Production Of High-Quality Paper Grades Utilizing Deinked Pulp

Rošker Michael

Bio-Data

Mr Michael Rošker is Vice President (Recycled Fiber Systems)at the ANDRITZ Pulping and Fiber Division at Graz, in Austria. He is with the ANDRITZ GROUP since 1990. As Vice President (Recycled Fiber System), he is the global product group manager for deinking and recycled fiber systems.

He started his career with Andritz in the R & D Department for dewatering and bleaching of all kinds of fiber. Thereafter he had a challenging role to take over the responsibility of sales of the Fiber Preparation Systems in 2007 after Andritz took over Ahlstrom.
He is a Chemical Engineering graduate from the Technical University of Graz, Austria.


Mr Michael Rošker

ABSTRACT

As a growing nation, India is experiencing a dramatic increase in paper consumption. Yet, the quantity of domestically produced quality virgin fibre for the manufacture of high-quality paper grades remains scarce, so the focus is on recycled fibres. Currently, only about 20% of waste paper in India is being recovered. The lack of source segregation capabilities results in high levels of waste paper contamination.

With a steady development of technologies for processing recycled fibre, the range of paper grades that can be successfully produced from it has grown. The development started with partial replacement of mechanical pulp for newsprint. This was followed by total substitution for newsprint and other basic grades. Today, many grades of calendered and coated printing/writing papers are routinely produced with 100% recycled fibre.

Depending on the grade, a mixture of old magazines (OMG) with mixed office waste (MOW) or sorted office waste (SOW) or pure office waste is used. Recovered office papers have different characteristics, compared to OMG or ONP, requiring different deinking technologies and processes to efficiently utilize them.

The critical parameter is the type of ink and the printing process. Magazine papers are mostly coated, with the ink smoothly printed onto the coat with offset or gravure presses (“soft” inks). Office papers are uncoated or only lightly coated, and the laser print is virtually fused onto the paper surface (“hard” inks).Another consideration is the level of contaminants in the incoming waste paper, especially the stickies load. Removing these contaminants requires different system configurations.

The requirements of the final stock quality also differ. Apart from high brightness and high stickies removal, which are common for all grades, attributes such as dirt specks and ash content must be tailored to the paper grade produced. On the positive side, the high brightness of most office waste opens the door for a broad employment of this furnish: from high-grade printing and writing papers to art coated paper, white top board, copy papers, and tissue products.

From a sustainability and environmental perspective, the use of deinked pulp (DIP) is also beneficial. Of particular importance to Indian producers, who often face a shortage of raw material at reasonable pricing, is the factor of yield.

The state-of-the-art in deinking technology produces a furnish that is excellent for the production of high-quality printing and writing grades. This paper explores the gradual differences of tailor-made deinking lines suitable for producing various paper grades. It examines the operating parameters of a mill's deinking system, describes the major process stages and technologies employed, and presents the results obtained to date in the production of environmentally friendly, high-grade pulp obtained from processing waste paper. It discusses the results obtained from a state-of-the-art, three-loop DIP facility in India with a capacity of 300 t/d for the production of high-quality printing and writing papers. It reflects on the mill's experience in managing its raw material supply chain and its desire to utilize “green” technology when compared to virgin fibre pulp lines.

Deinked Pulp As A Raw Material

With a steady development of technologies, the range of paper grades that can be successfully produced from recovered fibres has grown. It started with partial replacement of mechanical pulp for newsprint. This was followed by total substitution for newsprint and other basic grades. Today, many grades of calendered and coated printing/writing papers are routinely produced with 100% recycled fibre. There are several key factors which encourage the substitution of deinked recycled fibre for virgin fibre in the production of high-quality paper grades:

- From a sustainability and environmental perspective, recycling of paper is beneficial in that it reduces the volume of landfills considerably and the air emissions and effluents resulting from the processing of recycled fibres are minimal.
- From a fibre cost perspective, the maximum utilization of good fibres within the raw material can be quite attractive when compared to virgin pulp.
- From an operating cost perspective, although a deinking plant is a comprehensive system, less total energy is needed for paper production compared to virgin fibre sources.

If virgin fibre pulp properties are considered to be the standard against which deinked pulp is measured for the production of high-quality paper grades, the main goal of technology suppliers and paper producers must be to narrow the gap in areas where the deinked pulp is perceived to be deficient so that paper with the same or similar quality can be produced at economically reasonable cost.

Accepting the fact that virgin fibre pulp is still the leading furnish for certain grades, the final product targets vary depending on many recipes. Table 1 compares the main characteristics of virgin fibre pulp with pulp produced from office waste and old magazines.

The main differences between standard deinked furnish used for newsprint or SC papers (from ONP/OMG) are the significantly higher initial stickies load and the type of ink particles. A critical parameter is the type of ink and the printing process. Office papers are uncoated or only lightly coated, and the laser print is virtually fused onto the paper surface ("hard" inks). Additionally, significant amounts of shaded or even coloured papers can be found in office waste, including labels and stickers, which contribute to a high stickies load.

What are the process design data based on these characteristics? An important parameter is how to detach the ink particles from the surface of office papers. Using a pulper only, either a drum pulper or a high-consistency pulper, is not sufficiently effective. The process can only be partly supported by chemicals or increased temperature, and requires strong mechanical forces to be imposed on the pulp at higher consistency and temperature. In a recycled fibre line, this task can be fulfilled in an efficient way by the application of a disperser. This leads to a three-loop system design, independent of the final paper grade for which the deinked pulp will be used.

TABLE 2 MAIN QUALITY PARAMETERS FOR PRINTING/WRITING GRADES

Property	Virgin Fibre Pulp	Mixed Office Waste (MOW)	Old Magazines (OMP OMG)
Brightness	++	+	o
Opacity	o	+	++
Dirt	++		-
Ash	o	+	+
Stickies	++	--	-
Strength	++	+	o

Legend:Impact on property: Very high: +++ / Neutral: o / Very low: ---

TABLE 3 MAIN QUALITY PARAMETERS FOR TISSUE GRADES

Property	Virgin Fibre Pulp	Mixed Office Waste (MOW)	Old Magazines (OMP OMG)
Brightness	++	+	O
Dirt	++	-	o
Ash	o	-	--
Stickies	-	--	-
Strength	++	+	o
Softness	+++	+	o

Legend:Impact on property: Very high: +++ / Neutral: o / Very low: ---

TABLE 1 COMPARISON OF FURNISH PROPERTIES

Property	Unit	Virgin Fibre Pulp	Mixed Office Waste (MOW)	Old Magazines (OMG)
Brightness	[% ISO]	>86	60-64	50-55
Visible dirt	[ppm]	<3	600-800	400-600
Ash	[%]	<0.5	12-18	18-30
Initial stickies content	[mm²/kg]	-	6,000-12,000	4,000-7,000
Freeness	[SRU]	26	33-38	35-42
Breaking Length	[m]	≥ 6,000 / ≥ 4,500	~4,200	~3,800

Requirements For Different Paper Grades

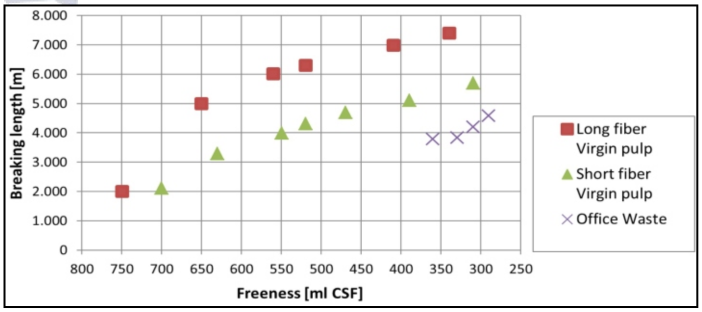
To distinguish the influence of different furnishes on main quality parameters, the following tables show an overview for printing/writing grades (Table 2) and tissue grades (Table 3).

ANDRITZ AG, Stattegger Strasse 18, 8045 Graz, Austria

Virgin fibre pulp offers optimum quality in regard to optical properties as well as for the fibre strength and the cleanness of the pulp whereas secondary fibre pulp has got advantageous features for the opacity which is important for publishing and graphical paper grades. For tissue grades virgin fibre provides still the best quality parameters since this paper needs the relevant softness.

Considering the suitability of different furnishes for the different paper grades, it is obvious that virgin fibre pulp cannot always be completely replaced by deinked pulp. However, virgin fibre pulp also needs to be processed somewhat to utilize its excellent properties, which are mainly achieved by refining, an increase in SRU (Schopper-Riegler units), and freeness drop respectively. The focus is based on development of strength properties and Figure 1 shows the different approach to meet such targets for virgin fibre pulp and for office waste.

FIGURE 1 **Breaking length of different furnishes**



The target (high breaking length) in the low freeness range can easily be obtained with virgin fibre by just applying low-consistency refining. Unrefined office waste has already a freeness level of the target area, but at lower breaking length. To improve the breaking length to the same level as for virgin fibre requires again refining efforts, but would become uneconomic and leads to undesired low freeness, which affect the dewatering capacity on the paper machine.

Contaminants Coming With The Raw Material

Due to impurities coming with the secondary fibre furnish, deinked pulp systems require a series of process stages in order to remove and/or reduce the impurities without harming the fibre material. Table 4highlights which process stages fulfill the technological requirements of improving the final fibre quality with respect to optical characteristics and the treatment of contaminants.

Deinked Pulp System Design

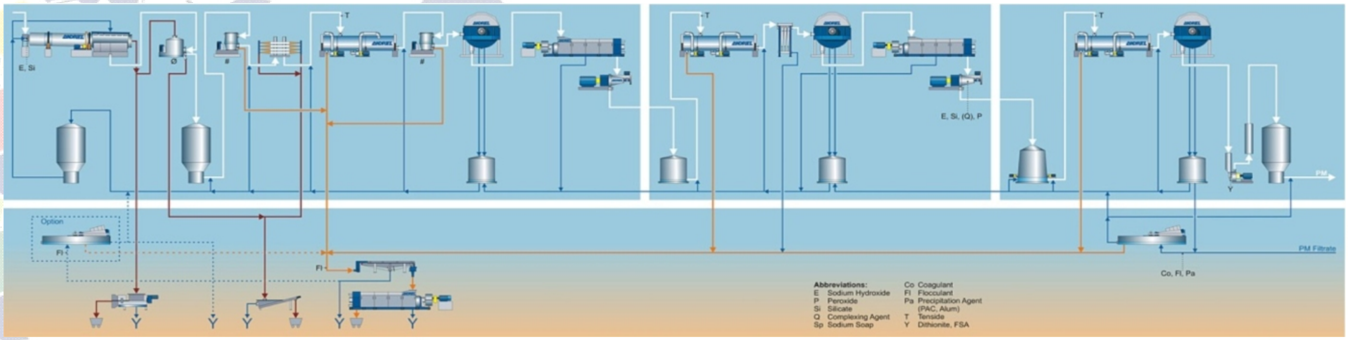
Taking the before-mentioned topics into account, an efficient deinked pulping process can now be designed. Figure 2 represents an advanced three-loop deinked pulp system being capable of providing for high-quality paper grades (e.g. printing/writing grades).

Disintegration without destruction of the secondary fibres is the main task of the pulping stage. Detachment of ink particles takes place during this stage as well. There is no difference with regards to ink detachment whether a drum pulper or a high-consistency (HC) pulper is utilized. Since chemicals have only minor impact to support this process, pulping of sorted office papers is performed in a more or less neutral range. The use of clarified process water in terms of COD (Chemical Oxygen Demand) and PCD (Particle

TABLE 4 PROCESS STAGES MODE OF OPERATION

Process stage	**Optical cleanliness**	**Debris and stickies reduction**	**Ash content**
Pulping	Print ink detachment	Saving screenability, pre-screening	Ash enrichment by process water
High-density cleaning		Heavy particles removal	
Medium-consistency hole screening		Flat disturbing components removal	
Low-consistency cleaning	Removal of dirt ink particles	Fine sand and debris removal	Minor ash reduction
Low-consistency slot screening		Stickies removal	
Dispersion 1	Print ink detachment and fragmentation	Stickies dispersion	
Flotation 1	Brightness increase, dirt speck reduction	Stickiesremoval	Ash reduction
Dispersion 2	Ink detachment and fragmentation, bleaching chemical mixing	Stickies dispersion	
Bleaching (oxidative)	Brightness increase		
Flotation 2	Brightness increase/removal of dispersed dirt specks and residual inks	Stickies removal	Ash reduction
Bleaching (reductive)	Brightness increase/colour stripping		

FIGURE 2 **Advanced deinked pulp processing system (three-loop design)**



Charge Detection) is beneficial for the operation.

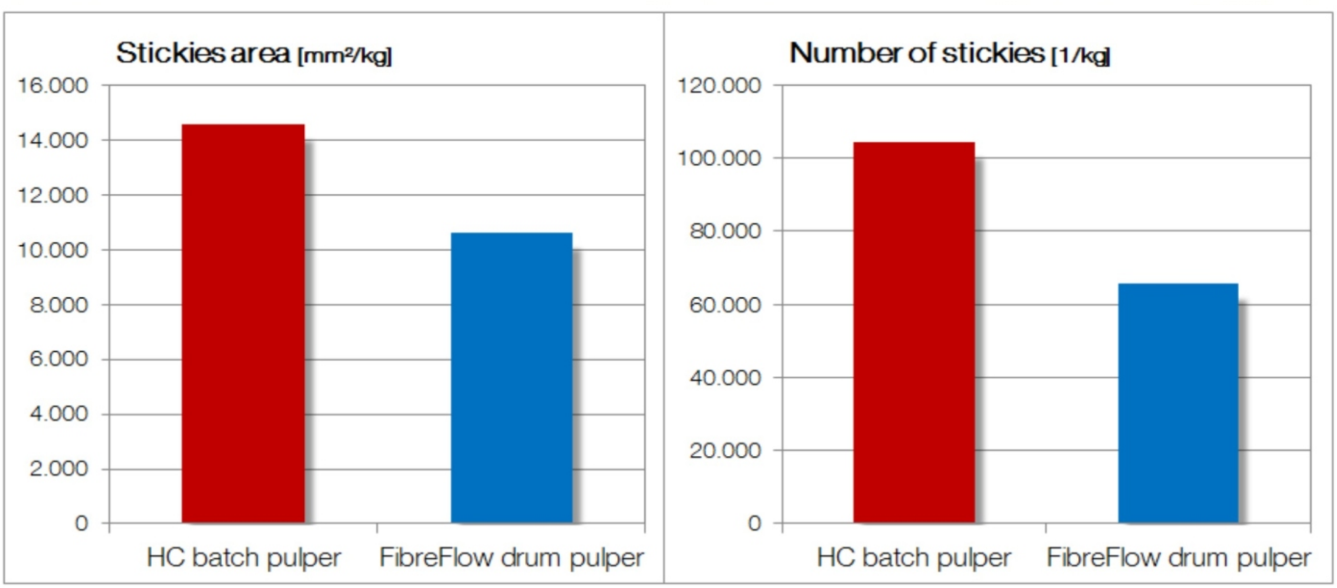
The pulping process contributes significantly to the final quality of the furnish. The selection of the optimum pulping technology is mainly based on the most efficient removal of one of the most disturbing contaminants: stickies. The high level of stickies in most office papers points strongly to the employment of drum pulping technology for achieving the smoothest disintegration process. Drum pulping sorts out contaminants at the beginning of the whole process, making it a core technology. It is the best method to keep the contaminants intact as much as possible so they can be effectively removed. Figure 3 compares the stickies load and fragmentation after a HC and a drum pulper.

After the pulping stage, the next concern is the removal of heavy particles. This process reduces the wear on equipment at subsequent process stages. At the moment, the most efficient way to remove these particles is via a two-stage cleaning system. The primary stage utilizes high-consistency cleaners (3-4% consistency). After dilution of rejects and settling of bigger heavy particles in a tank, the second stage utilizes medium-consistency cleaners (typically 1.2-2% consistency).

The main consideration for the coarse screening stage is to utilize the smallest possible hole diameters in the screen baskets. There is an increasing tendency of fraction with smaller holes, which is especially critical for office waste, which contains a higher portion of bleached long fibres. Currently, 1.4 mm perforations have proven to be a good compromise. An intermediate medium-consistency cleaner protects the tail screen, which combines screening, fibre recovery, and dewatering of rejects in one effective unit.The latest technology, for example the Bar-Tec W rejector screen basket with slot widths in the range of 0.3-0.4 mm, provides a superior alternative to drilled baskets for coarse screening, and achieves optimal impurity reduction in primary screening. This takes the load off of subsequent screening stages and provides higher efficiency throughout the entire screening line. A specially

FIGURE 3

Comparison of stickies area (left chart) and number of stickies (right chart) after pulping for high-consistency pulper (red bar) and FibreFlow drum pulper (blue bar).



(high-resolution picture delivered in addition)

developed profile wire with a diagonal slot geometry generate directed flows which result in higher rejects removal.

Alternatively, heavy and light contaminants can be eliminated simultaneously in a special screen called ModuScreen CR-H, which combines both requirements in one machine. This not only makes it possible to eliminate separate high-consistency cleaners, it also requires less energy and pumping equipment.

As shown inFigure 2, the first loop is focused on screening and cleaning technology. Two full-stream slot screening stages are a requirement for this kind of furnish. A slot width of 0.15 mm is selected for the screen baskets in medium-consistency screening, with 0.12 mm slots for low-consistency screening. This is a very economic gradation of the slot width sequences to keep the medium-consistency screens at a reasonable size without sacrificing screening efficiency or final product quality. The minimum slot width in low-consistency screening again is determined by the amount of long fibres which would be sent to rejects if the slot widths are too narrow. Although it is technically possible to reduce the slot to 0.1 mm, it is not recommend due to the above reasons. Furthermore, screening efficiency is not only determined by slot width, but by the more complex interaction of the relevant screen components like rotor design, rotor speed, casing, baskets, etc.

The low-consistency cleaner plant ahead of the fine screening is mandatory, since the fine slots and the bars need particular protection.

Although ink detachment is not fully completed at this stage for newsprint and magazine waste, it is essential for final product quality to remove free ink from offset and gravure printing (soft inks) as well as dirt particles with flotation equipment already in Loop 1.

With the exception of ink and small dirt particles, the removal of contaminants is completed in Loop 1 and the clean pulp is forward in the system. The thickening stage is based on the requirements of the final product. Conventional pre-thickening is accomplished with a disc filter, followed by a pulp screw press. If low ash content levels in the final deinked pulp are desired, a full-stream washing device can be used instead of a disc filter. Or, both machines can be installed in parallel.

The disperser at the end of Loop 1 should operate at high temperature and be pressurized condition. The dispersion process has two main objectives. In addition to detaching ink particles, it reduces the size of all other impurities to achieve a homogeneous particle size distribution. The disperser does this by creating mechanical shear forces which cause intense friction between the fibres at high-consistency.The importance of adjusting the specific energy input in the disperser cannot be downplayed. There must be sufficient energy to obtain maximum ink detachment, but the action cannot be so aggressive as to smear soft inks back onto the fibres. This smearing is irreversible and leads to mottled fibres. The right balance must be maintained.

Flotation 2 is now challenged with mainly removing the detached laserprint ink particles (hard ink). This means that the flotation equipment must have sufficient flexibility to capture and remove all these different particles.

Office waste also contains fragments of varnished and special coated papers. Due to their specific weight and shape, these particles are difficult to float, but they can be eliminated at least partially by special low-consistency cleaners, which provide high centrifugal separation forces. The position of these cleaners within the system is such that the pulp has to be treated by mechanical forces first. The integration in Loop 2, after the first disperser but before the bleaching process, is the most suitable position.

For high-quality paper grades, a second disperser is needed in Loop 2. The machine has to disperse the most resistant ink particles as well as some very small stickies and dirt particles.To disperse these particles, higher energy input is required when compared to the first disperser. Oxidative bleaching chemicals are also mixed into the pulp at this dispersing stage to enable high-consistency bleaching. A typical retention time of one hour is assigned to efficiently gain brightness in the subsequent high-consistency bleaching tower underneath the disperser.

A thickener and a dewatering machine are basically the last equipment in Loop 2. Based on the ash removal required, the type of machine for pre-thickening is selected either a belt washer, drum filter, or disc filter.

The third flotation stage removes the remaining dirt and ink particles. The third thickening (disc filter up to 12% consistency) is followed by the reductive bleaching stage. This bleaching stage is important not only for bleaching of colored fibres, but also to achieve final brightness required for high-quality paper grades (above 80% ISO).

Due to the high thickening rate compared to the previous Loop (from approximately 1% to30% consistency), Loop 3 is clearly separated from Loop 2. One of the main benefits of this water separation is a less carry-over of anionic trash and COD to the next loop and to the paper machine. This also creates an additional benefit for bleaching. The anionic trash consumes bleaching chemicals without any contribution to brightness increase. Hence, the reduction of these detrimental substances also reduces the amount of bleaching chemicals required to achieve a given brightness level.

Water Management System

To fulfill the particular requirements for the production of high-quality paper grades, water management is the important design factor. The water system has to be designed based on a strict countercurrent flow (Figure 2).

All the make-up water and a portion of Disc Filter #3 filtrate used to balance the deinking plant processes are clarified using micro-flotation technology. A dissolved air flotation unit should be operated in precipitation mode to remove colloidal substances which cause anionic trash.

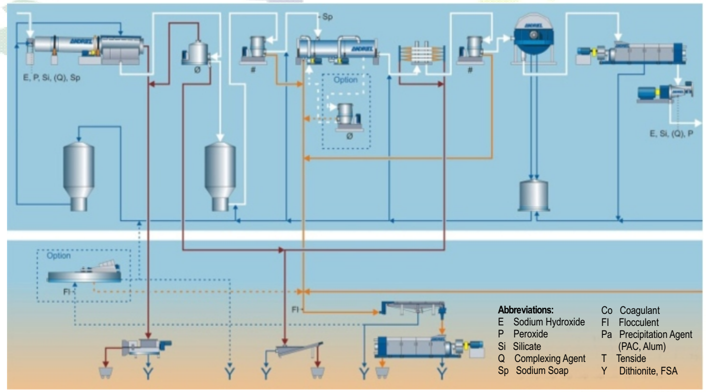
A low level of the anionic trash in the process water results in either a higher brightness of the final paper at a given consumption of bleaching chemicals or the reduction of bleaching chemicals for the same brightness level.

An appropriate water management system reduces overall fresh water consumption. Filtrate from sludge dewatering, which usually is sent to effluent, can be clarified in an additional micro-flotation unit and partly reused as dilution water for pulping in Loop 1. This reduces the effluent volume and make-up fresh water required.

Deinked Pulp With Low Final Ash

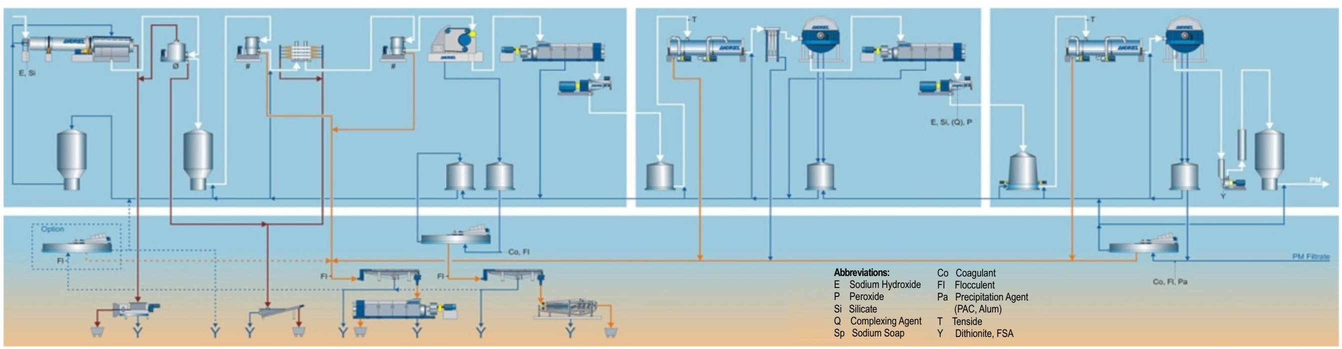
When the final ash content needs to be less than 1.5%, special de-ashing devices should be incorporated into the system design. A possible solution, already discussed, is full-stream washing in Loop 1 (Figure 4).

FIGURE 5 **Partial de-ashing in Loop 1**



washing unit is not required as long as the initial ash content does not increase above 15-16%. Partial de-ashing with a washer and a disc filter operating in parallel could be an alternative solution. This, however, is very expensive. For such a case, flows with high ash load are targeted (e.g. the overflow of primary flotation cells or the filtrate of screw presses).

FIGURE 4 **Deinked pulp concept for low final ash**



This arrangement provides an additional advantage in that fines and small ink particles are removed before the first disperser. This avoids the potential for these ink particles to re-attach themselves to the fibres. The size of subsequent equipment can also be reduced.

However, to match the above-mentioned goal of low ash in the final pulp, further adjustments have to be made. Another full-stream

To selectively separate residual ash, fines, and small ink particles from good fibres requires a special screen, the RotoWash, equipped with a very fine perforated screen basket, can be utilized to reduce the ash content of the final deinked pulp to a desired level (Figure 5). Only ash and fines can pass thru the screen basket, and good fibres are completely recovered.Deinked pulp treated with such a concept will fulfil the requirements of certain applications (e.g. tissue).

FIGURE 6 **Flowsheet for deinked pulp plant for high-end printing/writing grades installed in Southern India**

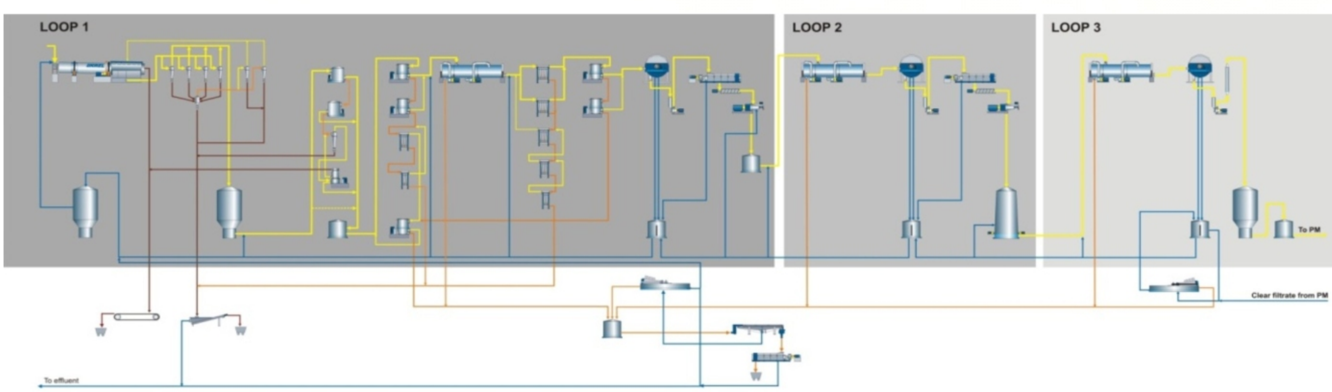


FIGURE 7 **The three-loop deinked pulp system in India**

State-Of-The-Art Deinked Pulp Facility in India

In July 2013, a state-of-the-art deinking system for the production of high-end printing/writing grades went successfully into operation in the Southern part of India. Applying the latest deinking technology, the system operates using 80% sorted office papers (SOP according to SCRAP #37) and 20% old magazines (OMG according to SCRAP #10). The flowsheet for the system is shown in Figure 6.

This is a first-of-its-kind in India. It consists of three loops, including drum pulping, three flotation and two dispersing process stages, and a sludge dewatering system. The plant's design capacity is 300 t/d.

Due to the excellent operation and high final recycled pulp quality of the deinking plant virgin fibres are replaced as much as possible for the production of high-end paper grades. This contributes to the strong economics of the mill (less virgin fibre utilization, lower energy consumption, etc.) and also makes a positive environmental impact.

The raw material enters the three-loop deinking line with an initial brightness of 60-65% ISO. The deinking and bleaching processes increase the final brightness up to 87% ISO charging lowest essential chemicals. The Effective Residual Ink Concentration (ERIC) of the final pulp is as low as 50 ppm and the mill is very satisfied with the cleanliness of the pulp transferred to the paper machine.

Apart from the high final brightness and cleanliness of the pulp, another highlight is the excellent yield of the system -- 75%+. This is outstanding for a three-loop line.

Conclusions

The state-of-the-art in deinking technology is such that higher grade raw materials such as sorted office papers can be effectively substituted for virgin fibre in the production of high-quality papers. Depending on the final paper quality requirements, a suitable system configuration can be designed with the flexibility to handle variances in incoming furnish quality. In fact, market pulp quality can be achieved, but lower yields have to be considered.Based on the high brightness levels of many office papers, this raw material source can be employed for a broad range of paper grades in addition to printing/writing grades (e.g. art coated paper, white top board, copy papers, and tissue products). Rejects from the system furnish, when carefully separated into metals, combustibles, and other categories, can be used and to reduce landfill costs and save energy resources. A recent, well-functioning mill reference in India showcases the ability of a three-loop deinking plant to produce high-quality paper grades while improving mill economics, contributing to sustainability requirements, and lowering the environmental impact.