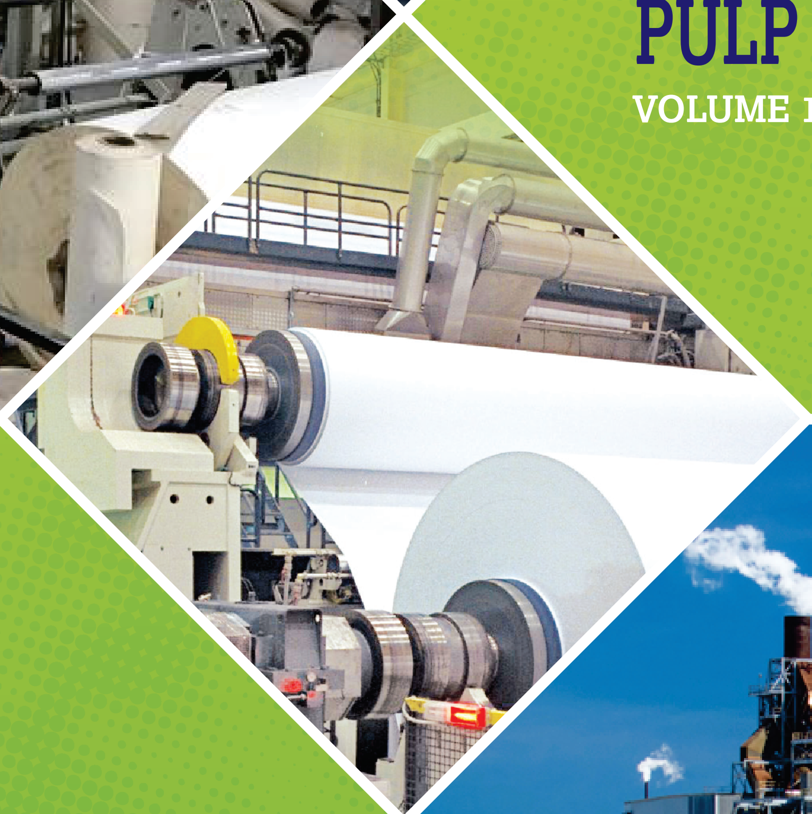
Confederation of Indian Industry

BEST PRACTICES MANUAL
PULP & PAPER INDUSTRY

VOLUME 10



DISCLAIMER

While every care has been taken in compiling this Manual, CII-Godrej GBC and Indian Paper Manufactures Association (IPMA) accept no claim for any kind of compensation, if any entry is wrong, abbreviated, omitted or inserted incorrectly either as to the wording space or position in the manual.

The manual is only an attempt to create awareness on Energy, Water and Environmental management and sharing of best practices being adopted in Indian Paper industry and the international cleaner production technologies.

Published by Confederation of Indian Industry

CII-Sohrabji Godrej Green Business Centre,

Survey # 64, Kothaguda Post,

R District, Hyderabad 500 032

India.

FOREWORD

The Indian Paper industry has been highly competitive. Competition, as we know, is not only from our competitors within India, but also from external players in the form of imports. As you know well, paper that is being imported to our country is at a reduced or 'NIL' duty, under various "Free Trade Agreements".

To combat such competition, we need to produce a quality product at a competitive cost and deliver the same "on time".

We also should be proud that we are in an industry where the product and the input raw materials like Wood, Agro Residue or Waste Paper are sustainable, and the process of manufacture is environmentally friendly.

The sector in itself is highly energy- and water-intensive, and therefore has a lot of potential for improvement. These two ultimately lead to a necessity where we all have to closely watch the environmental performance of the mill.

We have to do everything possible to reduce our energy consumption and maximise green energy usage to meet our energy requirement.

Some parts of our country are going through a tough drought situation. It is therefore our responsibility to consume less water for every tonne of our production.

It is in this respect that this conference, viz. PaperTech 2019, assumes great significance. The conference will focus on Energy, Environment and Water related issues of our industry.

I am happy to inform you that in this conference, there will be more than twenty technical paper presentations covering the above subjects, and it is also proposed to release a "Best Practices Manual" covering the best practices adopted in various paper mills, which will be useful to other paper mills.

I really appreciate the efforts and help provided by various paper mills in sharing their data for publication in the Best Practices Manual.

I thank all CEOs of the paper mills for their guidance and support for this wonderful programme.

My hearty congratulations to the working group who have taken enormous pains to put together all best practices and convert the same into a very useful manual.

I am sure that the Best Practices Manual, which is now going into its 10th year, has been continuously benefiting and inspiring paper mills to learn and implement new practices. CII will be happy to hear from the units about such implementations, and to take valuable suggestions to further improve them. These "Best Practices" will go a long way in helping our paper mills conserve energy, water, etc., and also become more and more environment friendly.

Sanjay Singh
Chairman, Paper Tech 2019
Divisional Chief Executive, ITC Ltd., PSPD

PREFACE

Paper Industry is one of the key manufacturing industries in our country, which contribute significantly to the GDP. Paper is a noble product that not only helps spread literacy among the masses but is a very strong medium of communication. Just like many other manufacturing industries, our industry also faces many challenges.

The following are opportunities which, if focused on, can help us face some of these challenges:

- Optimal utilization of resources like Energy, Water and Raw Materials.
- Converting waste to wealth.
- Environment Management.

PaperTech is a great forum which brings like-minded engineers and technocrats together in finding innovative ways to tackle these concerns. "World Class Energy Efficiency in Paper Sector", which is one of the thrust areas of PaperTech, is an excellent initiative taken up by CII with the support of all the stakeholders. It provides the much-needed platform and support to all of us in handling these issues. The activity, now running in its thirteenth year since inception, has come a long way in serving and benefiting all of us.

This initiative follows a unique model of "Learning through Sharing". It engages all stakeholders and creates a conducive environment where we all meet, deliberate on, and share our knowledge without inhibitions, to achieve the common objective.

The activity has given us immense benefits, be it the improvements in the operation of our plants and machineries or creating awareness on the latest trends and technologies. The platform has attracted many international agencies like Swedish International Development Agency (SIDA) and Swedish Energy Agency (SEA) to work with us. Their association with us has given us detailed insights into international technologies and best practices adopted by international paper plants.

Perform, Achieve &Trade (PAT) and Renewable Purchase Obligation (RPO) have become the reality. We now have Mandatory Energy Audits in place. On the one side, the regulations have created many opportunities, indicating areas of improvement, but at the same time, they pose many challenges to the plants for compliance. This forum has created an opportunity for us to interact amongst each other and also interact with the Government agencies like Bureau of Energy Efficiency to understand regulatory aspects better, and prepare to meet the requirements.

“The Best Practices Manual”, which is being released every year, showcases our efforts and implementation of project ideas in our plants. All these ideas are technically feasible and commercially viable, and have very high replication potential. These ideas can be fine-tuned to meet individual requirements. I am thankful to all the technology suppliers and plants for coming forward and sharing these case studies.

I wish that everyone connected with our industry gets an opportunity to go through these manuals, evaluate the case studies, modify the ideas to suit their respective plants, and explore the possibility of implementation. A thoughtful implementation will definitely give you the desired benefits.

I wish you all the very best.

A S Mehta
President, IPMA & President & Director, JK Paper Ltd.

ACKNOWLEDGEMENT

We wish to express our sincerest regards to the working group on "Make Indian Pulp & Paper Industry World Class" for their invaluable contributions.

We deeply express our sincere thanks to the following paper plants for sharing the technical information for the identified best practices:

- Seshasayee Paper and Boards Limited, Erode.
- Tamil Nadu Newsprint and Papers Limited, Karur.
- Emami Paper Mills Ltd., Balasore.
- ITC Ltd., Kovai.

We would also like to express our gratitude to the following technology suppliers for providing case studies:

- Forbes Marshall.
- ETA Purification.
- Turbotech Precision Engineering Pvt Ltd.
- Retas Enviro solutions Pvt Ltd.
- Elof Hansson India Pvt Ltd.
- Chargewave Energykem Pvt Ltd.

We also sincerely thank the following committee members for their contribution to bringing out the "Best Energy Practices Manual, Volume 10".

- Dr T G Sundara Raman (Enmas Pulp & Paper Projects Ltd.).
- Mr. Ganesh Bhadti (Vice-chair Papertech 2019, & Vice President – Technical, Seshasayee Paper & Boards Ltd.).

EXECUTIVE SUMMARY

The Indian Pulp & Paper industry has taken several efforts in the recent past for improving its environment performance. However, energy, water and environment continue to be the key issues for the sector. The available quantity and quality of water for the paper plants even pose challenges for regular operation.

The recent government regulations such as "Perform, Achieve and Trade" and "Renewable Purchase Obligation" have given additional fillip to the efforts taken by the industry for improving their energy efficiency levels and utilisation of renewable energy sources. At the same time, these regulations also have posed many challenges to the industry for meeting the requirements.

The Indian paper sector has reacted to the challenges positively, and taken initiatives to address the issues related to energy, water, utilisation of renewable energy and environment performance.

Against this background, CII-Sohrabji Godrej Green Business Centre has been promoting the concept of “Make Indian Pulp & Paper Industry World Class” with the support of all the stakeholders in the Indian Pulp & Paper sector for the last 12 years.

The main objective is to facilitate continuous performance improvement in energy, water and environment, and help them in achieving the world class standards. This has been taken up through the following:

- Visit to the best operating pulp & paper industries in India and identifying the best practices adopted in various sections.
- Compiling the best practices in the form of a manual for information sharing amongst the paper plants.
- Identification and transfer of technologies suitable for Indian paper plants and adoption of the same.

DEVELOPMENT OF "BEST PRACTICES MANUAL"

The 10th edition of the Best Practices Manual has been developed with the support of various stakeholders. Apart from focusing on energy, water and environment performance, the 10th edition has a special focus on energy, environment and chemical leasing concepts

The manual was developed based on the information collected from actual implementation of projects from leading Pulp & Paper plants and technology suppliers from India.

A separate discussion paper on “Circular Economy” has also been presented at the end of the manual, to introduce the concept. International case studies from the Pulp & Paper sector also have been included to highlight its importance, and strategize the need for the same in the Indian paper sector.

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HOW TO USE THE MANUAL

The objective of this manual is to act as a catalyst to promote activities in the Indian Pulp & Paper industry towards continuously improving the performance of individual units, and achieving world class levels (with thrust on energy, water & environmental management).

To set a clear goal for improving the performance and move towards international standards, the best practices adopted in some Indian Pulp & Paper plants and latest technologies from suppliers have been included as a part of the "Best Practices Manual Pulp & Paper Industry".

These best practices may be considered for implementation after suitably fine-tuning the requirements of individual units.

Suitable latest technologies may be considered for implementation in existing and future Pulp & Paper plants for achieving world class energy efficiency. Further investigation needs to done for the suitability of these technologies for individual plant conditions.

The collated best operating parameters and the best practices identified from various plants need not necessarily be the ultimate solution. It is possible to achieve even better energy efficiency and develop better operation and maintenance practices.

Therefore, Indian Pulp & Paper plants should view this manual positively, and utilise the opportunity to improve the performance and "Make Indian Pulp and Paper Industry World Class".

BEST PRACTICES FROM UNITS

CASE STUDY 1: ELIMINATION OF CAUSTIC ADDITION DURING OXYGEN DELIGNIFICATION

BACKGROUND

The Bagasse pulp from the digester is screened, washed in three stages of Twin Roll Press (TRP) and mixed with sodium hydroxide. The pulp is deposited in the oxygen reactor; steam heated and injected with gaseous oxygen to undergo oxidative delignification. After ODL, pulp is washed to remove the dissolved lignin before moving to the bleach plant. The lignin content in Bagasse ODL pulp is reduced by maximum 20% as kappa number, resulting in reduction of bleaching chemicals and chlorinated compounds. Effluent from the oxygen reactor is recycled in pulp mill and recovery cycle, further reducing the dissolved solids going to the bleach plant, as well as effluent load from the bleach plant. The net effect is reduced effluent flow and less solids generation.

Normally, oxygen delignification in CBECF is carried out in alkaline pH range of above 10.5 to control effective solubility of dissolved lignin from Kraft pulping. Higher pH >10.5 increases the delignification efficiency, but simultaneously decreases the dissolved lignin content in bagasse washed pulp. In this project, through extensive laboratory studies, kappa number reduction data were carried out before implementation. Before implementing this project, R&D officials called for a meeting with the top management of the pulp mill to discuss the laboratory trial results of bagasse pulp properties before and after ODL, pollution load reduction, and cost savings, etc. There were no significant bottlenecks observed for implementing this project.

PROJECT DESCRIPTION

In continuation of the lab scale study, the ODL stage caustic addition was reduced accordingly by elimination of caustic addition with continuous laboratory monitoring of kappa number and alkali loss. The process was implemented in CBECF Fibre line continuously from May 2015 onwards. The results show that reduced sulphuric acid addition in D_0 stage has improved pulp bleaching without affecting pulp properties and reduced TDS in D_0 effluent. The target brightness was achieved easily, if the ODL stage without caustic addition was done effectively by proper washing of reaction products in POW_1 stage and extracting alkali soluble compounds in POW_2 stage and followed by chlorine dioxide bleaching. During the modified ODL stage, behaviours of both POW_1 and POW_2 pulps were found any differences in kappa number and alkali loss.

Figure 1: NaOH Valve in closed condition

The caustic added ODL pulp shows high initial pH which consumes more sulphuric acid in D_0 stage and maintains higher TDS level in D_0 filtrate which let out into the effluent. There was no change in pulp brightness and pulp properties. However, the caustic eliminated ODL pulp consumes lower sulphuric acid in D_0 stage followed by lower caustic addition in extraction stage without affecting pulping characteristics. The caustic elimination in ODL stage and sulphuric acid reduction in D_0 Stage do not significantly reduce any of the bleached pulp properties assessed.

The caustic consumption was eliminated in ODL stage and subsequent sulphuric acid reduction in D0 stage followed by sulphur dioxide (SO_2) addition was stopped in D_0 tower outlet pulp due to lower residual chlorine content in D_0 filtrate.

SAVING DETAILS

The project does not involve any significant investment. The details of savings as achieved by the unit are given below:

Table 1: Annual saving Figures

S. No.	Chemical	Before Implementation	After Implementation			
		Kg/MT	Kg/MT			
		2014-15	2015-16	2016-17	2017-18	2018-19
1	NaOH	540	Nil	Nil	Nil	Nil
2	H_2SO_4	1,832	852	583	1037	997
Annual chemical consumption		2,372	852	583	1037	997
Annual Chemical saving		-	1,520	1,789	1,335	1,375

Table 2: Total cost savings per annum

S. No.	Chemical	Cost saving after implementation in Rs.			
		2015-16	2016-17	2017-18	2018-19
1	NaOH	2,06,82,000	1,99,44,000	1,43,64,000	1,72,80,000
2	H_2SO_4	88,20,000	1,12,41,000	71,55,000	75,15,000
		2,95,02,000	3,11,85,000	2,15,19,000	2,47,95,000

Table 3: Annual average of CBECF effluent

S. No.	Filtrate parameters	Before Implementation	After Implementation			
		2014-15	2015-16	2016-17	2017-18	2018-19
1	COD, mg/l	2,030	2,016	1,874	1,864	2,201[1]
2	BOD, mg/l	916	889	772	763	868[2]

Details of other savings as reported by the unit include:

- Improvement in initial alkali loss carried over to bleaching stage.
- Decreased alkali loss carries over to bleaching stage, required lower sulphuric acid to maintain the D_0 stage pH and pulp properties with same bleaching chemicals.
- Decreased sulphuric acid additions in D_0 stage has increased pulp pH and thereby reduce the organic acid generation in bleach filtrate and pulp.
- Higher end pH in chlorine dioxide bleaching has decreased the residual chlorine content in pulp, which eliminated the sulphur dioxide usage.
- Reducing sulphuric acid addition in D_0 stage has reducing caustic consumption in extraction stage and thereby reduces the recycling filtrate dissolved solids.
- Caustic solution addition stopped from October 2015 onwards, and subsequent sulphuric acid reduction in D_0 stage was 980, 1,249, 795 and 835 MT during this period against 1,832 MT in 2014-15.
- Total chemical cost savings per annum were INR 2.95, 3.12, 2.15 and 2.48 Crore for 2015-16, 2016-17, 2017-18, and 2018-19 respectively.
- Let out effluent COD content was 2,016, 1,874, 1,864 and 2,201 mg/l against 2,030 mg/l, whereas BOD content was 889, 772, 763 and 868 mg/l against 916 mg/l.

This project was implemented in CBECF from October 2015. Oxygen delignified pulp without NaOH shows minor change in kappa number with decreased alkali loss. Post oxygen washer number-2 filtrate contains lower dissolved solids and residual alkali, which is used as counter current washing liquor of previous stage pulp. This lower alkali carrying over ODL pulp requires lower sulphuric acid in D0 stage to maintain the pulp pH for chlorine dioxide bleaching.

Bleach filtrate pH is observed as on higher side in D_0 stage and contains lower COD and BOD.

[1] * HW combo pulp bleaching from July 2018 onwards
[2] * HW combo pulp bleaching from July 2018 onwards

REPLICATION POTENTIAL

This project can be implemented in any Bagasse pulp mill having ODL stage immediately, without using any modification or material cost. This project can be implemented in agro-based pulp and paper industry.

CONTACT DETAILS

TAMIL NADU NEWSPRINT & PAPERS LIMITED
DR S. SUBRAMANIAN
DGM (R&D/QC)
EMAIL: SUBRAMANIAN.S@TNPL.CO.IN

CASE STUDY 3: ALKALINE CHLORINE DIOXIDE BLEACHING THROUGH ELIMINATION OF SULPHURIC ACID IN HWECF PLANT DHOT STAGE

BACKGROUND

In HWECF plant, super batch digester wood chip is cooked using white liquor as cooking chemical and Medium Pressure Steam is used to cook at 160˚C.The cooked chips are displaced into a discharge tank and screened in Delta Combi screen. The accept pulp is fed to Brown Stock Washer 1 and 2 to remove the carryover black liquor. The washed pulp is subjected to a two-stage Oxygen Delignification (ODL) using oxidised white liquor, oxygen and steam, to delignifying the unbleached pulp. The ODL pulp is bleached with chlorine dioxide, extracted with caustic reinforced hydrogen peroxide and finally send to chlorine dioxide bleaching stage to achieve target brightness of 86.0% ISO.

PROJECT DESCRIPTION

The washed oxygen delignified pulp was acidified with sulphuric acid in Dhot stage Chlorine dioxide bleaching done at 95˚C using LP steam. After bleaching, the residual chlorine carrying over along with pulp was reduced by using Sulphur dioxide solution. The Dhot stage pulp was extracted with caustic solution followed by Oxygen and reinforced Hydrogen peroxide at 80˚C in EOP stage. After that, the extracted pulp was acidified with sulphuric acid and bleaching was done with chlorine dioxide bleached at 65ºC in D1 stage. After bleaching, the residual chlorine dioxide in the pulp was reduced by using sulphur dioxide before fed to the Dewatering press.

Table 4: Chemical consumption in HWECF plant before implementation of this project

S. No.	Chemical consumption	MT per annum
		2013-2014
1	Sulphuric Acid	1,591
2	Caustic solution	1,524
3	Sulphur Dioxide	15.97
Total		3,131

In Dhot stage, ODL washed pulp was bleaching with chlorine dioxide without using sulphuric acid and steam at 75˚C. The Dhot stage reaction tower outlet pulp was tested for residual chlorine, and it was found that there was no residual chlorine in the reactant pulp. The Dhot stage press outlet pulp shows consistently higher %ISO brightness than acidified Dhot stage pulp with an increased end pH. The Dhot stage pulp was extracted with a lesser caustic solution followed by hydrogen peroxide at 80˚C in EOP stage.

The elimination of Oxygen in Extraction stage does not find any significant adverse impact on the Extraction stage brightness and filtrate characteristics. The Extraction stage filtrate, containing lesser organic acid, carrying over suspended solids, was recovered using an alkali wash filter, and the filtrate was continually recycled in ODL stage feed pulp dilution. Finally, the extracted pulp was bleached with chlorine dioxide at 65^0C in D1 stage by using minimum sulphuric acid. Any residual chlorine carrying over was reduced by using sulphur dioxide before enter into dewatering press.

The oxidizing equivalent made available by reduction of one mole of chlorine dioxide to chlorous acid ($HClO_2$) is taken up by the pulp instead of by oxidizing another mole of chlorine dioxide to chlorate ion.

$$ClO_2 + Pulp \rightarrow HClO_2 + Oxidised\ pulp$$

As the pH increases, this reaction becomes increasingly vigorous and at higher pH the cellulose, as well as the lignin and resin, is attacked. The HClO2 formed very rapidly establishes equilibrium with its dissociation products, chlorite ion and hydrogen ion, the position of the equilibrium being dependent on the pH of the solution.

$$HClO_2 \rightarrow ClO_{2-} + H^+$$

As the pH becomes higher, the concentration of chlorous acid becomes lower.

The chlorite ion is unreactive towards lignin, but chlorous acid is very reactive. It oxidizes lignin and is thereby reduced to hypochlorous acid (HClO) which in presence of chloride ion enters into the following equation which is also pH dependent:

$$HClO + Cl^- + H^+ \rightarrow Cl_2 + H_2O$$

in the absence of chloride ion, HClO reaction with $HClO_2$ to form ClO_2 and HCl.

$$HOCl + 2HClO_2 \rightarrow 2ClO_2 + H_2O + H^+ + Cl^-$$

Simultaneously HClO2 reacts with itself to form chlorate, Hypochlorous acid and hydrogen ion.

$$2HClO_2 \rightarrow H^+ + HOCl + ClO_2^-$$

The HOCl from the above reaction is then available to form ClO_2 by reaction, which is then available to react with lignin to form more chlorous acid.

The ClO_2 is converted to chlorate, chlorite and chlorine, the proportions of which are highly dependent on the pH of the solution and on the lignin concentration in the pulp.

Since the pH tends to decrease during all oxidative pulp bleaching, the best that can be done is to have the optimum amount of alkali present, when the ClO_2 is mixed with the pulp to maintain the pH in the optimum range at the end of the treatment. The end pH depends on the amount of alkali left in the pulp from previous stage due to incomplete washing and on the amount of acid in the ClO_2 solution, which depends very much on the process and the type of equipment used. The decrease in pH occurring during bleaching also a function of the reducing capacity of the pulp, on the amount of ClO_2 added, and on the temperature and retention time.

SAVING DETAILS

Table 5: Chemical consumption per annum after implementation of this project

S. No.	Chemical consumption	2014-15[3]	2015-16	2016-17	2017-18[4]	2018-19[5]
1	Sulphuric Acid	1,233	419	466	299	469
2	Caustic solution	1,290	1,152	1,106	878	1,547
Total		2,523	1,571	1,572	1,177	2,016
Bleached pulp production		93,833	96, 312	82, 335	68, 032	1,19,012

Table 6: Annual total chemical saving at source after implementation of this project

S. No.	Chemical consumption, MT	2014-15	2015-16	2016-17	2017-18	2018-19
1	Sulphuric Acid	358	1172	1124	1292	1122
2	Caustic solution	234	372	418	646	87
Total		591	1,543	1,543	1,938	1,099

Table 7: Annual cost saving after implementation of this project

S. No.	Cost saving in Rs.	2014-15*	2015-16	2016-17	2017-18	2018-19
1	Sulphuric Acid	32,20,200	1,05,44,400	1,01,19,600	1,16,27,100	1,00,97,100
2	Caustic solution	84,09,600	1,33,84,800	1,50,55,200	2,32,59,600	31,50,000
Total		1,16,29,800	2,39,29,200	2,51,74,800	3,48,86,700	92,69,100

[3] Alkaline ClO2 bleaching from Oct.2015
[4] Lower pulp production due to water crisis
[5] Higher bleached pulp production

The details of the some of the savings attained include:

- The caustic solution consumption during 2018-19 was higher due to higher HWECF bleached pulp production compared to previous years.
- The reduced chemical consumption of sulphuric acid and caustic solution at source were decreasing the dissolved inorganic solids load of HWECF effluent.
- A lower dissolved solid from bleach filtrate was reducing the scale formation in the pipeline, pump impellers and press rolls even continuous recycling of the Extraction filtrate.

The total elimination of sulphuric acid used in HWECF plant considerably reduced the successive extraction stage caustic consumption, without affecting pulp brightness and strength properties. Elimination of sulphuric acid, sulphur dioxide and lower caustic consumption was significantly reducing the bleach filtrate inorganic dissolved solids content which minimise the pipeline, impeller and press roll scale formation. The only filtrate which was let into effluent treatment plant contains lower dissolved solids, sulphate and sodium content. Also, the enhanced pH of the D0 and D1 stage reaction tower pulp does not contain any residual chlorine, which not required sulphur dioxide to neutralise it.

Table 8: Yearly average HWECF Effluent load (mg/l)

S. No	Effluent parameters	Before implementation, mg/l	After Implementation, mg/l				
		2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019
1	pH	3.4	4.2	4.8	4.5	4.1	4.7
2	TDS Inorganic	5,508	4,614	3,912	4,103	5,059	5,002
3	COD	1,703	1,504	1,560	1,651	2,042	2,227
4	BOD	791	746	728	721	873	935

- Monthly average pH of the HWECF effluent was 4.2, 4.8, 4.5, 4.1 and 4.7 against the acidic pH of 3.40.
- The total dissolved solids as inorganic generation decreased at source was 4,614, 3,912, 4,103, 5,059 and 5,002 mg/l during 2014, 2015, 2016, 2017, 2018 and 2019, against the acidic pH of 5,502 mg/l.
- The Soluble COD generation decreased at source of alkaline chlorine dioxide bleaching was 1,504, 1,560, 1,690, 2,042 and 2,227mg/l during 2014, 2015, 2016, 2017, 2018 and 2019, against the acidic chlorine dioxide bleaching of 1,567 mg/l.

- The Soluble BOD generation decreased at source of alkaline chlorine dioxide bleaching was 746,728, 702, 873 and 935 mg/l during 2014, 2015, 2016, 2017, 2018 and 2019, against the acidic chlorine dioxide bleaching of 791mg/l.
- Increased COD and BOD content during the year 2017-18 was due to water crises and the year 2018-19 was high bleached pulp production.

This project was implemented in plant scale based on the intensive laboratory studies with and without using sulphuric acid in chlorine dioxide bleaching of wood pulp and its environmental impact of the bleach filtrate. This study does not show any significant disadvantage of the bleached pulp optical properties, strength properties and filtrate characteristics. This project was successfully carried out in plant scale for 42 days from September 2011. But this project was implemented continuously from December 2014, with close monitoring of the process variables, pulp quality and filtrate characteristics. Every month, the shutdown time, the scale samples collected from the feed pipeline, impeller and press rolls were analysed to identify any significant variation in scale formation due to process modification.

REPLICATION POTENTIAL

This project could be implemented in all integrated pulp and paper industries where the wood or Bagasse pulp is bleached with or without ODL stage using Chlorine dioxide solution as bleaching chemical. The 1.0 to 2.0% chlorine in chlorine dioxide solution is helping in first stage wood pulp delignification and increase the brightness without using sulphuric acid. This chlorine is a strong bleaching chemical, which is present in chlorine dioxide solution, and is reducing the hypochlorous acid generation due to higher initial pH pulp. In order to obtain the maximum brightness benefit from Dhot stage, it is critical to achieve the target brightness in D1 stage.

CONTACT DETAILS

TAMIL NADU NEWSPRINT & PAPERS LIMITED
DR S. SUBRAMANIAN
DGM (R&D/QC)
EMAIL: SUBRAMANIAN.S@TNPL.CO.IN

CASE STUDY 3: ADDITION OF SILICATE FREE PEROXIDE STABILIZER TO IMPROVE OPERATING COST AND REDUCE THE POLLUTION LOAD IN THE DEINKING FIBRE LINE

BACKGROUND

Silicate is playing dual role in deinking. Silicate is used in pulper (prevent redeposit of the ink particles on fibre) as well as oxidative bleaching (as a metal chelate). Bleaching with hydrogen peroxide is less efficient for secondary fibre than for virgin fibres. Trace metals catalyses the decomposition of hydrogen peroxide. Chelating agents such as sodium silicate (water glass) and EDTA are commonly used in secondary fibres bleaching to deactivate the heavy metal ions that contribute to the wasteful decomposition of hydrogen peroxide. The most commonly used stabilizer is sodium silicate, used in colloidal polymerized form.

Sodium silicate also has some undesirable properties. For example:

- Dehydration can give a hard hand to the processed goods.
- Precipitation of Silica $SiO_2.nH_2O$ in process street.
- Anionic property.
- Increased conductivity.

This difficulty has led to a demand for sodium silicate free stabilizer. To address these issues, TNPL has done a study on Hydrogen peroxide bleaching with silicate free organic peroxide stabilizers (substituted oxycarboxin acid based) from various suppliers against conventional peroxide stabilizer sodium silicate.

PROJECT DESCRIPTION

To address the issues, plant scale studies were carried out on Hydrogen peroxide bleaching with organic silicate free peroxide stabilizers from various suppliers against conventional peroxide stabilizer sodium silicate.

Silicate free organic peroxide stabilizers are:

- Organic in nature.
- Ecologically accepted.
- Substituted poly carboxylic acid derivatives.
- Non-corrosive.
- Good for the whiteness of the pulp.
- More sensitive, with metal ion reactivity.
- Stabilizers for the Peroxide, more efficient than Sodium Silicate.

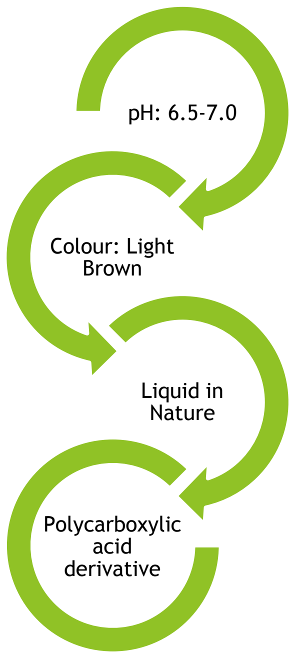


Figure 2: Properties of silicate free peroxides

This dissimilar stabilizer brings about encouraging possessions in quality of the pulp and also operational practices too. The following are the benefits observed from the usage of silicate free stabilizer.

Table 9: Benefits of silicate free stabilizer

S. No	Particulars	Unit	Silicate stabilizer	Silicate free stabilizer	Reduction in consumption %	Remarks
1	Hydrogen peroxide H_2O_2	Kg/T	25.05	19.96	20.3	Organic peroxide stabilizer stabilizes more efficiently than silicate, hence the specific consumption of H2O2 peroxide is reduced
2	Sodium silicate	Kg/T	12.3	-	100%	Sodium silicate has been completely eliminated in Oxidative bleaching
3	Magnesium sulphate	Kg/T	0.8	-	100%	Use of $MgSO_4$ also has been stopped
4	EDTA	Kg/T	1	-	100%	Usage of Chelating agent EDTA also stopped.
5	Silicate free organic stabilizer	Kg/T	-	0.12	-	Eliminates all the above peroxide stabilizer and chelating agents.
6	Sodium in waste water	ppm	720	490	31.9	Reduced sodium content

The characteristics of wastewater before and after the silicate free stabilizer addition are shown below:

Table 10: Wastewater characteristics

S. No	Parameter	Unit	On Silicate stabilizer	On Silicate free stabilizer
1	pH	-	7.9	7.1
2	COD	Ppm	1,750	1,620
3	Sodium	Ppm	620	480
4	TDS	Ppm	3,180	2,360

SCALE DEPOSITION IN DISPERSER

Usage of silicate free stabilizers leads a solution to a very mammoth operational problem such as scale deposition in disperser plates. There is frequent jamming of pulp in dispersers plate due to scale deposition of silica by sodium silicate, leading to frequent breakdown of the plant.

After the usage of silicate-free organic peroxide stabilizers, TNPL – DIP plant put an end to the frequent jamming and deposit problem in disperser.

SAVING DETAILS

- Reduction of Sodium (TDS) load in waste water stream by eliminating the sodium silicate in oxidative bleaching stage.
- Reduction specific chemical consumption of Peroxide and silicate and other chelating agents, and thus reduce the production cost.
- Reducing deposit and scaling issues caused by sodium silicate in disperser.
- Apart from operational and quality improvements, the peroxide stabilizer has reduced the overall cost of production of deinked pulp. By decreasing the operating cost and production cost, the plant performance has been considerably improved.

Figure 4: Sodium Silicate as peroxide stabilizer

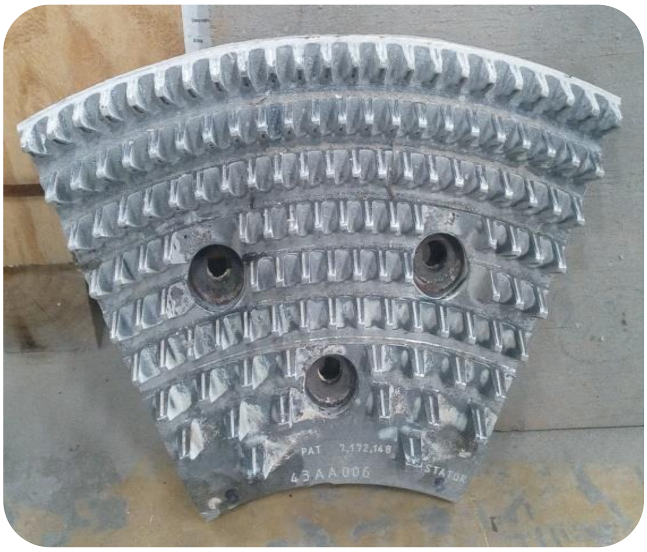


Figure 4: Silicate free organic peroxide stabilizer

COST SAVING CALCULATION

By reduction of sodium silicate consumption	: 12 Kg X 10: 120 per Tonne of Deinked pulp
By reduction of hydrogen peroxide consumption	: 5 Kg X 36: 288 per Tonne of Deinked pulp
Reduction of other chelating agents (EDTA)	: 1 Kg X 220: 220 per Tonne of Deinked pulp
Total cost savings per ton of pulp	: INR 628.
Total cost savings per day	: INR 1,75,840.

REPLICATION POTENTIAL

This is applicable in all waste paper plants that have peroxide-based oxidative bleaching stage.

CONTACT DETAILS

TAMIL NADU NEWSPRINT & PAPERS LIMITED
DR S. SUBRAMANIAN
DGM (R&D/QC)
EMAIL: SUBRAMANIAN.S@TNPL.CO.IN

CASE STUDY 4: PARTIAL REPLACEMENT OF FURNACE OIL IN LIME KILN BY CO-FIRING BIOGAS GENERATED FROM ANAEROBIC LAGOONS

BACKGROUND

The waste water generated from various sections of the mill are collected in an equalization tank and treated in primary clarification, vacuum filtration, aeration system, by activated sludge process followed by secondary clarification. The treated final effluent confirming to inland surface water discharge standards is sent from the factory and used by the farming community in the neighbourhood. The quality of waste water varies in organic load in different streams.

To assess the organic load for effective treatment, the environmental cell analysed the various parameters to minimize the load to ETP at source. Based on the study, it was found that the waste water from bagasse pulp mill and foul condensate from SRP were in the top list. To counteract this, a scheme was formulated to reduce the organic load before it enters ETP.

PROJECT DESCRIPTION

The conventional way of treating foul condensate is to install an expensive stripper column in black liquor evaporation plant and to spend steam to convert it as Stripper off gas and burn it in lime kiln.

But the plant adopted a unique route in which the treatment of foul condensate is done along with bagasse effluent biologically for generation of biogas, the first of its kind in the treatment of foul condensate. The foul condensate from SRP evaporators is treated by anaerobic digestion. Generated bio-methane gas is burnt in the rotary lime kiln to replace a part of furnace oil.

An anaerobic lagoon was installed early in 1984 to treat the High BOD effluent from bagasse plant. The biogas generated was let to the atmosphere without any collection device. A suitable supplier was identified to make a balloon cover above the anaerobic lagoon to collect the biogas and was pumped by a blower to the power boilers to a tune of 2,000 Nm^3/day.

Meanwhile, odour nuisance in the surrounding SRP evaporator area was found. To mitigate the odour, a system was formulated to collect the foul condensate and pump the same to the anaerobic lagoon to convert the organic matter into a valuable biogas, one of the unique features in the pulp and paper industry sector. The biogas collected was analysed for the quality of methane content, which was found to be 0.65%. Adequate care was taken to avoid the impact of sulphide in the anaerobic digestion by regular addition of Ferric chloride. Regular supplementation of nitrogen and phosphate is done for biological activity in addition to micronutrients for enhancing the methanogenic activity. Regular testing of the performance of the anaerobic system is monitored by laboratory for the percentage reduction in BOD, COD and VFA ratio.

COST SAVING CALCULATIONS

Initial investment to capture biogas in boiler	:	INR 68 Lakhs
To divert foul condensate to anaerobic lagoon and extend the gas line to Lime kiln	:	INR 29 Lakhs
Total Investment	:	INR 97 Lakhs

Figure 6: Lagoon in place at SPB, Erode

Figure 6: Co-firing arrangement

SAVING DETAILS

Details of other savings attained:

- Reduction of furnace oil in the rotary lime kiln to a level of 3-3.5 kl/day, saving INR 1-1.25 lakhs/day.
- Mitigation of biogas to the atmosphere.
- Elimination of odour nuisance.
- Reduced organic load to ETP and improved performance of the treated wastewater.
- Reduced energy and nutrient consumption in the aeration system.

REPLICATION POTENTIAL

The above mode of treatment methodology adopted can be replicated by the other mills effortlessly.

CONTACT DETAILS

SESHASAYEE PAPER AND BOARDS LTD.
MR. GANESH BHADTI
VICE PRESIDENT - TECHNICAL
EMAIL: GANESHB@SPBLTD.COM

CASE STUDY 5: OPTIMIZE L/G RATIO ACROSS COOLING TOWERS TO IMPROVE CONDENSER VACUUM

BACKGROUND

Cooling towers are among the most important auxiliaries in any power plant. The water that gets circulated through the condenser to remove the heat from the steam has to be cooled and bought down to saturation temperature levels prior to it being used for cooling purposes. This heat and mass transfer that takes place across the cooling tower is expressed in terms of the L/G ratio across the cooling tower. The L/G ratio of any cooling tower is the ratio of the water & air mass flow rates. Any variations in the L/G ratio across the cooling tower will also have an impact on the vacuum that needs to be maintained at the condenser

PROJECT DESCRIPTION

This project was implemented at Emami Paper Mills Ltd., Balasore. During the analysis of their power plant cooling tower, it was seen that the L/G ratio maintained across the cooling tower is 1.4 kg/kg of liquid. The CT fans were operating at 72% load condition. The plant team considered this as an opportunity and laid down steps to improve the cooling tower performance. The blade angles of the fan were increased from 11 to 14^{0}C. The following were the benefits achieved:

Figure 7: Cooling Tower in Plant

- L/G ratio increased to 1.5–1.7.
- Reduction in approach by 1.5^{0}C and increase in range by 1^{0}C.
- Improvement in overall cooling tower effectiveness: 8%.

SAVING DETAILS

Owing to these changes, the major impact the plant has encountered was in terms of the improvement in the overall condenser performance. The condenser vacuum increased from 0.88 to 0.91 kg/cm^2 and the turbine exhaust temperature reduced from 52 to 47^{0}C. With these changes in the operating parameters of the power plant, the plant team were able to generate 132 kW per hour of additional power. The cost overall savings achieved as reported by the unit was INR 44 Lakhs, based on a unit cost of INR 4 and 350 days of operation.

REPLICATION POTENTIAL

The project can be replicated in all CPP-based cooling tower for performance improvement, and does not involve any significant investment.

CONTACT DETAILS

EMAMI PAPER MILL LIMITED,
MR. G. NAGESWARA RAO,
SR. DGM (POWER & UTILITY)
MOBILE: 7893955991
EMAIL: GNRAO@EMAMIPAPER.COM

CASE STUDY 6: MAXIMIZE RECYCLING OF HOT WATER GENERATED IN HARDWOOD PLANT TO WATER TREATMENT PLANT

BACKGROUND

Excess hot water is generated in Super Batch digesters cooking process of hard wood plant, and it is pumped to Chemical Bagasse Plant fibre line usage through the hot water tank available at Chemical Bagasse plant. Due to disturbance in the Chemical Bagasse Plant fibre line, the water is overflowing from hot water tank and going into the drain.

PROJECT DESCRIPTION

Whenever the hot water tank reaches 90% level in Chemical Bagasse Plant fibre line due to stoppage and/or disturbance in Chemical Bagasse Plant operation, the excess hot water generated in Super Batch digesters cooking process is pumped to Water Treatment plant, by operating two manual valves. To avoid manual operation and to avoid draining of hot water during valve changing, two control valves were introduced in this line and the operation was made automatic with necessary logic in the Distributed Control System in Hard Wood Plant.

Figure 8: Arrangement made for recycling hot water

The reduction in pulp mill fresh water consumption over a one-year period is shown below:

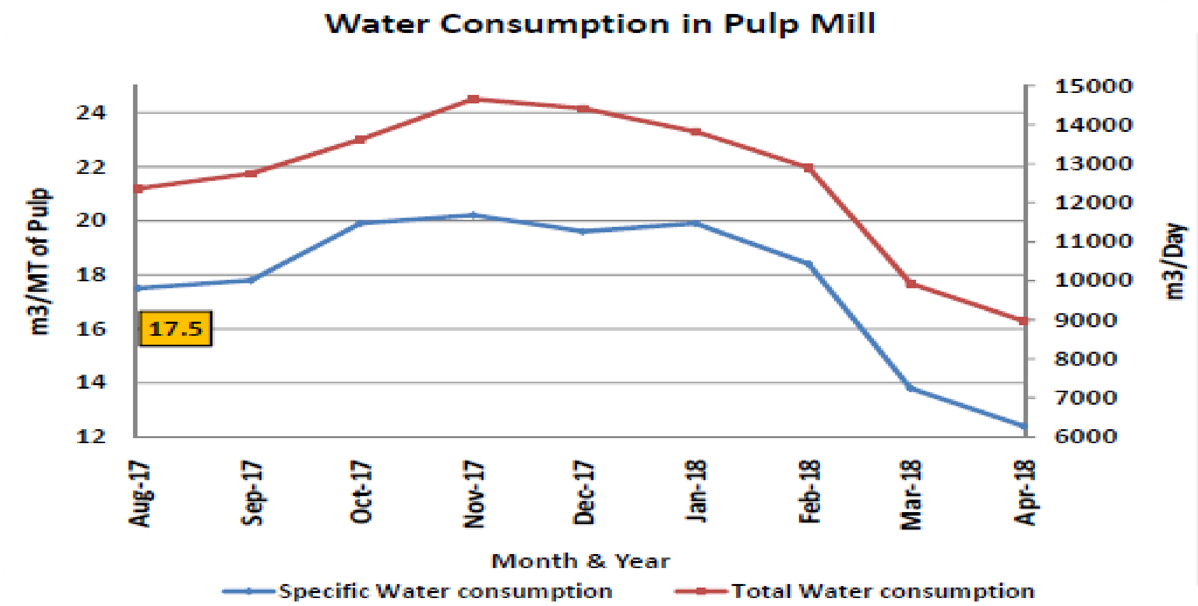


Figure 9: Trends in freshwater consumption

SAVING DETAILS

Details of freshwater saved, investment, and monetary savings as estimated by the unit are shown in the table below:

Table 11: Details of Savings Achieved

S. No	Particulars	UOM	Value
1	Planned date of completion	-	Mar'18
2	Actual date of Completion	-	Mar'18
3	Water savings per day	M	100
4	No. of days of operation per year	No	330
5	Water savings per annum	m	33,000
6	Cost of Raw Water	INR/month	10.21
7	Cost of treated water	INR/month	3.61
8	Savings per annum	INR in lakh	4.56
9	Investment made	INR	5,00,000
10	Payback period	Months	13

REPLICATION POTENTIAL

The project can be replicated in all paper plants.

CONTACT DETAILS

TAMIL NADU NEWSPRINT & PAPERS LIMITED
DR S. SUBRAMANIAN
DGM (R&D/QC)
EMAIL: SUBRAMANIAN.S@TNPL.CO.IN

CASE STUDY 7: CLARIFLOCCULATOR FOR WASTE WATER REUSE

BACKGROUND

Water is one of the major resources in the production of paper. It is used as a medium to transport fibrous products, chemicals, etc. The major usage of water in any paper plant is the paper machines itself.

Emami Pulp & Paper Ltd., Balasore, has made arrangements to recover the water from their paper machine & board machines. They have installed clarifiers & clariflocculator respectively for these sections.

PROJECT DESCRIPTION

Clariflocculator is a combination of flocculation and clarification in a single tank. It has two concentric tanks where inner tank serves as a flocculation basin and the outer tank serves as a clarifier.

Figure 11: 20m clariflocculator unit

Figure 11: 9m clarifier unit

In the Clariflocculator, the water enters the flocculator, where the flocculating paddles enhance flocculation of the feed solids. As heavy particles settle to the bottom, the liquid flows radially upward in the clarifier zone. The clarified liquid is discharged over a peripheral weir into the peripheral launder. The deposited sludge is raked to the bottom near the central weir from where it is routed to the sludge chamber and discharged.

SAVING DETAILS

FOR BOARD MACHINE

The plant team have re-routed nearly 2,500 m^3/h of the effluent from their board machine to the newly installed clariflocculator system.

The clarified water gets reused in their Deinking plant. Nearly 1,500 m^3/h of clarified water has been reused which has reduced an equivalent quantity of fresh water, and also reduced the effluent load on the ETP.

The project had an investment of **INR 250 Lakhs**. The cost saving is **INR 64 Lakhs (based on 1,500 m^3 of fresh water consumption @ INR 12 per m^3 considering 350 days of running savings).**

FOR PAPER MACHINE

A total of 900 m^3/h of clarified water has been reused in their de-inking unit.

The project had an investment of **INR 60 Lakhs**. The cost saving is **INR 37 Lakhs (based on 900 m^3 of fresh water consumption @ INR 12 per m^3 and considering 350 days of running savings).**

REPLICATION POTENTIAL

The project has a high replication potential in all paper & pulp units where water consumption is of high priority.

CONTACT DETAILS

EMAMI PAPER MILL LIMITED,
MR. G. NAGESWARA RAO,
SR. DGM (POWER & UTILITY)
MOBILE: 7893955991
EMAIL: GNRAO@EMAMIPAPER.COM

CASE STUDY 8: HEAT EXCHANGER LINE MODIFICATION FOR WATER RE-USE

BACKGROUND

Water is one of the major resources in any paper plant. Any possibility to recover or re-use water available from different sources should be immediately pursued. The current project is based on recovering heat available at lower temperatures from one process for further preheating at another source that is at a much lower temperature. The project is based on using hot water for preheating in two different heat exchangers operating in series.

PROJECT DESCRIPTION

Fresh water was being used initially in both the Drum Pulper gear box heat exchanger & Drum Pulper compactor heat exchanger. The plant team have made modifications in the existing line to use the hot water at the exit of the gearbox heat exchanger to the compactor heat exchanger.

The overall layout of the system is as shown in the figure.

The modifications done by the unit have helped in reducing nearly 120 m^3/day.

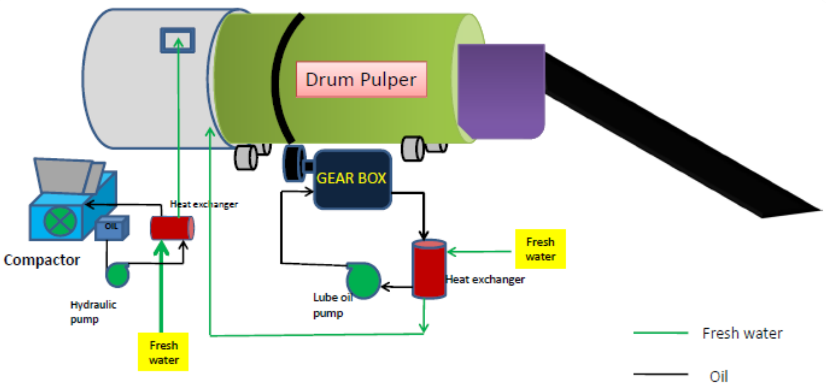


Figure 12: System Layout Schematic

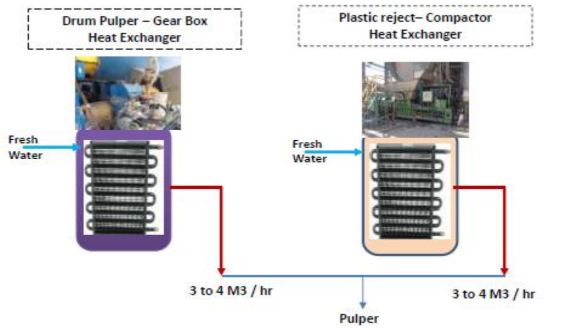


Figure 14: The system before implementation of project

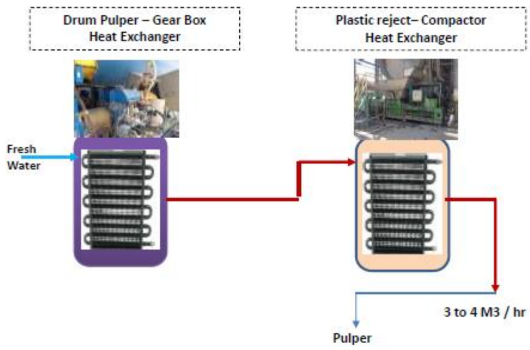


Figure 14: System after implementation

SAVING DETAILS

The water saving estimated by the unit is **42,000 m^3/yr.**, with an annual saving of **INR 1.10 Lakhs.** The project does not require a significant investment.

REPLICATION POTENTIAL

The project has a high replication potential in all paper & pulp units where water consumption is of high priority.

TECHNOLOGY SUPPLIERS

CASE STUDY 9: AMINE BASED REAGENTS OVER HP DOSING CHEMICALS - CHEMICAL CONDITIONING FOR BOILER FEED WATER

BACKGROUND

Conventional chemical feed water conditioning is being practiced in industrial and power plant steam generators. Coordinated phosphate pH feed water treatment - Ammonia/ Morpholine/ Hydrazine hydrate as LP dosing and TSP as HP dosing in steam drum are being practiced in power/ industrial boilers.

INTRODUCTION

As an alternative, amine-based reagents have been introduced as a single point dosing to do away with High Pressure [HP] dosing. Polyamine based reagent under the trade name of Eloguard 86 was formulated by M/s Elof Hansson. The Swedish based reagent was first introduced in India way back in 1985/86 in the boilers of Tamil Nadu Paper & Newsprint Limited [TNPL], Pugalur plant. The conventional dual stage chemical boiler feed water treatment gave way to single LP dosing of Eloguard 86 chemical reagent for boiler feed water.

Eloguard 86 is essentially a multiamine based on encompassing Filming and Neutralizing amines. As it is, in India, the polyamine treatment gained prominence in Pulp & Paper mills of the sub-continent viz., TNPL, RNPL, etc.

Rama Newsprint & Papers Limited [RNPL] had gone in for Eloguard 86 reagent for their HP boilers feed water conditioning. Eloguard 86 is being dosed in very small dosages (~ 2 ppm) to the boiler feed water as LP dosing reagent ahead of HP Boiler feed pump. RNPL has gone in for HP Boilers for their cogeneration plant.

The boilers are operating at main steam pressure of 87 kg/cm^2 and temperature of 510 Deg^0C. HP steam is being led to the steam turbines for generating power, as also LP & MP steam for process use.

After initial study in the plant premises, the exact dosage of the chemical regent for the HP boilers was firmed up and ever since the last decade, Eloguard 86 treatment of boiler feed water had been continuing without any interruption and with resounding success.

KEY CHANGES & RESULTS

Switching over from conventional dual pressure level conventional boiler water conditioning to single point low pressure amine dosing is the key change. Chemical leasing in the style of initial trials with the reagent, right dosage and supplying just the amount of the reagent on a continuous basis and regular follow up/feedback are essential trademarks of Chemical Leasing success. The results are one of energy saving through blow down reduction and small saving in DM water.

No scaling on boilers and steam turbine blades were reported (based one RLA report of certified inspection agency of BHEL). Spin-off effect is one of heat transfer enhancement through steam containing traces of filming amine entering the drying cylinders of paper machines; the reagent is certified to be non-carcinogenic (safe handling).

RESULTS & CRITICAL ANALYSIS

Performance gains accrued through switch over from Conventional to Polyamine based boiler feed water conditioning are depicted as under:

FOR HP BOILERS

Total HP Steam generation	:	200 TPH
Feed water consumption	:	201 TPH
Blow down from Steam Drum	:	0.5 %
Eloguard 86 Dosage	:	1.8 ppm
Daily Eloguard 86 consumption	:	9 kg/d
Monthly reagent consumption	:	270 kg

PAPER MACHINE - DRYING CYLINDERS

Changing chemical type from contact to non-contact type has helped in improving the heat transfer coefficient/ Thermal Conductance from 600 kcal/hm^{2}C to 1,400 kcal/hm^{2}C.

OVERALL BENEFITS

Economic benefits, Environmental gains, Low Carbon Economy benefits (emission reduction) & social impact are illustrated through actual performance and summarized below:

Table 12: Overall benefits

Economic	Environmental	Global	Social
Fuel saving through reduced blowdown.	Minimal discharge of residual impurities in blowdown water.	Marginal emission reduction through fuel/steam saving in co-gen boiler and paper machine.	Non-carcinogenic, safe-to-handle reagent.
Marginal steam consumption reduction in paper machine.	Trace reduction in stack pollutants and bottom ash discharge.	Lowered quantity of chemical haulage reduces diesel consumption.	
Marginal reduction in power consumption through HP dosing avoidance.			

CONTACT DETAILS

ELOF HANSSON INDIA PVT LTD
MR. T RAMANATHAN
DEPUTY GENERAL MANAGER
MOBILE: 9444046103
EMAIL: RAMANATHAN.THANTHONI@IN.ELOFHANSSON.COM

CASE STUDY 10: USING COAL OPTIMIZER IN AFBC BOILER FOR REDUCED COAL & SPECIFIC HEAT CONSUMPTION

BACKGROUND

Combustion reaction occurring in boilers is accompanied by formation of carbon monoxide. It happens in a number of stages during the overall combustion process and is highly endothermic in nature, reaching levels of 6,000 kcal/kg. If this reaction is blocked or lowered, the energy generation of coal would be enhanced. This can help in reducing the coal and specific heat consumption for all loads of boiler operation.

INTRODUCTION

M/s Raymonds Ltd. Chindwara, has a 14 TPH coal-fired AFBC (Bubbling Fluidized Bed Combustion Boiler). It is a low-pressure boiler operating at 10.5 kg/cm^2 pressure with steam at saturation conditions, catering to the steam requirements of the process. High ash indigenous coal is used as fuel for the boiler. Combustion efficiency with lowered LOI in bottom ash and increased GCV of as delivered coal was affected through Coal Optimizer – an inorganic fuel additive chemical-manufactured by M/s Chargewave Energykem PVT. Ltd. based in Hyderabad.

Different tests to certify the reduced coal and specific heat consumption were carried out by the unit. Chargewave Engineers and Raymond Engineers together certified the coal weight, steam generation, and lab reports; and the monitoring was done on an hourly basis till the completion of the tests. By chemical addition, the result was an increase in GCV delivery of coal, thereby lowering kcal required to generate 1 tonne of steam.

The Coal Optimizer achieved the objective of lowering the incidence of Boudouard Reaction, lowered Kcal required to generate 1 tonne of steam, by 14.5%.

After successful demonstration, the fuel additive was used for 6 months, with the Chargewave Engineer stationed at the site for monitoring the fuel additive performance. The required chemical additive was being supplied on a regular basis by M/s Chargewave Energykem Limited.

Over a 6-month period, the specific input heat energy savings to generate 1 tonne of steam varied from 13% to 18% as reported by the unit.

OVERALL BENEFITS

Overall benefits accrued by going for fuel additive for enhanced boiler performance are summarized in the table below:

Table 13: Overall benefits

ECONOMIC	ENVIRONMENTAL	GLOBAL/LCE	SOCIAL
Fuel saving due to increase in delivered GCV - Combustion efficiency (Lower Boudouard Reaction).	Bottom ash from boiler is readily acceptable as raw material to cement mill because of lowered LOI.	Marginal Emission reduction through fuel saving.	Non-carcinogenic, safe-to-handle chemical
	Trace reduction in Stack pollutants and Bottom ash discharge.		

M/s Chargewave Energykem's expertise in bringing out the best of the products to the plant operating executives resulted in optimized usage of Coal Optimizer chemical in boiler as fuel additive on a continuous basis. Fuel wastage is not only reduced but the resultant bottom ash from the boiler is also converted into a valued resource (lower LOI levels in bottom ash).

CONTACT DETAILS

CHARGEWAVE ENERGYKEM PVT LTD
MR. P SRINIVAS ANAND PRAKASH
CHIEF EXECUTIVE OFFICER
MOBILE: 7013068530
EMAIL: SAP@ENERGYPLUS.COM

CASE STUDY 11: STEAM OPERATED PRESSURE POWERED PUMP PACKAGE UNIT IN PAPER INDUSTRY

BACKGROUND

Paper making process is a large dewatering process. While the maximum water is removed in forming and press section, normally 1.1 to 1.3 Kg of water is removed per Kg of finished product in the dryer section, with help of dryer cylinders. Steam enters in the dryer and condenses after releasing its heat to dry the paper. This condensate is required to be sent back to the boiler feed water tank. In paper industry, paper makers use electrically operated centrifugal pumps for this operation. These centrifugal pumps are normally not able to handle temperatures beyond 70º C. They also require regular maintenance and a need to address issues like cavitation, leakages and replacement of seals, etc.

TECHNOLOGY

Considering the above-mentioned limitation of electrically operated centrifugal pumps, Forbes Marshall introduced a steam-operated pressure powered pump package unit in the paper industry, and implemented it in various paper mills successfully. It is a steam operated mechanical pump with almost no maintenance. While the electrically operated centrifugal pump requires tentatively two units of electricity to handle every 1,000 Kg of condensate, FM steam operated pump requires only 3 Kg of steam to handle 1,000 Kg of condensate.

Figure 15: PPPU Pump

SAVINGS ESTIMATED

The estimated savings is as shown in the table below. The data shows savings for both the coal and wood operated boilers. While some of the assumed values of coal and wood price and its respective calorific values, electrical cost may slightly very, we can figure out that the implementation of Forbes Marshall steam operated pimp will certainly give a good amount of saving compared to its implementation cost, which varies from INR 2.50 Lakhs to INR 13.50 Lakhs, depending on the capacity of machine.

Table 14: Estimated Savings

Paper Machine Capacity	Condensate load (Moisture % as 50-10-30-7)	Fuel saving in Lakh/Year (Considering 20 °C rise in temp.)		Benefit due to use of steam instead of electricity to operate pump in Lakh/Year	Total saving in Lakh/Year	
TPD	**Kg/Hr.**	**Coal**	**Wood**	**Rs**	**Coal**	**Wood**
50	3928	9.3	9.6	4.5	13.7	14.1
100	7856	18.6	19.2	8.9	27.5	28.2
150	11785	27.9	28.9	13.4	41.3	42.3
200	15712	37.2	38.5	17.9	55	56.4
250	19640	46.4	48.1	22.4	68.8	70.5
300	23568	55.7	57.7	26.8	82.6	84.6

REPLICATION POTENTIAL

This pump can be installed in almost every paper industry. Such savings will definitely give an advantage in today's competitive paper market, where the profit margins are low.

CONTACT DETAILS

FORBES MARSHALL
MR. DATTA KAVULEKAR
MOBILE: 9823199619
EMAIL: DKAVULEKAR@FORBESMARSHALL.COM

CASE STUDY 12: OZONE BASED SYSTEM FOR WATER PURIFICATION – ETA PURIFICATION

BACKGROUND

ETA purification provides water treatment solutions using ozone-based systems. It uses the concept of micro plasma ozone technology. Ozone is a strong disinfectant & oxidizer available commercially. The technology can be of extensive use in the treatment of chemical waste water & cooling tower water in various pulp & paper units. The short lifetime of ozone and the fact that it produces almost no harmful by-products or decomposition products make it an attractive alternative to traditional forms of water purification and wastewater treatment as well as other niche applications. Ozone is increasingly replacing chlorine-based products for disinfection applications, not only because of the extraordinary efficacy of ozone in destroying pathogens, but also due to the adverse impact of chlorine on the environment and water resources, in particular.

TECHNOLOGY

MICRO PLASMA-BASED SYSTEMS

Microplasma-based technologies are powered electrically by integrated electrodes and have properties unlike those of macroscopic or large volume plasmas. ETA based micro plasmas are spatially uniform "glow" plasma produced in microchannels that are generally several hundred micrometers in width and several cm in length. On a single microchannel based 'chip', oxygen or air is introduced at one end of an array of parallel microchannels. Plasma produced in the channels efficiently converts oxygen into ozone which then leaves the channels. The microscopic, intense plasma environment produced within the channels is ideal for the generation of ozone from oxygen or room air. Also, ozone is produced along the entire length of the microchannels, as opposed to only in the immediate vicinity of a high voltage streamer.

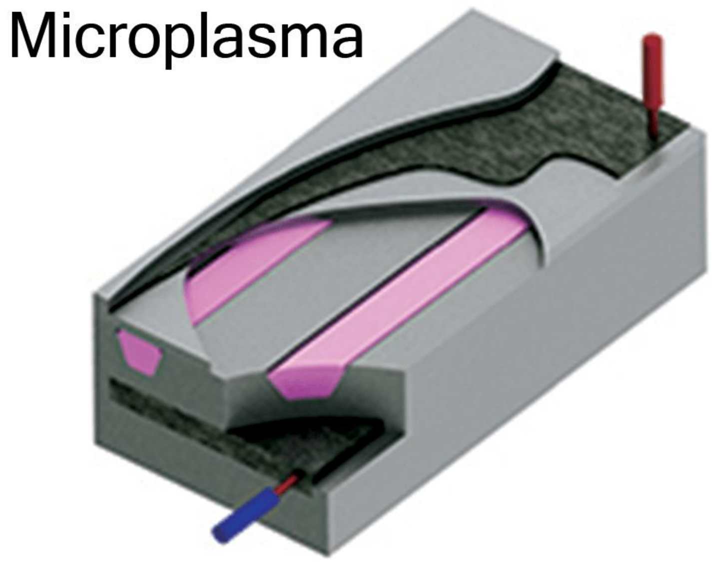


Figure 16: Microplasma based system

The end-on view of several microchannels during the production of ozone is as shown below, the blue glow from each channel underscores the uniformity of micro plasmas which is a key factor leading to the efficiency and small size of our ozone systems.

Microchannel plasma arrays are fabricated from thin aluminium sheets by a proprietary, patented process and are lightweight and compact. Because the micro plasmas in the channels are protected by aluminium oxide, however, these arrays are robust and not sensitive to water vapor in the oxygen or air flow stream that can be lethal to conventional ozone systems. Unlike conventional ozone generators which are limited by their large size, weight and high cost of ownership, the size and weight of our micro plasma reactors are a factor of ten (10x) less than the conventional system of equivalent output, which greatly reduces cost and footprint making it suitable for treating water in resource constraint environments.

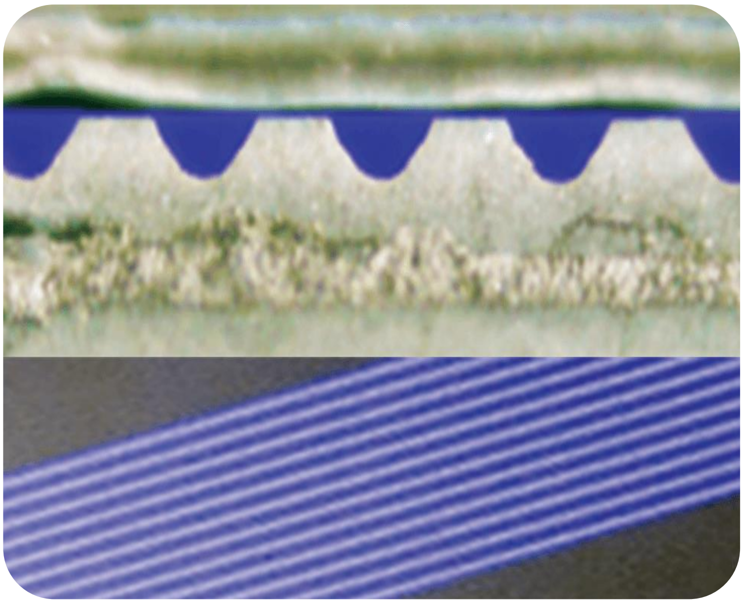


Figure 17: Microplasma Array

MODULAR DESIGN

A modular technology has been developed incorporating up to 10 micro plasma chips that is readily scalable to accommodate the client's requirements. Each chip produces 2 grams of ozone per hour from an oxygen feed which is more than sufficient, for example, to disinfect 200-300 gallons of water per hour. Stacking five chips in a module results in an ozone production rate above 10 grams per hour.

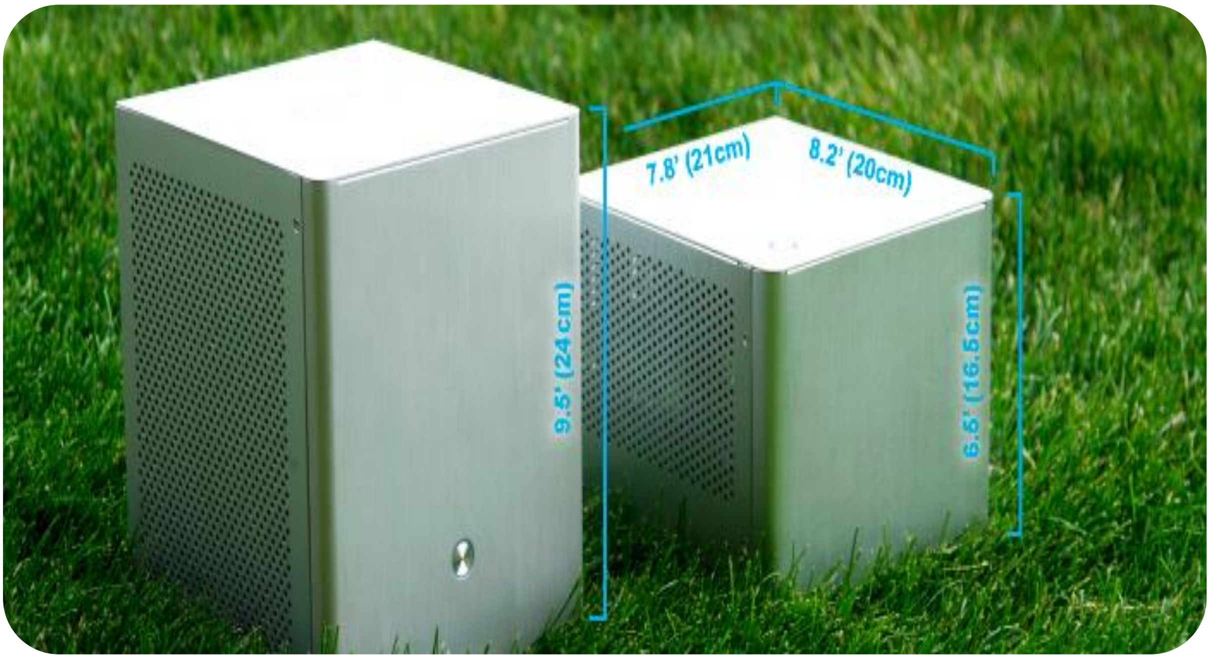


Figure 18: Modular Microplasma Design

FEATURES OF THE PRODUCT

- The technology eliminates the use of chlorine & other toxic chemicals.
- The ozone production is done online, thus eliminating the transport, storage & handling risks of hazardous chemicals.
- Unused ozone in the process is converted back to oxygen.

CONTACT DETAILS

ETA PURIFICATION
MR. DINESH VENKATACHALAM
EMAIL: DINESH.VENKAT@ETAPURE.COM

CASE STUDY 13: INCIDENTAL POWER GENERATION – MICROTURBINES

BACKGROUND

ECT™ Turbines are aimed at conserving the unutilized pressure energy in a process plant PRV/ PRDS that is otherwise simply throttled. It reduces the steam pressure to the required process (Back) pressure. In addition, it converts this pressure energy to high velocity, giving an impulse to rotate the turbine wheel at a speed of 12,000 RPM. This high speed is reduced through a reduction gear box to 1,500/3,000 RPM to generate incidental clean, green electric power. Since ECT™ can utilize saturated steam, it becomes highly beneficial for industries using saturated steam.

Figure 19: Microturbine Installation

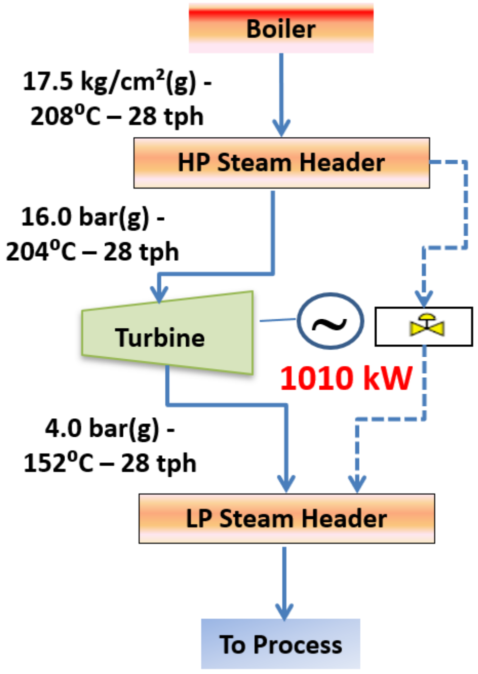
The ECT™ Quick Start Feature offers start-up time from cold condition of less than 15 minutes.

PROJECT DESCRIPTION

Paper mill systems need steam turbines that can handle saturated steam at a pressure ranging from 3.5 bar(a) to 32 bar(a). Saturated steam causes severe blade and housing erosion in conventional turbines.

TurboTech's ECT™ Turbines are specially designed to not only handle saturated steam, but are also tolerant of corrosive impurities in the steam. This is because TurboTech's ECT™ Turbines are the only turbines in the world which offer a flow-path where all steam-wetted surfaces are made of corrosion- and erosion-resistant Stainless Steel.

SAVING DETAILS



Sr. No	Description	Details
1	Power Generated by Turbine (kW)	1010
2	**Units generated yearly basis** (Considering 24 Hrs per day and 300 working days per year i.e. 7200 working hours yearly)	72,72,000
3	**Gross Yearly Savings** Considering ₹ 6/unit, for the yearly unit savings	**₹ 4,03,19,565**
4	Less - Maintenance Cost (Consumables)	**₹ (3,00,000)**
	Total Yearly Saving	**₹ 4,00,19,565**

REPLICATION POTENTIAL

TurboTech's ECT™ Turbines are applicable in all paper industries using raw materials based on wood, agro, and waste paper.

CONTACT DETAILS

TURBOTECH PRECISION ENGINEERING PRIVATE LIMITED
MR. GIRIDHAR HEGDE
VP – SALES & MARKETING
MOBILE: 9448285600
EMAIL: GIRIDHAR@TURBOTECHINDIA.COM

CASE STUDY 14: MODULAR RAINWATER HARVESTING SYSTEMS (RAINMAXX TANKS)

BACKGROUND

The concept was developed in the situation that normal rainwater harvesting solutions could not be an option, owing to different factors like depth of the tank time for construction, etc. The RAINMaxx concept of rainwater harvesting solution is basically a 100% recycled PP modular-based tank used for rainwater harvesting. These modular tanks are used to collect, store and infiltrate rainwater for later use. The modules are designed in such a way that it conserves rainwater at its optimum level when executed. It aids self-sufficiency and helps the overall environment. The concept is developed by **Retas Enviro solutions Pvt Ltd.**

Table 15: Comparison of Modular & Conventional Tanks

S. No	Criteria	Modular Tanks	Conventional Tanks
1	Time for Installation (Tank)	This process takes merely 1 to 15 days, irrespective of tank size.	30 days to months to lay out PCC, Brickwork, Plaster, Steel framework, Roof RCC.
2	Effective detention volume (Storage Capacity)	Above 95% of tank Volume.	Reduced Tank Volume.
		Very compact, optimal space utilisation.	Free board space (0.5 to 2) meters.
			Filter media volume (20 - 30 % of tank volume)
3	Space utilisation	Top surface may be used for parking lots, children’s play area, gardens, sports field.	Generally located where land use is demarcated as unusable.
			Requires overdesigning of cover slab to accommodate lawn or parking lot at surface level.
4	Load Bearing Challenges	Load bearing capacity of Rainmaxx tanks are very high up to 45 tonnes/ Sqm without requiring any structural design or special load bearing.	Architects/ Structural Consultants involvement is must and contactor work quality are essential to ensure load bearing of cover slab and structure.
5	Environmental Impact	Material is made up of 100% recycled polypropylene.	Virgin Material, Sourcing Boulders and pebbles is a challenge, effecting our eco system.
		Eco friendly and hence qualifies for green rating.	
6	Reduce/ Extend Tank size	Tank size could easily be reduced or extended or even relocate as per future use.	Requires construction of new tank, if future land requirement changes.

7	Life and Material Standardization	Modules, Geotextile and waterproof liners are lab tested based on technical parameters.	Life with good quality work is 15 - 20 years. Poor quality work may cause the project to fail.
		Long shelf life.	Quality assurance is a challenge.
8	Aesthetics	Does not affect aesthetics of the property, rather helps to improve the same.	Non-aesthetic.
9	Seasonal Challenges	Could be installed between rainfall events, as 1 or 2 days are sufficient for installation of tank generally.	Work completion dependent upon good weather. Monsoon season can stall work.
10	Safety Aspect	Completely underground and no easy access to storage space.	Manhole access to hollow storage space.
		No risk foreseen.	Accumulation of poisonous gases owing to deterioration of organic elements inside tank.

Figure 20: RainMaxx Module

PROJECT DESCRIPTION

The RainMaxx modular tank concept was developed for a capacity of 344 m^3 for one of the suppliers in Agra. A total number of 6 RainMaxx tanks were installed with one recharge well each. Capacity of each recharge tank was different depending on the area. Installation of all the six tanks was completed in record six days' time.

Sectional photograph of the rainwater harvesting system is as shown:

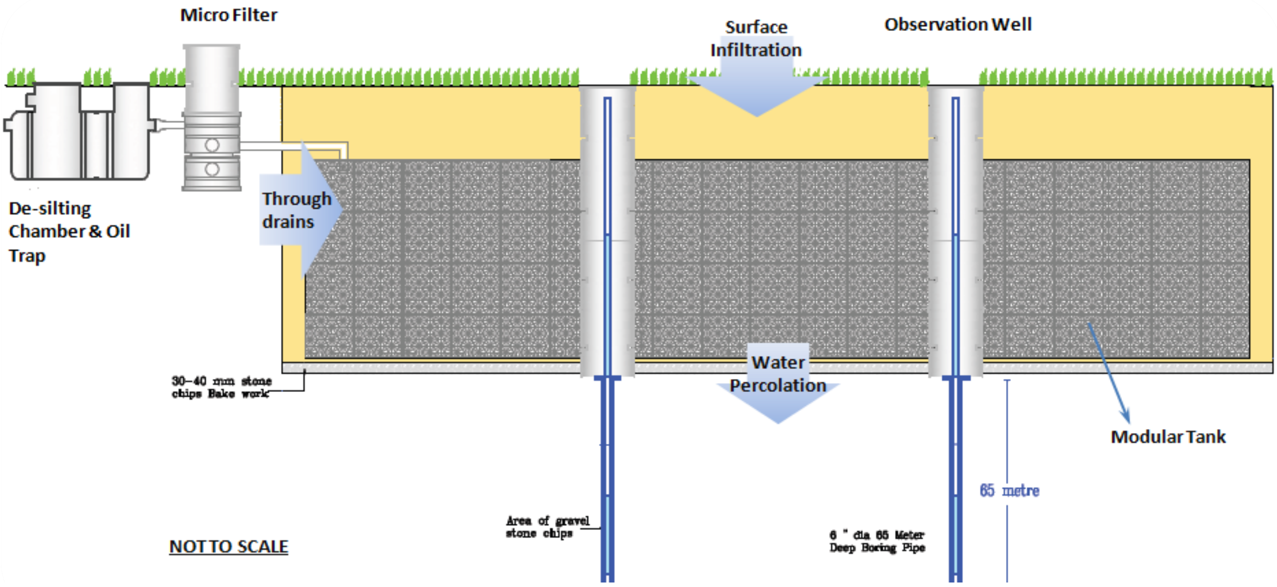


Figure 22: Site Installation

Figure 21: Actual site installations

Some of the project features include:

- Considering the large volume of suspended matter anticipated in the runoff and to ensure efficient functioning of RWH system, an advanced dual-step external filtration system was developed to address the sediments issue specific to urban conditions and for achieving high quality water stored in tank as also for recharged to groundwater. Desilting chamber along with micro-filter has also been installed to take care of the above aspect.
- The supplier has designed point solution so that water travel the minimum area. This saved a lot of excavation and other civil costs. Also, because storm water is travelling minimum area, quality of water was also better as compared to earlier design.
- It is recommended to install butterfly valve near the external stormwater drain to prevent water from entering inside the premises.

BENEFITS

For an annual rainfall capacity of 700 mm & 26-27mm/h, the savings estimated were:

- Total Recharge through 6 Modular tanks: 3.32 Lakh litres/ hour
- Total Recharge annually: 90 Lakh litres.

REPLICATION POTENTIAL

The RainMaxx concept has been implemented and RWH units of Retas are operating successfully in various parts of the country. The RWH scheme with its Modular construction can very well be replicated in all Indian Pulp and Paper mills to generate sources of fresh water input, especially in areas with space constraints & constructional issues.

CONTACT DETAILS

RETAS ENVIRO SOLUTIONS PVT LTD.
MR. PRIYANK JAIN
MOBILE: 7289965519
EMAIL: PRIYANK.JAIN@RSPINDIA.COM

DISCUSSION PAPER

AN INTRODUCTION TO CIRCULAR ECONOMY

Countries across the globe have been following the concept of ***linear economy*** for a long period of time. Raw materials are used to manufacture a product and any kind of waste that gets generated in the process gets discarded. In other words, the process may be described as **'take, make, & dispose'**.

CONCEPT OF CIRCULAR ECONOMY

Circular Economy is an economic system employing recycling & refurbishment to develop a closed loop, with minimum use of resources, and minimum waste generation. Basically, in a circular economy, products are designed to be reusable. For instance, plastic being recycled into pellets to further manufacture plastic products. Products & raw materials get used multiple times.

The concept of circular economy helps in promoting sustainability. That means preventing waste by making products and materials more efficiently and reusing them.

The ultimate aim of circular economy is the conversion of waste to resource, whereas linear economy is aimed at reducing the waste generated.

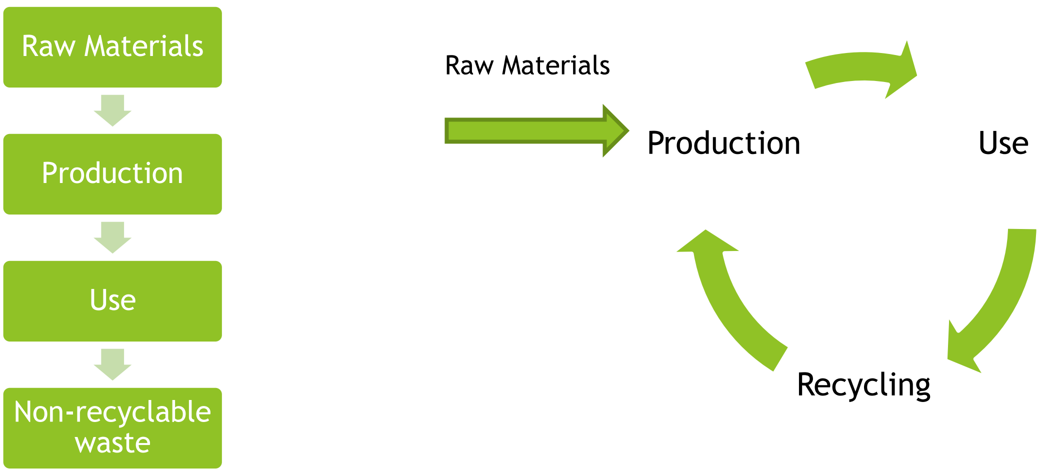


Figure 23: Linear & Circular Economy

CIRCULAR ECONOMY IN INDIA

With a population of 1.3 billion & GDP growth of 7%[6], the need for resources & energy is expected to see more challenges in the years to come. Promoting circular economy & establishing necessary steps for its promotion therefore can help India's economic prosperity.

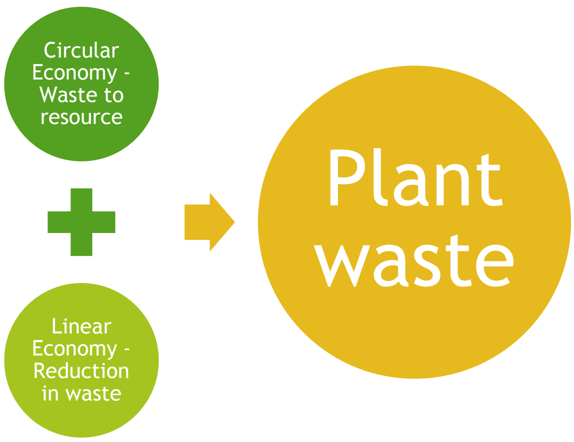


Figure 24: Concept of Circular Economy

As reported by the **Ellen Macarthur Foundation,** a circular economy path to development could bring India

[6] http://statisticstimes.com/economy/gdp-of-india.php

annual benefits of INR 40 lakh crore (USD 624 billion) in 2050 in comparison with the levels in 2016 – a benefit equivalent of 30% of India's current GDP.

SALIENT FEATURES OF CIRCULAR ECONOMY

- Continuous improvement and upgradation of waste to resource.
- Optimization of resource efficiency.
- Chemical and Energy recovery.
- Flexible energy production.
- Reduce use of non-renewable/fossil fuels.
- Waste reduction.
- Economic return.
- New bio-based products.
- Increasing life-cycle of products.

Figure 25: Schematic of circular economy in Paper plant

(Source: Luxembourg Wood Cluster)

Circular ecomony may be promoted in industries in two ways:

- Within the sector – Waste from one paper plant may be used as a raw material in another paper unit.
- Cross sectoral – Waste from any process plant may be used as raw material in paper plants or vice versa.

EXAMPLES OF CIRCULAR ECONOMY IN EUROPEAN PULP & PAPER MARKET[7]

1) **CartaCrusca** – This project is based on producing paper from rice bran residue. The concept is based on using waste available after the processing from Barilla wheat to be used as a raw material alomg with cellulose for paper production. CartaCrusca contains 20% of bran residues, replacing cellulose and filler materials to produce high-quality paper, which is used for all corporate communications. The colour of CartaCrusca is that of bran, and the paper has an authentic rough feel to it.

   ***Source of waste: Food processing*.**

   (https://www.favini.com/gs/en/fine-papers/crush/cartacrusca-case history/)

2) **Shigo Alaga Carta Paper** – Patented in 1990, it is a technology based on using damaging algal blooms of the Venice lagoon to produce ecological paper. The concept has also been extended to fragile marine areas.

   Source of waste: Algal bloom

   (https://www.favini.com/gs/en/fine-papers/shiro/features-applications/)

3) **Remake Paper** - Remake uses as much as 25% of pulp material from discarded residue of the leather manufacturing process. The process of paper production from this technique is called

[7] https://circulareconomy.europa.eu/platform/en/sector/pulp-and-paper-industry-ppi

‘upcycling’. Remake is not only a unique paper made of leather, it is also 100% recyclable and compostable, and perfectly suited to luxury printing and packaging. The residues, which are visible on the surface, give the paper its distinctive look and its amazing soft and velvety feel. In full respect to the environment, Remake contains 40% recycled pulp.

***Source of waste: Leather Industry*.**

4) **Eurocities –** The city of Ljubljana is faced with significant overgrowth of Japanese knotweed, a plant on the list of 100 most invasive non-native species worldwide. The production of paper here is based on this waste usage.

   (http://www.eurocities.eu/eurocities/documents/Full-Circle-cities-and-the-circular-economy-WSPO-ASRCM7)

5) **EcoEnergySF Oy** – The technology is based on biogas production from paper & pulp side-streams.

   Source of waste: Forest-based slurries from pulping process.

   (www.ecoprotech.fi/en/References/Case%20%E2%80%93%20pulp%26paper%20slurries)

6) **Inventia Sweden:** Inventia (Sweden) has developed the technology for manufacturing paper by using the secondary waste stream of the textile mill (recycling plant). During pilot study, fibrous paper was manufactured on a small scale.

   Source of waste: Textile wastes

WAY FORWARD

All of the above are examples of how waste can become a resource as well as contribute to green growth. These case studies offer a model for Low Carbon Economy and are perfect examples of how the Indian Paper sector can look into avenues for “waste to resource” conversion. The Indian paper sector should relook on their waste being generated and dumped without any return; and should develop strategies to start looking for schemes – conventional or innovative – for the waste to be converted to resource (raw material) for other industry (cross-sector) or even within the sector.

ACTION PLAN & CONCLUSION

ACTION PLAN

- The individual paper plants have to assess the present performance and should develop their own individual targets for improving all the parameters.
- Set and achieve voluntary targets of at least 1% to 5% reduction in specific energy consumption every year.
- The best practices and the performance improvement projects compiled in this manual may be considered for implementation after suitably fine-tuning to match the individual plant requirements.
- If required, CII-Godrej GBC will help the individual units improve their performance by providing energy audit services and identifying performance improvement projects specific to individual units to achieve the targets.
- The present level of performance and the improvements made by the individual units have to be monitored.
- The performance improvement of these units will be reviewed in the "Papertech" every year, and the information will be disseminated among the Indian Pulp and Paper plants.

CONCLUSION

The objective of the project will be fulfilled only if the performance of all the pulp and paper units improves, and achieves world class standards.

We are sure that the Indian Pulp and Paper units will make use of this opportunity, improve their performance and move towards world class Energy Efficiency.

About CII

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering industry, Government, and civil society, through advisory and consultative processes.

CII is a non-government, not-for-profit, industry-led and industry-managed organization, playing a proactive role in India's development process. Founded in 1895, India's premier business association has around 9000 members, from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 300,000 enterprises from around 276 national and regional sectoral industry bodies.

CII charts change by working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness and business opportunities for industry through a range of specialized services and strategic global linkages. It also provides a platform for consensus-building and networking on key issues.

Extending its agenda beyond business, CII assists industry to identify and execute corporate citizenship programs. Partnerships with civil society organizations carry forward corporate initiatives for integrated and inclusive development across diverse domains including affirmative action, healthcare, education, livelihood, diversity management, skill development, empowerment of women, and water, to name a few.

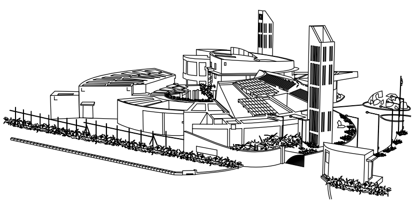
India is now set to become a US$ 5 trillion economy in the next five years and the Indian industry will remain the principal growth engine for achieving this target. With the theme for 2019-20 as 'Competitiveness of India Inc - India@75: Forging Ahead', CII will focus on five priority areas which would enable the country to stay on a solid growth track. These are – employment generation, rural-urban connect, energy security, environmental sustainability, and governance.

With 66 offices, including 9 Centres of Excellence, in India, and 10 overseas offices in Australia, China, Egypt, France, Germany, Singapore, South Africa, UAE, UK, and USA, as well as institutional partnerships with 355 counterpart organizations in 126 countries, CII serves as a reference point for Indian industry and the international business community.

About CII-Godrej GBC

CII-Sohrabji Godrej Green Business Centre (CII-Godrej GBC) was established in the year 2004, as CII's Developmental Institute on Green Practices & Businesses, aimed at offering world-class advisory services on conservation of natural resources. The Green Business Centre in Hyderabad is housed in one of the greenest buildings in the world and through Indian Green Building Council (IGBC) is spearheading the Green Building movement in the country. The Green Business Centre was inaugurated by His Excellency Dr. A. P. J. Abdul Kalam, the then President of India on 14 July 2004.

The Services of Green Business Centre include- Energy Management, Green Buildings, Green Companies, Renewable Energy, GHG Inventorization, Green Product Certification, Waste Management, and Cleaner Production Process. CII-Godrej GBC works closely with the stakeholders in facilitating India emerge as one of the global leaders in Green Business by the year 2022.



Confederation of Indian Industry
CII-Sohrabji Godrej Green Business Centre
Survey No. 64, Kothaguda Post
Hyderabad - 500 084 India
Tel: +91 40 44185111
Fax: +91 40 44185189