In the wash

De-inking used paper is a major step towards making recycled paper, but can established de-inking processes keep up with advances in printing technology?

There is a generally accepted principle that it is better to recycle as much paper as we can, rather than cutting down trees to make paper from virgin fibres. Recycled paper can be put to many uses, including tissue paper and cardboard. But contaminants within the mass of paper to be recycled, including the inks that have been used on it, can cause the resultant recycled paper to be discoloured or grey. Such paper is not really suitable for graphic arts use, where there is a preference for a white appearance. One obvious solution is to bleach the paper white, but there is a trend against bleaching, which is not seen as the most environmentally friendly option.

A better solution is to de-ink the paper first, removing as many of the contaminants as possible to get a paper pulp clear enough to produce white paper suitable for graphic arts use. There are two established methods for de-inking paper, known as washing and flotation. De-inking by washing involves mixing the paper in a pulper to produce a slurry. From this, waste objects such as staples are filtered out, and then the water, together with most of the ink, is drained away, leaving the paper fibres which may be rinsed again. This method can be very effective at recovering paper fibre, but uses lots of water, which then needs to be treated, somewhat undermining the environmental benefits of recycling the paper.

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Flotation Devices

For this reason, most recycling plants in Europe use the flotation method, which, Andy Gordon, operations manager for Aylesford Newsprint's fibre preparation plant in the UK, says is optimised for offset inks, which nowadays use mineral oils. Gordon says: "In the deinking process we add a simple sodium soap prior to injecting the 'pulp' into a flotation deinking cell. The conditions must be alkaline and the presence of plenty of calcium ions is essential. It is also important for the pulp to be in the range of 45°C to 55°C. The consistency of the pulp at this stage is very important, it must be between one and two percent. The hydrocarbon chain of the soap molecule is hydrophobic and is attracted to the mineral oil which is a hydrocarbon and therefore also hydrophobic. The calcium ions attract the other charged part of the soap molecule and cause the ink/soap particles to agglomerate and get larger. When the pulp is injected into the flotation cell the injectors are designed to pull in air and mix it with the pulp. The resulting air bubbles pick up the calcium/soap/ink agglomerated particles and float them to the surface. The inky scum that results is overflowed into a trough and the 'deinked' pulp is fed on to further processes."

The de-inking cells and giro cleaners at the Aylesford Newsprinters in the UK, which produces recycled newspaper stock.

A single loop ought to be enough in theory, but in practice just about all mills use a two-loop process because the paper sent for recycling is often contaminated with other materials, such as staples, sticky labels and plastics. Each loop involves several separate stages, as Nils Miller, HP's senior scientist for inkjet R&D and environmental strategies, explains: "A two-loop process means that after the initial pulping and screening and cleaning stage, that you have a flotation stage, and after that first flotation stage which is a multistep process, you then go through a very high sheer device that chops up whatever contaminants you have in there and ideally chops them up in a small enough size that they can then be effectively

removed during the second loop of flotation de-inking. This could be chunks of toner, dirt specs, it depends on what's coming in on the recovered paper side of the mill. But that two loop process is designed to treat the real world paper streams of today."

The deinking process itself produces a waste sludge consisting mainly of paper fibres, ink and some fillers such as aluminium oxide. Most paper mills burn this residue as part of their own power generation. It's also used in cement production where its aluminium content compensates for poorer quality clay, and in making bricks, where the fibres are burned when the bricks are fired in a kiln, leaving micropores which can increase the insulation and stability of the bricks.

Different standards

When it comes to standards for de-inking, most companies refer to those set by Ingede, a German trade body (Internationale Forschungsgemeinschaft Deinking-technik, the International Association of De-inking Technology) set up in 1989. Ingede includes most European paper manufacturers and brings together paper manufacturers, ink developers and digital printer vendors. Together they ensure cooperation in the production of printed matter that can be de-inked for future recycling.

The air bubbles used in the flotation process can clearly be seen here in this image from Aylesford Newsprint.

Four companies developing inkjet presses - HP, Océ, Kodak and InfoPrint Solutions - have joined together as the Digital Print De-inking Alliance (DPDA) to support research into recycling inkjet-printed paper. In public, Ingede has welcomed this move, though in private it fears that the DPDA's main aim is to call Ingede's methods into question.

Although the need to recycle paper is becoming accepted around the world, not everyone has the same environmental standards. As a general rule, de-inking standards appear to be higher in Europe where a lot more printing and writing grades are produced from recovered paper. Axel Fischer, press officer for Ingede, says: "We have about the same volume of paper being collected in Europe and the US – both have about 50m tonnes per year – but in Europe more than 50 per cent goes into printing and writing grades and in the US it's around 20 per cent or so."

He continues: "In the US they produce more packaging and they export more paper to Asia. In Europe all our newsprint is produced from recovered paper and that's not the case in the US, and so we have a far more advanced system than in the US, where there are only a few mills that produce at the same high level."

Fischer says that there are lots of joint ventures and cooperations in Asia: "In China, for instance, the mills that have been set up there within the last five years are all working with European standards because the engineering companies are the same as in Europe, through joint ventures with people like Stora Enso or UPM. And the same is true of Australia."

What can be de-inked?

Ingede carries out its own tests on different printing processes and issues certificates to vendors. It also co-ordinates research on printing and de-inking technologies and encourages the development of systems for collecting material to be recycled, as well as better awareness amongst consumers of the need to separate papers for recycling from other material.

The bulk of the papers that are being recycled to make graphic arts papers are those that were originally printed via offset litho and Fischer says that the flotation deinking process can cope well with this: "When you de-ink offset the ink breaks into particles which consist of binders and pigment and these particles are very small, but they are

still hydrophobic. The oil-based ink goes into the foam and the fibres which are water-loving stay in the water, so you separate the oil-based from the water-based part." However, according to Fischer UV and UV offset inks aren't so easy to de-ink cleanly.

Axel Fischer, press officer for Ingede.

Fischer also says that dry toners are deinkable in a single loop: "We have no issues with dry toner. Dry toners happen to break apart in the right size and they happen to be hydrophobic so they are even better than standard offset in the de-inking process. Some experimental systems showed deviation but everything which is currently on the market, especially the high speed machines, from Xerox, Nexpress, Océ and so on are all perfectly deinkable."

Problems with Indigo and Inkjet

However, Ingede is embroiled in a long running argument with HP over the Indigo Electro-inks, which Ingede claims are harder to de-ink than they should be. Fischer explains: "We tested the Electro-ink version 4.0 and, compared with dry toner machines from Xerox and Océ, there was a factor of at least 35 in terms of dirt specs from the HP Indigo."

According to HP, the Ingede method 11 test is a highly simulated piece of data from lab tests not taken directly from the real world. Miller explains: "The two-loop process is designed to treat the real world paper streams of today. But the Ingede method 11 makes no attempt to simulate two-loop processing. Instead it treats things as if there were no intermediate chopping up or dispurging stage and so they focus on simulating a one loop deinking flotation."

But Fischer says that this second loop, the grinder or dispurger, is the highest consumer of energy in the entire system and is the highest cause for the loss of fibre in the whole recycling process. "No matter which way you look at it, everything which challenges this kind of equipment increases the carbon footprint and the energy needed to recover the paper for recycling so it's definitely something that we would not want in the system and we would not call it a good deinkable or recyclable for higher grade papers," he says.

HP's giant Inkjet Web Press uses a bonding agent to help the ink stick to the paper, but this also helps to make it easier to deink for recycling.

The argument hinges around the amount of paper sent for recycling that has originated from an Indigo press, and here HP has a reasonable argument, that its Indigo printers represent a fairly small section of the market, and the existing two-loop flotation system can cope with this. However, there is potentially a much bigger problem with the high speed inkjet printers which were demonstrated at the last Drupa show, and which are expected to be commercially available in time for the

next IPEX show. These could potentially challenge offset presses and take a much larger slice of the market than digital printers currently do, as Tim Taylor, marketing manager for Screen Europe, explains: "I don't think that anyone would doubt in years to come that there would be B1 inkjet presses eventually and they will then compete directly with offset, if not actually replace offset over a period of time."

Fischer likens de-inking water-based inks to having a red sock in the washing machine: "If you put something in the system and it's water-based it dissolves. We have closed water loops in all of the mills so the main difference between a washing machine and a paper mill is that in a washing machine you change the water but still you get pink underwear when you have a red sock in it. In the paper recycling mill the water-based inks accumulate in the system and the only exit is the fibres, which reduces the brightness of your final product. Offset inks are hydrophobic so it's not a problem."

But it will be some years before these inkjet printers start to take a serious chunk of the market, and for now these vendors argue that water-based inks have an insignificant impact on the recycling process. However, Fischer says that the biggest problem comes from direct mail because there is a very short interval between the mailshot being sent out and ending up in the recycling plant. "It comes like a wave to the paper mill and you cannot say that in average it is a low percentage because in that one week you have a higher load." He adds: "The German automobile association is an example, because they have over 20 million members and they regularly produce direct mail advertising, say, their insurance, but imagine having 20 million four-page, four-colour leaflets printed in inkjet or on an Indigo – you would really see that in the mills."

And this is an issue that we should deal with sooner rather than later, as Michael Has, director of marketing and software strategy at Océ, says: "The paper recycling companies are very sensitive to this issue because about 20 years ago when flexo started to become very successful they missed the chance to deal with it and as a result flexo print is not recyclable which causes a degradation to the quality of the paper. They do care that this doesn't happen again to them and it makes sense if parties that are involved in the same value chain should be aware of problems that the others have."

Nils Miller, senior scientist, inkjet R&D and environmental strategy, for HP.

Potential solutions

However, it is not necessarily the case that all water-based inks will definitely cause a problem with de-inking. Ingede has already said that print from HP's Inkjet Web Press can be de-inked according to its criteria, due to the bonding agent applied to the media immediately prior to jetting the ink. Miller explains: "On the Inkjet Web Press, the things that we do to enhance printability are in fact the same things that enhance de-inkability. For flotation de-inking to be successful requires that the colourants be in a form that is hydrophobic, so chunks of wax, or things that don't dissolve in water, and they need to be in the size range that they are not too big or

too small to be effectively removed by the bubbles in a flotation process. And the bonding agent that we add to our Inkjet Web Press, or the ColorLok additive in our ColorLok media, these additives are designed to help aggregate our pigments at the surface of the paper. This is because by aggregating them we are quickly converting them to a state that is hydrophobic so they are no longer water dissoluble at that point."

Clearly, given HP's approach with the Inkjet Web Press, it is possible to develop aqueous inks suitable for de-inking with the current flotation method. No one doubts that it is possible to come up with other solutions, but development is expensive, so who pays for it? Should it be companies such as HP or Océ, already investing a fair chunk of R&D on printheads and ink systems for these printers? Or should it be the recycling mills or paper companies who will ultimately sell the recycled paper? Or should we simply not worry about how grey the paper is and start bleaching it? These are questions to bear in mind at IPEX where the inkjet printer vendors will be extolling the environmental benefits of water-based inks.

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