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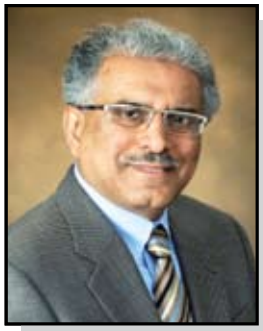
PROFICIENT WAYS OF PAPER MACHINE DESIGN CONCEPTS (Fluting/Linerboard machines)



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Abstract :

Paper is one of the most prominent input material used for packaging as compared to other packaging materials. Hencethesame has the high demand due to its cost effectiveness and environmental friendliness. Paper packaging is an eco-friendly option as the resulting damages to the environment are minimal. Moreover, the ban on the usage of LW plastic bags has impacted the paper packaging market positively.However, manufacturers are expected to face some challenges such as deforestation associated with the manufacturing of paper material.

The global paper packaging material market was valued at around USD 286.61 billion in 2015 and is expected to reach USD 362.65 billion by 2021, growing at a CAGR of 4.4% between 2016 and 2021. Paper packaging material market was dominated by Asia pacific with 35% share in 2015 due to advancement in the paper industry and government regulations.

This article gives an overview of some fresh concepts to install new paper machines and convert existing newsprint, writing &printing machines into kraft fluting/linerboard machines by implementing proficient know-how technologies.

1.0. INTRODUCTION

MiniMill Technologies (MMT) is a boutique DEPCOM (Development / Engineering / Procurement / Construction / Operations / Maintenance) firm and an eminent provider of turnkey solutions for the pulp and paper industry. MMT has been recognized in USA for implementing and leading successful projects such as brownfield remediation, design and construction of new mills, and conversion projects from Newsprint / Light Weight Coated Paper (LWC) to Kraft Paper (Medium Grade) in the packaging sector.

In the past, MMTI had participated in some most efficient projects of fluting and linerboard industries which are taken for reference in this article. This includes a new linerboard machine installed with brand new OCC recycling pulp line and conversion of two (2) existing (newsprint/ LWC grade) machines into high efficient kraft/fluting machines with very low capital investment for OCC line and fewer machine upgradation. (Refer: figure – A).

A – Reference Mill Data

Description	Units	New	Conversion	
		Mill # 1	Mill # 2	Mill # 3
Furnish				
OCC	%	90	90 - 100	90 - 100
Mixed Waste	%	10	0 - 10	0 - 10
Grade of Paper		Linerboard	Medium	Medium
Basis Wt.	lb / 1000 sq.ft	20 - 35	20 - 26	20 - 26
Year of Comission		Jul-2013	Dec-2013	Jan-2016
Reel production	stpd	1874	1200	596
Reel production	TPY	6,00,000	3,84,000	1,90,720

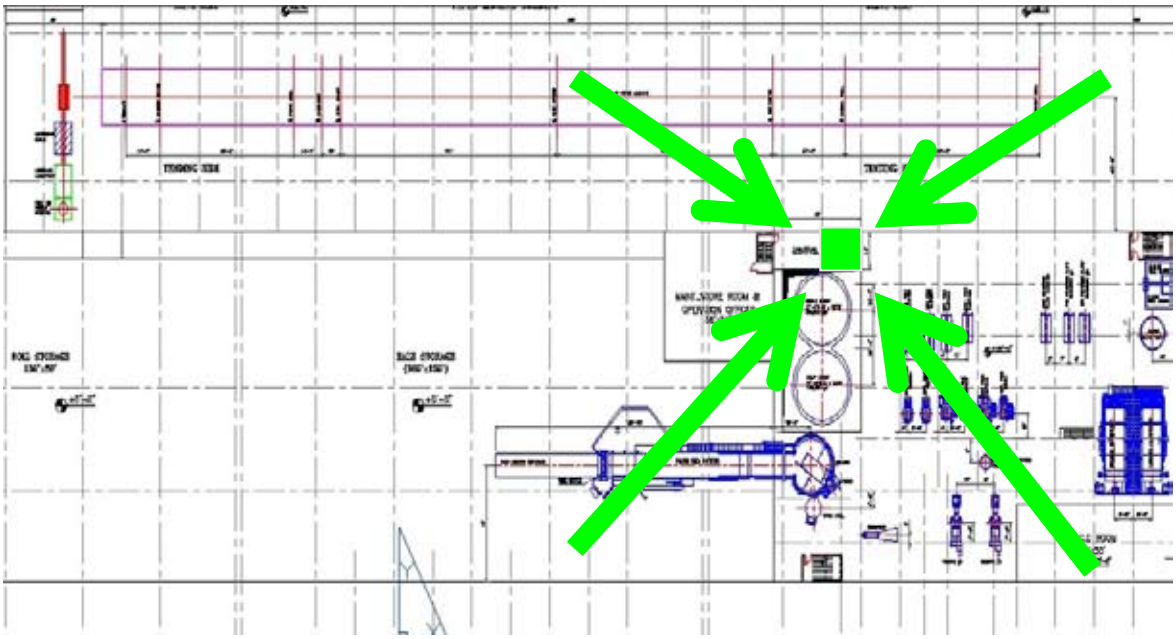
Compact Layout Design

- Designing a paper mill is not just about the size, but about the whole concept of building efficient one and with high automation and fewer trained & experienced people. It is possible to build a global scale mill on a minimill concept. Our goal is to build mills that meet the requirements of box plants and tissue customers, with a concept that is efficient, sustainable and profitable.

- Equipment Layout shall be designed effectively in such a way to create a compact "single department" concept (Common DCS for OCC Stock Prepand Wet End system) Ref. figure– B.

- Compact OCC & PM building with ware-house layout design looks confined yet convenient which brings down the investment on land.
- Inserting "Plug & Play" concept in almost all the process modules like OCC, stock preparation, paper machine, rejects handling and utilities and etc.
- Final broke tower and dump tower are located together in such a way to have the broke overflow directly feed into dump tank without any additional pumping.

B - Common DCS for OCC Stock Prep and Wet End



Transition of Paper machine modules

Proficient aspects to be considered while designing a fluting/linerboard machines:

- Basic design and dimensioning is are based on low energy consumption.
- Reduced number of drive points, no over dimensioning for future phases.
- Products shall be significantly lower basis weight which matches the performance of the higher basis weight product. This results in some savings of MSF.
- Separate plies for optimized ply split, low tensile MD/CD ratio and better formation.
- Long dewatering tables for optimized headbox flows and gentle dewatering.
- Optimized number of dewatering elements and with low friction covers.
- Press section with high dryness and wet pressing (densification) – shoe press with top side of the sheet against plain roll for improved smoothness.
- Minimized or no open draws from press section to the dryers.
- Minimized open draws through dryer section for runnability and minimized shrinkage.
- Higher fabric tension for improved sheet contact to the dryer surface.
- Size press for better smoothness and to assist higher burst factor
- Oil heated Calender with high loading.
- New runnability components with low air flow requirements optimized for grade and speed.
- Size of auxiliary systems.

Headbox upgradation:

- The headbox as the link from the approach flow system to the forming section is one of the most important tools for reaching best paper sheet properties. The need to achieve best sheet quality criteria such as CD basis weight profile, fiber orientation, homogeneous sheet structure, and so on, largely depends on the headbox concept.
- Packaging grade fluting/linerboards, is greatly measured as the selection of headbox and flow patterns would strongly decide the end user's (Box converting/manufacturer) service demands such as compressive strengths (RCT, SCT, ECT,BF & BCT), tensile stiffness index (TSI), low tensile MD/CD ratio and so on.
- Though the RCT and burst test are the most commonly accepted methods in Asia region, SCT is the efficient parameter to define the exact compressive and structural capabilities of linerboards.

Why Headbox with Dilution water profile control ?

- Fluid friction occurs at the sides of the headbox and against the slice lip surfaces. This results in a drop in the pressure at the two gables, therefore, a lower exit velocity. One can compensate this by pumping in white water there to boost the pressure.
- The web edges are freer to shrink in the CD than the rest of the web. This shrinkage gives the edges higher basis weight unless the slice bar is lowered at the edges. However, a slice bar adjustment results in edge waves and fibre misalignment.

- Shear field occurs at the headbox sides which tends to orient the fibres and create a fibre-free layer at the wall. Uneven exiting velocity from the turbulence generator especially at the sides is a common problem.
- To subdue/minimise/overcome all the above mentioned drawbacks, headbox with dilution water control system with CD profile control would be the right choice. The fibre orientation profile can be optimized by the slice lip, the basis weight profile can be influenced through the dilution water system with profile control. The dilution control system on the headbox ensures the independent optimization of the paper sheet properties, CD basis weight profile and fiber orientation. (Refer: figure – C).

Benefits:

- More uniform basis weight and fibre angle profiles.
- With dilution control headbox, the slice can be built smaller and sturdier, thus allowing a shorter free jet which has several advantages.
- The edges are not stretched more than the rest of the web, and therefore, do not shrink excessively in the cross direction.
- The dilution can be varied significantly without influencing the total flow rate from the module; this is an important feature to avoid cross currents on the wire and resulting fibre angle deviations from the machine direction.

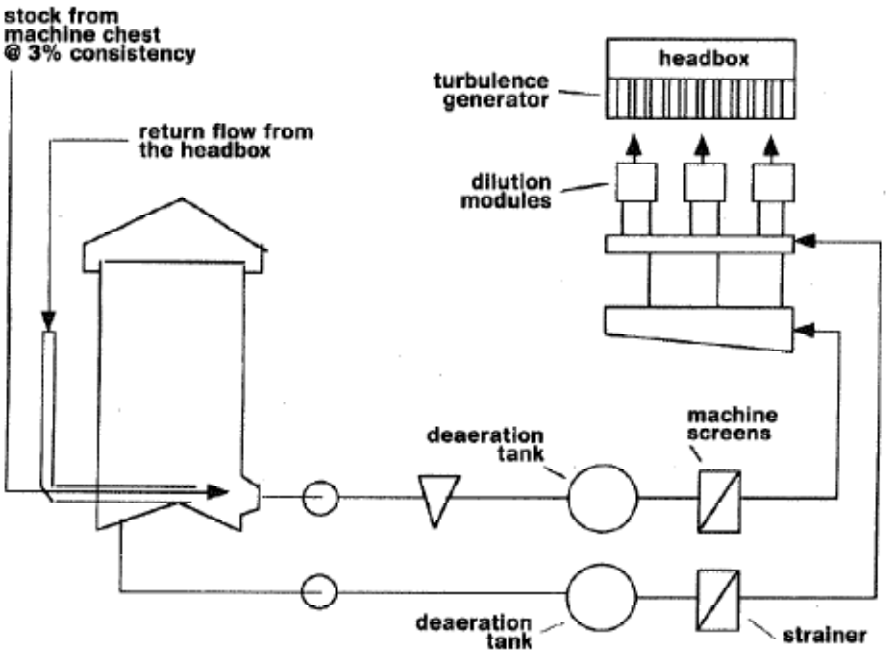
Press section upgradation:

- A shoe press can have considerable impact on both capital and energy costs for a new and rebuildkraftor linerboard paper machines.
- Raising the dryness level after pressing, from 45 to 50%, we can achieve 20% reduction in water evaporation and a comparable reduction in the number of dryer cylinders.
- Moreover, the high dryness after pressing reduces the CD shrinkage considerably. So that a higher trim is obtained. (Refer: figure – D).

Shoe press configuration:

- Exemplary conventional tri-nip press section with shoe press in 3rd nip position is beneficial for fluting/liner grades up to lower and intermediate basis weight ranges. The 3rd nip shoe

C - Schematic of Headbox for CD profile



D–Shoe Press(Figure: a) & Tri Nip Press with Steam box (Figure: b)

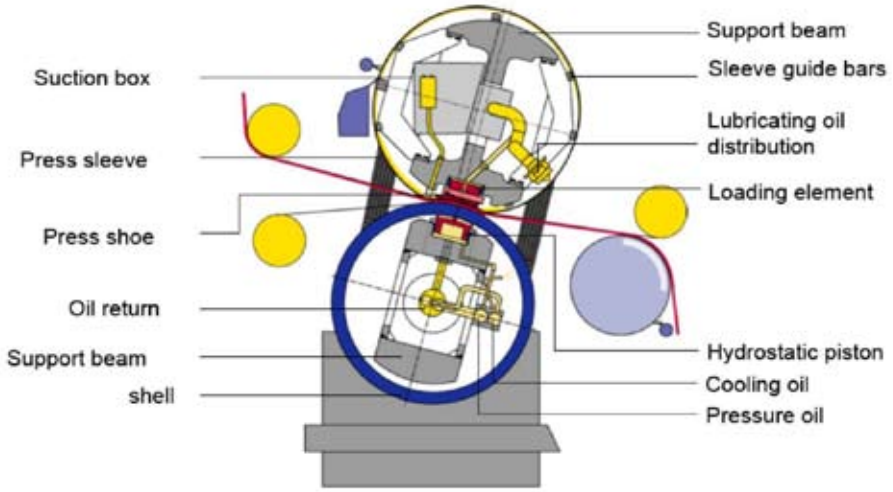


Figure: a - Shoe Press

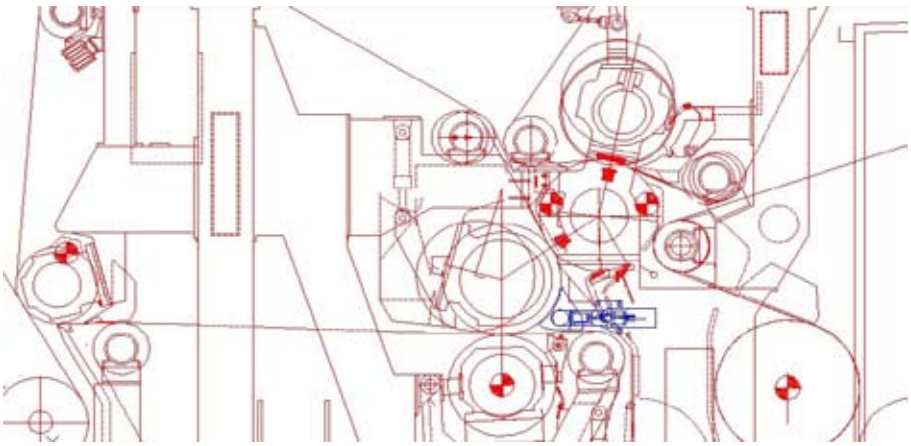


Figure: b – Tri Nip Press with Steam box

press usually is single felted with ceramic/solid centre roll to attain appreciable smoothness and higher dryness value. The centre roll has a ceramic cover for low adhesion and in anti-deflection. In this arrangement, one side of the paper only contacts with felted roll which is conducive to two-sidedness. However this can be addressed in the calendaring.

- One or two separate shoe presses with double felted arrangement is recommended for higher basis weight linerboard grades. The double felted press, has a longer press nip, half the flow path for expressed water to reach the nearest paper/felt interface, and half the flow rate per unit area of paper/felt interface.

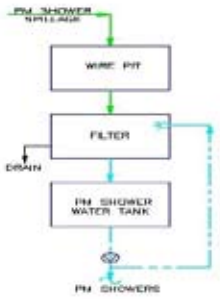
- A serious drawback of double felting is the doubled rewetting. Rewetting is proportional to the surface area of the paper, and therefore, inversely proportional to the basis weight. At heavier basis weights, the advantages of double-felting are more than the disadvantages.

Steam boxes:

- A steam box is often placed opposite the suction box of a suction roll. The steam from the box is then sucked into the paper web and condensed there. From an efficiency view point, it would be better to heat the web at last nip, but too much steam escapes into the atmosphere without the suction roll. Steam should not be sucked through the paper into the felt; where this occurs, the steam outflowing the paper is wasted.

- In general, increasing sheet temperature from 10 - 14 °C in the press section will improve sheet dryness by 1%, leading to increased production or comparable 3-4% reduction in steam consumption in the dryer section (TAPPI TIS 0404-22). The steam pressure in the box is generally 15kPa only. The web temperature going into the dryers is increased which allows the operator to increase the steam pressure/ temperature in the dryers without fiber picking.

E – Closed loop PM Shower water system



Closed loop shower water system:

- Instead, of the wire rolls shower water being mixed with PM WW circuit through wire pit, recoverthe shower water spilled in wire pit by introducing a gravity filter andreuse them. By doing so, the shower water tank make up will be minimised.

- Filtrate from Uhle box seal tank also shall be reused for PM showers with the help of simple gravity filters which is quite common in practice. (Refer: figure – E).

Vacuum system upgradation with Ecopump turbo blower:

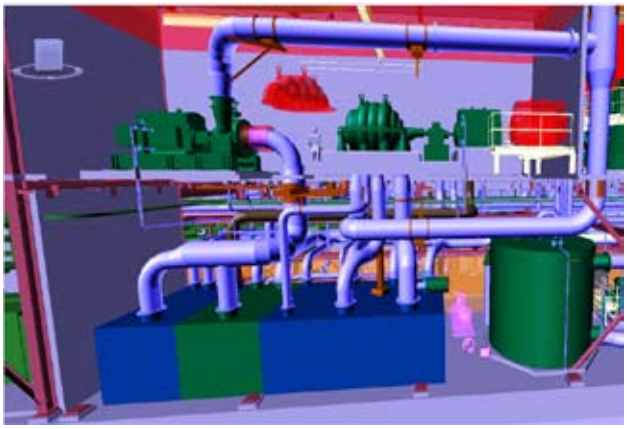
- Replacing the conventional liquid ring vacuum pumps with high energy & efficiency multi-stage turbo blower (along with or without single stage turbo blower depends on the paper machine vacuum requirement) will have considerable impact on capital cost but substantial cost saving on energy over long operation.

- Further, substituting with the latest state of art technology, Eco pump turbo blower preserves layout space and easy maintenance.

Benefits over conventional turbo-blower:

- Easy to operate, optimal energy conservation, no need for sealing water circuit since it is a dry system, easy fine tuning to get the best out of the process, ability to adjust the vacuum level one by one in DCS, online maintenance measurements and its simple construction gives way for easy maintenance.(Refer: figure – F).

F–Vacuum Blower Cross Section View

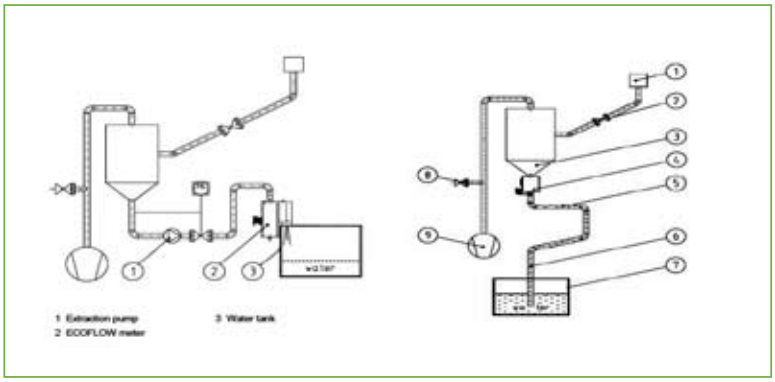


Flow meters to determine the press section dewatering:

- It is a simple flow meter installed in press section uhle box drop legs that uses weir measurement principle.

- The water flows through the specially dimensioned vertical weir. The water forms a column by which the hydrostatic pressure can be measured. This pressure can be translated to the flow volume by using calibration data.

G – Flow meter in Uhle box drop legs



- The flow dewatering meter has been developed for felt control on the paper machine. The performance of different felts can be compared by measuring the water flow from save all's and suction boxes. With the help of press section dewatering meters, the operation of the forming section can also be followed. (Refer : figure – G).

Recuperation of Potential Energy:

From outbound effluent & PM condensate:

- Final mill effluent and PM return condensate has some heat energy which can be utilized to pre-heat the fresh water by employing water to water heat exchangers. The resultant warm water is used in PM shower water purpose. (Refer: figure – H).

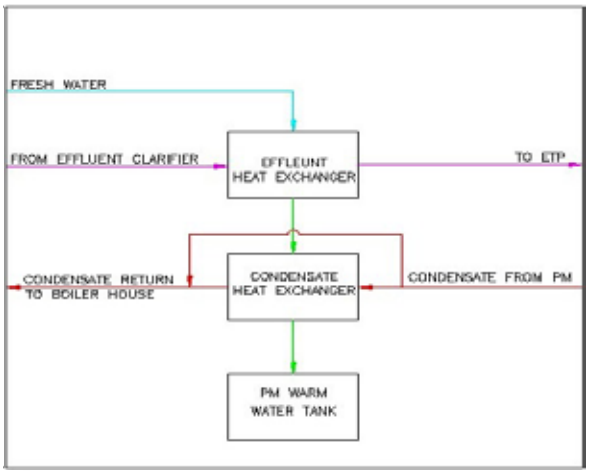
Cutting off energy losses:

- Mill wide energy consumers are of two cases, intermittent and continuous.
- This continuous consumers like stock and water pumps, vacuum turbo blowers etc. are the main sources where useful energy is being wasted by the throttling of control valves and bleeding ports at discharge points.
- Using variable frequency drives wherever possible (>50% of mill pumps) to eliminate control valves will redeem the usable energy. (Cost of instruments as well). (Refer: figure – I).

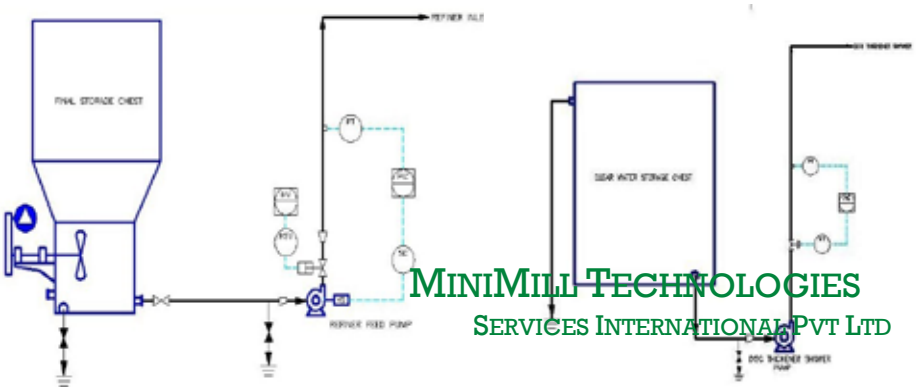
Conservation of fresh water:

- As we are facing at present the crisis of fresh water scarcity, make sure all stock and water pumps, agitators for tanks and towers are equipped with dynamic seals and no sealing water system is required. Noteworthy items in the cost balance sheet include the monitoring costs and the expenditure for the replacement of parts subject to wear and tear, which are unavoidable with conventional seals.
- Moreover, In addition to the cost of a separate sealing system, the plant also has to consider the cost of power to run the seal water pump and the cost of fresh water. The high operating reliability averts emergency shutdowns and is therefore a definite advantage especially with process systems. In a typical papermaking mill, the costs – resulting from a single stoppage of the plant with corresponding production short fall caused by the mechanical seal – are almost as high as those needed for the required. Noteworthy items in a period of ten years.

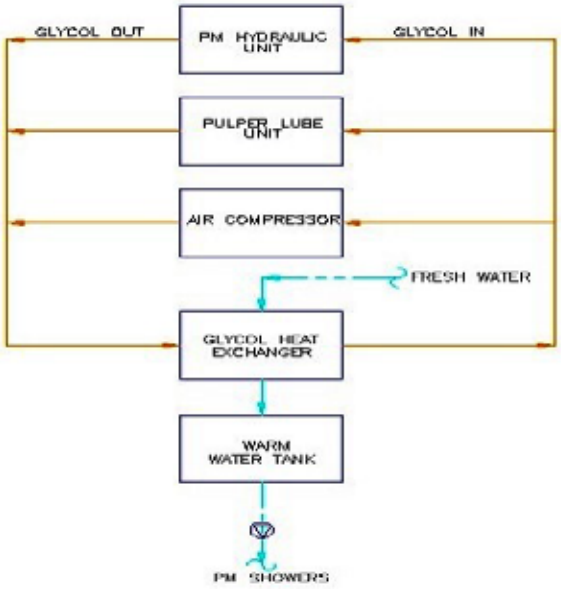
H – Potential energy from out bound effluent and PM condensate



I – Conceptual VFD Vs Conventional control loop



J – Conceptual closed loop equipment cooling system



a) Another area where we are required to use fresh water though it can be substituted by other media is heating and cooling system of equipment. The fresh water is used as coolant in equipment such as pulper gearbox, air compressors, turbo-blowers and Paper machine hydraulic

❖ As we thrive under heavy fresh water scarcity& crisis at present, make sure all stock and water pumps, agitators for tanks and towers are equipped with dynamic seals and no sealing water system is required. Noteworthy items in the cost balance sheet include the monitoring costs and the expenditure for the replacement of parts subject to wear, which are unavoidable with conventional seals.

units, HVAC cooling units etc. Hence this closed loop equipment cooling water system can be converted into a complete closed loop of glycol system where no make-up fresh water is required.

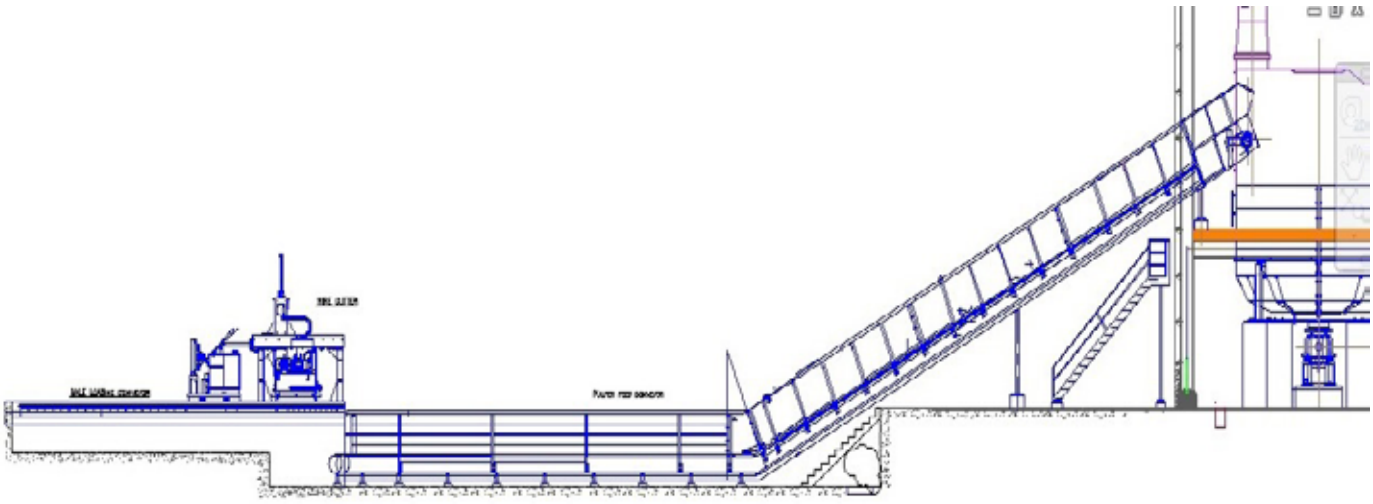
However, for the existing mills, if the capital cost can be justified and if the design of the existing closed loop fresh water system has enough excess capacity to absorb the extra energy that a glycol system requires (i.e., the heating/cooling load can be comfortably met with the existing water system), it will be suited well. The standard materials of construction (i.e., steel, cast iron, copper, brass, bronze, solder and most plastics) that are found in closed loop water systems are also acceptable for use in glycol systems.(Refer: figure – J).

Green thoughts in OCC recycling plant:

c) Bale loading conveyor (Walking floor conveyor):

- Need of frequent maintenance and repair in conventional OCC bale feeding conveyor is quite common in an OCC plant. Maintaining uniform pulper discharge consistency around-the-clock in a recycling plant is also an inconceivable task. These two issues are somewhat associated with each other to the extentdue to the following.(Refer: figure – K).

K – Cross view of Bale loading conveyor& OCC Pulper



a) OCC raw materials are fed directly on the feeding conveyor by fork lifts.

b) Damages of conveyor slots caused by rough handling of OCC bales and loading vehicles while feeding,

c) Regardless of conveyors with variable speed drive, it has to be operated on timer sequence mode which interrupts the uniformity of pulping consistency.

d) Pulper will be fed with randomly ordered bales and shuffled as conveyor had to stop/start for bale cutting operation.

- To protect the feeding conveyor from major damages and run the pulper with stable output consistency, it is suggested to install a walking floor conveyor where we can employ manual/automated cutting operation and leave the feeding conveyor in continuous running mode with respect to measured consistency value at pulper discharge pump.

Benefits:

a) Maintenance free operation of bale feeding conveyor,

b) Better pulper performance and uniform discharge consistency which improves the performance of subsequent recycling plant modules such as HD cleaning, coarse screening etc,

c) Increased plant uptime in turn, higher production probabilities and less operational cost,Process stability and uniform pulp quality since the classification of bales based on fibre quality is possible on the walking floor conveyor. Refer figure (OCC Feeding Sequence).

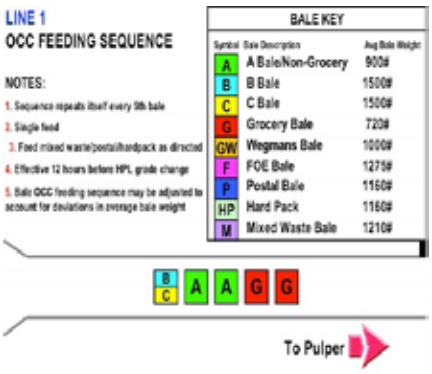
d) The walking floor conveyor speed can be synced with bale feeding conveyor and is of hydraulically operated. Thus ease off maintenance.

Gas pedalling of OCC production:

- The pulper discharge consistency measured at pump discharge is used to compute the actual pulper production (bdtpd) by relating it with HDC accepts flow. This value is taken as reference for pulper feed control (interlocked with feeding conveyor speed) and coarse screening feed.
- This helps us to have an automated control over the production and pulper performance.

Minimill Water circuit:

- A well designed water system is essential for management of paper fines and contaminants that can have a negative impact on paper quality. Prompt usage of OCC filtrates and paper machine white water circulation is the egress of "Minimill" concept. There's no need of separate fibre recovery system for fluting and linerboard paper machines. (Refer: figure – L).
- All the excess white water from the PM excess white water chest is to be consumed in OCC plant fine



screening and light weight cleaning consistency dilution and rest are stored in a water storage tower.

- During enormous white water flow, itshould be treated in the process clarifier and taken back to the process. This results in efficient water recirculation and fibre recovery with minimum system equipment. Fresh water is limited to a few specific locations in the paper machine area only.
- Recycling of Water: Any spills or excess water from routine wash ups will make it's way to the U-drains. The U-drains are collected in various sumps and then pumped to a process clarifier so the water can be reused in the process.

Centralised rejects handling system:

Excellence in housekeeping:

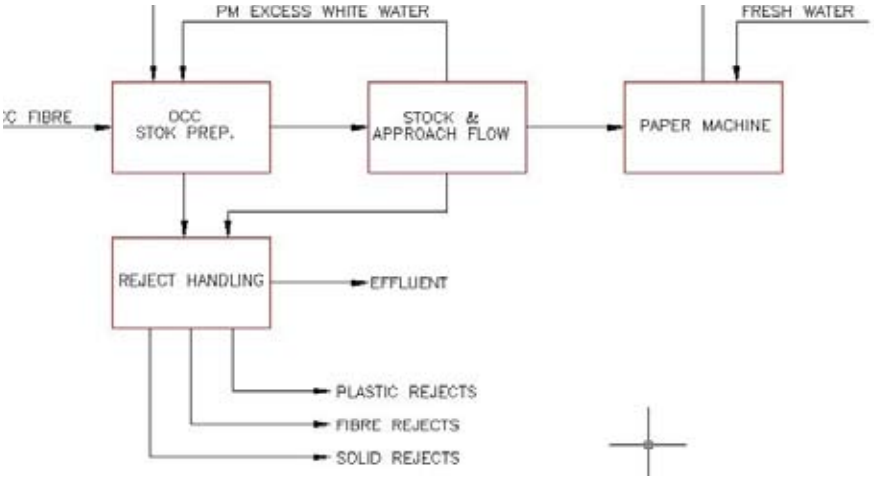
Floor wetting and rejects accumulation are the major cause for congestion under the pulper area in ground floor. The flooding of rejects and water on the ground floor leads to major accidents to personnel and makes maintenance of equipment around the pulper area, a difficult andtime consuming task. It can be avoid by adopting the following alternative methods.

a) Grapple Hoist:

- Replacing the conventional junk trap with grapple hoist will eliminate the floor wetting and rejects spill below the junk trap. The grapple hoist pulls out the heavy weight contaminants from the top of the junk tower, thus no dumping of rejects and water at the bottom through junk trap. This also eliminates the troublesome operation of junk trap jam removal and dumping valves.

b) Spill containment system:

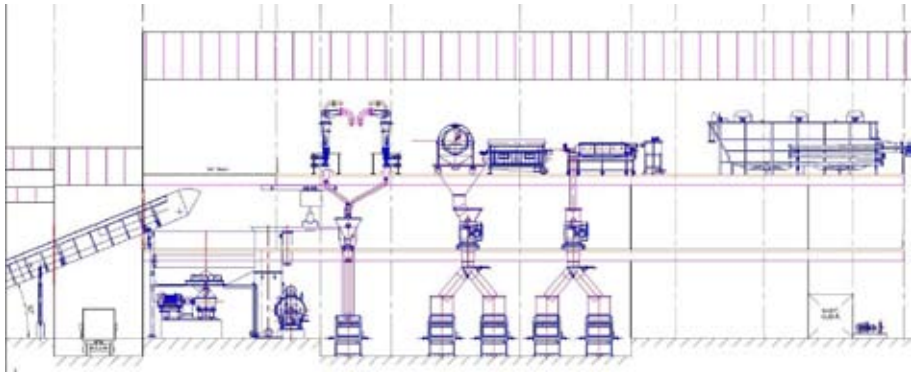
- Spills from pulper, dump tower and operating floor stock tankages are piped to a dedicated spill containment tank which will be located near pulper. This is to prevent the pulper and other pulp tank sover-flowing to the pulper pit through



drains/trenches which is tedious when the pulp slurry consistency is on the higher side. The idea is no pulp flow in the drain routings. All the spills are pumped back to the pulper in a controlled manner.

- Handling, transportation and disposal of rejects out of the mill premises plays a vital role with environmental protection agencies and their regulatory norms. The concept of "Centralised rejects handling system" makes foresaid functions

M – Centralized Reject Handling system



possible in simple and efficient way. Also rejects leaving out of an OCC mill such as ragger tails, drum screen rejects and final screen sludge are still have some money value being left idle.

- Further compacting of each type of rejects with dedicated compactors helps to reduce the volume of rejects which makes the handling and transportation much easier. The idea is to collect all kind of rejects in a single place, categorise them based on their composition, and separate them in such a way to transport them to the relevant destinations.

a) Centralize ragger tails and heavy metals – metals segregation; ferrous metals to steel manufacturing companies and non-ferrous metals disposed outside.

b) Centralize light rejects& plastics for recycling – HD Plastics to plastics manufacturing facilities and LD plastics to incinerators or to cement plant kiln as fuel substitute.

c) Centralize fibrous rejects for recycling – as a fuel substitute in power boilers,

d) Design to reduce operating costs and increased safety around rejects handling

Conclusion:

- Though this article will not cover the entire liner board machine areas starts from the development of preliminary concepts for each specific machine configuration to the saleable end product in the loading bay, it may enlighten every paper maker a bit to conceive many new ideas and serve the fluting and linerboard industries to their best.
- The performance targets tabulated here against the traditional way, is achievable if all the aforesaid concepts, designs and changes are adopted.

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