REPLACEMENT OF STEEL / ALUMINIUM BLADE WITH FRP BLADES IN WITHERING FAN

(*ForJorhat Tea Cluster*)

Cluster Brief:

The Assam tea industry is one of the most enterprising tea-producing regions in the world. Tea estates in Assam collectively produce close to 507 million kg of tea every year, making the state of Assam the world's largest tea-growing region. The territory of Assam is characterized as having low altitude, rich loamy soil, ample rainfall, and a tropical climate which allows the region to produce some of the best loose-leaf orthodox teas. Only those teas grown and manufactured in tea estates located in the Brahmaputra Valley in the northeast India qualify to be called as Assam teas. In Assam, tea is grown both in the Brahmaputra and Barak plains. There are about 767 tea gardens in Upper Assam, out of which 471 tea gardens is having their own factory and 242 bought leaf tea factories (BLTF) run by the entrepreneurs. Tea cluster in Assam are mainly divided into three zones viz, Jorhat zone, Tezpur zone and Tinsukia zone.The sector is unorganized in nature, mostly using old and inefficient technologies. There is a significant potential to make these units energy efficient and cost competitive, through accelerated adoption of energy efficient technologies in the cluster.

Existing practice:

Withering is principally a drying process to remove the surface moisture and partially the internal moisture of the freshly harvested green leaves. In addition, withering is done to get the correct physical condition, which will allow the leaves to be rolled without breaking. Also, the withering promotes dissipation of heat generated during continuous respiration (chemical changes). There are two major types of withering, open or natural withering and artificial or trough withering. Usually, the green leaves from the tea estates are brought to the factory in the afternoons and are spread thinly on banks of troughs (tats). The troughs are made of metal wire meshes with wooden support on which tea leaves are spread and the air is blown from the bottom so that the air passes through green leaves.

The air is the exhaust from the heater, which is located at ground level whereas troughs are located in an upper floor. Withering is done at 20-25 ^{0}C depending on the climatic conditions. For best withering, a wet and dry bulb temperature difference of 4 ^{0}C is maintained. During withering, the moisture content of the green leaves is reduced to 55% (wb) (hard withering) for Orthodox tea production and 70% (wb) (light withering) for CTC tea production. Depending on the weather and condition of the leaf, the process takes about 6 hours for light withering and about 12-18 hours for hard withering. In withering, more air is blown in the initial stage and on an average the air flow rate should be reduced to two-thirds of its initial value. Once proper withering is achieved the airflow is continued to prevent the spoiling of withered leaves.

One of the critical equipment for the withering process is the withering fan. The withering fans have typically the following broad specifications:

Table 1: Basis specification of withering troughs

Sl.No.	Parameter	Range
1	No. of withering troughs per unit	2 - 32
2	No. of withering fans installed	2 - 34

Sl.No.	Parameter	Range
3	Rating of fan motor (kW)	2.2 to 7.5
4	Motor RPM	950
5	Casing Diameter	38-55 inch
6	Average air flow per fan	30000 – 50000 m^3/hr
7	Impeller Diameter	940-1200 mm
8	Number of Blades per fan	8

Conventionally, the withering fan blades were made of steel. With development, steel was replaced gradually by Aluminium. Aluminium being lighter than steel blades led to reduction of power consumption. The recent development has led to the replacement of Aluminium blades with Fibre-glass reinforced plastic (FRP) blades. However, the blades were non-axial in nature.

Proposed technology:

It is proposed to replace the conventional Steel/ Aluminum in withering fans with best-in-class Axial FRP blades. The technological advantages for adoption of axial flow FRP fans are as follows:

- ✓ Maximum fan performance with maximum air flow with minimum horsepower requirement.
- ✓ Light-weighted components including fan blades and impeller leading to less torque requirement on the drive.
- ✓ Improved fan efficiency by incorporating aerofoil design to maximize airflow and lesser number of blades.
- ✓ Higher service life, lower noise and less maintenance.

Note: In order to maximize the performance of the withering fans, it is proposed to incorporate IE-3 motors along with the axial flow FRP blades.

Justification of technology selection:

FRP, or fibre-reinforced plastic as it is also referred to, has been a blessing to multiple industries. Developed in the early 1900s and used mostly for military applications in the early stages, this material was quickly adapted to industrial processes that required a material that not only had a great strength to weight ratio, but one that was also resistant to many of the corrosive elements that are present in the production and transportation of chemicals and other corrosive materials. Gradually, FRP blades had its increasing use in the industrial cooling tower application.The advantages of using FRP in withering fan application compared to its metal counterparts like steel and aluminum are as follow:

Figure 1: Axial flow fan with airfoil design

- **Shape:** FRP fan blades are ideal for the withering application because they allow designers a greater degree of control over the shape of the fan blades and mold them

into the best shape possible to achieve the airflow that must be achieved. Traditional steel and aluminum blades could only be shaped to a certain degree before the structure of the blades themselves was compromised. Additionally, metal fan blades must be attached to an axis at multiple points, greatly increasing the chances that a connector will fail or the balance of the fan will be thrown off. Because FRP fan blades are molded into a single piece, there are far fewer points on the entire fan assembly that can fail. Even better, these fan blades can be shaped to the most optimal angle possible, meaning that they are able to circulate air more efficiently than steel / aluminum fan blade could ever hope to accomplish.

- **Resistance to Corrosion:** FRP fan blades are highly resistant to any and all corrosive elements and are able to stand the test of time in a way that is vastly superior to any other substance used in the construction of fan blades. Steel / aluminum blades, on the other hand are subject to corrosion, which effects the far performance on a longer time.
- **Weight:** Because withering fans tend to run at high RPMs, it is necessary to construct fan blades out of a material that is not only strong enough to stand up to the rotational forces that are placed on it but a material that is also light enough to place unneeded stress on the motor of the fan assembly. Before the introduction of FRP materials, aluminum was the best option for fan blade design because of its excellent strength to weight ratio. FRP fan blades, however, are even better than aluminum at providing a fan blade that is both strong and light.
- **Energy Efficient:** Due to its lighter weight, FRP fan blades draw less power for a particular air-flow compared to steel / aluminum blades. Also, the aerofoil design allows limiting the torque required for the drive thereby reducing the specific power consumption.

The table below summarizes the type of withering fans and power drawn for different grade of the fan material:

Table 2: Comparison of different grade of withering fan

Type of blade material	Steel Blade	Aluminum Blade	Axial flow FRP Blade
Rating of Fan Motor (kW)	5.5	5.5	5.5
Motor Speed (rpm)	950	950	950
Casing dia (inch)	48	48	48
Average air flow per fan (m^3/hr)	40000 to 45000	40000 to 45000	40000 to 45000
Impeller dia (mm)	1200	1200	1200
Number of blades	8	8	8
Loading of motor (%)	100%	90%	80%
Power consumption (kW)	5.5	4.95	4.4
Average operating hours	2880	2880	2880
Annual Power Saving per fan for the same air flow and static pressure Post intervention (kWh)		1584	3168

Estimated energy & monitoring saving:

Depending on the tea processed per month, units have different numbers of withering troughs. The number of withering trough typically varies for 10 to 35 nos. However, for calculating the energy and monetary benefits, only one withering trough has been considered. The energy and monitoring saving through replacement of aluminium blades with FRP blades in one withering trough has been summarized below:

Table 3: Cost benefit analysis for FRP based withering fan

Parameter	UoM	As is	To Be
No. of troughs installed	Nos.	1	1
No. of fans per trough	Nos.	2	2
No. of withering fans installed	Nos.	2	2
Type of trough		Closed	
Type of Fan Blades		Aluminium	Axial FRP
Rating of Fan Motor	kW	5.5	5.5
Average Air flow per fan	m^3/hr	40159	40159
Power drawn for the same air flow and static pressure (considering 90% motor loading)	kW	4.95	4.4
Saving in power drawn per fan for the same air flow and static pressure	kW	0.55	
Total Power Saving for all fans	kW	1.1	
Average running hours per annum for withering considering 200 days/annum and 24 hrs/day and 60% utilization factor)	hrs	2880	
Annual Power Saving	kWh/y	3168	
Weighted average Power Rate	Rs / kWh	8.68	
Annual monetary benefit due to power saving	Rs in lakh	0.27	
Estimated Investments per FRP Fan Impeller with hub	Rs in lakh	0.3	
Total Investment	Rs in lakh	0.6	
Simple pay-back	years	2.22	

* extracts of calculation provided

In case, in addition to the replacement of the withering fan blades, the existing motor is replaced with IE 3 motors, the energy and cost savings will be as follows:

Table 4: Cost benefit analysis for FRP based withering fan and IE 3 motors

Parameter	UoM	As is	To Be
Motor efficiency	%	84	89.2
Saving in power drawn per fan due to installation of IE 3 motor	kW	0.23	
Total Power Saving (due to motor replacement)	kW	0.46	
Total Power Saving (due to blade replacement)	kW	1.1	

Parameter	UoM	As is	To Be
Total Power Savings	kW	1.56	
Average running hours per annum for withering considering 200 days/annum and 24 hrs/day and 60% utilization factor)	hrs	2880	
Annual Power Saving	kWh/y	4493	
Weighted average Power Rate	Rs / kWh	8.68	
Annual monetary benefit due to power saving	Rs in lakh	0.39	
Estimated Investments per fan (for IE 3 motor plus fan replacement)	Rs in lakh	0.5	
Total Investment	Rs in lakh	1.0	
Simple pay-back	years	2.56	

* extracts of calculation provided

The benefits can be summarized as:

- ✓ 10-15 % reduction in specific power consumption
- ✓ Improvement in service life
- ✓ Less maintenance

Replication Potential:

The upper Assam tea processing cluster termed as "Jorhat Tea Cluster" under the project has close to 350 tea factories consisting of both bought-out tea factories and estate tea factories. These tea factories are operational in clusters in and around Jorhat, Golaghat, Sibsagar, Dibrugarh and Tinsukia. A large number of associations are operational in the cluster. The tea board of India is the governing body for the tea sector and is responsible for licensing of new units, maintaining quality, setting tea prices and promoting tea across segments. To establish the replication potential of the technology in the sector, the following were considered:

- ✓ Technology feasibility and adaptability through energy audits in 8 units.
- ✓ Survey of 100 units (under process)
- ✓ Meetings held with associations / stakeholders (including technology suppliers)

However, during the survey, it was observed that there is a significance knowledge barrier towards adoption of energy efficient technologies in the cluster. The identified technologies have either been implemented in limited number of units or have no implementation records. Most of the units showed interest for implementation only after successfully demonstration in the technology. Out of 50 surveyed units till date, the technology penetration for identified energy efficient technologies has been as follows:

1. FRP based withering fan : Implemented in 4 units
2. Withering process automation: Tried by 2 units; dismantled due to lack of after sales services.
3. Energy Efficient Modulating burners with temperature based automation in NG fired dryer: Modulating burners implemented in 8 units; however not coupled with automation
4. Automation and control system in Coal fired dryer: No implementation.

The proposed energy efficient technologies for Jorhat Tea Cluster have been identified based on proven track records in other clusters such as West Bengal & Coimbatore. The technologies were discussed in detail in two nos. of brainstorming meetings held at Golaghat and Dibrugarh respectively. Based on the deliberations, the units approved the technologies and agreed on their saving projections. unitsofreplacement of withering fans with FRP blade and IE 3 motor has a significant demand.

Considering the outcome of the energy audits and based on further discussion with associations, units and stakeholders, including technology suppliers and it is estimated that the technology has a replication potential in atleast 70 units.The tea processing factories has large number of withering troughs ranging from 10 to almost 40 in some units. For calculation purpose, 15 withering troughs has been considered per unit. Based on 20% replication, the overall project benefits will be as follows:

Table 4: Impact of technology replication

Parameter	UoM	Value
Annual electrical energy saving (one trough) – with blade alone	kWh/y	3168
Annual electrical energy saving (one trough) – with blade and IE3 motor	kWh/y	4493
Annual electrical energy saving (one trough) – with blade alone	MJ/y	11399
Annual electrical energy saving (one trough) – with blade and IE3 motor	MJ/y	16167
Annual energy saving (considering 20% replication) – with blade alone	MJ/y	11969186
Annual energy saving (considering 20% replication) – with blade & IE 3 motor	MJ/y	16975237
Annual CO_2 emission saving (one trough) – with blade alone	tCO_2/yr	2.85
Annual CO2 emission saving (considering 20% replication) – with blade alone	tCO_2/yr	2994
Annual CO_2 emission saving (one trough) – with blade & IE 3 motor	tCO_2/yr	4
Annual CO2 emission saving (considering 20% replication) – with blade & IE 3 motor	tCO_2/yr	4246
Estimated investment in technology (one trough) – with blade alone	Rs in Lakh	0.6
Estimated investment in technology (one trough) – with blade & IE 3 motor	Rs in Lakh	1.0
Estimated investment in technology considering 20% replication – with blade alone	Rs in Lakh	630
Estimated investment in technology considering 20% replication – with blade and IE 3 motor	Rs in Lakh	1050
Total Investment – for blade alone	in million USD	0.9
Total investment – for blade and IE 3 motor	in million USD	1.5
Total energy savings (in 10 years) – for blade alone	TJ	11.96
Total energy savings (in 10 years) – for blade and IE 3 motor	TJ	16.97
Annual CO_2 emission saving (in 10 years) – for blade alone	tCO_2/yr	29940
Annual CO_2 emission saving (in 10 years) – for blade and IE 3 motor	tCO_2/yr	42460

Barrier for implementation:

Altough the technology has been successfully proven in few units; there has been limited replication of the technology in the cluster. The barriers identified for limited penetration of the technology in the cluster are as follows:

- ✓ **Knowledge barrier:** Based on discussion with units, it has been found that knowledge dissemination related to the technology has been limited.
- ✓ **Unavailability of technology suppliers:** Although few of the technologies in the cluster are known to the units, the implementation has been hindered by the lack of technology supplier in the cluster.
- ✓ **Risk related to implementation:** The units lacks confidence related to performance of the technology. The risk of performance has been covered under the project.

Availability of technology supplier:

The technology of FRP based withering fanis well established. A large number of reputed technology suppliersare available for the technology. However, local service offices for the technology supplier need to be established. Some of the established technology suppliers are:

- ✓ Parag Fans
- ✓ Maya Fans
- ✓ Encon Fans