Saving Opportunities contd.

Use of Energy Plantation crops

Specific fuel consumption - 0.60 – 0.65 kg firewood/ kg made tea (excluding heating up)

Gliricidia sepium
4,900 kcal/ kg

Calliandra calothyrsus
4,500 – 4,750 kcal/ kg

Energy Saving Opportunities contd.

TRI Developments for energy saving

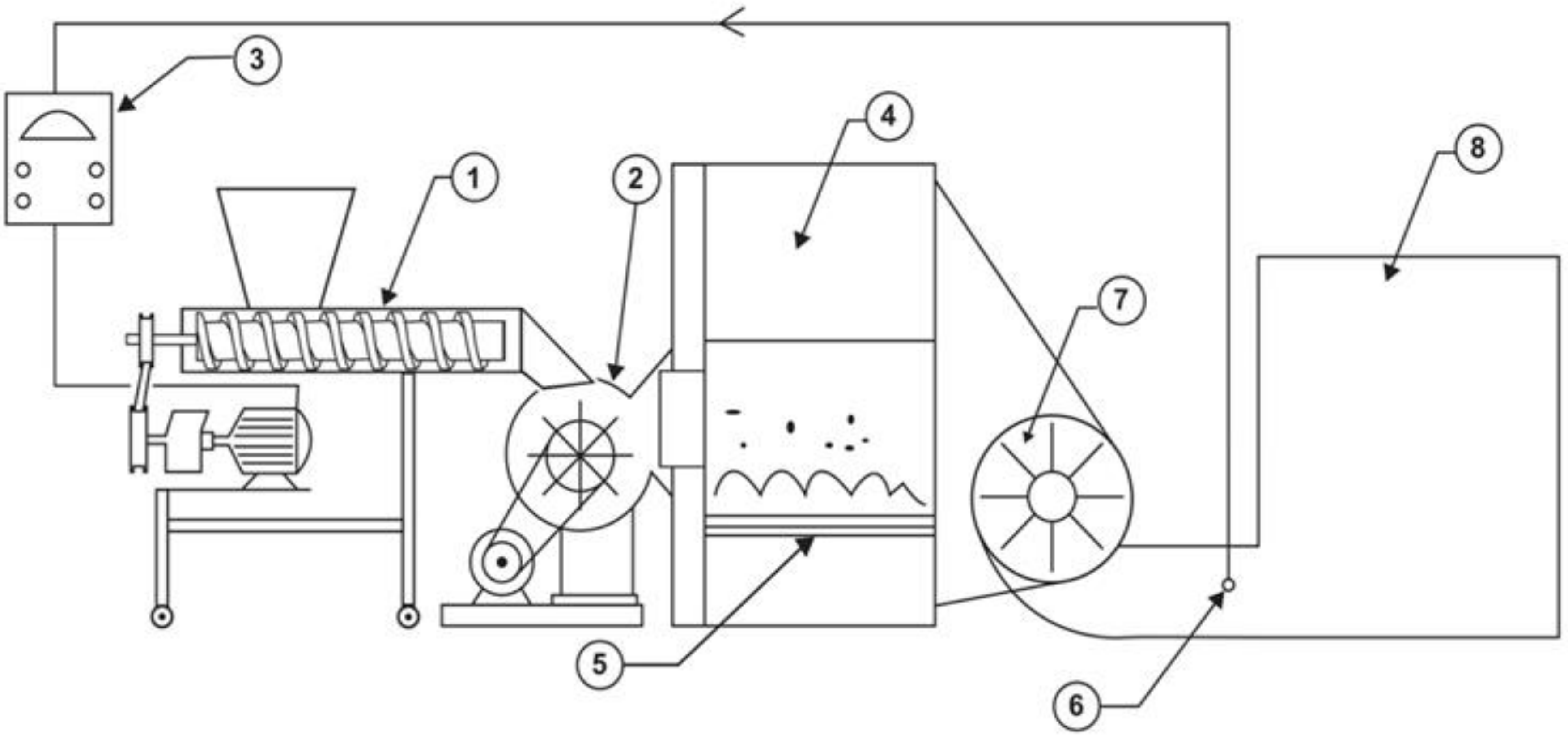
- A semi-automated feeding system for feeding of wood chips into a conventional furnace/air heater-drier system

Semi-automated feeding system for feeding of wood chips

Wood chips

- ✓ Offer more surface area.
- ✓ Could generate more energy with less quantity
- ✓ Handling could be mechanized

- ✓ Maintaining steady inlet drying air temperature
- ✓ Facilitate proper drying of tea
- ✓ Specific firewood consumption < 0.6 kg/ kg Fired-tea
- ✓ Less damage to fire bars



1. Screw Conveyor
2. Drum Spreader Stoker
3. Control Panel
4. Furnance / Air heater
5. Fire grate
6. Temperature Sensor
7. Main Fan
8. Drier

Schematic diagram of wood chip feeding unit with control system

Energy Saving Opportunities contd.

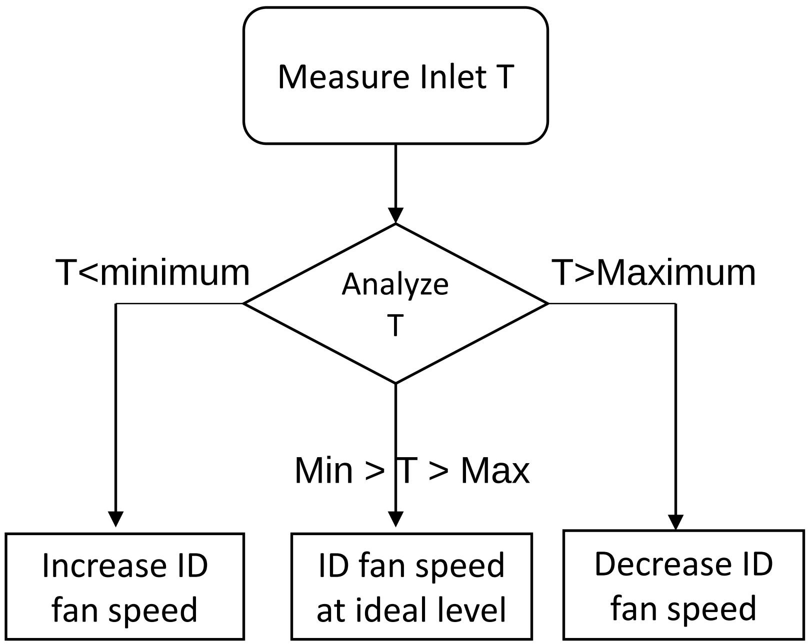
TRI Developments for energy saving

- Combustion control system to Hot Water Generator

Combustion control system to HWG

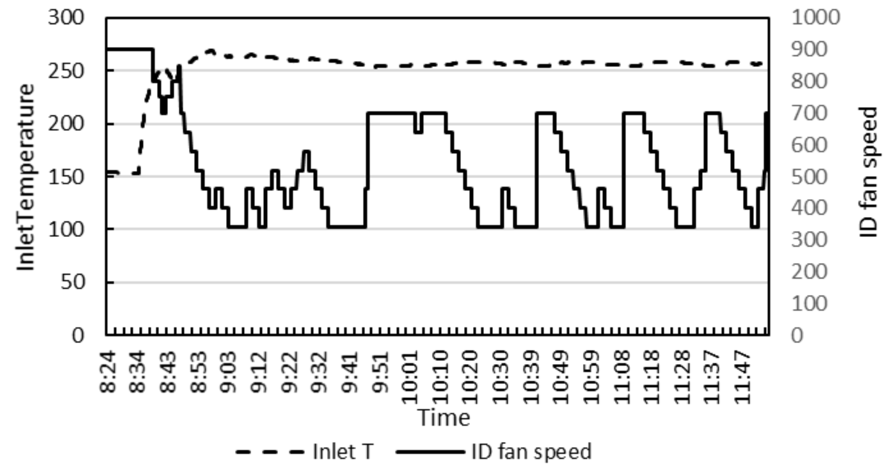
Controlling combustion by regulating ID fan speed automatically to obtain desired Inlet temperature in Dryer.

Control program



Data obtain from a trial

Dryer output	290	kg/hr
Firewood consumption	170	kg/hr
Specific firewood consumption	0.59	kg FW/kg MT



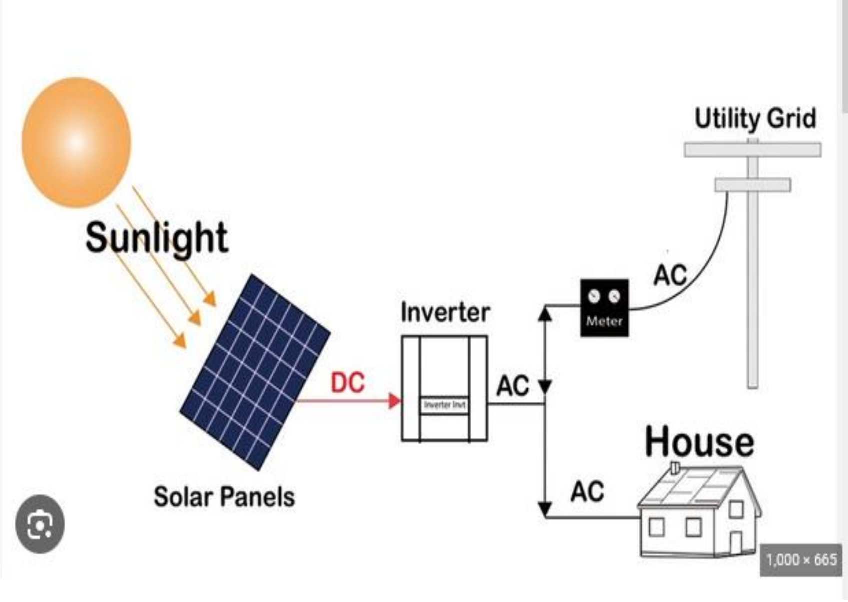
Renewable Energy for Tea Industries

Rooftop solar power generation

- A rooftop solar power system, or rooftop PV system, is a photovoltaic (PV) system that has its electricity-generating solar panels mounted on the rooftop of a residential or commercial building or structure.

components of a system include,

- Photovoltaic modules
- Mounting systems
- Cables
- Solar inverters
- Other electrical accessories.



Types of solar panels

Three main types of solar panels

- Monocrystalline (produced from pure silicon. Mainly used for power generation as this has higher efficiency 17-22%)

- Polycrystalline (efficiency13-17%)

- Thin film (efficiency10-18%)

For Typical Tea Factory

Total Capacity	- 250 kW
Module wattage	- 560 W
Module dimension	- 2278 x 1134 x 35 mm
Cost for module	- Rs. 28,500 + VAT
Total cost (latest)	- Rs. 37,500,000
Efficiency of the plant	- 21.68%

Installation

Rooftop solar installation is impacted by the following:

- Sunshine hours
- Latitude
- Weather conditions
- Roof slope
- Roof aspect
- Shading from adjacent buildings and vegetation

Structural analysis should be done by chartered Engineers or CECB or Estate Engineering Corporation or District Engineer for installation of PV modules

Tariff for Rooftop Solar PV (RTSPV) Systems

- Fix tariff

Capacity (kW, AC)	Tariff (LKR/kW)
Up to 500	37
More than 500	34.5
Solar aggregation	34.5

The revised tariff is effective from 2022-11-16 until further notice

- Variable tariff (adjusted every 3- 6 months)

Capacity (kW, AC)	Tariff (LKR/kW)
0<x<=20	48.89
20<x<=100	47.79
Up to 500	44.17
More than 500	43.77
Solar aggregation	34.5

Applicable flat tariff for 20 years agreement period

Factors affecting to the total annual photovoltaic power output

1. Solar radiation pattern at factory location – a software is available in the SLSEA website for this and experts use this for the feasibility analysis.
2. Capacity and efficiency of Solar PV modules – Example: Monocrome half cut modules, 400-450 W/module with 20 - 21% efficiency
3. Number of PV modules that could be installed on the roof
4. Tilt of PV modules (whether, all the modules are installed at optimum tilt)
5. Regular cleaning of solar panels –this need arises when dust in the exiting air deposit on the panels.

Advantages and Disadvantages

Advantages:

- Reduced electricity costs
- Renewable energy source
- Reduces greenhouse gas emissions
- Low maintenance

Disadvantages:

- High initial cost
- Reliant on sunlight (can generate electricity only on day time)
- Requires sufficient roof space
- Air pollution & whether effect on efficiency of cells
- Efficiency is low (below 40%)