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REVIEW & ADOPTION Of BEST PRACTICES FOR RECOVERY PLANT & ENVIRONMENT CONTROL FOR Efficient operation & Cost reduction

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Abstract: ***The Main objective of this Paper is to provide guidelines and suggest various steps to the operating team members of Chemical Recovery to improve working in the department and de -bottle neck the process and suggest remedial measures continuous operation***

In this Paper we will discuss about various problems being faced in plant operation & how it can be avoided by monitoring & taking timely corrective action to avoid the occurrence.

This Paper is intended for the use of qualified personnel who are experienced in operation and maintenance of boilers and auxiliary equipment's. It is not intended or possible to cover all the possible variations in equipment and operating conditions or to provide for specific operation or maintenance problems, which may arise in day to day operation. Therefore, it is the operation's crew responsibilities to take appropriate measures in boiler operations in sudden disturbance and hazardous situations at their discretion in safe way.

Introduction: The prime purpose of the Soda Chemical Plant is to recover chemicals and heat from the black liquor, while performing to operate & run the plant under current stringent emission standards, in the conventional Chemical Pulping Process.

The most important factor in operation of the Recovery Plant is the fuel itself, i.e. the black liquor and its quality. Black liquor characteristics are the vital factors in designing & then operating the Recovery Plant. The variation in black liquor characteristics starts from raw material used, digester plant operation & cooking condition followed, pulp yield and brown stock washer's efficiency and Recovery plant operation.

The choice of raw material used for preparation Chemical pulp will mainly decide the type of equipment's to be used in evaporator & Recovery boiler.

Causticizing Plant configuration will remain mostly same with both wood based & agricultural based raw material like Bagasse & wheat Straw.

Type of plant for silica rich raw material will be different for lime kiln re-burning & Two stage causticizing Plant to be used for better & more efficient operation.

There are safety hazards in the operation of the Recovery Boiler, which must be monitored closely. Continuity in operation is a very important factor.

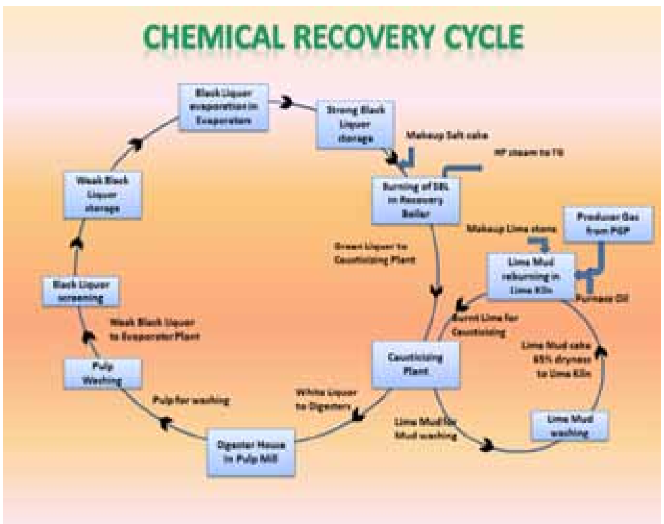
These operational problems result into poor quality of Black liquor, poor pulp quality, increased mill energy consumption and decreased mill production capacity at higher cost converts into lower profitability.

This also make difficult for mill to comply with stringent regulations in control of air emission from recovery cycle in particulate matter, TRS & recently NO2.

Taking small, small & various steps to prepare the plant for increased efficiencies, focusing on reducing cost & adopting new technology for future.

MATERIALS & METHODS

Simple flow sheet of chemical recovery process is given below



This process has four main function:

1-Recycling of of pulping chemicals like mix of NaOH & Na_2S / or only NAOH agro based raw material

2- Co-Generating Steam Power

3- Minimizing the environmental impact of waste material generating from process, maximizing use of lime mud use & convert it to reusable lime.

4- Key environmental challenges is control of air emissions from recovery cycle. The main concern been particulate matters, TRS, SO_2 & recently NO_2.

With today's increasingly high energy & chemical costs, and stringent environmental regulations that limit particulate & gaseous emissions, solid waste disposal & mill effluent discharge, the need of improved Recovery of Energy & chemicals from the black liquor has become a critical economic factor in chemical Recovery operation.

It is essential for mills to maximize the steam& power production capacity, reducing recirculating chemical dead load & minimize chemical losses.

The reliability and efficiency of evaporators, recovery boiler causticizing plant & lime kilns have a direct impact on the quantity & quality of white liquor and ultimately the quantity & quality of pulp produced.

The Soda Recovery Process has following major operational steps:

A – Concentration of dilute black liquor to the level making it suitable to be fired in Recovery Boiler.

B. Recovery of the sodium and Sulphur from the spent pulping liquor in forms suitable for regeneration of cooking liquor.

C. Recovery of the energy values in the liquor as high pressure steam

D- Conversion of recovered caustic in suitable form to be used in Pulp Mill

E – Re burning of lime sludge to active lime to be again used in Process within cost & also to meet control solid waste from plant

Major Factors affecting these Process are explained below & the importance of maintaining the correct parameters are mentioned below

Evaporation –

The black liquor rinsed from the pulp in the washers is an aqueous solution containing raw material lignin's other organic material and inorganic compounds oxidized in the cooking process.

Multiple effect evaporator often experiences problem of liquor side fouling, tube corrosion & fouling particularly as the liquor becomes concentrated. These problems result into frequent evaporator boil out, high steam consumption & low solids in product liquor.

Reducing the energy consumption by maintaining the cleanness of tubes, following proper washing cycle of concentrated effects, segregation and cleaning of condensates, handling of non –condensable gases are the most important factors

Recovery Boiler –

The process of burning black liquor in a recovery furnace is complicated. The chemistry of Sulphur retention and sulphide formation is not straightforward and only partly understood.

The formation of gaseous combustibles by the pyrolytic decomposition of black liquor solids and char gasification is critical to the combustion of liquor and is not well understood.

Material flows follow a complicated path with a number of internal recycle loops. Proper understanding of furnace chemistry and internal process is essential to the proper interpretation of the effects of operating variables.

The black liquor elemental analysis and gross heating value are the main factors to determine the chemical and thermal performance of the recovery boiler.

The organic and inorganic material in the black liquor is intimately mixed. Combustion in the furnace converts the organic material into gaseous products in a series of process involving drying, pyrolysis, char gasification and finally homogeneous combustion in the furnace volume.

Droplet size and size distribution are key variables in controlling black liquor droplet combustion, char bed combustion, smelt reduction, entrainment and carryover.

Black liquor sprayed into recovery boilers, should ideally form droplets small enough to dry before reaching the char bed but large enough to avoid being entrained in the furnace gas flow.

Two of the most important processes, which take place in the lower furnace during normal operation, are combustion of char and reduction of the oxidized forms of Sulphur, primarily Sulphate to Sulphide.

Causticizing -

In this plant problem often encountered are wide variation availability of quality of purchase lime, resulting in poor mud settling & washing efficiency, lower causticizing efficiency, high dregs carry over & in efficient dregs washing & removal system.

Main problem is low dry solids contents in Lime mud filter going to lime re-burning plant.

Depending upon the raw materials used the presence of non-process element like Chloride, silica & potassium, higher Na2So4 dead load create other operational problems.

Lime kiln –

In this plant main problem encountered is the dryness of Mud obtained from lime mud filter. Main reason is the type of raw material used. With wood raw material used in pulp there is no problem of silica, but with mills using combination of both wood & agricultural raw materials like wheat straw & Bagasse main problem is high silica content in calcium sludge obtained from causticizing.

Use of chemical additives for improving oil burning can be alternately can be used.

Oil burners manufactures also have to take lead in this to produce more efficient burners & need for getting highest possible dryness from lime Indian mud lime filter /alternate for imported filter will be main topics in Recovery eye-land.

RESULTS & DISCUSSION

Summary of Operational problems

The Chemical Recovery process is straight forward in principal, but it is not easy to operate in high efficiency range, key is to run the process without variation & study running without interruption.

Evaporator often experience problems with liquor side fouling, foaming & corrosion. These problems result in frequent boil outs, high steam consumption & low solids in product liquor. Recovery Boilers also have many problems including fouling of heat transfer tubes and plugging of flue gas passages, by fire side deposits, unsteady smelt run –off, high dregs in smelt, poor smelt reduction. low steam production & high air emissions.

In the causticizing problems often encountered are over-liming, poor lime settling and washing efficiency, high sodium & low dry solids contents in lime mud and dregs carry over to kiln.

Many problems can occur in lime kiln low thermal efficiency, high fuel consumption, ringing, balling, dusting, refractory & chain damage, poor lime quality,

ENVIRONMENTAL CHALLENGES

One of the Key environmental challenges is control of air emissions from recovery cycle, Main concern is Particulate matters

TRS (total reduced Sulphur) gases mainly H2S So_2 & now NO_2 .

The second major challenges is how to reuse various aqueous effluents within the pulp mill & recovery. Target is to reduce overall water usage.

Condensate is used where possible instead of fresh water. This requires greater efforts to clean up condensate, to make them suitable for reuse sometime after cooling. Any organic substances will also to be minimized.

Potassium & Chlorides also have large effects on recovery operation specially with mixed agricultural raw materials. A high potassium level in liquor specially in eucalyptus /hardwood increase fouling in recovery boiler, particularly when it is also accompanied by high chloride level. As a degree of mill cycle closure increase deliberate purges for CL & K from the recovery may be required.

To reduce the silica and AL is to use two stage causticizing process to reduce the level, but due to high capital cost only very few mill used this & other stopped this method.

But now 3-4 mills are in process to install lime kiln presently lot of focus have come on this process of lime sludge re-burning. Use of alternate heating medium, like producer gas, pet coke or natural gas is the top most priority

SAMPLE SHEETS FOR DATA RECORDING

- Section wise these are given below from Table 1 to 7 For the operating datas
- For comparison of operating cost details given in Table 8-10

Chemical Recovery section Questionnaire - Table -1

KPI

Parameter	Unit	Value
Recovery Efficiency	%	
Total Make up chemicals	Kg as Na2SO4/ T UBP	
Caustic for cooking	Kg as NaOH / T UBP	
Salt cake	Kg as Na2SO4/ T UBP	
Furnace oil consumption for RB	Ltrs/ T UBP	
Total Recovery Power consumption	KWH / T UBP	
Total Recovery Steam consumption	MT / T UBP	
Ratio of white &Yellow salt cake	:	
Steam generation as HP (net)	MT/ T BLS	

Black liquor characteristics

Parameter	Unit	Value
Raw material furnish at Pulp mill	%	
WBL Concn. , TS, % (w/w)	% (w/w)	
Inorganic /organic ratio	%	
RAA	gpl as Na2O	
TTA	gpl as Na2O	
‘pH		
Silica	%	
Suspended Solids at Evaporator inlet	ppm	

List out operational problems (no restriction on nos. of problems)

1. Leaky Lamellas affecting TBL concentration & pure condensate quality.
2. Water entering the control panel during rainy season due to low elevation.
3. Water conservation & gland cooling water circulating system status
4. Fouling of condensate during water boiling or liquor boiling of finisher
5. Mechanical seal status of pumps
6. Variable speed drive system status
7.

List out Maintenance problems (no restriction on nos. of problems)

1. CBL storage tank no-1 agitator low RPM causing jamming in the tank.
2. Leaky valves like finisher pumps valves
3. Time to bypass system (one body)
4. All instruments. temperature indicators. vacuumndiactors to be in working condition

Evaporator Plant Table -2

	Street 1	Street 2
Type of Evaporator (LTV/FFFF)		
Street No.		
Make		
No. of Effects		
Liquor flow pattern		
Water Evaporation capacity (Designed) , TPH		
Temp. Of WBL at pulp mill supply point °C		
Temp. Of WBL at Recovery inlet point °C		
Vol. of Black Liquor recd from pulp mill, m3/day		
Actual Water Evaporation, TPH		
Feed rate. Kg/hr		
Feed WBL concentration, % Total Solids		
Final TBL Concentration, % Total Solids		
Liquor feed temperature, 0 C		
Dry solid flow, Kg/hr		
LP Steam consumption, T/hr		
MP Steam consumption, T/ hr		
Steam consumption T/ T UBP		
Steam consumption T/ T UBP		
Steam pressure in evaporator plant, Kg/cm2 (g)		
Steam temp in the evaporation plant °C		
Steam economy		
Vacuum at Surface condenser, mm Hg		
Mode of vacuum		
-Cleaning frequency of steaming vessel		
- Cleaning frequency of 1st effect		
- Cleaning frequency of Vacuum effects		
Surface condenser inlet water temperature (separate for Summers and winters)		
Surface condenser outlet water temperature (separate for Summers and winters)		
Weak black liquor storage capacity, M3		
Thick black liquor storage capacity, M3		
Down time, hrs/ annum		
Power consumption, KWH /UBP		
All effects foul condensate level control system		
Permissible conductivity in foul /pure condensate		
High pressure cleaning done by which contractor		
Tubes cleaning (High pressure jet cleaning) cost per month, Rs		
High pressure cleaning rate, Rs./Hour		
Water, Acid, Caustic boiling schedule		
Mode of control system (Manual / DCS)		

Recovery Boiler -Table 3

Thick Black Liquor Analysis

TBL concentration, % (w/w)	
Calorific value Kcal/ Kg	
Solids, % (w/w)	
Inorganic /organic %	
RAA, gpl as Na2O	
SVI ml/gm	
Silica, %	
Viscosity cp at 90 deg C	

Recovery Boiler design parameters

Recovery Boiler No.	RB1	RB 2
Make		
Designed dry solid Capacity, tds/d		
Designed dry BLS GCV, kcal/ Kg		
Design black liquor solids, %		
Designed steam temperature, ºC		
Design steam pressure, kg. /cm2		
Design Steam production, t/t BLS		

List out operational problems (no restriction on nos. of problems)

1. Can not fired more than mt BLDS/day due to high temp in BB zone (high GCV of BLDS)
2. Time for continuous running before shur down for cleaning
3. Operation of soot blower operation is high or low
4. Air temperature ok or not
5. Status of particulate matter
6. Sulfate reduction /sulfidity status

List out Maintenance problems

1. Cannot operate soot blowers in Super heater & BB zone over 19 kg/cm2
2. Frequent soot blower glands failure
3. Frequent flue gas duct leakages
4. Liquor firing pump status
5. Tertiary Air pressure status ok or not

Recovery Boiler operating parameters

Recovery Boiler No.	1	2
Thermal efficiency %		
Black liquor firing, tds/d (All days average)		
Black liquor firing, Temp deg. C		
Black liquor firing, Pressure Kg/Cm2		
BL firing guns, no		
BL firing gun nozzle size / type		
BL firing type (oscillation/stationary)		
HP Steam pressure, kg/cm2		
HP Steam temperature, ºC		
HP Steam generation TPD		
HP Steam generation T/TUBP		Net
HP Steam generation, T /T solid fired (HP)		Net
Primary air flow, % of total air		
Primary air flow, TPH		
Primary air temp, ºC		
Secondary air flow, % of total air		
Secondary air flow, TPH		
Secondary air temperature, ºC		
Tertiary air flow, % of total air		
Tertiary air flow, TPH		
Tertiary air temperature, ºC		
Excess air at Boiler bank outlet %		
Flue gas temp after economizer, ºC		
Sodium sulphate Reduction ratio, %		
Primary air pressure at wind box, mm WG		
Secondary air pressure at wind box, mm WG		
Tertiary air pressure at wind box, mm WG		
ESP Secondary Voltage, KV		
ESP secondary current, mA		
% Na2SO4 in ESP Ash		
% NaCl in ESP Ash		
Cold shut frequency and duration		
Partial shut frequency and duration		
Cleaning mode – water washing / Manual		
Whether common FD fan or separate FD fans for Primary, Secondary and Tertiary Air		
BL system water boiling frequency like firing Ring header, mixing tanks etc.		
Steam used LP / T UBP+ MP/T UBP		
Power consumption / T UBP		
F. oil consumption T/ UBP (for Power House)		
Availability %		
Planned Downtime		
Unplanned downtime		
Soot blowing frequency / shift		
Total No of Soot blowers		
Soot blowers for Superheaters, Nos.		
Soot blowers for Boiler bank, Nos.		
Soot blowers for Economiser, Nos.		
SB operating pressure, Kg/cm2 (g)		
SB steam flow t/hr		
Mode of control system (Manual / DCS)		

CAUSTICIZING –Table 4

White liquor production, as Active Alkali TPD		
Green liquor processed T Na2O / day		
Lime consumption/ T UBP		
Lime consumption/ T of AA		
Lime purity (% CaO)		
MgO in lime, %		
Silica in lime, %		
Steam consumption, TPH		
GL processing rate, m3/hr		
GL temp to slaker deg. C		
Causticizer temp deg. C		
Hot water temp deg. C		
WL temp. at WLC Overflow , deg C		
Type of slaker		
Nos. of slaker		
Stages of lime mud washing		
White liquor production, m3/d		
Quantity of lime sludge produced, t/d		
Mud cake dryness, %		
Vacuum at filter Drum mm-Hg		
Vacuum at vacuum pump delivery mm-Hg		
Lime mud disposal (dry) T/day		
Mode of disposal of lime sludge		
Suspended particles in White Liquor Overflow		
Suspended solids at GLC inlet ppm		
Suspended solids at GLC outlet ppm		
Dregs handling system		
Mud settling aid, if any (type and quantity)		
Mud filtration aid, if any (type and quantity)		
Volume of WLC		
Volume of LMW S		
Volume of Green Liquor Clarifier		
Volume and no of Causticizers		
Volume of hot water tank		
Mode of control system (Manual / DCS)		
Man power/ shift		
Yield of WL from GL (%)		
Active Alkali of White liquor, gpl as Na2O		
TTA of White liquor, gpl as Na2O		
Causticizing Efficiency %		
NaOH in White Liquor, gpl as Na2O		
Na2S in White Liquor, gpl as Na2O		
Na2CO3in White Liquor, gpl as Na2O		
Na2SO4 in White Liquor gpl as Na2O		
NaCl, gpl in White Liquor		
Sulphidity of WL %		
WL Suspended solids to Pulp mill, ppm		
GREEN LIQUOR ANALYSIS (TYPICAL)		
NaOH in GL, gpl as Na2O		
Na2S in GL, gpl as Na2O		
Na2CO3 in GL gpl as Na2O		
Na2SO4 in GL, gpl as Na2O		
Total Alkali of Weak White liquor gpl		
Filtrate strength, gpl		
Dregs washer O/F gpl		
Mud consistency of WLC U/F %		
Mud consistency of LMWs U/F %		
Total Alkali as % Na2O in Filter cake		
CaO % in Filter cake		
Moisture content of Slaker grits %		
CaO % in Slaker grits		
Alkali as Na2O % in slaker grits		
Moisture content of Classifier grits %		
CaO % IN Classifier grits		
Alkali as Na2O % in Classifier grits		

List out operational problems (no restriction on nos. of problems)

1. Mud disposal during rainy season gets affected due to poor road conditions & unloading area.

2. Dregs removal from dregs washer where???

3. Dregs handling system

4. Filter for white liquor???

5. Water conservation & circulating system for pumps & vacuum Pump

6. Whether Two stage causticizing system installed or not

List out Maintenance problems (no restriction on nos. of problems)

1. WLC U/F distance pc and valves conditions are very poor.

2. Foul condensate from evaporator gets contaminated during water boiling & this spoils hot water quality in washing system

Lime Kiln-Table 5

Lime production design capacity, t/hr	
Make	
Length, m	
Diameter, m	
Type of Cooling for Lime,	
No. Of coolers	
Lime sludge feed, t/hr	
Temperature of lime sludge, oC	
CaCO3 in lime sludge, %	
Loss on Ignition (LOI) of lime sludge, %	Same As Above
Lime stone or sea shell feed, t/hr	
Moisture in lime stone, %	
Specific F. oil consumption, Ltrs / t lime produced	
Lime stone or Sea shell make up, %	
Actual Lime production, TPD	
Product lime temperature after coolers, oC	
Moisture in lime stone/Sea shell, %	
RPM of Rotary Kiln	
Temperature in the firing zone	
Feed end temperature	

List out operational problems (no restriction on nos. of problems)

1.Dryness of Mud????

2.

List out Maintenance problems (no restriction on nos. of problems)

1.

2.

ENVIRONMENT-Table 6

	RB1	RB2	Caust.	Lime kiln
E.S.P. outlet SPM.				
Flue gas temp. at ESP inlet, deg C				
Flue gas temp. at ESP outlet, deg C				
O2 content at Boiler bank outlet, %				
CO2 content at Blr bank outlet, %				
CO2 content at ESP outlet, %				
Oxygen content at ESP inlet, %				
Oxygen content at ESP outlet, %				
Mud disposal quantity, TPD				
Slaker and classifier grits disposal quantity, TPD				
Dregs disposal to effluent Kg/day				
Alkali losses through Rec drains Kg/day				
Temp of Recovery drains deg C				
S.D.tank vent scrubbing system				
S.D.tank vent temp, deg C				
SPM at Lime Godown, mg/ NM 3	NA			
If Lime dust extraction system, Yes / No				
SPM at Recovery Boiler operating floor				NA
HOUSEKEEPING LEVEL (on the scale of 1S to 5S)				
Evaporator				
Recovery Boiler				
Causticizing				
Rotary lime kiln				
No. of reportable accidents/year				
No. of non-reportable accidents/year				
Mandays lost /year				
Departmental safety committee meeting frequency				
No. of workers given safety training /year				

MANAGEMENT INITIATIVES- Table 7

QM	
No. of Dept. employees given TQM training	
No. of Dept. employees involved in TQM projects	
Total no of TQM projects completed	
Total no of TQM projects in progress	
Skill level of total workmen as on	
No of workmen identified for skill enhancement	
Expected skill level of identified workmen by	
Skill level of total workmen as on	

Table -8

Recovery - Sample Cost Sheet (All assumed)				
Particulars	**UOM**	**Qty/MT**	**Rate/Mt**	**COST/MT**
Production White Liquor as Na2O				
Recovery Chemicals	-			
Salt Cake- White	Kg	57	5,355	305.2
Salt Cake- Yellow	kg	3	3,539	10.6
Caustic Lye-Makeup	kg	5	22,200	111
Lime	MT	0.1651	7,500	1,238.53
Own Lime	MT	0.897	7,500	6,727.80
Furnance Oil	-	0.005	30,000	150
Total Chemical Cost				8,543.10
Power	Kwh	433	5.12	2,216.96
Steam	MT	9.25	1,606	14,855.50
Total Utility Cost				17,072.46
Cr for Recovery Steam		-12.15	1,606	-19,512.90
Total Cost				6,102.70

Chemical Recovery Plant - Basis of Calculations	
Alkali Charge -17 % as AA	
Bleached Yield 39.52%	
BD Raw Material Required -1/0.3952= 2.53 MT	
Active Alkali required per ton = 2.53*0.17 = 430.1 kgs /ton	
Make up required at 93% efficiency = 430.1*.07=30.1 kgs Na2O	
Make Up as such	Make up as Na2O
Salt Cake (White) - 57 Kgs	24.88
Salt Cake (Yellow) - 3 Kgs	1.32
Caustic -5 Kgs	3.87

Table -9

Steam Generation		
BLS calorific Value	3400 Kcal /kG	
Rec Boiler efficiency	58 % Approx	
Heat available for steam	3400 *58=1972 Kcal /Kg	
Enthalpy of Steam - Feed water Temp	766-125 =	641 K cal
Steam Gen /Kg	1972/641=	3.07 Kg / Kg

LIME COST CALCULATION –Sample cost sheet			
Kg/MT	Norms	Rate Rs	Cost Rs/MT
Coal for Gssifier	---		
Pet Coke	---		
Furnace Oil	195	30	5,850
Lime stone (15% make up)	163	3.25	529
Dynamix-F (Fuel- Catalyst)	0.102	202	21
Drainage Aid - NACLO 7560	0.452	274	124
Steam cons of lime prod	0.35	1,606	562
Power P/to of lime production	75	5.53	414
Total Cost			7,500

CONCLUSION

In any process operation, importance of operational data logging, making history sheet of operation problems regularly and regularly noting down variation of operational parameters are the best practices, the mill should follow. These data's give the true representation of Mill operation health.

If a mill is running without any major variation & fluctuations in consumption norms & other parameters is an indicator of good operational & Financial health.

Monitoring and recording of these parameters & then review of these data at departmental levels & at production and operation head level at profit center wise or Mill level is the best methodology can be adopted for operational excellence.

Variation will occur in any process but it should be explainable and data should point out the reason for variation. A sample of data should be recorded at department level is given bellow and can be modified as per need.

Comparison of these data with other mills should be a routine at some interval to know the comparative level one is standing.

Routine Mill visit of other units in highly recommendable for adoption of best practices being used in their mills.

Nothing is hidden nowadays, efforts should be to use best practices at continuously & all time. Process should be always on & continue.

Acknowledgements

This Paper was prepared to share my personal experiences in various Mills in India & abroad working with both agricultural & wood based Recovery & Pulp Plant. Every mill has his own particular types of problems related to type of raw material, type of equipment's installed & the management principles in use .

I take this opportunity to convey my sincere thanks to all Mill's Management who have helped in my growth during my carrier & this attempt is to repay back in sharing my experiences to helped all operational people in improving plant working & improving the profitability of the Unit where ever they work.