WASTE PAPER & DE-INKING SYSTEMS

Background

Even the most vigilant source-separation program will yield a variety of contaminants in the paper stock, including adhesives from envelopes and pressure sensitive labels, the hot melts used in some document bindings, paper clips and staples, groundwood content from old newspapers, plastics, and obvious trash & contaminants.

The key to successful de-inking plant design is the ability to combine in-depth equipment knowledge; hard-won process and operational experience; with advanced dynamic process modelling and independent thinking. By doing so, the entire DIP process can be optimised for maximum performance and efficiency at minimum capital and operational cost. Clearwater offers this unique combination of talents.

Process Technology

There are two important goals of efficient modern de-inking plant design: how to increase the brightness as much as possible, and at the same time achieving the highest fibre yield possible.

In addition there is sticky separation; and it is essential that ash and fines are removed from the material. This has a strong effect on the yield, which can drop as low as 52%, making the specific energy consumption high.

Typical DIP indicators:

- Raw materials: 100% ONP; 50-70% ONP / 50-30% OMG; 100% MOW (mixed office waste)
- Percentage DIP material in end-product 100% DIP
- Brightness increase 42-70 → 52-84 ISO
- Ash content 8-35% → 1.5-5%
- Yield 52-75%
- Energy consumption 350-400 kWh/tonne

For a minimal ash content of 2% in the finished material, the DIP concept usually requires the use of 2 washers.

Ultimately, we believe that what is important for papermakers is not how much machinery they receive but achieving the best possible solution for a particular
application and furnish that also takes costs and environmental considerations into account.

Our approach is designed to identify the optimum equipment for every unit operation within the fibre recycling / de-inking process (irrespective of manufacturer, if appropriate). Each unit is then incorporated into an integrated process model so that the individual performance parameters can be fine tuned and assessed – both as individual components and as the complete process (this includes water loops, energy & chemical consumption, process stream temperatures, and effluent and rejects outflows). The result is a truly optimised fibre recycling / de-inking process capable of providing superior performance at lowest commensurate cost.

**Inks**

A significant contaminant in office paper is the growing quantity of "inks" from laser and xerographic printed matter.

The term "laser" is widely used within the paper industry to refer to all non-impact printing methods, including copier machines and laser printers. Both these processes use "dry inks," plastic toners which are transferred to the paper via electrostatic charges triggered by light. Visible or ultraviolet light is used in conventional photocopiers, and some laser beams are used in laser printers. The plastic toners are permanently fixed or "fused" by heat from a separate fuser unit.

Even state-of-the-art commercial de-inking systems can struggle to efficiently remove these inks. De-inking efficiency relates to the chemical and energy costs required to produce an acceptable pulp. Combined flotation/washing de-inking system can remove laser printing, but multiple cleaning and screening stages are required, which increases operational and capital costs. Residual laser particles cause holes and high dirt count in paper, resulting in unacceptable quality in the end product.

Low yields are another deterrent to the use of laser printed waste paper, with as much as 50% of laser-containing paper stock entering a de-inking system becoming unusable and rejected due to weakening of fibres during multiple de-inking sequences. The resulting sludge presents another solid waste disposal problem.
**Stickies**

The challenge of recent years has been, and continues to be, stickies removal - specifically, pressure-sensitive adhesives (polyacrylates).

**Dispersible Vs Screenable Adhesives**

An important goal of de-inking and wastepaper recycling mills is to remove all stickies entirely from the system - either through screening and cleaning or by dispersion. What the industry has learned is that there is a probability that dispersed adhesives will re-agglomerate and accumulate in the water loops and create problems. Therefore, the screening / filtering of recycled process water becomes necessary.

The days of 100% re-pulpable and water dispersible adhesives are long gone. Recycling mills with less advanced cleaning and screening equipment need to install ever more sophisticated equipment, especially as time goes by and further closure of water loops becomes an even higher priority requirement.

There are many factors that upset the ability to remove adhesives from a process, including:

- Temperature changes
- pH changes
- Types of surfactants used, as well as biocides and other chemicals
- Concentrations of electrolytes
- Electro-kinetic relationships (zeta potential)
- Mechanical forces such as pulping, kneading, dispersion, etc.

Trends toward tighter water loops increase the system water temperature and cause buildup of organic and inorganic contaminants in the form of suspended and/or dissolved solids.

The specific gravity of polyacrylate type stickies is very near 1.0. As these stickies travel through a de-inking system, they pick up small ink particles that attach themselves around the sticky, making the particle heavy. Consequently, these stickies are not removed very well by centrifuge-type reverse cleaners. The stickies deform to a flat shape to work their way through all but the finest slotted screen baskets. Small diameter forward cleaners can often be effective at removing these little balls of stickies, as long as they are correctly specified and positioned in the process.

The stickies show up in the end product not only as a sticky but also as dirt, since the particles are now dark in colour. Some of the most common problems experienced by papermakers due to stickies are the following:

- Build-up on wires, felts, and doctor blades
- Reduced quality because of holes and dark spots in the sheet
- Breaks and downtime
**Other contaminants**

It is imperative to remove major contaminants as early in the process as possible. To that end, correct selection of the pulper and pulper dump screening systems (if applicable) is vital.

Multi-stage coarse screening, followed by three-stage fine screening is nowadays the norm for conventional contaminant removal and for the partial elimination of stickies; working at medium consistency with a very low reject rate and fibre losses. Commonly in use in paper mills in Europe, such DIP screening systems contain baskets with slot widths of 0.15, 0.12 or even 0.10 mm. On top of the achieved quality level, the reduction in investment, energy and maintenance inherent in a well chosen system are extremely attractive.

Optimum tailing screen design - to prevent loss of (mostly long) fibre with the rejects - can increase the capacity of existing plants by the creation of two accepts streams.

Benefits include reduction in the size of the first stage(s) and the upstream cleaner plant, and, in the case of low consistency screening, the high quality level of the accepts stream allows a reduction of the total hydraulic flow out of the screening system.

Such equipment can enable two-loop de-inking systems to be considerably modified and simplified with dramatic cost savings and increased flexibility. The same applies to broke, approach flow systems or to stock preparation.

**Yield**

The key to optimising DIP yield lies in the rigorous application of process selection and design, in combination with correct operating procedures from fibre purchasing, through sorting, inspection and storage on site.

Our methodology for defining these operating procedures includes the following steps and activities:
• Measuring Yield
  o Yield measurement protocol
  o Actual industry experience based on products produced, recovered paper feedstock and cleaning/screening/de-inking system
  o Yield measurement trials
  o Recovered Paper Procurement Analysis

• Quality program analysis
  o Moisture measurement
  o Weight
  o Suppliers/sourcing
  o Process Optimisation

• Fundamental analysis and modelling of the efficiency of the unit operations in the cleaning/screening/de-inking system

• Rejects and sludge utilization analysis

Deliverables

• Recycle system yield enhancement compared to industry experience
• An optimised plan for recovered paper procurement
• An optimised processing unit operation plan
• A rejects/sludge reduction/utilisation program

**Flotation & Washing Systems**

A fairly typical system design uses a basic FDF (float/disperse/float) arrangement, with a High Consistency Pulper. High density cleaning, coarse and fine screening steps are performed in the front part of the system, with the fine screening stage using slotted pressure screens with 0.12 to 0.15 mm wedge wire slots. The next process step in the system is often a multi-stage flotation cell for the removal of visible ink specks. This can be followed by a Disperser / Kneader, to which peroxide bleaching and flotation chemicals are frequently added. Stock is treated at 25-32% consistency with 60-100 kW-hr/ton power input. The pulp is then discharged from the disperser / kneader by gravity into a high density peroxide bleach tower.

After the bleach tower, there will usually be a second multi-stage flotation cell for additional removal of small residual visible ink particles. The pulp is washed across a high speed belt washer to remove any small residual ink and ash particles, as well as some of the fines in the pulp. The washer thickens the stock to 11-12%, with the option to pump it into an upflow FAS bleach tower for the reduction of any colored dyes still present in the paper.
Many variations are possible on this conventional type of process. It is also true that no single equipment vendor has the best of every DIP unit operation within its arsenal – i.e. the optimum system design for a given duty will comprise equipment from several different suppliers. Clearwater can offer to design, engineer, procure, and install such de-inking systems (including EPC and turnkey contracts). Alternatively, we are happy to work with any individual equipment supplier to deliver a successful project.

Chemistry

Top quality paper production from recycled fibre requires a total chemistry solution.

Looking at the issue of contaminants, problems caused by ink and stickies fall into several major categories: Product quality is reduced, particularly brightness, holes, and spots. Machine efficiency drops, due to breaks and shutdowns for cleaning. The mill must purchase chemicals for cleaning. Often solvents are used, which can be a health, regulatory and environmental hazard. Problems can continue after the product is shipped, with breaks and other problems in printing and converting. Paper can be rejected and returned by the customer due to quality questions.

At some mills, stickies in the fourdrinier wire can require hundreds of hours / year of downtime for solvent cleaning: Calculating from the profit value of paper produced, this costs mills Millions of Euros or Dollars per year.

The three main processes crucial for efficient use of recycled fibre are detachment, separation, and removal of ink and other contaminants.

Detachment

It is necessary to adjust conditions in the pulper to get the most efficient detachment of inks and stickies, with minimal dispersion of stickies. Using the correct chemistry gives maximum detachment of inks and allows the de-inking system to work efficiently.

Separation of inks

Efficient removal of inks is crucial for production of high quality recycled fibre, because it directly affects quality. The best chemistry will maximize yield with top brightness, along with low residual ink or low dirt counts. It should also be able to handle flexo inks, and reduce the summer effect. (A factor in ONP de-inking,
the 'summer effect' is the fact that during the summer, increased temperatures and intensity of sunlight make the inks much more difficult to remove).

Separation of stickies

As with inks, efficient separation of stickies depends on effective detachment. The first step should be to maximize cleaning and screening efficiency. Next, papermakers must choose one of numerous chemistries available for stickies problems. One such solution is the use of enzymes. The active ingredient in these products can chemically modify some components of stickies.

Most stickies contain materials like polyvinylacetates (PVAc), common components of ink binders and pressure-sensitive adhesives. The enzymes can hydrolyse ester bonds, changing the stickies' characteristics, making them smaller and less "sticky" (from "macrostickies" to "microstickies"). The enzymes also have the effect of reducing overall stickies numbers.

The effect of the use of such enzymes can be dramatic. Stickies levels can be reduced by as much as 50% throughout the mill system (note: once the enzyme is removed from the system, the amount of stickies returns to previous levels).

Removal

Once contaminants have been efficiently detached from the fibre and separated from the stock, it is crucial that they be removed from the system. If such contaminants are not purged, they will come back to haunt the papermaker. So internal water clarification is crucial.

Dissolved air flotation systems (DAFs) and other clarifiers function as crude "kidneys" to remove impurities from the system. It is very important to maximize DAF efficiency in order to prevent re-agglomeration of the contaminants and to ensure that problem-causing materials are successfully purged. The benefits of improved water clarification have been seen in numerous mills. There is a major return in benefits from the investment required.

When dealing with chemical solutions to maximise quality in recycled fibre systems, it is important to remember that detachment, separation, and removal of contaminants are interrelated processes. The best total solution integrates all individual applications for the desired result.

Water Clarification

The key to our approach is the application of very specific solutions to process fluid treatment demands. We do not have a single "one size fits all" approach – rather, we focus on understanding exactly what is required and the packaged delivery of tailor-made solutions.
Clearwater uses advanced process modelling to determine the precise process dynamics and the effects of all process changes. The results from this work are used to guide the selection of the most appropriate technology for the specific application. Following laboratory testing and on-site pilot trials, the chosen (and by now specific application proven) technology is integrated into a complete modular, skid-mounted package ready for site installation.

We advocate three fundamental separation processes:

1. Physical separation – typically using DAF (Dissolved Air Flotation) clarifiers as the first stage. Often, this is all that is required for efficient system functioning. Sometimes, for those mills seeking to close water systems to a high degree, it becomes necessary to incorporate more advanced backwater cleaning systems, such as:
2. Membrane technology coupled with ultra-high shear forces (to minimise fouling and flux rate reduction)
3. Electro-chemical coupled with advanced oxidation (when needed)

**System Engineering**

Clearwater Consulting Partners specialise in the provision of full service process design, plant engineering and project management services to the international pulp and paper industry. We use leading edge, computer based mathematical modelling, drawing and design techniques and integrate them with the extensive experience of our engineers - all of whom have learnt their skills at the "sharp end", i.e. within mills.

The firm has specialist knowledge in a number of key areas of technology, as well as experience over a broad base of the industry, superb resources and capabilities in all engineering fields relevant to a project. The result is a range of exceptional engineering services that can be tailored to suit our clients' requirements. Above all, we believe that by being able to combine extensive experience with latest technology, we can offer **exceptional value for money**.

In particular we have vast experience of waste paper de-inking systems and paper machines. As an independent company, we are accustomed to working with all of the sizeable machinery and equipment suppliers and we pride ourselves on our flexible, and professional, approach.

CCP has an international outlook and operates currently in the UK, mainland Europe, North and Central America, the Middle East, Asia, India and Africa. We operate an international network of offices.
In terms of the scale of project within our capacity and capability, we have had responsibility for large mill projects up to US$ 180M in value, and have major consortium involvement with individual projects in excess of US$ 300M. In addition, we have successfully completed the turnkey design, engineering and management brief for new mills and DIP / recycled fibre plants.

For very large-scale project involvement, we have partnerships with a select number of trusted, well-established, competent, like-minded businesses who work with us to offer our clients the complete range of services, including total turnkey and EPC projects up to any scale and value.

Summary

CLEARWATER CONSULTING PARTNERS OFFER:

- **COMPLETE PULP & PAPER PROJECT SOLUTIONS:**
  - Any scale
  - Turnkey and EPC (with partners)
  - “Cradle to Grave” implementation

- **ADVANCED AUTOMATION AND CONTROL SOLUTIONS**
  - System-wide Predictive Control
  - DCS, PLC, SCADA solutions
  - Complete AC and DC Drive Systems Engineering

- **EXPERT ENGINEERING:**
  - All disciplines
  - Owners Engineer

- **ADVANCED WATER TREATMENT TECHNOLOGIES:**
  - Tailored to customer needs
  - Membrane Systems
  - Advanced Oxidative Processes
  - Electro-Chemical Processes
  - Anaerobic & Aerobic Solutions

- **UNIQUE PROCESS SIMULATION AND MATHEMATICAL MODELLING:**
  - Dynamic & stead-state
  - All variables
  - Advanced neural networks

- **POWER SYSTEMS ENGINEERING:**
  - Conventional
  - Gasification
- Biomass
- Wind & water power
- Pyrolysis systems
- Advanced Bio Flue Gas Desulphurisation

➢ BIO-TECHNOLOGY:
- Mass propagation solutions
- Ultra-high yielding fibre supplies

➢ COMMERCIALISATION:
- Feasibility studies
- Business Plans
- Due Diligence
- Transient, Interim and Ongoing Management
- Technology Transfer

CLEARWATER CONSULTING PARTNERS