



Environment Friendly Techniques for Wastepaper Based Pulp and Paper Industries

overview, approach and case examples

June 2015

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Foreword



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The Indo German Development Cooperation has “urban and industrial environmental policy & management” as one of priority areas of cooperation. The Indo German Environment Partnership (IGEP) Programme forms a part of this priority area, under which technical cooperation was provided to the identified Indian partner organizations by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ).

The IGEP Programme, which is implemented jointly by the Ministry of Environment, Forests and Climate Change (MoEF&CC) of the Government of India and GIZ, has a thrust area on Sustainable Industrial Development (SID). Under the SID component, “Environment Friendly Techniques in Identified Industry Sectors” is one of the core topics. In India, the Small and Medium Enterprises (SMEs) make up for a very large part of the industrial profile and are often characterised by the use of outdated/inefficient technologies and production processes resulting in pollution problems. The major forms of pollution include air pollution, water pollution, soil contamination, noise pollution, and thermal pollution. For the SMEs, constraints on using modern and environment friendly technologies vary from shortage of capital, limited access to technology, underdeveloped infrastructure, inadequate research and development, and the lack of awareness on the options available to them for pollution prevention and control.

The overall objective of the technical cooperation on the core topic of ‘Environment Friendly Techniques in Identified Industry Sectors’ is, “The use of environment friendly technologies and techniques is promoted in selected SME sectors”.

The pilot activities taken up in the waste paper based paper industries in Vapi in Gujarat had positive results. The present document is an effort to put together information on the pilot work undertaken under the IGEP Programme. We hope, the document will be useful for the policy makers, regulators and the industry alike for improving environmental performance in the pulp and paper sector.

June 29, 2015
New Delhi

(Dr. Dieter Mutz)

1. Chapter - Overview of the Paper Industry

1.1 Brief Introduction to the Global Paper Sector

The annual global paper and paperboard production was approximately 382 million tonnes in 2006. This is expected to increase to 490 million tonnes by 2020 (as shown in Figure 1). The global pulp and paper industry consists of about 5000 industrial pulp and paper mills, and an equal number of very small companies.

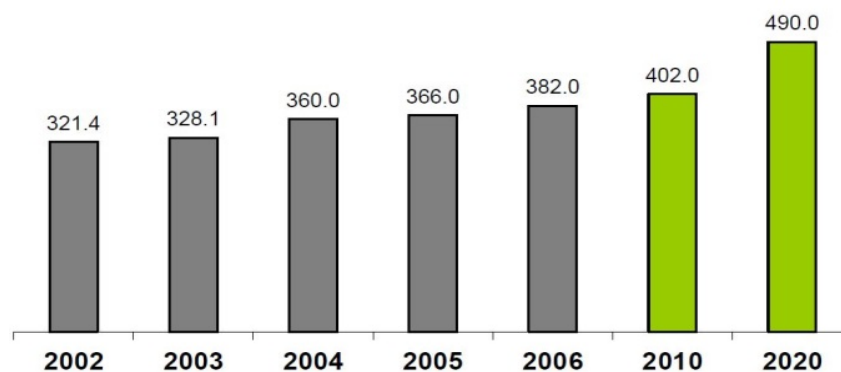


Figure 1: Paper and Paperboard Production – Global Market, 2002-20 (figures in million tonnes)
[Source: CEPI; RISI; European recover paper council; ICEM World Paper Conference (November 2005); Research India Analysis]

Broadly, the industries can be classified into two segments:

- Paper and paperboard (writing, printing, packaging and tissue). The writing and printing paper market can be further divided into coated and uncoated segments.
- Newsprint mainly uses for newspapers, flyers, and other printed material intended for mass distribution.

USA is the largest market for paper product and commands high per capita consumption. Asia's main markets are China, Japan, India, Malaysia, Singapore and Thailand (as shown in Figure 2).

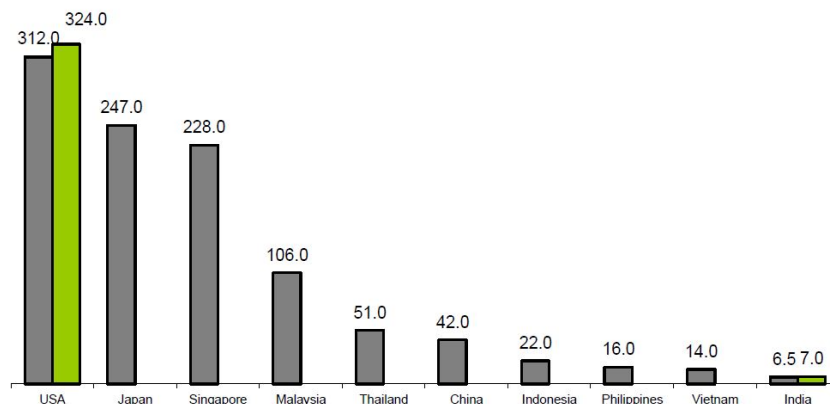


Figure 2: Consumption per capita, 2005 vs. 2006 (figures in Kgs)
[Source: CEPI; RISI; European recover paper council; ICEM World Paper Conference (November 2005); Research India Analysis]

In 2005, the USA had the highest per capita consumption (312 kg), followed by Japan (247 kg), Singapore (228 kg), Malaysia (106 kg), Taiwan (51 kg) China (42 kg), Indonesia (22 kg) and Philippines (16 kg). India's per capita consumption is estimated to be as low as 7.0 kg (as in 2006).

The paper and paperboard industry has witnessed a radical shift in the last decade. Due to the strong economic growth in both China and India, the demand for paper and paperboard is increasing at a fast rate i.e. 8-9%. Latin America in the south and Indonesia in the east have emerged as a fibre supplier with a concurrent decline in the North American pulp industry.

North America, Europe and Asia dominate the global pulp and paper industry. Asia, mainly China and India, would emerge as an important market for pulp & paper. India is the 15th largest paper producer in the world. It provides employment to nearly 1.5 million people and contributes INR 25.0 billion to the government's exchequer.

1.2 Brief Introduction to the Indian Paper Industry

In last 55 years, the number of paper mills in India has increased from just 17 mills in 1951 to more than 666 units engaged in the manufacture of paper and paperboard, out of which nearly 568 were in operation by 2006. Capacity utilization of the industry is just 79%, due to old technology. Moreover, 194 mills are under the purview of the Board of Industrial and Financial Reconstruction (BIFR) and nearly 60 mills (with a capacity of 1.3 million tonnes) are closed.

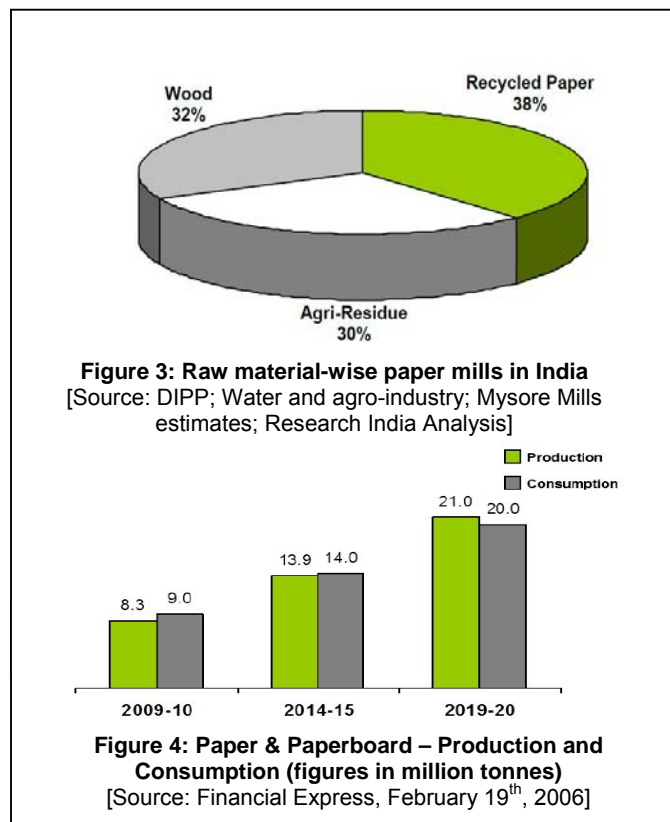
The Indian paper mills can be categorized based on the raw materials into:

- Wood / forest based mills;
- Agro-residue based mills; and
- Wastepaper-based mills.

Due to increasing regulations and raw material prices, the companies are increasingly using more non-wood based raw material over the years. In 2006, around 70% of the total production was based on non-wood raw material (as shown in Figure 3).

The focus on this document as its title indicates is on wastepaper-based mills and technologies tackling their efficiency.

India is self-sufficient in manufacture of most varieties of paper and paperboards. The imports are mainly related to certain specialty papers such as lightweight-coated variety of paper, cheque paper, etc. Due to the scarcity of raw material, the companies also need to rely on imported wood pulp and waste paper. In the last years, the capacity was increased mainly through expansion and modernization of the existing facilities rather than setting up of new projects.



Various macro-economic factors like national economic growth, industrial production, promotional expenditure, population growth and the government's allocations for the educational sector influence the demand for paper. The growth in paper consumption is directly related to GDP growth in the country. With expected GDP growth of 9-9.5%, the demand for Newsprint and Writing & Printing Paper is expected to grow at the same rate. According to ITC's estimates, the total demand for paper is around 8 million tonnes and is expected to grow to 21 million tonnes by 2020. According to the Indian Paper Manufacturers Association (IPMA), consumption of paper in India is set to double from the current 14 million tonnes per annum by 2015 (refer to Figure 4).

The Indian paper industry is currently in the midst of a transformation with major capital expenditure (capex) underway and improving operating efficiencies is the major concern of all the players. The focus appears to be on:

- Improving the operational efficiencies through rightsizing pulping capacities.
- Brown-field capacity expansions.
- Backward integration into captive power.
- Adherence to pollution norms by chemical recovery.

1.3 Pulp and Paper Manufacturing Process

1.3.1 General introduction

The pulp for paper making may be produced from virgin fibre by chemical or mechanical means or may be produced by the re-pulping of recovered paper. A paper mill may simply reconstitute pulp made elsewhere or may be integrated with the pulping operations on the same site. A wide range of fibrous raw materials, chemicals, fillers & additives, water, energy and labour are utilised during the pulping and paper making process. Better utilisation of the inputs and reuse of by-products / wastes is a key factor (Refer Figure 5), which controls the economics of pulp and paper manufacturing. This section will give a general overview about the pulp and paper process.

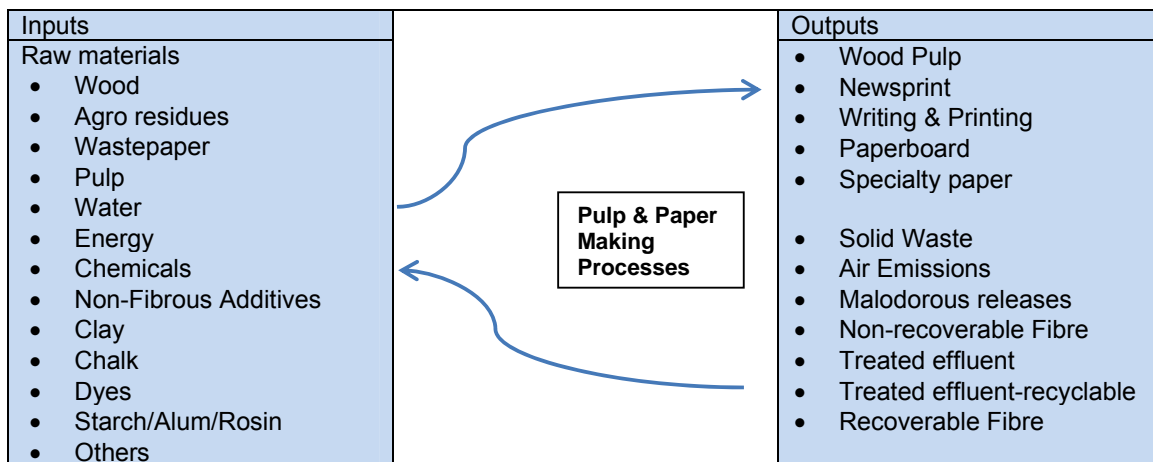


Figure 5: Broad input and output features of pulp & paper making processes
 [Source: LVK Enviro Consultants]

From the global perspective, the overall pulp & paper sector could be understood from the following broad production classification:

- Kraft pulping process
- Sulphite pulping process
- Mechanical pulping and chemo-mechanical pulping
- Recycled fibre processing and
- Papermaking and related processes

From the Indian perspective, the overall pulp & paper sector could be understood from three broad groupings:

- Wood based
- Agro based
- RCF/Wastepaper

Refer to Figure 6. below

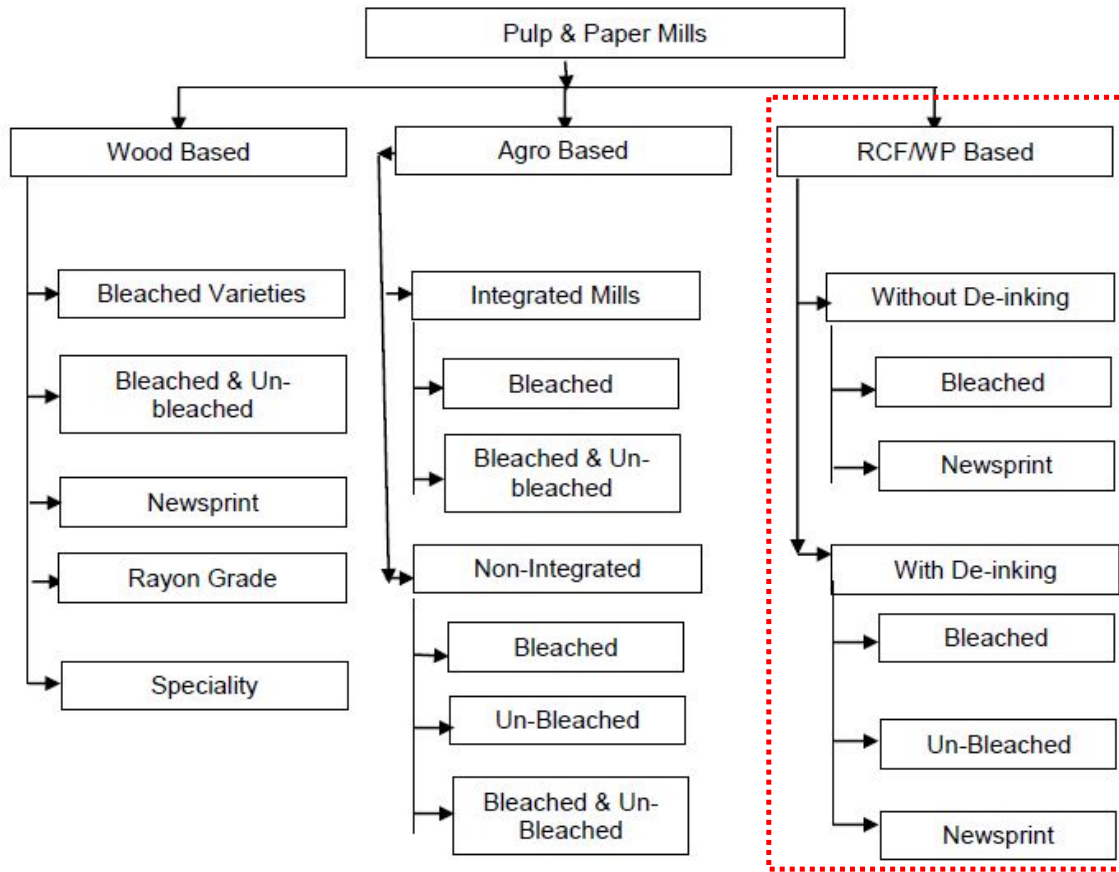


Figure 6: Broad classification of pulp & paper sector from Indian perspective
 [Source: LVK Enviro Consultants]

The sulphate or Kraft process is the dominating pulping process worldwide due to the superior pulp strength properties and its application to all wood species. The production of sulphite pulp is much smaller than the production of Kraft pulp. The pulping process can be carried out with Magnesium or Calcium bi-sulphite process routes. In India, no such mills exist though there has been one plant involved in producing dissolving grade pulp (or Rayon grade pulp). In mechanical pulping, the wood fibres are separated from each other by mechanical energy applied to the wood matrix. The objective is to maintain the main part of the lignin in order to achieve high yield with acceptable strength properties and brightness. The manufacture of newsprint in the country started with the commissioning of National Newsprint & Paper Mills (Nepa Mills) in 1955 at Neapanagar (M.P.). Till 1981, it was the only unit manufacturing newsprint paper, based on wood as the raw material.

This document focuses on the specific set of paper making process that is recycled fibre or wastepaper based, which are detailed below.

1.3.2 Recycle Fibre/Wastepaper based Paper Mills

Unlike other types of mills mentioned above, the recycle fibre or wastepaper based mills do not require any forest based wood or non-conventional agricultural residue resources as raw materials. The recovered fibre has become an indispensable raw material for the paper manufacturing industry world over. For effective use of recovered paper, it is necessary to collect, sort and classify the materials into suitable quality grades. Wherever organized wastepaper logistics prevail, recovered paper is brought to the collection yards, where it is then sorted out. The detrimental substances such as plastics, laminated papers etc. are removed before balling. Otherwise, these impurities need to be removed as an integral part of wastepaper processing.

The recovered paper processing system varies according to the paper grade to be produced, e.g. packaging paper, newsprint or tissue paper and the type of furnish used. Generally, recycled fibre (RCF) processes can be divided in two main categories:

- Processes with exclusively mechanical cleaning, i.e. *without deinking* comprising products like test-liner, corrugating medium, uncoated board and carton-board; and
- Processes with mechanical cleaning and *de-inking* comprising products like newsprint, tissue, printing and copy paper, magazine papers (SC/LWC), coated board and carton board or market De-Inked Pulp (DIP).

All processes aim at de-fibration, de-flaking and removal of impurities, i.e. efficient separation of fibrous material and impurities and contaminants. The recycled fibre plants consist of similar "building blocks" designed for the specific task.

1.3.3 Processes of Recovered Fibre (RCF) in wastepaper-based mills

There are a series of unit processes and operations conveniently put into preparatory processes (sorting, screening, hydro-pulping, impurity removal, refining etc.), formation processes (deployment of retention aids, chemicals, fillers, colour and auxiliaries) and finishing processes (various grades of product making, drying and finishing etc.).

The products made through RCF route are diverse in nature, with integrated Hydro-pulper and associated purification processing or non-integrated speciality product steps. Such products, after discarding phase, become raw material through supplier chain route. Thus, understanding the nature of product itself is vital to decide the nature of pulp slashing & purification processes.

Although there is a possibility for a large variety of paper products and different process lay-outs in paper mills, almost all types of paper and board-making processes have the following basic units:

- Pulp preparation and purification and stock preparation
- Paper and board formation via "Paper Machine Approach system"

1.3.4 Pulp preparation and purification & stock preparation

- **Wastepaper Storage:** Wastepaper or raw material furnish is normally delivered to the paper mill in the form of bales. The bales are opened by cutting the wires or straps that are collected and sold as metal waste. To some mills, raw material furnish is also delivered as loose material in truck or by bulk dumping. The pre-cleaned raw material furnish is stored in stock yard for further processing.
- **Re-pulping of the raw material furnish:** The pre-cleaned wastepaper or raw material furnish is put into a hydro-pulper together with hot water or white water, and pulped with mechanical and hydraulic agitation resulting in their disintegration into fibres. As per paper grade, at times certain chemicals are also added (say for newsprint variety). Different technical solutions are available for various types of raw materials and products. There are three types of hydro-pulper: low consistency (LC: 4-6% DS), high consistency (HC: ca. 15 - 20%) and drum pulpers. There are batch and continuous types. Contaminants and clusters are removed continuously during operation by a dirt trap (e.g. screen plate) and are sent to a reject conveyor, in order to avoid the contaminants breaking into small pieces or accumulating in the hydro-pulper. There is an increasing use of secondary pulpers for further defibration, deflaking and cleaning from heavy-weight (HW) and lightweight (LW) dirt. The installations trade under different names but are based on similar functioning. Also screening drums are used. Various types of "Hydro-pulpers" are used to convert recycle fibre to pulp by mechanical slashing. Normally, the water for disintegration is totally re-circulated as process water that comes as white water from the paper machine.
- **Mechanical removal of impurities (Pre & Post Cleaning):** The removal of mechanical impurities is based on the differences in physical properties between fibres and contaminants, such as size, specific gravity compared to fibres and water. Basically there is screen-type equipment with different dimensions of screen opening (holes and slots) and various types of hydro-cyclones (high

consistency cleaners, centrifugal cleaners etc.). Any plastic material impregnated in raw material furnish is removed using turbo-separators.

The next process stage is **screening** to separate contraries, which are larger than the openings of the perforated baskets of the pressurised screens. The selection of screen type depends on end product and the quality of the fibre furnish used. Coarse screening (3-4% consistency) for the removal of coarse contaminants during stock preparation can be distinguished from fine screening in the approach flow (1% consistency) of the paper machine. Depending on the furnish quality to be achieved, the stock preparation plant for recovered paper processing has to be equipped with additional machines such as fractionators, dispersers or refiners. A fractionator separates the pulp in two fractions rendering it possible to treat short and long fibres of the pulp slurry in different manners. The energy demanding process of disperging can be performed in order to achieve improved fibre-to-fibre bonding (better strength characteristics) in the paper produced and to reduce visible dirty specks in size. A stock preparation plant for the processing of recovered paper can be optionally equipped with refiners to improve optical and strength characteristics of the paper. Refining is associated with a substantial energy demand.

For the production of **packaging papers or board** from recovered paper i.e. test-liner and corrugated medium, only mechanical cleaning is applied i.e. no deinking process is needed. Closed water loops operate satisfactorily from the point of view of manageable plant conditions and good product quality if around 3 to 4 m³ of process water per tonne finished stock are treated in an integrated biological clarification plant.

In the case of newsprint, the raw material used is a typical deinked pulp consisting of a 50:50 mixture of newspapers and magazines. The system is characterised by a two-stage flotation and bleaching combined with an intermediate dispersion. For De-inked Pulp, this process is applied. Generally ink constitutes 0.5 to 2% of the mass of the waste paper.

Deinking can be done by two methods, washing and flotation depending upon the requirement. The washing deinking is less effective in the removal of large ink specks >20 microns whereas flotation deinking is less effective in removal of small ink specks <20 microns. Though smaller particles can be removed by flotation, if they are agglomerated to form large particles. Better results are achieved by combination system of the above two methods. Although some ink is removed by screens as well as centrifugal cleaners. Most ink is removed by either or both flotation and washing.

The major components of a modern paper machine are:

- Head box: introduces suspension of fibres to the wire belt and creates a uniform dispersion of fibres across the total width of the wire belt.
- A wire section: here the endless moving Fourdrinier fabric (or cylinder moulds) forms the fibres into a continuous matted web, while the Fourdrinier table (or cylinder mould) drains the water by suction forces drains paper web to around 12 - 20% solids.
- A press section: removes more water out of the web by pressing down to about 50% moisture content.
- A drying section: removes rest of moisture by heating the web with drying cylinders.
- A re-winder reels the paper web into a roll.
- Depending on the paper and board grade, there are additional process units (optional) like calendars, coaters, a coating colour kitchen, winders, re-winders and a roll wrapping station. A typical process sequence showing major components of modern machine is shown in Figure 7.

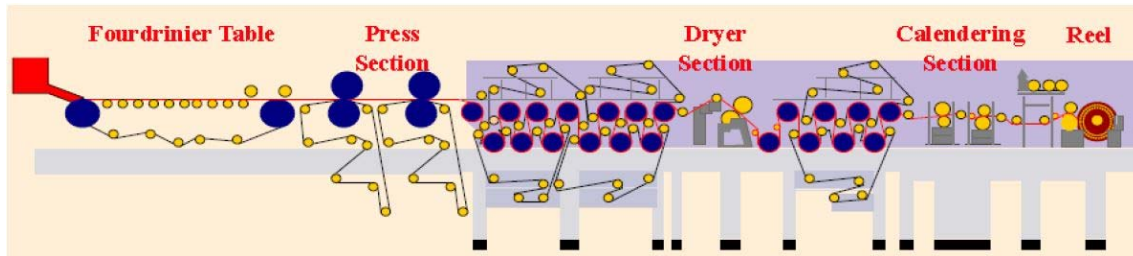


Figure 7: A typical process sequence showing major components of modern machine
 [Source: GIZ-IGEP & GCPC Team]

Various **process aids**¹ are deployed to facilitate the operation of paper processing for enhanced performance of the process. All the applied chemicals, except the retention aids, will re-appear in the wastewater or circulating process water streams. Any on-line or off-line effluent treatment system must take care of required pre-treatment needs.

1.4 Key Environmental Issues in General

Identification and assessment of critical environmental issues of the Pulp & Paper sector as a whole is complex because of the diversity of products involved. The focus of this document has been confined to wastepaper or RCF based processing mills, for which the environmental impact potentials are comparatively lower than those of other sub-sectors. However, by virtue of having large number of mills, their tremendous growth prospects in future, and their distribution being in-and-around human settlements, the environmental issues deserves due consideration.

The raw materials for RCF based paper production consists mainly of local and imported wastepaper and water, as well as some chemical additives. Major water consumption is process and cooling water. To improve the product properties (paper auxiliaries), various additives are applied as processing aids during paper manufacturing. The environmental impact potential from RCF based paper processing encompasses pollution from waste water discharge, solid waste generation and air emissions mainly related to boiler or on-site energy generation facility. When abatement techniques are applied to reduce pollutants, cross-media effects can occur such as build up of TDS in wastewater.

The negative environmental impacts from paper manufacturing in RCF based paper mills is mainly based on the quality of local or imported wastepaper and its quantity, energy consumption, chemicals used (product aids, process aids and utility, refer to Annexures 6.1.), water used and wastewater generated, emissions from boiler or energy sources and solid wastes (mainly plastic & ETP Sludge). The environmental concerns from pulp & paper industry are due to:

- Water use
- Use of additives
- Energy consumption
- Wastewater quality & quantity
- Solid waste generation from stock preparation, process water clarification and wastewater treatment
- Atmospheric emissions
- Noise from rotary equipment (local)
- Odour from vapours (biofouling within process area) and from wastewater treatment plant (local)

For further details on environmental concerns from pulp & paper industries, refer to Annexures 6.2.

The classification of available wastepaper, in terms of quality & cost, varies from country to country. The imported wastepaper is roughly classified into four groups, corresponding to ordinary, medium,

¹ For details, refer to annexures 6.1.

high and extra high qualities, which are further sub-classified with varying costs of procurement. Similarly, locally available wastepaper will differ in quality, depending on source of procurement (institutional or from waste-mart). The lower grade wastepaper contains more impurities and must be cleaned more intensively to fulfil the product requirements compared to higher grade recovered paper. It is expected that the percentage of impurities in recovered paper will increase because of the continuous increase of recycling of waste paper. This effect will be enhanced by intensified use of fillers in the paper production. Overall, it is expected that the amount of impurities in wastepaper will increase, which in turn will lead to increased cleaning and bleaching steps. It will also lead to increase in solid wastes in RCF paper mills. The quality of waste paper used as raw material will have influence on yield of final product, energy requirements for effective separation, consumption of materials/chemicals, disposal burden of solid wastes and treatment cost of waste water.

1.5 Environmental Regulatory Framework

The major environmental legislations related to environment are:

- The Water (Prevention and Control of Pollution) Act, 1974.
- The Water (Prevention and Control of Pollution) Cess Act, 1977.
- The Air (Prevention and Control of Pollution) Act, 1981.
- The Environment (Protection) Act, 1986, various relevant Rules notified thereof.
- The Hazardous Waste (Management, Handling and Trans-boundary Movement) Rules, 2008 and amendments thereof.
- The Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989.
- The Coastal Zone Regulation -Declaration Notification, 1991.
- The Environmental Impact Assessment Notification 2006 and amendments thereof.
- The Bio-Medical Waste (Management and Handling) Rules, 1998.
- The Rules for the Manufacture, Use, Import, Export and Storage of Hazardous Microorganism.
- Genetically Engineered Organism Cell, 1989.
- Plastics Waste Management Rule, 2012.
- Utilization of Fly Ash - Notification of Directions, 1999.
- The Noise Pollution (Regulation and Control) Rules, 2000.
- The Ozone Depleting Substances (Regulation and Control) Rules, 2000.
- The Municipal Solid Waste (Management and Handling) Rules, 2000 and amendments thereof.
- The Batteries (Management & Handling) Rules, 2001.
- The Environmental Audit Scheme, 1996
- The Public Liability Insurance Act, 1991.

In addition, various environmental standards applicable to pulp & paper industries cover MINAS (Minimal National Standards), boiler stack emission standards linked to capacity & fuel type, diesel generator set stack height and acoustic enclosure stipulations and national ambient air quality standards. Moreover a voluntary programme called CREP² (Corporate Responsibility on Environmental Protection) applies to the pulp & paper sector.

The Ministry of Environment, Forests and Climate Change (MoEF&CC) is the nodal agency in the administrative structure of the Central Government for the planning, promotion, co-ordination and overseeing the implementation of India's environmental and forestry policies and programmes.

The Ministry is involved in implementation of policies and programmes relating to conservation of the Country's natural resources including its lakes and rivers, its biodiversity, forests and wildlife, ensuring the welfare of animals, and ensuring prevention and abatement of pollution. While implementing these policies and programmes, the Ministry is guided by the principle of sustainable development and enhancement of human well-being. The broad objectives of the Ministry are:

- Conservation and survey of flora, fauna, forests and wildlife.

² Office of the principal scientific adviser to the GOI, 2014, Opportunities for green chemistry initiatives: pulp and paper industry, New-Delhi, retrieved from http://psa.gov.in/sites/default/files/Pulp_Paper_-Final.pdf

- Prevention and control of pollution.
- Afforestation and regeneration of degraded areas.
- Protection of the environment.
- Ensuring the welfare of animals.

These objectives are well supported by a set of legislative and regulatory measures, aimed at the preservation, conservation and protection of the environment.

The Central Pollution Control Board (CPCB) was constituted in September 1974 under the Water (Prevention and Control of Pollution) Act, 1974. CPCB was subsequently entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981 and various provisions under the Environment (Protection) Act, 1986.

The State Pollution Control Board (for Gujarat State - Gujarat Pollution Control Board) aims at developing all round capabilities in the state level to protect the environment by preventing and controlling pollution by effective law enforcement and by adopting best environmental management practices to keep the State on course of sustainable development. The State Pollution Control Boards and the Pollution Control Committees (in respect of Union territories) implement various provisions under the Water (Prevention and Control of Pollution) Act, 1974, the Air (Prevention and Control of Pollution) Act, 1981 and the Environment (Protection) Act, 1986.

The Gujarat Pollution Control Board, commonly known as GPCB, was constituted by Government of Gujarat on 15th October, 1974 in accordance with the provision of the Water Act, 1974. Several critical issues in the field of environment are being tackled by GPCB through its existing Regional Offices located at Ahmedabad, Vadodara, Bharuch, Surat, Vapi, Rajkot, Jamnagar, Godhra, Mehsana, Bhavnagar, Bhuj, Nadiad and Junagadh. Stress is laid on environmental infrastructures to meet challenges of environmental pollution under the 'Swarnim Gujarat' programmes of Government of Gujarat. Though the basic functions of the Board remained as regulatory, it has also been organising various awareness programmes on local issues of municipal solid wastes, bio-medical wastes, plastic issues besides water, air and land pollution generated from various industrial clusters. Efforts are being made for pollution control with a view to minimize and prevent pollution.



2. Chapter - Approach Followed for the Pilot Work in Gujarat

2.1 Methodology

The main steps involved in the demonstration of solutions on pilot basis included the following (ref. Figure 8 below):

- Baseline data compilation.
- Mapping of core issues.
- Identification of potential solutions.
- Consultations on applicability of identified solutions.
- Implementation of solutions on pilot basis.
- Monitoring of results and documentation of case examples.

Capacity building measures including awareness and training measures were undertaken at various stages. After the pilot testing, activities were then undertaken for enabling up-scaling of the successfully implemented measures.

The key roles were played in the above steps by the GIZ IGEP Programme and the Gujarat Cleaner Production Centre (GCPC). The Gujarat Pollution Control Board played a supporting role in the discussions on taking forward the successfully demonstrated solutions.

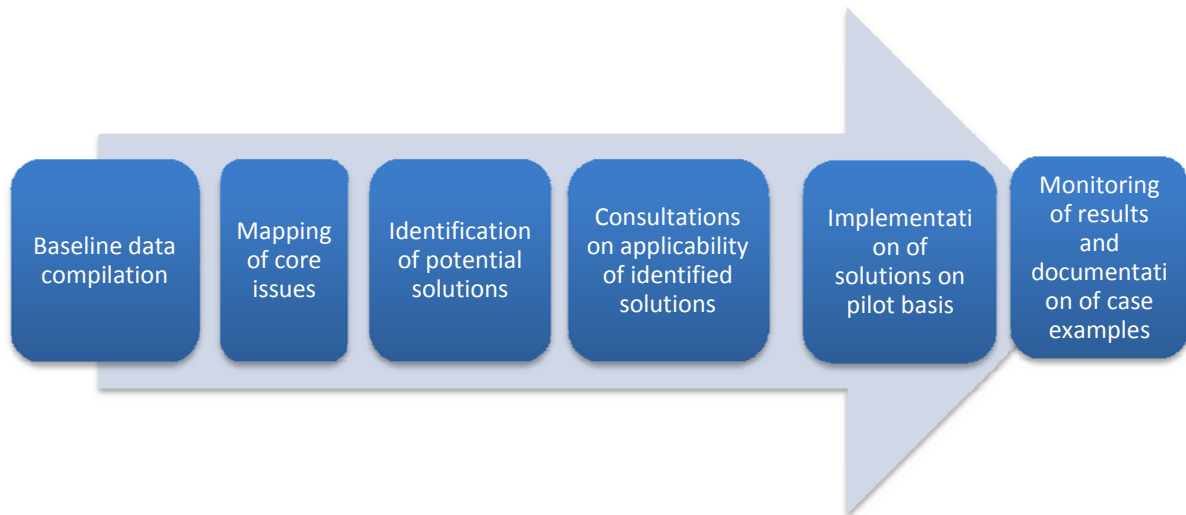


Figure 8: Various steps followed in designing and execution of pilot plan

The baseline data was required to identify core issues and problems of concern related to environment, resource efficiency, and process inefficiencies. To the identified problems, potential solutions were identified and then discussed by the IGEP team together with the GCPC team with the industries for their techno-economic viability and implementation possibilities. The volunteering industries then implemented these measures with their own funds. The results were monitored for environmental and economic benefits and documented.

► **Identification of problems/issues:**

In the first step, the collection and analysis of data was done from various sources such as historical track record on production, energy consumption, water consumption, effluent disposal, waste

generation and environmental data. The issues and problems were identified in general through desk research for the whole sector in India initially through baseline data/information collection studies based on secondary data, situation analysis based on the collected data/information, and afterwards confirmed through various stakeholders' consultations and workshops.

In the second step, the specific issues and problems related to the recycled paper industries of Vapi were then verified through in-depth analysis in each of the volunteering industries (10 nos.) where pilot measures were later implemented. The following core environmental issues were accordingly identified for finding solutions for pilot work:

- Issue 1: Less efficient electrical equipment
- Issue 2: Inefficient fibre recovery system
- Issue 3: Looping of waste (processed paper)
- Issue 4: Management of plastic waste
- Issue 5: Inorganic build up and high COD stream generation
- Issue 6: Inappropriate water quality for high quality product.
- Issue 7: High heat loss through dryer

The reasons for these environmental issues were closely looked into so that solutions could suitably be found. In the Vapi cluster, paper industries already achieved a very low water consumption of 2-10 m³ per ton of paper produced as compared to other paper industries in the country, depending upon the type of product manufactured, due to intense looping of process water (recycling). However, this low water consumption and closed loops resulted in high COD & TDS content in the recycled water. A few industries have taken up systematic approaches/programmes for reduction of pollutants at source, beyond the regulatory requirements, however this is yet to be taken up by several others. There are a number of pulp and paper mills with open or partially closed brown stock washing and paper making process. The effluent treatment plants are not always designed on the basis of proper characterization of effluent. Also, there lacked adequate training to the people operating effluent treatment plants. On the energy front, many of the electrical equipment work on lower efficiencies and with energy losses.

► **Identification of potential solutions:**

For the identified problems, the potential solutions were identified looking into the following:

- BREF (Best Available Techniques Reference Documents) from EU;
- Cleaner Production measures implemented in industries by the Gujarat Cleaner Production Centre;
- Some of the known solutions from the market;
- Local and national technical consultants also were consulted while analysing the possible solutions on their suitability and feasibility.

The identified solutions were 94 in number, which were then discussed with the individual industries that volunteered for implementation on pilot basis. On voluntary basis, 16 of these measures were then implemented by 7 industries.

► **Identification of volunteering industries:**

At the start of the project activities in Vapi, discussions were then held with the Vapi Industries Associations for nominating willing industries to participate in the pilot activity. Studies were undertaken in 10 representative units that eventually volunteered. After a thorough walk-through survey, industry specific diagnostic reports were prepared, including certain historical track record on production, energy consumption, water consumption, effluent disposal, waste generation etc.

2.2 Stakeholder Landscape

It was important to understand various stakeholders associated for making the pilot demonstration successful and eventually ensure their replication. The stakeholders map is shown in Figure 9. The key stakeholders were the Vapi Industries Association and GIZ. They played a very important role in the steering processes. The Association of the Pulp & Paper Industries in Vapi supported the steering

processes. GPCPC and GIZ provided technical support and training, besides monitoring results and documenting. GPCB was active in understanding, implementing measures and strategise their up-scaling. The roles played by different stakeholders is summarised hereafter.




| | | |
|--|---|--|
| <p>Key Stakeholders</p>  | <ul style="list-style-type: none"> • Vapi Industries Association • Gujarat Paper Mills Association, Vapi • GIZ | <ul style="list-style-type: none"> • Lead the steering processes and initiated discussions for application of the approach in other key industry sectors in Vapi. • Supported the steering processes and facilitated various steps used in methodology, viz. consultations with industries, finalization of solutions etc. • Technical support, training, support to steering processes |
| <p>Primary Stakeholders</p>  | <ul style="list-style-type: none"> • Gujarat Cleaner Production Centre (GCPC) • Vapi Industries Association • Volunteering pulp & paper industries in Vapi • Gujarat Pollution Control Board (GPCB) | <ul style="list-style-type: none"> • Technical support • Facilitation of interactions within the pulp & paper sector and initiated discussions for application of the approach in other key industry sectors in Vapi. • Replication of the successful pilot cases. • Regulatory mechanisms for up-scaling successful pilot cases. |
| <p>Secondary Stakeholders</p>  | <ul style="list-style-type: none"> • GIZ's national and international consultants • UBA (German Federal Environmental Agency) • Service providers and technology providers | <ul style="list-style-type: none"> • Technical services. • Technical input on best available techniques (BAT) • Information input |

Figure 9: Stakeholders landscape

As a part of formal arrangements, a MoU was signed between GPCB and GIZ to promote state-of-the-art environmental management and pollution control in the state of Gujarat. Also, a Joint Declaration of Intent for Promotion of Best Available Techniques [BAT] not Entailing Excessive Cost was signed between GIZ, GPCB and the German Federal Environmental Agency (UBA) for facilitating capacity building of GPCB to promote state-of-the-art environmental management and pollution control in the state of Gujarat. GIZ had its local cell in Gujarat at the Gujarat Cleaner Production Centre (GCPC) in Gandhinagar to work hand-in-hand for ensuring success of the pilot measures and ensuring their replication.



Image 1: Signing of MoU between GIZ-IGEP and GPCB



Image 2: Signing of JDI between UBA, GPCB and GIZ

2.3 Processes

The different stakeholders associated with the pilot work were involved in different processes, including steering processes, core processes and auxiliary processes as shown in Figure 10.

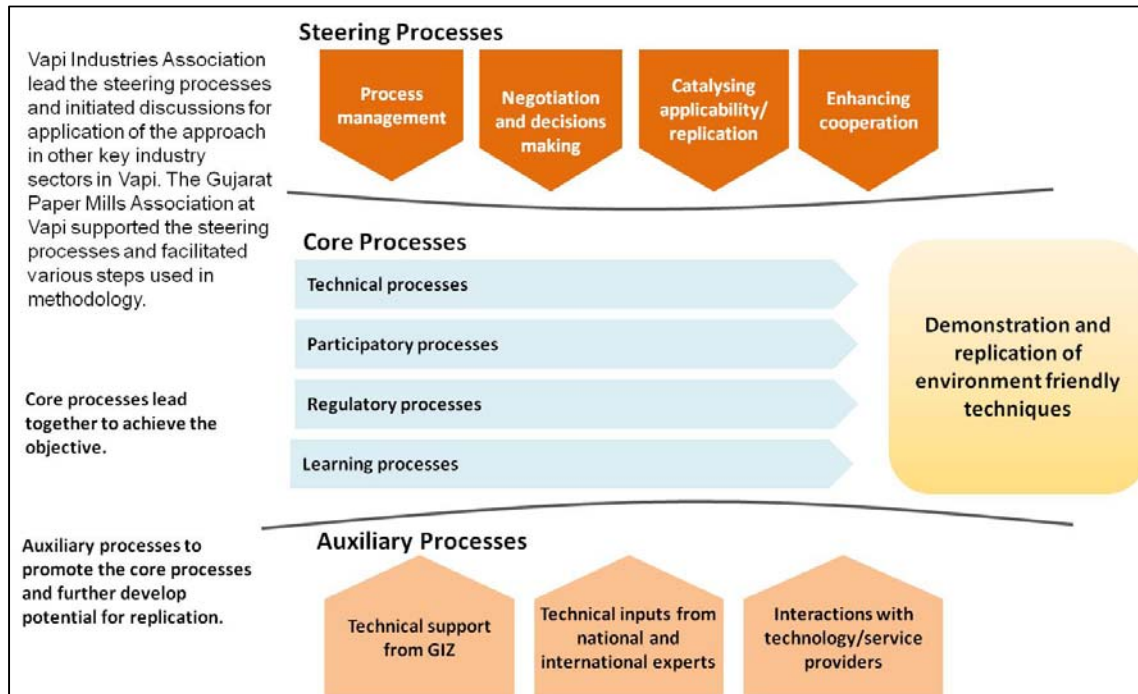


Figure 10: Process Landscape

► **Steering processes:**

The Vapi Industries Association lead the steering processes, which mainly included:

- Process management, including support to core processes and auxiliary processes.
- Negotiating on and decisions making, including collation of different industry specific information and implemented measures.
- Catalysing applicability/replication of implemented measures.
- Enhancing cooperation among partners and stakeholders.

The Gujarat Paper Mills Association at Vapi supported the steering processes and facilitated various steps used in methodology, viz. consultations with industries, finalization of solutions etc.

► **Core processes**

The core processes that were the essential inputs of the project to the development goal were unique in nature and delivered a direct contribution towards achieving the project objectives. The core processes included technical processes, participatory processes, regulatory and learning processes. Brief details are given below.

a) Technical processes

Various activities that were undertaken as part of the technical processes included mainly:

- Problem analysis.
- Identification of viable solutions.
- Implementation on pilot basis.
- Monitoring and documentation of case examples.

The different steps involved in the technical processes are shown in the methodology section.

b) Participatory processes

The participatory processes included roles of various stakeholders at various stages of implementation of the project. The participatory processes included:

- Consultations with different stakeholders, viz. Industries and industrial associations, environmental regulatory agencies, experts etc. on problems/key issues and viable solutions.
- Consultations on developing regulatory measures for improved pollution control, recycle/rescue etc.
- Consultations on upscaling of successful models.

The main outcomes from the participatory process were:

- Mapping of the critical environmental issues.
- Discussing matching national and international solutions.
- Nominations of participating units for pilot demonstration.
- Consolidation of the applicable and most suitable pilot measures
- Evolving a replication strategy.
- Exploring regulatory measures for prescription as consent conditions in the permits issued by GPCB.

c) Regulatory processes:

The regulatory processes included:

- Seeking information on statutory requirements and understanding the compliance requirement.
- Assessment of compliance scenario.
- Discussing possibility of linking the best practices as consent conditions.

d) Learning processes

The learning processes included various activities related to consultations, workshops, documentation, training programmes etc. Brief details are given below.

• **Round Table Discussions**

Two half day round table discussions were held in New Delhi and Vapi. In these consultations, the mapping of environmental issues that was carried out by GIZ consultants was discussed most critical ones were shortlisted. The possible solutions for mitigating the issues were also discussed.



Image 3: Round table discussions at Delhi, September, 2013



Image 4: Round table discussions at Vapi, September, 2013

This roundtable on “Environmental Friendly Technologies in Pulp & Paper Sector” was held on August 05, 2014 at Vapi, Gujarat. The environmental friendly technologies that were implemented in various recycled paper industries of Vapi, and the way forward for replication as well for improving of environmental status in other recycled paper industries in Vapi were discussed in this round table.



Image 5: Roundtable at Vapi, August 2014

- **Workshops**

A one State level workshop was held on “Environment Friendly Techniques in Identified Industry Sectors – Pulp & Paper” held on February 27, 2013 at COE (Center of Excellence), Phase - I, GIDC Vapi, Gujarat - 396 195 (Gujarat).

A regional workshop on “Environment Friendly Techniques in Pulp & Paper Sector” was held on February 27, 2013 at the Center of Excellence, GIDC Industrial Estate, Vapi (Gujarat).



Image 6: Workshop on Environmental Friendly Techniques in Identified Industry Sectors – Pulp & Paper, February 2013, Vapi

A 3-day brainstorming session with the GPCB nominated ‘Working Group’ was organised on April 13-16, 2015 to discuss the status and way forward on the ‘Reference Document’ in collaboration with GPCB and Gujarat Cleaner Production Centre (GCPC) with the active support from the experts from German Federal Environmental Agency, UBA.



Image 7: Workshop at Vapi, April 2015

- **Training programmes**

- a) **Training Programme on “Environment Friendly Techniques for Pulp & Paper Sector” for GPCB Officials**

The two-days training was organized on November 19-20, 2013 at Gandhinagar, Gujarat. The objective of the two-days training programme from the regulatory bodies' perspective was to facilitate promotion of Best Available Techniques (BAT) without entailing excessive cost in various industry sectors which would strengthen the environmental management and pollution control in the industries of these sectors. Know-how on the various barriers and their solutions is also expected to provide added advantage in assessing the industries environmental integrity by the regulatory representatives. The target group included participants from relevant filed offices and unit heads of GPCB.

- b) **Training Programme on “Environmental Friendly Techniques for Pulp & Paper Sector”**

The two-day training programme was held at Center of Excellence, GIDC, Vapi, Gujarat on 25th and 26th November 2013.

This two day training programme was held for the environmental managers and process managers of the paper industries and was conducted by the experts from UBA (German Federal Environmental Agency).The key aspects were covered in the training programme:

- Best Available Techniques in the Pulp and Paper Sector – European experience.
- Techniques for waste-water treatment for different paper mills – removal of colour, COD, AOX, and TSS.
- Fibre recovery from paper machine effluents.
- Energy efficiency in pulp and paper mills, e.g. energy recovery.
- Solutions for residues of waste paper processing, reutilisation of biogas from anaerobic waste water treatment.



Image 8: Glimpse of training programme at Vapi, November, 2013

c) Training Programme on "Treatment of Pulp & Paper Industry Wastewater"



Image 9: Glimpse of training programme at Vapi, November 2014

A one-day training programme on 'Treatment of Pulp & Paper Industry Wastewater' was organized on 7th March, 2014 at Vapi, Gujarat.

The training programme focused on treatment requirements for ETPs in pulp & paper industry and areas of intervention to achieve compliance:

- Cleaner Production in pulp and paper industries Technical solutions for improving ETPs in pulp and paper industry.
- Process optimization for improved wastewater in pulp and paper industry.
- Optimizing an existing ETP – Case examples and practical exercise.
- Operation and maintenance of ETPs of pulp and paper industry - case examples and practical exercise.

Dr. Christian Kazner from FHNW (University of Applied Sciences and Arts, North Western Switzerland), was the lead international resource person for this training programme. The training programme had participants from the pulp & paper industry, CETP managers, technology suppliers and ETP solution providers.

d) Two-Day Training on "Environment Friendly Techniques in Pulp & Paper Sector"

An interactive 2-day training session on "Environment Friendly Techniques in Pulp & Paper Sector" was conducted by GIZ-IGEP in cooperation with the Gujarat Pollution Control Board (GPCB) and the Gujarat Cleaner Production Centre (GCPC) on August 25-26, 2014 at Vapi, Gujarat. The training was intended to facilitate the paper industry cluster of Vapi with skills, knowledge and awareness on environmental friendly techniques (EFTs) so as to enable them replicate the pilot measures implemented in some of the pulp & paper industries. The target group included representatives of pulp & paper industry (21 nos. of industries), the Gujarat Pollution Control Board, the Vapi Industries Association and the Vapi Waste and Effluent Management Company Ltd. (VWEMCL).



Image 10: Glimpse of training programme at Vapi, August 2014

- **“Knowledge Platform on Environment Friendly Technologies for Industries”**

The Knowledge Platform provides access to reference documents, case studies, guidelines, presentations and other relevant information related to ‘Environmental Friendly Technologies’ for the Textile and Pulp & Paper sectors.

The Hon'ble Chief Minister of Gujarat, Mrs. Anandiben Patel launched the “Knowledge Platform on Environment Friendly Technologies for Industries” on June 5, 2014 at GIDC Industrial Estate, Vatva (Gujarat) on the occasion of the World Environment Day. Link for the knowledge platform is. www.gpcb-kp.in

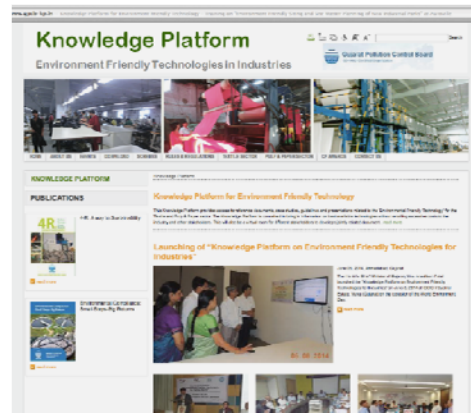


Image 11: Snapshot of knowledge platform

- ▶ **Auxiliary processes**

The auxiliary processes provided the back-up and support that facilitated and enabled the other processes to operate. These processes included:

- Technical support from GIZ, including suggestions on setting up of the processes, guiding through various processes and providing trusted opinions for taking decisions at various stages of site master plan preparation.
- Consultations with national and international experts for multi-sectoral inputs, benchmarks/standards, and for review and feedback of the site master plan at various stages of its development.
- Interactions with technology/service providers to understand the viable solutions available and their implementation.



3. Chapter - Experiences from the Pilot Work

3.1 Participating Pulp & Paper Industries

The State of Gujarat was taken up for piloting the activities to promote environment friendly techniques in the wastepaper based pulp and paper industry. The State has as many as 70 paper mills, which largely depend upon recycle fibre as raw material, barring a very few mills that are wood and agro residue based. The main locations of production in Gujarat are Rajkot, Vadodara, Surat, Barjod, Bilmoria, Navsari, Songarh, Ahmedabad, Vapi, Bharuch, Dijandranagar, Limbdi, Gondal, Udvada and Bavla. The number of mills, in and around Vapi alone is about 36.

Though the current contribution of paper & paper-board from Gujarat is about 12.5% as compared to all India level, there is a plan to go beyond 35% by modernization of the existing mills and allowing growth of new large scale mills.

There are reported 36 pulp & paper mills in-and-around Vapi having the following product-mix:

- Kraft Grade paper makers = 26 Nos.
- Duplex Grade paper makers = 7 Nos.
- Newsprint grade paper makers = 2 Nos.
- Writing & Printing grade = 1 No.

Of these 36 industries in Vapi, 10 industries volunteered to participate in the pilot work taken up under IGEP Programme. All these industries were waste paper based pulp & paper industries.

3.2 Raw-Materials & Product Mix and Specific Water Consumption

The information on type of wastepaper or raw materials used, product mix (capacity & GSM), type of paper machine and specific water consumption were collected for individual mills.³ The water consumption levels varied from 0.71 to 5 m³/T. However, in the absence of actual onsite water metering system, the accuracy of this data could not be verified.

For overall water conservation and fibre recovery, the key process equipment are Hydro-pulper, Thickeners and Fan-Pump integrity. For the raw material mix and the type of product made, key process systems were compared among the participating units:

- **Hydro-pulpers:** Of the 10 mills, 7 mills use low consistency Hydro-pulper (< 2.5%) and that too without much control over feed furnishes and water addition for slashing. Only 2 mills are using high consistency Hydro-pulper (15 to 17%), which are of Newsprint and Writing & Printing grade making units. A medium consistency Hydro-pulper (3.5 to 4.5%) has been deployed by only one mill. The fresh water or recycled water consumption is directly linked to “Consistency” of the pulp. For a typical unit of 100 TPD raw material furnish capacity, the water requirement with various Hydro-pulpers will be approximately:
 - » Low Consistency (2.5%) = 4,000 m³/day (1 m³ for every 25 Kg)
 - » Medium Consistency (4%) = 2,500 m³/day (1 m³ for every 40 Kg)
 - » High consistency (15%) = 667 m³/day (1 m³ for every 150 Kg)

Thus, the choice of appropriate Hydro-Pulper and control over “Feed Furnish & Water addition” are both essential.

- **Thickeners:** Of the 10 mills, 8 mills are using conventional Drum Thickener, with Side Hill Screen system, where the filtrate quality in terms of TSS is in the range of 400 to 3,000 mg/l. Ideally, the filtrate quality should be less than 100 mg/l. The filtrate with high TSS in circulation system leads to “Bio-fouling” and associated problems in producing “Fines accumulation” in circulating system.

³ Detail data are available in the Reference Document

It is an indirect indication of “Fibre Loss” as well. Only 2 mills are using state-of-art thickeners, like Poly Disc, wherein the filtrate quality in terms of TSS is < 50 mg/l.

- **Fan-Pump Integrity:** Of the 10 mills, 4 mills did not have dedicated fan-pump sump to maximise primary water circuit (for water & fibre recovery). Of the remaining 6 mills, only 3 had good control over minimizing the “Surplus” flow.

3.3 Typical Wastewater Characteristics of Vapi Paper Mills

The wastepaper based mills in Vapi area are adopting “Closed Water Loop” system, where the water consumption range is from 0.7 to 12 m³/T only, with an average of 4 m³/T of product. Due to such extreme low level of water consumption, the COD values, by and large are greater than 7,500 mg/l and sometimes as high as 33,000 mg/l. The TDS build-up is also very high. Typical waste water characteristics of a 50 TPD mill are shown in Table below.

Table 1: Performance Data of CETP and Typical Pulp & Paper Member Unit

| Parameter | Treated CETP Outlet | Typical Representative Kraft Mill Audit Data | | |
|---------------------|---------------------|--|--------------|--------------------------------|
| | | CETP Pre-Treatment Norm | Raw Effluent | Clarifier & Bio-Process Outlet |
| pH | 7 to 8.5 | 6.5 to 8.5 | 6.5 to 7.0 | 6.5 |
| Temperature [°C] | < 35 | 40 | < 35 | < 35 |
| TSS [mg/l] | 185 | 300 | 3,780 | 1,170 |
| Oil & Grease [mg/l] | - | 10 | - | - |
| Sulphide [mg/l] | - | 2 | - | - |
| BOD [mg/l] | 99 | 400 | - | - |
| COD [mg/l] | 556 | 1000 | 33,000 | 3,025* |
| Chloride [mg/l] | 3,000 to 4,000 | 600 | - | - |
| Sulphate [mg/l] | 1,700 to 2,100 | 1,000 | - | - |
| TDS [mg/l] | 7,000 to 8,000 | 2,100 | 40,756 | 40,644 |

* Not a reliable data due to very high TDS & TSS; COD of inlet to bio-process is high and no anaerobic cum aerobic infrastructure capable of bringing down COD to such a removal efficiency.

The above characteristics are almost in agreement with Agro & RCF mill characteristics, if one applies the “Linear consumption” versus “Closed Loop” consumption, where the absolute pollution load is not being reduced.

3.4 Challenges identified

The collection and analysis of data regarding certain historical track record on production, energy consumption, water consumption, effluent disposal, waste generation were the basis to identify the following core environmental issues:

- Issue 1: Less efficient electrical equipment
- Issue 2: Inefficient fibre recovery system
- Issue 3: Looping of waste (processed paper)
- Issue 4: Management of plastic waste
- Issue 5: Inorganic build up and high COD stream generation
- Issue 6: Inappropriate water quality for high quality product.
- Issue 7: High heat loss through dryer

In a second step the reasons for these environmental issues were looked into closely. The results were the basis to propose further measures to reduce resource consumption and negative impact of pulp & paper sector on society and the environment:

- The performance is far from satisfactory as the industry with a few exceptions continues to consume large quantities of water, i.e. 2-10 m³ per ton of paper. In view of such low water consumption the process water goes into intense closed looping resulting in high COD & TDS in process water.
- There appears to be very few mills, which have taken up programmes of reduction of pollutants at source.
- There are number of pulp and paper mills with open or partially closed brown stock washing and paper making process.
- The effluent treatment plants are designed on the basis of improper sampling for characterization of effluent.
- Lack of adequate training to the people operating effluent treatment plants.

3.5 Potential Solutions – Environmental Friendly Techniques

3.5.1 BREF (best available techniques reference) documents from EU

The European IPPC Bureau, under 'Integrated Pollution Prevention and Control' (IPPC) Directive/ Act, has prepared reference documents on Best Available Techniques Reference Documents, called BREFs. These documents are for use by member countries in Europe for the purpose of issuing operating permits for the installation of significant pollution potential industries, processes or operations.

The conclusions of Best Available Techniques (BAT) do not prescribe the use of specific techniques, but a level of environmental protection that can be achieved by the application of BAT. The BREF document for paper Industry is available for public use⁴. In order to improve the overall environmental performance of plants for the production of pulp, paper and board, BAT cover the following topics of pulp & paper industry:

- Materials management and good housekeeping
- Water and wastewater treatment
- Energy consumption and efficiency
- Emission of odour
- Waste management
- Emission to water

The BREF document was referred to check for potential solutions for the identified problems in the pulp & paper industries in Vapi. These may be useful to any other pulp & paper industry in the country for general reference.

3.5.2 Technical measures identified for Vapi industries

The environmental improvement measures identified for Vapi industries fall under the following four categories:

- | | |
|---|------------|
| • Fibre and process water recovery | 8 measures |
| • Substitution and Process optimization | 5 measures |
| • Energy Conservation strategies | 6 measures |
| • Waste Utilisation | 2 measures |

Details are given below.

- **Fibre and process water recovery**
 1. Control over "Deckle Guard" and "Edge Cutter" to minimise circulating Pulp load.
 2. Secure fan pump to have dedicated sump to maximise paper machine approach system white-water recovery.

⁴ <http://eippcb.jrc.ec.europa.eu/reference/pp.html>

3. Deploy on-line Bentonite treatment for enhanced process water circulation quality and yield improvement.
 4. Side Hill Screen/Drum Thickener versus better thickener system for least carryover of TSS (Fibre equivalent) in process circulation water.
 5. Introduce "Save-All" for pulp making or paper machine surplus stream or combined one, with control over COD & conductivity build-up, with planned purging to ETP.
 6. Avoid centri cleaner & Pressure Screen rejects getting into Back-water (or white-water) circulation.
 7. Introduce poire system for effective separation of plastics waste from residual recoverable fibre contents.
 8. Introduce dedicated "Broke-Pulper (slasher)" for processing Machine Broke & Trimmings directly to Machine Chest, as against current system of contaminating entire pulp stream via Hydro-Pulper (start of process).
- **Substitution and process optimization**
 1. Replace "PAC & Rosin" size chemicals with AKD sizing chemicals for overall reduction in circulating process water chemical build-up & yield improvement.
 2. Segregate salt laden softener discharge, boiler blow-down and domestic wastewater from the process water circulating system.
 3. Sustain circulating process water quality in terms of COD within 5,000 to 7,500 mg/l (or Conductivity < 10,000 μ siemens/cm) by controlled purging via primary & secondary wastewater treatment system.
 4. Inter-lock Hydro-pulper and down-stream Thickener operations to avoid overflow of pulp and/or filtrate from filtrate storage tank.
 5. Introduce automatic self-cleaning Rotary Screen as pre-treatment to raw effluent at inlet of ETP, with an aim to eliminate primary clarifier system.
 - **Energy conservation strategies**
 1. Insulate "Drier Ends" for reduction in steam consumption; thereby reduce fuel consumption as well.
 2. Aim for condensate recovery > 85%.
 3. Introduce VFD for Turbo-separator, Torque Control Unit for Hydro-Pulper and review all rotary drives > 15 H.P for Power Factor improvement beyond 0.95.
 4. The biological treatment system requires upgradation, preferably in diffused aeration mode and with better control over "Activated Sludge Process" mode, including MLSS Control.
 5. Opt for low head, high discharge submersible type pumps in ETP area and applicable in-process areas for energy efficiency in effluent & pulp transfer operations.
 6. Introduce three levels Controller (regular, peak & dry run protection) for critical feed pumps (inlet of ETP) for energy efficiency and to avoid effluent back-up in drains and improve local hygienic conditions.
 - **Waste utilisation**
 1. The centrifuge for sludge dewatering is not energy efficient. It is operation & maintenance intensive, consumes spare parts heavily and cannot inherently generate sludge cake beyond 30% solids content. In lieu of this, a polypropylene cloth based Filter Press (with Pressure Regulating Device) is advantageous to deliver cake > 45% solid content. Use such cake after solar drying as fuel in boiler operations.
 2. The plastic waste may be subjected to extrusion to get fuel pellets, after pre-drying, and both fibrous sludge & plastic pellets could be a better fuel alternative for at-source (or cluster level) management. However, air pollution control systems need to be upgraded.



4. Chapter - Case Examples

In the following sections, successful case studies captured from seven industries in Vapi are reflected. From the 94 project ideas that resulted from two rounds of discussions with 10 participating industries, seven industries were showed interest on the 71 implementation options of short, medium and long-term nature.

From the 21 of the tested measures on pilot basis, 16 of the measures are presented as case examples covering fibre and process water recovery, substitution and process optimization, energy conservation strategies and waste utilisation.

Summary of the benefits from implementation of the measures in the five of the waste paper based industries in Vapi is given below:

| | |
|--|------------|
| Number of Pilot Industries (Nos.) | 5 |
| Raw Material Saving - Fibre (tons/yr) | 1292.5 |
| Electrical Energy (kWh/yr) | 348428 |
| Fuel - Coal (tons/yr) | 642 |
| Process Water Saving (m ³ /yr) | 45000 |
| Water Pollutant Reduction (tons/yr) | 31680 |
| Reduction in Chemical Usage - Dyes (tons/yr) | 7.2 |
| Monitory Savings (Rs./year) | 24,236,000 |

Through Environment Friendly Techniques project, it is evident that, small solutions to prevent pollution at source and increase of resource efficiency, helps in big way to sustain industrial development without compromising on environment.

**Mr. Hardik Shah, IAS, Member Secretary
Gujarat Pollution Control Board (GPCB)**



Case Example 1: Broke & Trimming Reprocessing Optimisation

Description & achieved environmental benefits

The term 'broke' refers to any formed paper from the beginning of the paper making process to the finished product. Broke will exist in many forms and varying quantities and it will always be generated by the paper making process. Depending on the particular case, machine broke will be generated at different locations.

The main goal of a broke system is to return the paper fibre back to the process with no disruption in the uniformity and quality of the stock flowing to the paper machine. In the pilot industry, the paper machine broke and trimmings generated

were collected and fed back into the Pulper for reprocessing in between consecutive batches and fed directly to machine chest through fan pump, thereby avoiding undergoing the entire process cycle.

For environmental benefits see Operation Data.



Image 12: Broke & Trimming generation in industries

[Source: GIZ-IGEP & GCPC Team]

Cross-media effects

There are no two paper machines that are exactly the same, even machines producing the same paper grades. It follows therefore, that no two broke systems are alike and thus particular broke system needs to be identified according to the process applied and thus vary in resource consumption & additional space for segregated storage is required.

Operation data

The amount of broke produced during papermaking is normally 5 – 20% of the machine capacity. Wet broke is generated even during normal operation in the form of edge trimming at the wire section, and dry broke is produced during start-ups, grade changes and during all finishing operations. The broke pulps originating from the wet and dry ends of the paper machine are not identical in terms of their papermaking characteristics.

Before:

During the paper reel production, prior to final packaging of the rolls, the paper is required to pass through the Pop Real & Re-winder process, in which paper broke& trimmings of about 5% are generated as process waste.

This waste was collected and recycled by directly feeding into the Hydro Pulper for reprocessing and thereby again undergoing the entire cycle of process steps. This reprocessing accounted for additional costs in terms of energy, man power and chemicals consumed, eventually increasing the overall production cost.

The continuous reprocessing of fibre also degrades the fibre strength and thus affects paper quality.

After:

With small operational change in the process, the broke & trimmings are now collected and fed back into the Pulper for reprocessing in between consecutive

| | |
|---|---|
| | <p>batches and directly fed to the Machine Chest through fan pump in place of Hydro Pulper.</p> <p>This change in process circumvents additional reprocessing of material by again undergoing 8 to 9 process steps, and therefore helps in optimising the costs of power, chemicals, man power etc.</p> <p>It directly results in net saving of energy (electrical power used in reprocessing) to the tune of approx. 50 kWh/ton of paper. By avoiding reprocessing the strength of fibres is also found to be improved giving an improved paper quality.</p> |
| Applicability | The reprocessing of broke in same pulper (i.e., without dedicated broke pulper) is feasible for industries producing same quality or low grade paper. On coated paper machines the broke system needs different storage towers for uncoated and coated broke. |
| Economics | The company implemented change in March 2014 by investing a capital cost of only Rs. 10,000. The observed savings in the electric cost was Rs. 30,000 per month, giving simple payback of 10 days. The total savings of Rs. 3,60,000 per annum (only electricity cost) is thus estimated. |
| Driving force for implementation | To return the paper fibre back to the process with no disruption in the uniformity and quality of the stock flowing to the paper machine. Electrical power saving by avoiding reprocessing as well as quality of fibre remains good. |
| Example plants | Daman Ganga Paper Mills, Vapi, implemented the operational change in March 2014. |
| Reference literature | EU BREF for Pulp & Paper Sector |

| Case Example 2: Continuous Operation of Clarifier as "Save All" | |
|--|---|
| Description & achieved environmental benefits | 'Save-all' system separates solids (fibres and filler) from the process water. An efficient 'save-all' system that produces clarified water with a low suspended solid content is essential to use process water instead of fresh water for select applications. |
| Cross-media effects | Sedimentation installations are suitable for the clarification of filler-loaded process water but necessitate large volumes and therefore a large space requirement. |
| Operation data | <p><u>Before:</u></p> <ul style="list-style-type: none"> • The surplus flow from different storage / holding systems was going to ETP and was intermittent, thus the clarifier operation was not continuous. • The recirculating water quality from ETP to process was very poor due to stagnation of organics resulting in bio-fouling. • There was hardly any recovery of fibre, which in turn increased solid sludge generation at sludge dewatering system. |

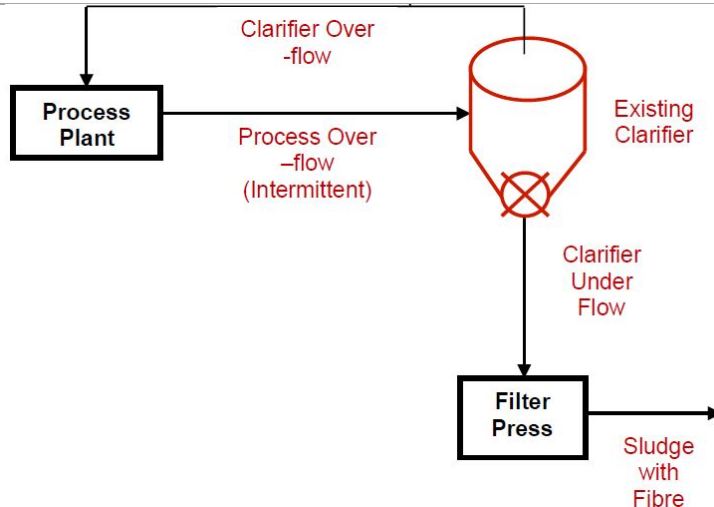


Figure 11: Process Water Flow without Fibre Recovery
 [Source: GIZ-IGEP & GCPC Team]

After:

- The existing clarifier was made into continuous operation as “save all”, due to which recirculating water quality is improved from overflow of clarifier. The clarified water is now recirculated to process.
- Underflow of clarifier is now passing through Sliding Screen for recovery of fibre which is reused into the system.
- This reduces the TSS⁵ up to 40% in non-recoverable impurities which were earlier going directly to the filter press and finally as sludge.
- The capital cost invested was negligible, since the TSS level has been reduced by 40 %; the value of recovered fibre is significant.
- The problem of high sludge generation and its eventual disposal is also resolved.

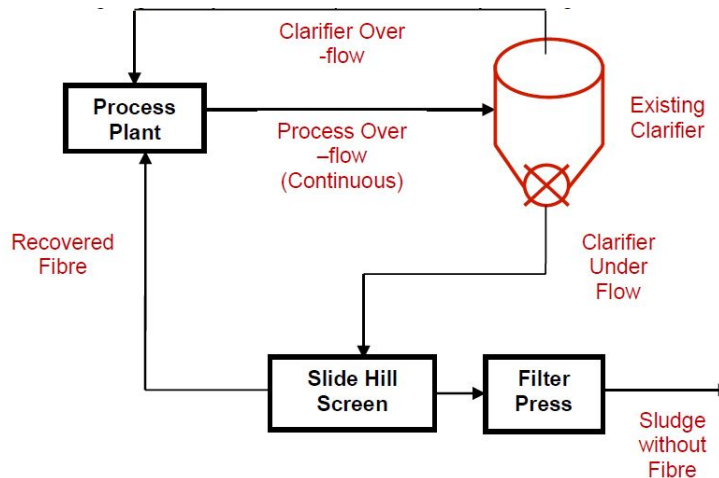


Figure 12: Process Water Flow using Existing Clarifier as Save-All for Fibre Recovery
 [Source: GIZ-IGEP & GCPC Team]

Applicability

This technique is applicable for plants that have existing floatation system which can be used as Save-All (Flotation plants consist of a clarifying basin

⁵ Total suspended solids

| | |
|---|---|
| | with sludge removal, aeration equipment for a partial stream of clarified water, and a dosing plant for the flotation chemicals). |
| Economics | No information on economics of the technique available. |
| Driving force for implementation | Fibre stream that is recovered in save-alls is returned to the stock chest and the different quality waters are returned to different uses relevant to their quality where replacing fresh water. |
| Example plants | Daman Ganga Paper Mills, Vapi is operating the clarifier as Save-All since March 2014. |
| Reference literature | EU BREF Document for Pulp & Paper Sector. |

We are benefited by implementing “Environment Friendly Techniques”. It is very difficult to become more precise and figure out the benefits. Whatever will be earned will be hidden and not visible by figures as the environment friendly techniques are implemented for the protection of our Globe and not the figures.

**Mr. Suresh Desai, General Manager (Tech.)
Vaibhav Paper Boards Pvt. Ltd.**



Case Example 3: Reduction in the “Edge Cutter” Waste by Adjustment of “Deckle Guard”

| | |
|--|--|
| Description & achieved environmental benefits | When the paper moves from Head box to wire section, generally, the required width of paper on Pop Reel and Rewinder is 102 inch (259.08 cm). Therefore, “Deckle Guard” is adjusted in order to increase the final paper width from 102 inch to 105 inch, to reduce the “Edge Cutter” (edge trim) waste as wet broke and its subsequent reprocessing. |
| Cross-media effects | - |
| Operation data | Before: <ul style="list-style-type: none"> When the paper is passed through the wire section for dewatering, total width of wire section is more than required width of the paper, thus, “Deckle Guard” is adjusted to get a final width of 102 inches. Due to this adjustment, when the paper is cut through the “Edge Cutter” for getting the desired width, there is generation of wet broke which is required to be reprocessed through the drum thickener via Couch Pit. This reprocessing increases production cost and resource consumption. |



Image 13: Edge Cutter at Wire Section
[Source: GIZ-IGEP & GCPC Team]

After :

- Industry after evaluation, readjusted the “Deckle Guard” with increase in final paper width from 102 inch to 105 inch.
- The waste from the “Edge Cutter” was reduced to about 2%-2.4%. Which in turn reduced the reprocessing cost i.e., about 7.5 Rs./kg.



Image 14: Reduction in Wet Broke from Edge Cutter
[Source: GIZ-IGEP & GCPC Team]

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| Applicability | The technique is applicable to all mills. |
| Economics | With no capital cost investment the industry saved Rs. 24,75,000 per annum in the reprocessing of broke. |
| Driving force for implementation | Reduction in wet broke or increase in final product. |
| Example plants | The technique is implemented by R. A. Shaikh Paper Mills Pvt. Ltd., Vapi. This technique is also mostly implemented all paper mills. |
| Reference literature | http://www.greycon.com/case-studies/case-study-durango-paper-company (for advanced trimming practices). |

Through the techniques implemented and under implementation we get benefit in terms of improved fibre recovery and reduction in water consumption. This project helped us understand the potential for making our operations more efficient and at the same time reduce the environmental emissions.

**Mr. D. B. Ashar, Director (Tech.)
Best Paper Mills Pvt. Ltd.**



Case Example 4: Installation of Poire for Fibre Recovery from Coarse Rejects (Plastic Waste)

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| Description & achieved environmental benefits | Poire system is used to remove the plastic waste from pulp slurry that comes from the Hydro Pulper and fibre loss due to mixing with plastic waste can be avoided. |
| Cross-media effects | This technique results in generation of plastic waste from the waste paper processing. |
| Operation data | <p>Before:</p> <ul style="list-style-type: none"> • Pulp slurry containing plastic waste was collected in a tank and then coarse rejects (plastic) were removed manually onsite. • Fibres loss with plastic waste was estimated to be around 0.5% (based on 160 TPD production). This plastic waste along with fibres was sent to a Cement factory for co-processing as waste from Paper industry. <p>After:</p> <ul style="list-style-type: none"> • Industry has planned to install a batch processing poire system for efficient defibring of the pulp and reduction in the fibre loss while removing the contaminants from the pulp. Thus, the loss of fibre to the cement industries as waste for co-processing can be avoided. <div data-bbox="532 1251 906 1677" data-label="Image"> </div> <p data-bbox="946 1251 1317 1331">Image 15: Poire System for Plastic Waste Removal [Source: GIZ-IGEP & GCPC Team]</p> |
| Applicability | This technique is applicable to all recycled paper mills. |
| Economics | The capital cost to be invested by industry is about Rs. 80,00,000 with estimated savings through fibre recovery will be Rs. 36,00,000 per annum i.e. with a payback in 26 months. |
| Driving force for implementation | Recovery of fibre from the waste. |

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| Example plants | Many recycled paper plants in India. Best Paper Mill, Unit 2 located in Vapi GIDC, will implement this technique. |
| Reference literature | http://www.pulpandpaperonline.com/doc/hydrapurge-ii-detrashing-system-0001 |
| Note: | The savings mentioned are calculated & indicative only, based on the information available & is subjected to verification from industry after completion and implementation of the system. |

| Case Example 5: Efficient Fibre Recovery through Poly Disc Filter & Quality Process Water for Recirculation | |
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| Description & achieved environmental benefits | <p>The process water from paper machine, passing through the poly disc filter via side hill screen, results in recovery of valuable fibres to be reused. Also the treating the overflow with coagulating chemicals such as Delfloc-5310 (Polyelectrolyte Polymer) reduces the TSS, resulting in improved recirculation of water.</p> <p>A disc filter precoated/conditioned with raw pulp produces stocks with the highest consistency (10 – 30%) and is designed to produce a three-way (or four-way) separation of the white water into fibre. The first draw is cloudy water and the subsequent draws are clear and super-clear filtrate. The cloudy filtrate is usually recycled back to the filter as dilution water, but can also replace fresh water in the process or be used for the dilution of the stock. A higher recycling rate of cloudy filtrate back to the disc filter results in a cleaner filtrate. The concentration of suspended solids in the clear filtrate (fines and fillers) is usually about 10 – 150 mg/l for virgin pulp or 100 – 400 mg/l for recycled pulp.</p> |
| Cross-media effects | None believed likely. |
| Operation data | <p>Before:</p> <ul style="list-style-type: none"> The surplus process water flow mainly from machine area was directly fed to the “Save All” via Side hill screen. The side hill screen generates high levels of residual fibre content as the fibre recovery is not efficient. <div style="text-align: center; margin: 10px 0;"> <pre> graph LR PP[Process Plant] -- "Process Over - flow" --> SHS[Side Hill Screen] SHS --> SA[Save-All Tank] SA -- "Save-All Over - flow (High Fibre)" --> PP SA -- "Save-All Under Flow" --> C[Centrifuge] C -- "Sludge with Fibre" --> Out[] </pre> </div> <p>Figure 13: The Process Water Flow with Fibre Loss [Source: GIZ-IGEP & GCPC Team]</p> <ul style="list-style-type: none"> The under flow from Save-All was diverted to ‘Sludge Holding Tank’ contained for post dewatering in centrifuge, while the overflow with high TSS (>400 mg/lit) was recycled back to process for reprocessing of fibre (internally and via “Save All” system) to various production steps. This leads to the reduction in strength of the fibre as well as increased reprocessing cost. |

- The presence of fibre in recirculating streams also results in problem of biofouling and unnecessary increase of TSS in the filtrate.
- The quality of recirculation water was checked for COD and if it exceeded 5000 mg/litre, then certain quantity was purged to downstream biological treatment system, to avoid potential effect on product quality.

After :

- Industry has planned to install the “Poly Disc Filter” for thickening of the pulp, also back water passing to ETP⁶ will be of much better quality and thus will reduce load on ETP significantly. Also, it will generate super clarified water which will be used in pulp mill & paper machine. The poly disc filter will be installed by December 2015, after side hill screen. It will recover about 0.5 % fibre (Base on 160 TPD Production) from water process stream and reuse into the process.

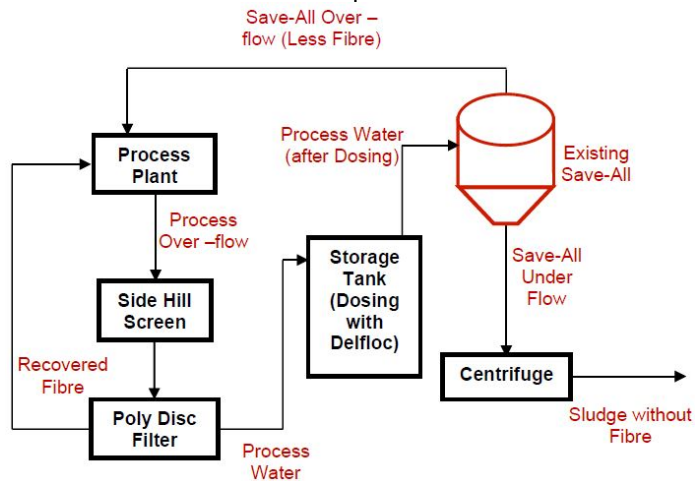


Figure 14: Process Water Flow with Efficient Fibre Recovery through Poly Disc Filter
[Source: GIZ-IGEP & GCPC Team]

- The filtrate from poly disc filter will be stored in a new tank with a capacity 100 m³ per day. Where Delfloc 5310 is introduced as a “Coagulant” through an online dosing system.
- The dosed water is transferred to the existing Save-All where the coagulant will adsorb the remaining fibres & fines (TSS) from the water, the flocs generated settles at the bottom of the Save-All. The overflow from Save-All (TSS<100 mg/litre) is re-circulated to the process plant which will also eliminate the bio-fouling within process water and the underflow goes to the sludge dewatering system through centrifuge.



⁶ Effluent treatment plant

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| | Image 16: Picture of Poly Disc Filter [Source: GIZ-IGEP & GCPC Team] |
| Applicability | This technique is applicable to all mills. |
| Economics | The capital cost to be invested by industry is Rs. 150,00,000 with total estimated savings to the industry of Rs. 36,00,000 per annum giving simple payback in 4 years (considering fibre cost saving only). |
| Driving force for implementation | Improved fibre recovery and clear process water for recirculation within process as well as reduced ETP load are major driving force for implementation. |
| Example plants | Best Paper Mill, Unit 2 located in Vapi GIDC, will implement this technique. |
| Reference literature | EU BREF Document for Pulp & Paper Sector. |
| Note | The savings are estimated and are subjected to practical verification after installation of system. |

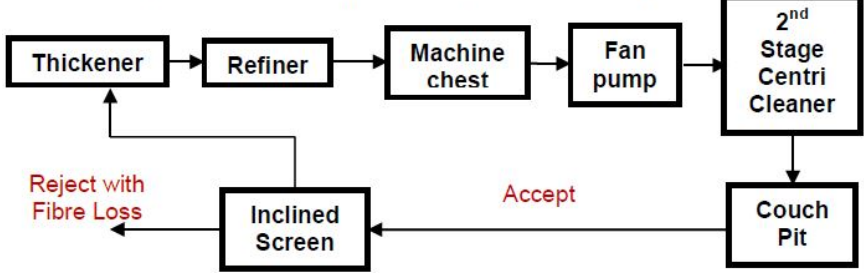
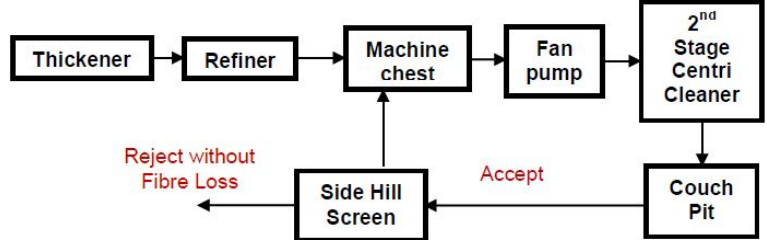
The project has given us the space to rediscover our process and rectify flaws leading to greater efficiencies. It has given us a recurring savings potential making our recycling facility highly viable economically and environmentally very sound. I have thoroughly benefitted individually intellectually through the dialogue

**Mr. Tushar Shah, Director
Damanganga Group**




Case Example 6: Process Modification - Recovery of Fibre from Couch Pit and 2nd Stage Centri Cleaner

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| Description & achieved environmental benefits | Extended process concepts with a higher number of process stages might be used to manufacture paper for special purposes or to meet the customers' needs (high-quality products). Reducing reprocessing of fibre from couch pit and 2 nd Stage Centri-cleaner by modifying the route of pulp and efficient fibre recovery reduces fibre loss and results in saving energy. A balance between cleanliness of stock, fibre losses, energy requirements and costs should be found and depend to certain extent on the paper quality produced. |
| Cross-media effects | The improved recycled fibre quality results in an improved paper quality. The rejects from different process stages need to be collected separately and used for different purposes. |
| Operation data | Before: <ul style="list-style-type: none"> • During Kraft paper manufacturing process, accept of 2nd stage Centri-cleaner collected in Couch pit was reprocessed after screening through inclined screen and sent to the thickener. • The inclined screen was found to be non-efficient and there was a loss of about 0,5% (based on 70 TPD production) fibre with the rejects. |


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| |  <p>Figure 15: Old Process Steps without Fibre Recovery [Source: GIZ-IGEP & GCPC Team]</p> <p>After:</p> <ul style="list-style-type: none"> Additional side hill screen is placed in process, after the couch pit, to reduce continuous recirculation of pulp and direct supply to mixing (machine) chest after screening and fibre recovery by-passing thickener and refiner.  <p>Figure 16: Modified Process Steps with Fibre Recovery [Source: GIZ-IGEP & GCPC Team]</p> <ul style="list-style-type: none"> This modification in process helps in recovery of about 5% (Base on 70 TPD Production) fibre. |
| Applicability | Rebuilds of stock preparation plants as well as of the stock approach flow system can usually be realised in existing mills. A 'standard' stock preparation plant typically uses more machines than are required for the 'minimised stock' concept, the shutdown of only a part of the equipment is necessary and probably some new pipes and pumps for the connection to the machine chest are required. |
| Economics | Total capital cost invested by industry was Rs. 1,70,000 with total saving of Rs.14,17,500 per annum giving a simple payback in 2 months. |
| Driving force for implementation | The driving forces to implement stock preparation plant concepts with 'minimised' process stages are lower investment and operation costs mainly saving in electrical power as a result of the fewer machines required. |
| Example plants | A kraft paper manufacturing mill in Vapi. (anonym). |
| Reference literature | <u>EU</u> BREF Document for Pulp & Paper Sector. |

| Case Example 7: Reduction in Fibre Loss at Drum Thickener | |
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| Description & achieved environmental benefits | To reduce fibre and filler losses, tuning of the pulp refining and screening just ahead of the feed to the paper machine to maintain a proper balance of different types of fibres in pulp is applied. Heavy refining increases the amount of short fibre that in turn may be removed as reject in screening. In integrated mills, certain fraction of rejects from the screening may be recycled to the |

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| | <p>pulping department. The optimised size of screening mesh as per process and quality improves the efficiency of the screening system and reduction in fibre losses.</p> <p>Efficient removal of suspended solids from white water is a prerequisite for further recirculation of treated water to production and a preliminary measure for closing up water loops.</p> |
| <p>Cross-media effects</p> | <p>Due to lower suspended solids discharge, the effluent treatment operation receives less solid load and less sludge from primary treatment is produced. Fibres and fillers are used for the product and must not be handled as waste. Improved performance promoted by a lower content of solids in white water circulations leads to fewer paper machine breaks.</p> |
| <p>Operation data</p> | <p>Before:</p> <ul style="list-style-type: none"> • At thickener the pulp slurry is adjusted for the consistency before processing to next step. • The screened pulp slurry is thickened in the thickener and the thickened pulp enters the thickener chest for further processing. The filtrate obtained through the 40 mesh screen contains around 1700 ppm fibres & fines. This filtrate is reused in the plant at different stages for dilution and the access is drained which goes to ETP. • The presence of fibre in recirculating streams also results in problem of biofouling and unnecessary TSS increased in the filtrate. <div style="text-align: center;">  </div> <p>Image 17: Screen [Source: GIZ-IGEP & GCPC Team]</p> <p>After:</p> <ul style="list-style-type: none"> • Industry has installed the screen with 60 mesh size in March 2014, which has reduced the SS in the filtrate upto maximum 700 ppm; this reduced the fibres leading to ETP. • It reduces recirculation and increase in fibre strength by avoiding continuous reprocessing of the fibre thus results in improved paper quality. • The reduction in biofouling results in more recirculation of process water, resulting in less waste water generation. The average COD is reduced from 6500 ppm to 5500 ppm; there is 50 % reduction in sludge quantity & also reduction in power & chemical consumption at ETP. |
| <p>Applicability</p> | <p>The listed improvements can be applied in both new and existing mills.</p> |
| <p>Economics</p> | <p>The fibre recovery and utilisation in paper making results in reduction of production cost. There is fibre saving of 1.33 Mt/day.</p> |

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| Driving force for implementation | Improved stock recovery is usually economically beneficial because of better raw material efficiency and less waste to be disposed off. Lower solid content in white water circulations improves the smooth working of the paper machine. Reduced solids load to the external treatment might also be a motivation to implement the described measures for fibre recovery or spill prevention. |
| Example plants | Rama Pulp & Papers Limited (Rama Pulp) in Vapi GIDC implemented the technique for better fibre recovery. |
| Reference literature | EU BREF Document for Pulp & Paper Sector. |

Case Example 8: Product Change – Natural Shade Paper Production

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| Description & achieved environmental benefits | To make recycled paper more environment friendly, use of natural shade of raw material as final product shade, reduces the use of synthetic dyes and pigments in paper making. The potential environmental impact of dyeing is mainly the releases to water. |
| Cross-media effects | None believed likely. |
| Operation data | <p>Before: The recycled Kraft paper produced by the industry was produced in brown shade for which approximately 600Kg/month dyes were consumed. Due to the addition of dyes, organic load in the effluent (COD⁷ and TDS) increases thus resulting in poor process water quality due to continuous recirculation and adds treatment cost of water at ETP.</p> <p>After: Company's commitment to make the recycled paper environment friendly, the use of dyes was eliminated and production of paper in natural shade is now practiced.</p> <p>Company also convinced its customers for the use of natural shade paper instead of coloured paper as an individual's responsibility to the environment.</p>  <p>Image 18: Recycled Kraft Papers using Dyes [Source: GIZ-IGEP & GCPC Team]</p> |
| Applicability | This technique is applicable for low grade kraft paper, the use of dyes are dependent on requirement of paper quality by customer. |
| Economics | There is no capital cost invested by the industry. Savings of Rs. 7,20,000 (Dye Cost) per annum with reduction in ETP load and improving recirculation water |

⁷ Chemical Oxygen Demand

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| | <p>quality are obtained.</p>  <p>Image 19: Recycled Kraft Paper without Dyes [Source: GIZ-IGEP & GCPC Team]</p> |
| Driving force for implementation | The potential environmental impact of dyeing is mainly the releases to water, by producing natural shade paper the impact on water can be reduced. |
| Example plants | Daman Ganga Paper Mills, Vapi has started producing the natural shade paper and is accepted by the customers as well. |
| Reference literature | Mr. Banjul Shah, Director, Email: banjul.shah@damanganga.com |


| Case Example 9: Efficient Fibre Processing by Recovery through Rotary Screen | |
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| Description & achieved environmental benefits | <p>Undissolved impurities are removed from the slurry by screening (screens) and cleaning (centrifugal cleaners). The objective of screening is the removal of interfering substances from the fibres. The acceptable fibre suspension is passed through a screen with apertures in the form of slots or round holes, while the impurities are separated and rejected by the screen. To improve the bonding ability of the individual fibres in order to strengthen the paper, refining is usually carried out. Refining is also done to condition the fibres to create the required properties of the finished product. Refining is carried out in refiners equipped, e.g. with rotating disks (or rotating disks combined with stationary disks) between which the stock is treated.</p> <p>The space between the disks can be adjusted, depending on the degree of refining desired and to control the fibre properties. Removal of contaminants and recovery of fibres and fines from process water including centri-cleaner & pressure screen rejects is necessary for cleaning process water. Use of Special Rotary Screen helps to maximise the process of recycling as well as recovery of fibre. Efficient fibre and filler recovery in all possible stages of the paper mill allows for the returning of raw materials to the machine feed instead of discharging them with the excess white water. The better recovery of solids means that this solid load is not passed to the primary effluent treatment and to effluent sludge disposal.</p> |
| Cross-media effects | <p>Due to lower suspended solids discharge, the effluent treatment operation receives less solid load and less sludge from primary treatment is produced. Fibres and fillers are used for the product and must not be handled as waste. Improved performance promoted by a lower content of solids in white water circulations leads to fewer paper machine breaks.</p> |
| Operation data | <p><u>Before:</u></p> <p>The Centri Cleaner reject and Pressure Screen reject containing fibre (0.5% of total production 160 TPD) were under constant re-circulation in paper machine process water which reduced the quality of water as well as that of product due</p> |

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| | <p>to reduction in strength of the fibre and TDS built-up within process water.</p>  <p>Image 20: Rotary Screen for Fibre Recovery [Source: GIZ-IGEP & GCPC Team]</p> <p>After:</p> <p>The Centri-cleaner & Pressure screen rejects are isolated from paper machine circulating system and subjected to a dedicated rotary screening system to recover fibre and water. Installation of a 0.5 mm slot Rotary Screen system is done for the isolated stream.</p> |
| Applicability | Improvements can be applied in both new and existing mills. However, in older mills the paper machine areas are more limited for rebuilds due to space or layout problems. |
| Economics | The capital cost of installing rotary screen is Rs 35,00,000, although industry has managed the available rotary screen with minor modifications recurring negligible cost, with total savings by recovering fibre of Rs. 36,00,000 per annum giving immediate payback. |
| Driving force for implementation | Improved stock recovery is usually economically beneficial because of better raw material efficiency and less waste to be disposed off. Lower solid content in white water circulations improves the smooth working of the paper machine. Reduced solids load to the external treatment might also be a motivation to implement the described measures for fibre recovery or spill prevention. |
| Example plants | Best Paper Mill, Unit 2 located in Vapi GIDC, implemented this technique. |
| Reference literature | EU BREF Document for Pulp & Paper Sector. |


| Case Example 10: Secondary Treatment at ETP for Meeting Discharge Norms” | |
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| Description & achieved environmental benefits | <p>Pretreatment is usually carried out ahead of biological treatment in order to facilitate and improve the treatment process. In some special cases where the organic load is too low for efficient biological treatment, primary treatment may be the only wastewater treatment. In most cases, effluents from kraft pulp and paper mills are treated with aerobic methods.</p> <p>The activated sludge process is mostly used. Some mills run moving bed</p> |

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| | <p>biofilm reactors (MBBRs) as a standalone technique or combined with activated sludge plants. Aerated lagoons are also still in use in a few cases. In order to meet the discharge norms (COD & TSS) by CETP⁸, a proper secondary treatment facility is required at the source industry that generates the pollutants. Reduction of emissions of organic matter (COD, BOD) etc.</p> |
| <p>Cross-media effects</p> | <p>Aerobic biological waste water treatment consumes energy (e.g. for aerators and pumps) and generates sludge that normally requires treatment before utilisation or disposal.</p> |
| <p>Operation data</p> | <p>Before:</p> <ul style="list-style-type: none"> • The industry was running an ETP plant with primary treatment only for the waste water generated. • The average discharge from industry after primary treatment was 3000 mg/litre COD & 300 mg/litre TSS. While the discharge norms by CETP is 1000 mg/litre COD & 300 mg/litre TSS. • Regular discharge of effluent not meeting discharge norms of about 40 m³ per day to CETP, industry has to pay the penalty against discharge to CETP operating company. • Also the treated water was reused as process water of about 150 m³ per day with high SS; the quality of product also gets affected. <div data-bbox="492 840 945 1180" style="text-align: center;"> </div> <p>Image 21: Effluent Treatment Plant without Secondary Treatment [Source: GIZ-IGEP & GCPC Team]</p> <p>After:</p> <ul style="list-style-type: none"> • Industry has upgraded the ETP in March 2014 with installing secondary (Activated sludge and diffused Aeration system) treatment with the help of local consultant Unitech Environment and Research Lab Pvt. Ltd. at Vapi, the treated water quality has improved with final discharge parameters of COD 800 mg/litre and TSS less than 100 mg/litre well within discharge norms by CETP. • Also industry now reuses about 150 m³ per day treated water as process water of better quality resulting in improved paper quality. |

⁸ Common effluent treatment plant

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| |  <p>Image 22: Effluent Treatment Plant with Secondary Treatment [Source: GIZ-IGEP & GCPC Team]</p> |
| Applicability | The technique can be applied to new and existing mills. |
| Economics | The capital investment done by the industry was Rs. 30,00,000 with savings in terms of penalty cost from CETP company. The investment made is not for economic gains but with an objective to preserve environment and complying with norms. |
| Driving force for implementation | Protection of water bodies from organics, suspended solids, nutrients and potentially toxic effluents. Legal requirements. Water quality objectives. |
| Example plants | Rama Pulp & Papers Limited (Rama Pulp) in Vapi has upgraded their ETP with Secondary treatment with required capacity to handle the entire waste water quantity generated. |
| Reference literature | EU BREF Document for Pulp & Paper Sector |

| Case Example 11: Acidic Sizing (Alum & Rosin) Replaced by Surface Sizing | |
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| Description & achieved environmental benefits | <p>Usually sizing means wet end sizing where starch or synthetic sizing agents are added directly to reduce the natural absorption capacity of the paper. In sizing, starch or other sizing agents are applied to the fibre matrix to increase the strength of the base paper web and to modify the surface properties with respect to liquid uptake during writing, printing or coating.</p> <p>Wet end sizing is applied for instance to fine papers and some special paper grades. The potential environmental impact of size application is mainly the releases to water. If sizes are added to the paper stock, a significantly higher concentration of COD in the water circuits can be measured. Also, the repulping of sized broke increases somewhat the COD in the water circuits. For instance, the repulping of starch-coated broke is one of the main sources of COD effluents in the writing and fine paper sector. Sizes may also be applied to the surface of the paper sheet (surface sizing) to avoid dusting (linting) of the paper in offset printing processes. Surface sizing also increases the surface strength of the paper. In surface sizing, the web is passed through the sizing liquor pond. As a result, the paper web absorbs the sizing liquor.</p> <p>Surface sizing technique replaces the internal acidic sizing and therefore eliminates consumption of chemicals such as Alum and Rosin which are a major cause of TDS formation in process water.</p> |



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| Cross-media effects | The water applied in the size press is evaporated in the after-dryer section, thus need additional thermal energy. Space is required as well for the press & post dryer. |
| Operation data | <p>Size press technology has advanced with the film size press becoming the norm in preference to the older flooded pond two-roll technology. Film size presses involve the application of a controlled amount of water-based size mixture evenly to the paper sheet by first creating a uniform film thickness on an adjacent roll and then transferring the film onto the paper sheet as if printing the size film onto the paper. The water applied in the size press is evaporated in the after-dryer section. If size is applied by a film size press, only relatively small amounts of concentrated size have to be discharged when operational conditions are changed.</p> <p>Before:</p> <ul style="list-style-type: none"> • In kraft board & MG kraft paper industries, alum & rosin are used for sizing process, which reduces drainability, and supports fibre retention. • Acidic sizing disables manufacturing of high GSM paper. It also increases total dissolved particles in effluent. • In chemical chest, alum and rosin were added about 30 Kg/Ton and 8 Kg/Ton respectively as sizing agent. • Aluminium sulphate (alum) combines with the Sodium rosinate to form Aluminium rosinate (the water-repellent size), along with the ions of sodium sulphate and sulphuric acid. • The acidic material is responsible for deterioration of cellulose and decreased paper permanence. It is also observed that rosin-sized paper has a lower thermal decomposition temperature and reduced paper strength. • Due to acidic nature, COD and TSS are also increased in the effluent. <p>After:</p> <ul style="list-style-type: none"> • Surface sizing of paper refers to the application of starch by means of a size press or film press which is placed after the M.G. Cylinder and 6 nos. Dryers. This process replaces the acidic sizing to neutral sizing.  <p>Image 23: Sizing Press for Surface Sizing [Source: GIZ-IGEP & GCPC Team]</p> <ul style="list-style-type: none"> • In surface sizing, Retention Aid K-301 150 gm/Ton and PAC (Poly Aluminium Chloride) 15 Kg/Ton are added as sizing agent to both sides of the paper web, as it passes through rollers that press the size on the sheet and remove excess size. • It Increases internal and surface strength from 16-18 BF (Burst Factor) to 24 BF, improved printing quality and paper stiffness, Surface sizing also affects the printing process by altering paper absorbency, flatness, density, fibre consolidation. |
| Applicability | Film size presses are mainly used for printing and writing papers and |

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| | packaging grades made from recycled fibre. |
| Economics | The Capital cost invested by industry was Rs. 54,00,000 with total revenue increase due to product quality improvement is Rs. 35,32,500 per annum giving simple payback in 19 months. |
| Driving force for implementation | Improved product quality and reduction in effluent load are major driving force for implementation of surface sizing. |
| Example plants | R. A. Shaikh Paper Mills Pvt Ltd. In Vapi GIDC implemented the technique. |
| Reference literature | EU BREF Document for Pulp & Paper Sector. |


It was a pleasure to be associated with GIZ and GCPC personnel. The time to time interactions with IGEP and the German delegates encouraged and motivated us to think, understand and act to improve our system by improving process conditions by reducing wastages and by adopting better housekeeping.

The various initiatives taken by the other paper mills and the discussions/presentations by them also helped us to implement some of them in our system.

**P.A. Pai, Technical Advisor & A.K. Sharma, Director
Rama Pulp & Papers Ltd.**

| Case Example 12: Condensate Recovery | |
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| Description & achieved environmental benefits | <p>Paper Recycling industry is a water intensive sector and a substantial water quantity is used for production of steam. Therefore, generation of waste water in any form subsequently increases the hydraulic load on the ETP/CETP.</p> <p>Recovery and reuse of hot water streams within process not only saves the water for reuse but also conserves valuable thermal energy which in turn reduces the fuel consumption to generate heat. Reduction in steam leakages also improves the overall condensate recovery in the system.</p> |
| Cross-media effects | The measure has no negative effects. |

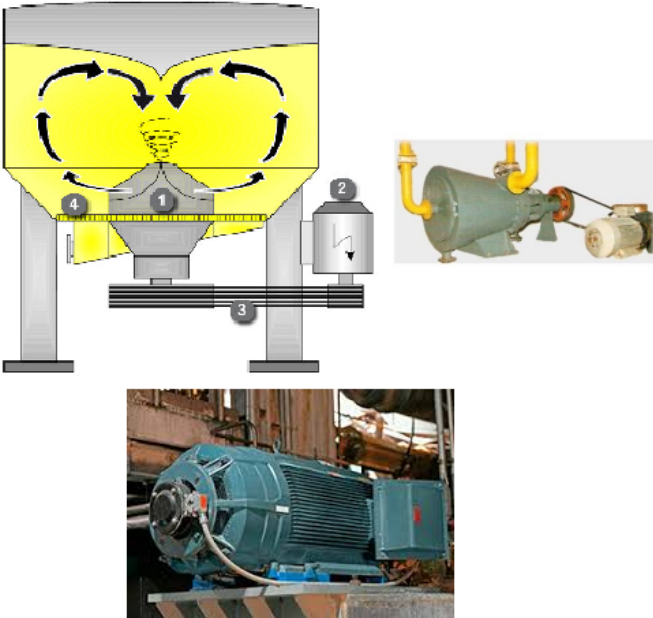
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| <p>Operation data</p> | <p>Before: Transfer of paper pulp from the pressure zone to the drying zone, resulted in removal of moisture, thereby, increasing the pulp consistency from 45%-50% up to 94%. For the purpose, a total 21 units of drying cylinders are installed for removal of moisture. The heating of these dryers was carried out by indirect supply of steam and eventually the steam converts to condensate.</p>  <p>The industry was able to recover only 48% of the condensate out of total steam supplied. The loss of condensate was due to leakages of steam in supply network as well as due to condensate handling losses.</p> <p>The plant was losing valuable heat content of the condensate. The maximum feed water temperature achievable at boiler was also only 80°C.</p> <p>Image 24: Wastage of Hot Condensate in Industries [Source: GIZ-IGEP & GCPC Team]</p> <p>After:</p> <ul style="list-style-type: none"> • A thorough inspection of the complete steam distribution system was done to identify the steam leakages. • The leakages as found in the steam network as well as the condensate return were plugged and rectified. • The total condensate recovery increased from 48 % to 68 % of the total steam supplied, resulting in an increase of feed water temperature at boiler upto 86.5 °C (Average). This helped in reducing the overall fuel consumption of 68 tons per annum. The purpose of the condensate recovery system is to utilise energy available in condensate to reuse as boiler feed water. Nearly all the heat energy consumed in a paper mill is used for paper drying, making the dryer section easily the largest thermal energy consumer in a paper machine. Thus it is possible to recover upto 90 % (indirect heating) condensate from the system. |
| <p>Applicability</p> | <p>The technique is applicable to both existing and new installations. In new installations condensate recovery system and a steam boost system as a measure is considered to save water and improve energy efficiency.</p> |
| <p>Economics</p> | <p>The capital cost invested by industry was only Rs. 20,000 with total savings achieved by reducing fuel consumption of Rs. 3,60,000 per annum. Simple payback in 20 days.</p> |
| <p>Driving force for implementation</p> | <p>Savings of energy & water.</p> |
| <p>Example plants</p> | <p>R. A. Shaikh Paper Mills Pvt Ltd., Vapi & many more all over India.</p> |
| <p>Reference literature</p> | <p>EU BREF Document for Pulp & Paper Sector & National & International Pulp & Paper Industry Best Practices Manual by CII.</p> |

Case Example 13: Optimisation of Heat Losses in Paper Dryers



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| <p>Description & achieved environmental benefits</p> | <p>Normally, in a paper dryer, the steam cylinders are about 4-5 feet in diameter. A typical paper machine has 40 to over 100 steam cylinders, requiring 1,275 to 1,575 BTUs steam input per pound of water dried from the sheet. The side plates of these cylinders, non-covered cylinder surfaces and non-isolated piping usually emit heat to the surrounding area and resulting in significant loss of energy.</p> |
| <p>Cross-media effects</p> | <p>The measure has no negative effect but improves work safety</p> |
| <p>Operation data</p> | <p>Before:</p> <ul style="list-style-type: none"> • Transfer of paper pulp from the pressure zone to the drying zone, resulted in removal of moisture, thereby, increasing the pulp consistency from 45%-50% upto 94%. For the purpose, a total 21 units of drying cylinders are installed for removal of moisture. • It was identified that the side plates of the cylindrical dryers were not insulated. With an open installation of a cylinder dryer, continuous thermal energy was lost due to radiation and convection. The side plates of cylinders and non-isolated piping emitted heat to the surrounding area. Additionally, removal of great quantities of ambient air from the area, resulted into even higher loss of energy by convection. <div data-bbox="527 800 1338 1123" data-label="Image"> </div> <p>Image 25: Dryers – before insulation [Source: GIZ-IGEP & GCPC Team]</p> <p>After:</p> <p>All the cylinder dryers were insulated at side plates with Rock Wool supported by aluminium cladding (specifically designed for motion at fixed RPM), the insulation provided is having following properties:</p> <ul style="list-style-type: none"> • The density varies according to the operation needs, 60kg/m³ to 160kg/m³ • The moisture absorbency is very less. • Very light and easy to apply. • Can be tailored to any requirement, set by the customer. • Has a thermal conductivity ranging from 0.07 W/mK to 0.21 W/mK. This depends on the product and the boundary conditions of the system. • Is very resistant to most alkalis. And the leachable chloride content is less than 5ppm, thus not propagating corrosion. <p>Thus, by insulating only the side plates of cylinder dryer reduced average steam consumption up to 75 kg per ton of paper and average fuel consumption up to 29 kg per ton of paper production.</p> |

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| |  <p>Image 26: Dryers – after insulation [Source: GIZ-IGEP & GCPC Team]</p> |
| Applicability | Can be applied to all mills except mills having covering hoods on the paper machine to reduce radiation losses. |
| Economics | Capital cost incurred by industry for insulation was Rs. 5,00,000 with no operational cost giving a total savings of Rs. 28,71,000 per annum giving return of investment in just 2 months. |
| Driving force for implementation | Energy saving and better working conditions to workers by avoiding heat emissions in process areas. |
| Example plants | The modification was done in-house by Daman Ganga Paper Mills, Vapi in December, 2013 with the help of local contractor |
| Reference literature | Energy Efficiency in India, Moving India's SMEs towards a sustainable future – Case study under KAEFER-GIZ partnership project in Paper sector |

| Case Example 14: Variable Frequency Drive on Major Electrical Motors | |
|---|---|
| Description & achieved environmental benefits | Almost all electric power in a paper mill is consumed by electric motors. For asynchrony motors, which are the most used type, different efficiency classes exist. The AC induction motor typically operates at 80% efficiency when under full load, but the efficiency drops dramatically at lower loads. Applications like Pulper, Turbo, Paper machine main drive etc. are having constant variation of load. The power consumption by these equipment motors must be optimised to have cost effective and environment friendly operations. The task of a variable speed electrical drive is to convert the electrical power supplied by the mains into mechanical power with a minimum loss. |
| Cross-media effects | The life of variable frequency drives is more under dust free and low temperature conditions and thus may require enclosed installation as per site conditions and may require the cooling of area resulting in increased electrical consumption. |
| Operation data | <p>Before:</p> <ul style="list-style-type: none"> The waste paper on the conveyor is added to the pulper along with water. The role of the pulper is to break apart the paper sheets into individual pulp fibres while leaving the contaminants as large as possible. The process conditions in the pulper are characterised by strong pressure shocks from falling bales, vortex formation from fast rotating agitators as well as heavy abrasion from foreign substances such as wires, glass, stones, etc. thus the load on the motor of 200 HP varies continuously. Turbo Separator is functional in separating unwanted material from pulp like metal pieces and heavy water resistant particle pins, this machine is efficient and reliable. Besides, it also acts as a plastic catcher in some plants and thus it is exposed to varying loading at motor of 120 HP. In paper machine, the paper produced varies in terms of length, grade, fibre concentration, quality which in turn affects the loading on the motor which is of fixed 200 HP capacity. When the motor is operating at light load for extended periods, the motor's efficiency falls due to the over-fluxing of the windings for the particular torque required to drive the load. At a constant terminal voltage this flux, often referred to as magnetising current, is fixed and accounts for around 30-50% of the motor's total losses. |

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| |  <p>Image 27: Equipments with Large Size Induction Motors [Source: GIZ-IGEP & GCPC Team]</p> <p>After:</p> <ul style="list-style-type: none"> • By installing VFD, when the frequency applied to an induction motor is reduced, the applied voltage must also be reduced to limit the current drawn by the motor at reduced frequencies. Apart from energy saving, VFD provides following benefits: <ul style="list-style-type: none"> ○ Motor is driven only as fast as needed in order to get the right speed and process control required ○ Soft start/stop means less wear on couplings, belts and motors. Controls prompts the operator as and when system needs attention • The VFDs on the major motor were installed by the industry. • The total electrical power consumption has reduced from 265 kWh per Ton of paper to 250 kWh per ton of paper. |
| Applicability | Can be applied to all plants |
| Economics | Capital cost to install the VFDs was Rs. 17,00,000, with minimum maintenance cost delivering a total savings of Rs. 20,79,000 per annum giving return on investment in 10 months. |
| Driving force for implementation | Considering the life cycle costs of an asynchrony motor, the initial price of a motor is approximately 2% of the entire lifetime costs of operation. Therefore it usually pays back sooner. |
| Example plants | Daman Ganga Paper Mills in Vapi implemented this technique. |
| Reference literature | Pulp and Paper Energy Best Practice Guidebook by Focus on Energy (https://focusonenergy.com/sites/default/files/pulpandpaper_guidebook.pdf) & http://www.pcra.org/english/latest/book/11-Chapter%20-%2011.pdf |

| Case Example 15: Efficient Plastic Waste Handling | |
|--|---|
| Description & achieved environmental benefits | In a waste paper based paper mill, plastic waste (about 3% per ton of paper) is generated and stored in loose form. Handling of compacted bailed plastic waste is more efficient in terms of storage, manpower & transport. Simplification of the stock preparation system resulting in less energy consumption, less material loss, and less space needed. |

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| <p>Cross-media effects</p> | <p>The rejects from different process stages can be collected separately and used for different purposes. For example, rejects containing high amounts of plastics can be incinerated or coprocessed in cement kilns with the benefit of considerable energy recovery, due to their high heating values.</p> |
| <p>Operation data</p> | <p>Before:</p> <ul style="list-style-type: none"> Plastic waste generated from the process is being stored onsite in loose condition and thus requires significant space, additional manpower to handle & transport the plastic waste from generation to storage area.  <p>Image 28: Loose Plastic Waste Generation in Recycled Paper Industry [Source: GIZ-IGEP & GCPC Team]</p> <ul style="list-style-type: none"> Because of very high calorific value of plastic waste, this waste has potential to be used as fuel but due to regulatory restrictions and consideration as hazardous waste, industry has to incur significant cost for handling & disposal. Also, this plastic waste (non-PVC) from paper industry has good potential to be co-processed in cement industries, for which, it is essential to have viable storage and transportation costs, till a permanent solutions could be found. <p>After:</p> <ul style="list-style-type: none"> Industry has installed an onsite “Bailing Machine”, which compresses the loose plastic waste into bails of proper dimensions with increased density as per requirement of cement industries for ease of handling & reduced transportation cost (high density bails).  <p>Image 29: Bailing Machine and Bailed Plastic Waste [Source: GIZ-IGEP & GCPC Team]</p> <ul style="list-style-type: none"> Gujarat Paper Mill Association (GPMA) in Vapi has started co-processing |

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| | of plastic waste by sending it to cement industries located in Gujarat and nearby states with the help of Gujarat Pollution Control Board (GPCB) for incineration purpose. |
| Applicability | This technique is generally applicable to all recycled paper mills. |
| Economics | This measure reduced labour cost of about Rs. 500 per Ton of plastic waste. The capital cost invested by industry is Rs. 5,00,000, with operating cost in terms of electricity consumption of bailing machine and operator cost. Since, there is no direct monetary benefit but it gives indirect benefits in terms of saving space, environment friendly disposal (co-processing in cement industries) in place of incineration. |
| Driving force for implementation | Requirement from cement industries to coprocess this waste as well as handling and transport cost. |
| Example plants | Many industries in Vapi have adopted the technique. |
| Reference literature | EU BREF Document for Pulp & Paper sector |

| Case Example 16: Pressure Regulating Device on Filter Press for Efficient Moisture Removal | |
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| Description & achieved environmental benefits | Biological and chemical sludges have poor dewatering properties. The sludge is usually thickened before being dewatered in a belt press, filter press, screw press or on a vacuum filter. Normally they are mixed with primary sludge (or bark if available) before dewatering. To improve the solid content in sludge with consistency >45% on dry basis, pressure regulating valve as automation is an option to improve filter press efficiency. |
| Cross-media effects | <p>The pressure regulating system at filter press additional power in terms of compressed air and thus increases the electricity cost for operation. Reject and sludge dewatering results in an increased volume of water to be treated. The water squeezed out is normally sent to the wastewater treatment plant. Dewatering is generally only performed by mechanical forces. The pollution of squeezed out water is equal to water attached to the rejects and sludge. When using screw presses, one has the possibility to heat the rejects by injecting steam, which affects the pollution of squeezed out water. This must be considered especially in cases where the wastewater treatment plant has already approached its maximum capacity. Injecting steam requires thermal energy.</p> <p>When the rejects and sludge are incinerated in power plants or in cement kilns, the energy demand for the evaporation of water in rejects and sludge decreases when higher dry solids contents are achieved by mechanical dewatering. This contributes to a higher energy recovery rate.</p> |
| Operation data | <p>Before:</p> <ul style="list-style-type: none"> Filter press was used to remove the moisture content from the final effluent and recover the solid mass as sludge for further disposal as required. The output of sludge cake from filter press consisted of solids upto 30% (approx. 4500 Kg/batch) and moisture upto 70% (10500 Kg/batch), the batch of 15m³ effluent took about 48 hours for dewatering at filter press. Thus the high moisture content required additional drying before disposal and required additional space, as well. <p>After:</p> <ul style="list-style-type: none"> A pressure regulating device has been introduced which supplies the |

compressed air intermittently to maintain the required pressure between the plates of the filter press, so as to achieve the solid contents in final sludge cake more than 45% (6750 Kg/batch) with reduction in moisture content up to 15% (2250 Kg/batch).

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Image 30: Filter Press with Pressure Regulating Device
[Source: GIZ-IGEP & GCPC Team]

- The pressure regulating system was installed along with a dedicated air compressor of 15 HP for compressed air supply.
- To obtain a high dewatering efficiency, screw presses have become more and more common.

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| Applicability | Reject and sludge dewatering facilities are common in new and existing paper mills. Retrofitting dewatering systems to run more effective equipment is possible. |
| Economics | Capital cost invested by industry is Rs. 3,00,000 with operating cost of compressed air, although the savings in terms of improved water recovery (not accounted). Additionally the space required and time for drying before disposal has reduced. |
| Driving force for implementation | Reduction in storage space, energy for drying and disposal cost of sludge is the main driving force to increase dewatering efficiency. |
| Example plants | Daman Ganga Paper Mills, Vapi has implemented this technique. |
| Reference literature | EU BREF Document for Pulp & Paper Sector http://www.mwwatermark.com/blog/what-is-a-filter-press/ |



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6. Annexures

6.1 Product Aids

The additives applied by the paper industry can be classified into “Product aids”, as shown in the following table. A large, major portion of additives become part of “Products made”, but however, are often not completely used up during the process or not completely retained on the paper sheets. A certain amount is discharged via wastewater. Excess additives are also leaving the system via rejects and sludge. Some of these additives can have a negative influence on the practical functioning of the wastewater treatment plant and/or the quality of the receiving water in case they are not degraded or eliminated in the wastewater treatment plant.

Table 1: List of Product Aids used in stock preparation (as per product needs)

| Product Aids | Purpose | Examples | Remarks |
|---------------------|---|--|---|
| Fillers | - Improve printability, opacity, brightness, smoothness and gloss - Replace fibres | Kaolin or clay, talc, lime, gypsum, titanium dioxide | - |
| Sizing agents | - Improve surface quality - Make paper hydrophobic | Modified starch, modified natural resins, wax emulsions, synthetic products like alkyl ketene dimers and maleic acid anhydride co-polymers | Some may be toxic to bacteria when they are cationic |
| Fixing agents | Improve adsorption of additives to fibres | Alum [Al ₂ (SO ₄) ₃] | Mostly cationic products which may be toxic to bacteria |
| Dry strength agent | Improve strength properties in dry Conditions | Modified starch | Some may be toxic to bacteria when they are cationic |
| Wet strength agents | Improve strength properties in wet Conditions | Urea formaldehyde polymer, melamine-formaldehyde polymer, Epichlorohydrin condensates | Usually toxic to bacteria, some increase the AOX |
| Dyes | Give paper a certain colour and/or Brightness | Azo compounds, quarternary ammonium compounds | Difficult to eliminate; some are toxic; may contain heavy metals |
| Optical Brighteners | Give paper a white impression | Chemicals based on 4,4-diamino stilbene-2,2-disulfonic acid | Some cationic substances may be toxic |
| Coating Chemicals | Give paper certain surface properties | Pigments, binders, wet strength agents, dispersion and lubrication agents, De-foaming agents, Slimicides | Binders must be destabilised before mixing with other white water, otherwise they may disturb the clarification |

[Source: Reference Document on Best Available Techniques in the Pulp and Paper Industry, European Commission, 2011]

6.2 Environmental concerns from pulp & paper industry

▶ Water Use

The paper and board mills commonly use large quantities of water, if water availability is not a constraint and price of water is low. Since most of the RCF mills are located in water starved areas and are land based (not riverside based setting), local environmental pressures are expected to grow. Thus, in most paper mills, a large amount of water is recycled and thus the specific water volume used for manufacturing of RCF paper has decreased during the last twenty years. Depending on the paper grade, the water must be pre-treated in order to fulfil the requirements set for process water. Water has various basic applications in the paper industry as process water, cooling water, boiler feed water and sanitation water. The process water is extensively recycled in the production process.

The overall impact by reduced water use will be:

- Poor segregation of wastewater streams.
- Generation of high concentrated wastewater demanding stages of add-on effluent treatment.
- Corrosion of process machinery.
- Enhanced consumption of biocides and process aid chemicals.
- For large production capacity mills, opportunity for on-site methane production & utilization as fuel.

▶ Use of Additives

To improve the product properties, various additives are applied in the paper and board industry. The amount and types of additives vary with the paper grade and the installed equipment. The additives applied by the paper industry can be classified into product aids which are applied to optimise the specific properties of the paper according to the customer's requirements and process aids, which enhance productivity of paper machine. Majority of the "Product-Aids" will not end-up in effluent, but only the associated preparation & dissolution losses in effluent. On the contrary, whatever "Process-aids" used, will re-appear in effluent (barring retention aids). The overall impact of Chemical additives will be:

- Shock load to effluent treatment system on account of system cleaning or batchwise additive adjustments to fulfil product requirements
- Opportunity for chemical substitution with an aim to reduce processing cost and reduce salt accumulation burden to effluent characteristics
- Depending on poor chemical optimization, negative effect of added chemicals in solids build-up in circulating wastewater system
- Toxicity of certain product & process aids to bio-mass in effluent treatment plant

Therefore, additives should be handled carefully, cautiously and as directed by specification of the manufacturers & suppliers.

▶ Energy Consumption

The paper and board mills require relatively higher amounts of steam for heating of water, pulp, air and chemicals to the demanded process temperature and above all for drying the paper. Besides, large quantities of electricity are required for driving the machinery, pumping, vacuum, ventilation and wastewater treatment. In paper mills, energy is usually the main factor in operating costs. Because the secondary fibres have already passed through stock-preparation equipment when the original paper was made, RCF pulping require comparatively less total energy for processing than is needed for chemical & mechanical pulp mills.

When specific energy consumption is compared, the following aspects should be kept in mind:

- The yield of the process varies mainly according to the raw material.
- The country and the area where waste is collected affect significantly the raw material quality.
- Because of bad wastepaper quality, some mills may have to take additional efforts in the stock preparation.

- Usually, when energy consumption is discussed, only main equipment are included i.e. pumps and agitators are not part of the system considered. These „passive“ process components do not improve pulp quality but are nevertheless relevant in terms of electricity demand (check for power factor improvement scope).
- The contribution of pumps and agitators to the total installed power may vary from 20 up to 30%. From the energy point of view process concepts that decrease the amount of pumps are therefore important.
- Peripheral sub-systems for water, sludge and rejects such as DAF, reject screw presses, or sludge presses are also not included because they are not considered as main equipment.
- Refiners demand the maximum specific energy consumption and so control over “Refining Time” and “Avoidance” by pulp grade are to be streamlined.

▶ **Wastewater Quality & Quantity**

The quantity of wastewater generation and energy demand are closely related to the requirements set for the paper grades, the quality of the raw materials (recovered paper) and applied abatement techniques. The additives used, internal process management, housekeeping and the technical status of the installation have also an effect on the extent of wastewater reduction achieved.

Therefore, the impact of wastewater quality from RCF based paper mills are influenced by:

- Water from reject separation by screens and centrifugal cleaners.
- Filtrates from washers, thickeners and sludge handling.
- Excess white water depending on the rate of recycling.
- Integrity of various “Water loops” and overall yield (increased or decreased fibre recovery).
- The wastewater characteristics of importance are with respect to pH, COD, BOD, TSS and TDS. Heavy metals are virtually negligible and colour is also not that much important. Only certain heavy metals are expected in traces, if de-inking process is adapted, particularly to Zinc and Copper. Nutrient will be absent and may have to be supplemented for biological treatment.
- AOX and other organic micro-pollutants: Sources of absorbable organic halogen compounds are some additives (especially wet strength agents), wastepaper based on chlorine bleached pulp and to some extent printing inks. The AOX concentration is expected to have a downward trend over the years.
- Salts, mainly sulphate and chloride, are introduced through recovered paper and some additives as alum. In certain areas, for instance if receiving surface water body is a main resource for the production of drinking water or for the water quality reasons, attention is given to the discharge of salts. Depending on the types of recovered paper used as raw material and the degree of closure of the water circuits, sulphate concentrations upto 1,000 mg/l have been observed even if during processing no aluminium sulphate has been used. Excessive “Closing of water loop” will be detrimental to wastewater treatment in achieving desired quality of treated effluent as well as product quality (say less than 4 m³/T).

▶ **Solid Wastes**

The major waste materials in pulp & paper industry are rejects, different types of sludge and ash from boiler operations. The residues can be sub-divided roughly into heavy and coarse rejects, light and fine rejects and sludge. Depending on origin and nature, the sludge again may be subdivided into de-inking sludge, sludge from micro flotation units from process water clarification and sludge from wastewater treatment (primary sludge, excess sludge from biological treatment).

▶ **Atmospheric Emissions (Flue gas from energy generation)**

The atmospheric emissions from paper and board mills originate mainly from energy generation (steam and electricity) and not from the manufacturing process itself.

▶ **Noise**

Some rotary equipment may be of relevance for noise issue, but generally confined within the mill boundary.

▶ **Odour from vapours and from wastewater treatment plant (local)**

The air pollution problems might occur due to odour from in-plant process water circulation system or from effluent treatment plant and coarse dust from coal storage yard. Especially in the case of closing up the water circuits below the consumption levels of around 4 m³/T, odours caused by lower organic acids and H₂S may be perceived in the neighbourhood of paper mills. Also in paper mills that have less water circuit closure, annoying odours may be found. They may be caused by too long retention times of process water in the water system (pipes, chests, etc.) or deposits of sludge causing the built up of hydrogen sulphide. They can be avoided by suitable process engineering measures. The wastewater treatment plant of RCF paper mills may also emit significant quantities of odour. If the wastewater treatment is well designed and controlled, odours can be avoided.

▶ **Rejects**

Rejects are impurities in recovered paper and consist mainly of lumps of fibres, staples, and metals from ring binders, sand, glass and plastics. Rejects are removed in the largest possible form and in the earliest possible stage in the stock preparation. Rejects constitute approximately 6.5% of the purchased recovered paper and have no recycling potential and so they are dumped or incinerated. If the thickened residues are incinerated in an environmentally compatible incineration plant, e.g., fluidised bed, the steam for the mill operation could be met, fully or partially. On-site incineration of rejects is only applicable to large mills, which generate higher amounts of solid waste.

▶ **Sludge from process water clarification (paper residue)**

These types of sludge are mainly generated at the fibre recovery in the white water circuits and the mechanical treatment unit of the wastewater treatment plant. The paper residue consists of mostly short fibres and fillers (both around 50%) depending on the wastepaper being processed. In the board industry and for production of corrugated medium, it is often recycled to the process. For higher-grade products, paper residue does not meet the quality requirements for recycling and is incinerated or dumped. Fibre recovery helps in minimising the quantity of residues.

▶ **Deinking sludge**

Depending on special process in stock preparation, deinking sludge may be produced, which will contain inks & pigment residues. This residue contains mainly short fibres, coatings, fillers, ink particles, extractive substances and deinking additives. Ink particles are a potential source for Zinc and Copper, but along with secondary bio-sludge, combined sludge is compatible for incineration. Deinking sludge is normally dumped or incinerated. The ash can serve as a resource for building materials.

▶ **Wastewater Treatment Sludge**

This sludge is generated at biological wastewater treatment plant and is either recycled to the product (corrugated medium and board) or thickened, dewatered and then incinerated (on- or offsite) or dumped.

▶ **Effluent Characteristics - Typical RCF Mill Characteristics**

The key characteristics of relevance are COD, BOD, TSS and Total Dissolved Solids. The concentrations of these parameters are directly related to the extent of water usage. In general, load reduction of pollution is seldom practiced. Thus, higher the water consumption, lower will be the concentration of these pollutants. The broad characteristics of wastewater for Writing & Printing and Kraft grade products, based on Agricultural & RCF pulp as feed stock, are shown in Table 4.

Table 2: Typical Raw Wastewater Characteristics of Agro & RCF Based Pulp & Paper mills

| Parameters | Raw Water | Rcf Writing & Printing | Rcf Kraft |
|-----------------------------------|------------|------------------------|-----------|
| Water consumed, m ³ /T | - | 30-50 | 15-35 |
| pH | 7.5 to 7.8 | 6.8-7.3 | 6 |
| TDS, mg/l | 290 | 800-1720 | 840-3240 |
| TSS, mg/l | Nil | 160-4387 | 56-680 |
| COD, mg/l | Nil | 262-1715 | 704-2016 |
| BOD, mg/l | Nil | 180-958 | 593-1058 |
| Colour | Nil | - | - |
| Turbidity, NTU | Nil | 2-35 | 22-299 |

[Source: Pulp & Paper Industries in Ganga Basin: Achieving ZLD, December, 2011 Expert groups from 7 IIT's]



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