Annex-2

CASE STUDY- 2

Enviro-Friendly Innovative Hybrid - Bagasse Drying & Flue gas cleaning scheme for making Pollution Control as Revenue Generating Model – at Daurala Sugar Works

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ABSTRACT

Subsequent to the successful running of three consecutive installation of Bagasse Dryers at Daurala Sugar Works (DSW), a Hybrid Dryer was considered for instalaltion on their new 90 TPH Boiler commissined in the beginning of crushing season 2018-19.

A Hybrid Model is an integration of Flash Dryer for bagasse (FDB) with Wet Eletrostatic Precipiator (WESP). The idea behind introducing this set up first time in the sugar Industry, was to utilize waste heat from the Boiler flue gas while aiming to meet most stringent environment norms on particulate emissions.

With the emission norms getting more stringent, the capital expenditure on Air Pollution Control Device (APCD) is increasing. Fast eroding profit margins in sugar business, motivated the authors to study and come out with a technology integration, wherein, meeting environment norms becomes a revenue generating model and not viewed as dead investment. This philosophy led to conceptualizing Hybrid Flash Dryers for Bagasse (HFDB) as installed at DSW.

This scheme from Enviropol, has already been awarded the patent by Government of India (Patent No- 363763).

Keywords : *WESP-Wet Electrostatic Precipitator, FDB- Flash Dryer for Bagasse,APCD- Air Polution Control Device, HFDB- Hybrid model of Flash Dryer for Bagasse , APH-Air Pre Heater, DSW- Daurala Sugar Works, EEPL-Enviropol Engineers Pvt Ltd.*

1.0 INTRODUCTION

Daurala Sugar Works [DSW] is presently having a Battery of High Pressure Boilers firing high moisture fuel. [DSM, in its quest for increasing boiler productivity converged on the stack heat losses to be targeted; with milled wet bagasse as the primary fuel, considerable thermal energy available in the waste flue warm gas is being lost to the surrounding environment through the connected Boiler stack.

As it is a well-known fact that Moisture losses from the bulk, any significant reduction in moisture in Bagasse the fuel -should lead to increase in steam to fuel economy. This apart, the particulate concentration in flue gas leaving the Boiler stack would be high in the absence of efficient APC at Boiler back end. ENVIROPOL, addressed both Energy Conservation and Cleaner Environment formulated an innovative scheme conceived and termed it as HYBRID DRYER.

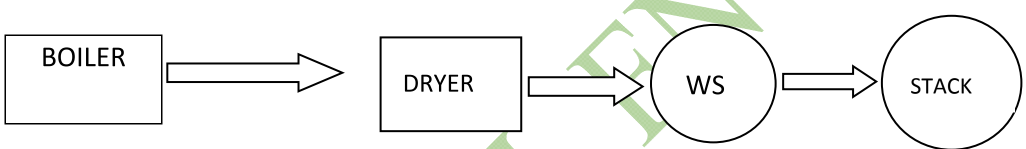
2.0 CASE STUDY – DAURALA SUGAR WORKS (DSW)

After successful operation of Hybrid Dryers during first ruhsing season, this Case Study is presented here highlighing their experience and learnings at DSW. The Case Study is divided in four Phases as described below :

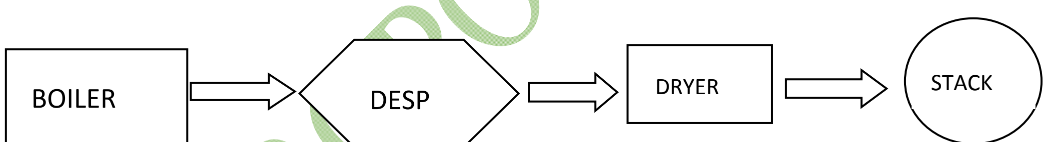
Phase-I : Study & Decision Making

Having rich experience on successful operation of three sets of Bagasse Dryers, Team DSW in association with Enviropol Engineers Private Ltd (EEPL) were exploring to utilize the hidden capability of substantially reducing the particulate emissions in the FDB. While going for a new Co-generaiton Boiler (90 TPH, 67 bar) last year, DSW had following three Options (Fig-1):

Option-A : To follow their existing setup with Bagasse Dryer & Wet Scrubber



Option-B : To follow Conventional Model with Dry ESP & Bagasse



Option-C: To opt for Hybrid Model consisting of Bagasse Dryer & Integrated

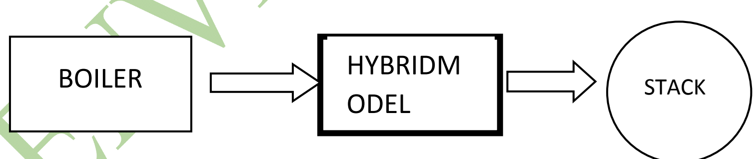


Fig. 1

After extensive research, study and visits made to see the functioning of WESP (Ref Fig 2) in Sweden, Option-C was concluded in view of following added advantages :

- Low Power consumption
- Most effective particulate control
- Smaller Footprints - Compact Layout
- Having APCD as last equipment before stack- uniform results on emission

Based on the above, a decision was made to proceed with HFDB despite the concern for not having any known refrence of similar installation around the world..

Fig. 2 WESP

3.0 BOILER DESCRIPTION

The steaming conditions of Cogen HP Boiler and other related parameters are elicited in Table -1.& the GA of boiler with hybrid Dryer is shown in Fig-3

TABLE -1

BAGASSE FIRED HP BOILER

Parameter	**Design Value**	**Units**
Fuel	Bagasse	
Moisture in Mill Bagasse	50	%
Steam Evaporation [MCR]	90	TPH
Steam outlet Pressure	67	Ksc
Steam outlet temperature	505	Deg C
Feed Water Temperature to Boiler Deaerator to Economizer	104	Deg C
Draught system	Balanced FD & ID Fans	
Back end Equipment	Economizer & APH	
SH Steam temperature Control	Interstage Attemperation between PSH & SSH	
Flue gas temperature at APH out	135	Deg C
APC	BD integrated with WESP	
Air Distribution-Multistage	PA & SA	

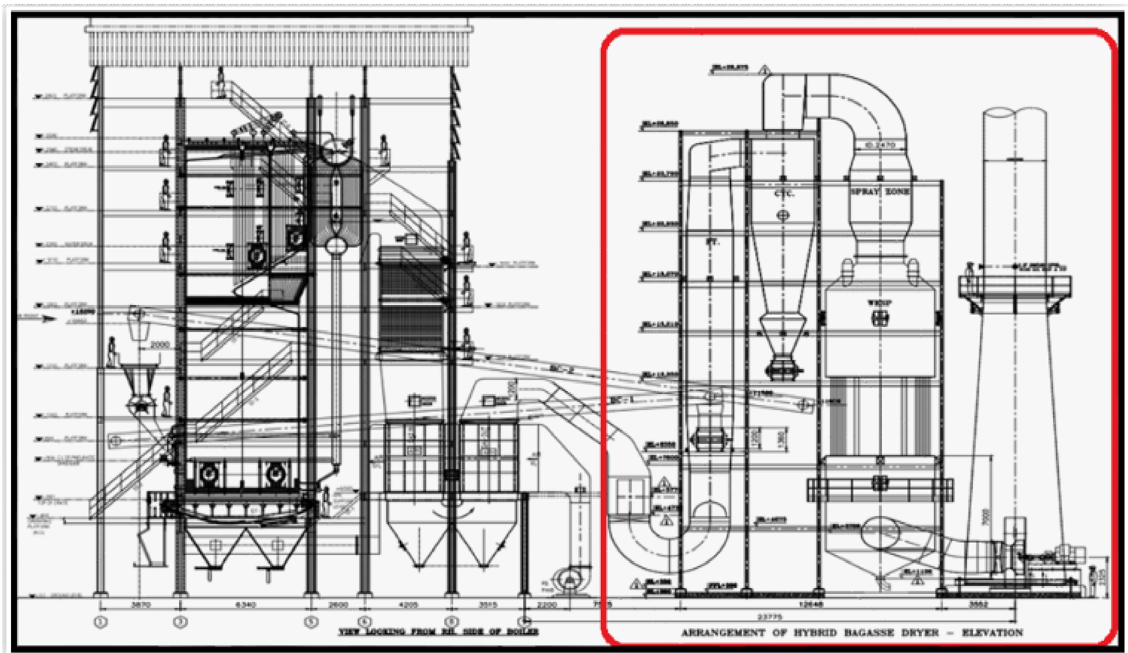


Fig. 3 G.A. Drawing of Bagasse Fired H.P. Boiler integrated with Hybrid Dryer

Warm flue gas leaving the economizer is passed through tubular APH wherein the air from ambient is being preheated before the same is led as combustion air onto the Combustion chamber.

The hot and dusty flue gas from the air heater is first passed through a flash dryer allowing the same to get mixed directly with wet Bagasse. During the process of Bagasse drying, the dust particle gets entrapped in the dried Bagasse.

The clean flue gas with remaining dust load of near 200 mg/Nm^3 is then made to pass through an integrated low pressure drop WESP for further cleaning down to as low as 10 mg/Nm^3 depending on the prevailing norms and target set by the end user

Flue gas flow path across Energy Scrubbing and Wet ESP

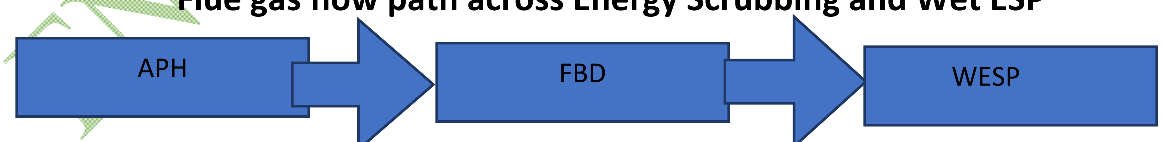


Fig.4.

Warm flue gas leaving air preheater is passed through Flash Bagasse Dryer [FBD] followed by WESP, before the clean de-dusted flue gas is sent to the connected tall stack with the help of ID fans (FIG-4)

The proposed integration, as shown in Fig.5., is capable of achieving the following major advantages:

1. Low emissions (< 10 mg/Nm3)
2. Reduced Drop in WESP (< 25mmwc)
3. Reduced capital cost on APCD-WESP.
4. Return on Investments due to Bagasse drying
5. Ability to control on gaseous pollutants

The HFDB at DSW was designed to handle 100% flue gas leaving at 150ºC after APH from 90 TPH Boiler and achieve :

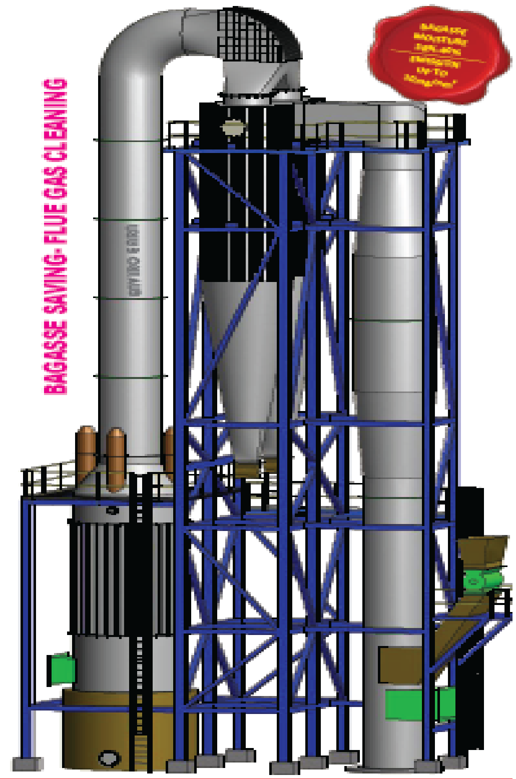


Fig. 5 HYBRID - WESP

Phase-II : Manufacturing & Installation

The complete System was designed by Enviropol under the collaboration with their Swedish counterpart for integrated WESP Technology. The Electrodes of WESP were imported along with Insulators and Heating Foils. Rest of the components were manufactured by Enviropol in India.

The system,as shown in Fig 6, was erected at Site within four months followed by electrical and instrumentation work within next one month time.:

Fig. 6 Hybrid System - Model

Phase-III : Commissioing & Adjustments

The Unit was commissioned within a week time after start of crushing season. During first few days of commissioning, one of the Insulator of WESP got cracked. The analysis revealed that due to high moisture content in the purging air, the Insulator got damaged. However,even with this problem, it was observed that the Hybrid system is capable of meeting current emission norms.

After replacement of Insulator and attending to other teething trouble faced during operation, related to air quality and ash deposition on gas distribution plate, the HFDB has been running successfully since January 2019 onwards(Ref Fig 7).

Fig. 7 Actual Installation - Hybrid Dryer

Phase-IV : Operation and Testing

The System was successfully operated till end of the crushing season. During the period, several testes were conducted under varying operating conditions to build up the data bank for future installations. On an average, the test results have shown reduction in bagasse moisture by 11 units with an outlet emissions ranging from 27 to 38 mg/Nm^3 as reflected from the one month data capcured abvoe.

Unlike Conventional model, such a high efficiency was recorded at lower voltage and current i.e at 30 KV / 400 mA (Ref fug 8)

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Fig. 8 Graph 1: 30KV at 400mA Trend Curve

During the fag-end of crushing season, wear & tear were noticed in some specific areas of HFDB besides deformation of non-matalic bottom positioning frame of WESP. Theses concerns have already been documented, analysed and being addressed during this off season as part of improvement on material slection in few areas.

Barring these concerns, overall operation has been consistant as depicted from operting dta compiled in table-2 & sumarised data for full season under Table-3 below:

TABLE-2

Operatiang Data-Feb 2019 : Represents :

MOISTURE REDUCTION 10-11 % POINTS, EMISSIONS – 31 MG/NM^3

Date	Flue Gas Temperature (ºC)		Bagasse Moisture (ºC)		Perticuate Emission (mg/Nm^3)		
	Dryer Inlet	Dryer Outlet	Dryer Inlet	Dryer Outlet	Dryer Inlet	Dryer Outlet	WESP Outlet
1.2.2019	133	77	50.8	39.2			
2.2.2019	134	77	50.9	40.1			
3.2.2019	138	79	51.2	40.3			
4.2.2019	135	77	51.0	40.4			
5.2.2019	135	77	50.0	39.8			
6.2.2019	132	75	50.9	38.8			
7.2.2019	128	74	50.7	39.5			
8.2.2019	133	76	51.3	40.1			
9.2.2019	134	78	51.1	39.7			
10.2.2019	136	78	51.2	39.6			
11.2.2019	137	77	50.9	40.1			
12.2.2019	141	77	50.7	39.3			
13.2.2019	133	76	50.9	39.7			
14.2.2019	131	74	51.3	40.2			
15.2.2019	128	75	51.2	40.2			
16.2.2019	133	75	51.2	39.2			
17.2.2019	136	77	50.8	40.3			
18.2.2019	133	76	51.2	38.7			
19.2.2019	130	75	50.7	40.2	4235	195	31
20.2.2019	127	75	50.8	40.0			
21.2.2019	131	77	51.2	40.2			
22.2.2019	134	77	51.3	40.8			
23.2.2019	132	76	50.8	38.9			
24.2.2019	136	76	51.2	40.3			
25.2.2019	132	76	50.8	38.9			
26.2.2019	132	75	51.2	38.8			
27.2.2019	131	76	51.4	39.0			
28.2.2019	134	75	51.7	38.8			

TABLE-3

SUMMARISED DATA OF FIRST FULL SEASON

Particulars	Unit	APH Outlet – Dryer Inlet	Dryer Outlet- WESP Inlet	WESP Outlet – Stack
Flue gas Temp	Deg C	140	71	68
Bagasse Moisture	%	50	40*	-
Particulate Emissions	mg/Nm^3	4000	195	35
Flue Gas pressure	mmwc	130	260	280

(*) Estimated bagasse loading on avg basis on dryer was 32 TPH as against 35 TPH designed capacity

4.0 ANALYSIS OF PERFORMANCE RESULTS

4.1 Waste Heat Recovery – Energy Conservation

Through scrubbing warm flue gas over the incoming wet bagasse at ambient, heat is directly transferred through reduction of flue gas temperature for effecting moisture in incoming wet bagasse reduction of 20 % [50% to 40%]. GCV of fuel increased in the same proportion; as can be seen from the month long tests conducted during month of Feb. 2019 Refer Table-4

TABLE-4

PERFORMANCE DATA WITH HYBRID BAGASSE DRYER

Parameter	Value with BD -Boiler	Units
Flue gas temp @ Bagasse Dryer in	140	Deg C
Flue gas temp @ Bagasse Dryer out	71	Deg C
Flue gas temp at WESP outlet	68	Deg C
Mois. In Bagasse in to BD	50	%
Mois in Bagasse out of BD	40	%
Draught loss across BD	260-130 =130	mmWC
Draught loss across WESP	280-260= 20	mm WC

4.2 Cleaner Stack- Environment Control

In order to meet the stringent air pollution norms – with the futuristic tightening of Clean Air act in the near future, with WESP at the back end of the boiler, the stack particulate emissions were recorded on an average at < 40 mg/Nm3 as can be seen from Table- 5 .As this would warrant additional draught of about 25-30 mmwc in for WESP, the small increase in overall station power consumption is unavoidable. Counteracting this, is the reduction in ID and FD fans Power consumption die to lowered FG & Combustion air flow requirements.

TABLE-5

Parameter	Value	Units
Particulate Concentration @ BD in	4000	mg/Nm3
Particulate Concentration @ BD out	195	mg/Nm3
Particulate Concentration @ WESP out	35	mg/Nm3
WESP Collection efficiency	82	%

4.3 Other facts & figures - Critical Analysis

With the modern design of high pressure boilers, the exit flue gas temperature is varrying between 130 to 140ºC. The flue gas based dryers, as under reference, have demostrasted a moisture reduction to the tune of 9-10 units while woking on design conditions even on such boilers.

With HFDB, an opportunity exist to extract more heat from the flue gas and allow the outlet flue gas temperature to reach near to the dew point. The performance of integrated WESP imporves as we go lower on flue gas temperatre.

As the outlet flue gas is near to the dew point after WESP, it is advised to take necessary protection against corrosion on succeeding equpment like ID Fan as normally being done with standard wet scrubber installlations..

5.0 SUMMARY OF FINDINGS

The combustion of dried bagasse in the boilers substantially reduces the heat loss on account of "moisture in fuel losses" resuliting increase in over all boiler efficiency .

5.1 Qualitative Benifits

- Bagasse Drying & Flue gas Drying -both in one
- Revenue generation through Additional Power generation & Particulate Emission Control well below MoEF/CC mandatory norms for Stack pollutants
- Substantial Control on Gaseous pollutants discharge
- Lower Power Consumption
- Carbon Emission reduction with increased Green Power and lowered GHG emission
- Smaller Footprint & Compact Lay-out for Enviro-Energy scheme

5.2 Quantitative Gains

- **BD & WESP integrated Particulate Emission reduction :** **> 99 %**
- **SPM in flue gas discharge through Boiler Stack-** **can be as low as < 10mg/Nm3**
- **Moisture reduction [& GCV in fuel increase]** :**18- 20%**
- **Net Bagasse saving**: **6-7%**
- **Productivity enhancement :** **5-9 %**
- **E carbon emission reduction-\:** **30-35 Co2 e/day**

6.0 TECHNO-ECONOMICS

6.1 Quantum Increase in Energy Gains

Through installation of Hybrid unit after APH of the bagasse fired boiler, not only SPM in flue gas discharge through boiler stack is drastically reduced but also moisture in bagasse is partly removed before the dried heated bagasse with increased heat content is fired in the furnace... Thermal efficiency of the boiler is increased by around 7 to 8 % [6 per cent points].

Considering the increase in thermal efficiency of the boiler, the gross mill bagasse saving is calculated at 2.25 TPH which is close to the actual savings validated by end user. This saved bagasse can easily produce extra HP steam to the tune of 5.2 TPH considering 2.3 as reported evaporation rate of boiler on mill bagasse.

With reported specific steam consumption of 4.0 kg / kWh [in condensing mode exclusively for Power generation] of installed HP turbine, the saved bagasse is capable to produce additional green power of 1300KWh.

6.2 Return on Investment

If we follow the power generation route, the net revenue works out to INR 88000 per day considering current power tariff of INR 3.0 /kWh to the grid.

The savings, on account of sale of bagasse to other industry is calculated to INR89000 per day considering the current rate of milled bagasse as INR1750/ Ton.

The above figure represents a Return on Investment of 600-700 working days for the complete hybrid model. If we set off the cost of conventional ESP from the total investment on Hybrid model, the return on extra investment is reduced to only 300-400 working days.

This truly represent the concept of "*Gaining while Greening*" – converting the Air pollution control in sugar Industry a revenue generating model.

7.00 OVERALL PERFORMANCE ANALYSIS

- The waste sensible heat in the flue gas escaping to the stack is being used for removing partly the moisture in fuel.
- The fuel is preheated by 50^0 C which also adds marginally to boiler performance.
- Flexibility exists for saved balance excess bagasse not required for safe storage in the yard for use at a later stage of use in the HP boiler-especially during lower cane crushing period specifically for power export to grid.
- Particulate reduction in flue gas after WESP in place ensures cleaner environment.
- Lowered excess air coupled with staged air combustion and preheated dried fuel admission is expected to contribute to NOx reduction to the tune of ~20%
- **RORT is < 2.0 years [Crushing Months],** Return extra investment over the conventional APC device (ESP)- < 1.2 Years [Crushing months]

- Furnace combustion temperature is expected to be higher due to lowered moisture and higher GCV in dried fuel fired as compared to the design stage. This would relate to reduction in N_2O [high potent GHG] further contributing to GHG Emission reduction.
- With increase in specific energy gains through increase in Steam economy[Specific steam evaporation], GHG Emission reduction through fossil energy offset with improved heat content in dried fuel and increased thermal efficiency of the boiler with bagasse dryer in place, GHG Emission Reduction is estimated at ~900 tCO2e/ month during crushing season

8.0 REPLICATION

Hybrid [Integrated BD and WESP] has great potential for replication in most solid fuel [fossil and agro] fired boilers as an add - on at the back end of the boiler.

9.0 CONCLUSION

The Hybrid Model of bagasse dryer is a way forward to view the investments on Air Pollution Control Device as revenue generating projects through bagasse saving. The Inetgrated Wet Electrostatic Precipitator, being the most advanced emission control technology in the world as on today, and its presence as last equipment before stack makes the Hybrid Model a perfect device to maintian cleaner environment even during varying operating conditions of Bagasse Dryer.HBD is truly an Enviro - Energy friendly integrated scheme

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