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INFLUENCE OF THE COMPOSITION OF THE CYAN OFFSET INK ON DEINKING FIBRES

ABSTRACT

The investigation results of deinkability of prints from sheet fed and web offset printing are presented in the article The model cyan inks of various composition in regard to the renewable raw materials are used. As printing surface the fine art papers and offset papers were yused. The measuring results of some optical values, the particle distribution and their size in the sample after deinking, show that the kind of oil used in ink preparation does not noticeably influence its removal in the deinking flotation. In the mean time, when in the flotation sample an additional parts of laser toner prints are added, the efficiency of the flotation process is somewhat lower.

INTRODUCTION

The recycled fibres have more and more become important source for the production of graphic papers. Some reasons supporting that fact are: resource economies, primarily of water, energy, forest preserving, as well as more favourable economical effect and the increase of environment quality.

At the other hand, the difficulties in preparation of the secondary raw material are detaching and removal of the ink from cellulose fibres. The successfulness of such process depends among other things on the technique and printing conditions, kind of ink and printing substrate (Dorris N., Sayegh N., 1997).

In such a way, the toner printed paper from the non-impact printing represents a valuable source of secondary fibres for the production of fine papers and other special grades. But there are possible problems with its usage in conventional flotation or flotation/washing deinking plants (Walmsley M.R., at all, 1997, Bolanča Z., Agić D. 1997). Unlike conventional printing inks, toner contains synthetic binders based on polyester or copolymers of styrene with acrylates, methacrylates or butadiene (Baur R., Machold H.T. 1995). In the printing process the toner is electrostatically transferred to the paper and heat fused into the substrate. In the paper repulping process, the toner breaks up in flat plate shaped particles, which are more or less detached from the fibres and differ significantly from particles of conventional inks. The ability to remove these toner particles from the fibres has been shown to be affected by their size and shape, as well as by the retention of fibres to the particles. These characteristics significantly effect to deinking efficiency (Dorris M., Sayegh N., 1997). Many of these plate shaped particles are too large to be successfully removed by flotation.

The problems in conventional flotation deinking are possible with the flexographic prints too. Flexo inks are water based. They are hydrophilic and cannot be agglomerated by chemicals in the conventional deinking. Although the particle size range is small 0,2 – 1,0 μm after repulping, so are too small for flotation (Larson E., 1997, Upton B.H. and all, 1997).

Ultraviolet inks and varnishes in printing process form hard polymers, which are difficult to break up in the pulper. This process produce thin plate-like particles, which are in the size range 50 – 250 μm, and may be too big to flotate. Their cross-linked surfaces make them resistant to attachment by collector chemicals.

The same problem is with conventional varnishes based on phenolic formaldehyde resins, modified alkyds, nitrocellulose and polyurethane (Hondsdorfer O., 1994). They cure, to form cross-linked networks, which the alkaline environment of the pulper is not stringent enough to break.

The graphic finishing process and materials can be influence on deinkability and the application of the secoundary fibres. Secondary fibre introduces a number of contaminants, categorized as "stickies", into papermaking system (Capozzi A.M., Rende D.S., 1997). These non-cellulose contaminants include: fillers (clay, titanium dioxide, calcium carbonate, talcum); natural rosin, wax and sizes, starches and gums; dyes and pigments, inks and toners; hot-melts, plastic coatings and asphalt, styrofoam and treated tapes. Of all the stickies types present in waste paper, adhesives present the greatest problem, because their formulations are both complex and various depending on their purpose (Hayes P.J., Kauffman T.F., 1993). Pressure sensitive adhesives include: solvent based adhesives (declining in use), emulsion based adhesives (tackified acrylate adhesives used in labelling applications), natural rubbers (used in self-sealing envelope) and PVAs (used in perfect bindings). Hot melt adhesives are used extensively in bookbinding and carton glues.

The investigation results of the influence of model cyan inks and printing substrate on the efficiency of the deinking flotation are presented in this article.

EXPERIMENTAL

The prints were made on Heidelberg sheet fed offset printing machines. The same test form was used on the printing form in printing all the papers. The surface coverage was about 45%.

The conventional ink and model inks with the composition and properties presented in table 1 were used for printing.

Table 1. Formulation and some properties of used inks

Sample	Formulation %	Tackiness	Viscosity (P)	Brightness %
1	Pigment 16,0 Resin 51,5 Mineral 27,5 Veget. oil 5,0	8,0	185	51,7
2	Pigment 16,0 Resin 45,0 Veget. oil39,0	8,5	188	45,0
3	Pigment 16,0 Resin 45,5 Mineral 5,5 Veget. oil 32,0	7,5	260	51,4
4	Pigment 16,0 Resin 47,0 Mineral 12,0 Veget. oil 25,0	8,5	320	51,3

Fine art papers and offset papers (80 g/m^2) with following properties which were used for printing, are presented in table 2.

Table 2. Some mechanical properties of paper

		Offset paper	Art paper
thichness	(mm)	0,098	0,081
smoothness	(s)	29,5 – 39,4	> 1000
apsortivity Colb	(g/m^2)	28 – 36	38,40
tensile	(m)	5,380 / 2,037	4,938/ 2,32
strech	(%)	1,95 / 4,0	2,4 / 4,25
tear	(mN)	500 / 580	480 / 700

The prints were made on web offset printing machines too. The conventional ink and model ink which contain 22% soybean oil were used. For recycling the prints were used sodium hydroxide water – glass, flotation collector, surfactant and deionized water were used. The mixture was disintegraded at 50 °C for 40 minutes with 120 000 cycles in Lorentzen and Wettre disintegrator. The slurry was diluted and handsheets were made. The rest of the slurry was treated in the standard flotation cell for 8 minutes. Handsheets were made from remaining slurry and from froth. The handsheets were prepared using the TAPPI T 205 test method. The optical properties of handsheets were determined by ISO 2470 and TAPPI T 52 testing methods. The size distribution of the toner particles was examined microscopically.

RESULTS AND DISCUSSION

For different printing techniques, inks are attached to the fibre in different ways and undergo different changes in their physical and chemical properties. In sheet fed offset printing, oil based ink is absorbed by pores of the substrate at room temperature leaving the pigment, resin and some solvent behind on the paper surface. The ink structure is obtained mainly by penetration of liquid phase into the paper, reducing the ink to a gel like state. In general, the changes in ink characteristics may have a direct influence on the efficiency of flotation deinking.

The following results show the influence of the composition change of cold offset oil based ink by substitution with different quantities of vegetable oil, on the efficiency of deinking flotation. As one of the efficiency indicators of deinking flotation is the presented brightness in figure 1.

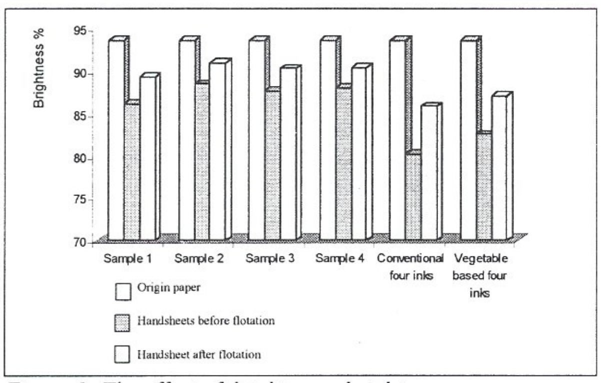

Figure 1: The effect of deinking on brightness

The results for origin paperand hadnsheets made from fiber before and after deinking are given. The prints were made from conventional and model cyan cold offset ink and four conventional and model cold offset inks. It should be mentioned that the ratio of vegetable oil almost non effect on the efficiency of deinking.

Because the focus of this study is the removal of colour (ink pigments) from paper and usage the recycled fibres for production the graphic paper, is interesting paper colour defined as white or very near white. White or near white papers are those that have $L^* > 84$, and $(a^{*2} + b^{*2})^{½} < 10$ according to TAPPI Official Test Method T 522.

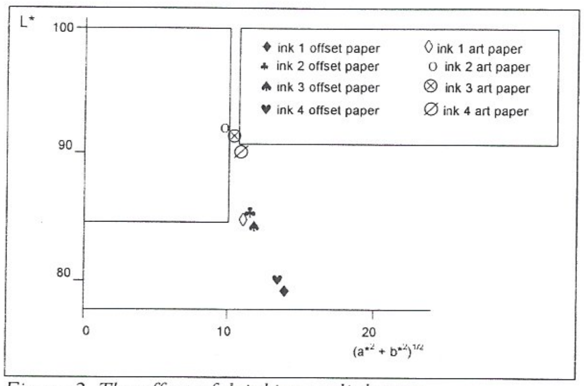

Figure 2. The effect of deinking on lightness

The investigated samples do not satisfy the mentioned values, however some of them are very close. The influence of printing substrate can be in a way noticed. That which could be concluded, that the increase of vegetable oil ratio in the tested offset inks does not influence the deinking flotation unfavourably.

This conclusion is sugested from analyse of figure 3, which shows handsheets before and after flotation prints with conventional and vegetable based cyan offset inks.

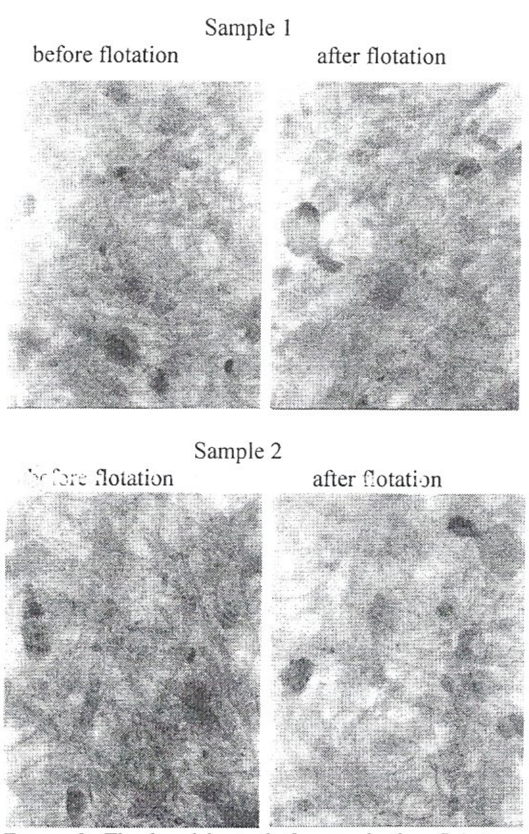

Figure 3. The handsheets before and after flotation prints with conventional and vegetable based cyan offset inks

Oil based offset heat set ink is physically dried by evaporating the volatile solvent, and leaving resins and other material to bind the pigments to the paper. Evaporation of volatile organic compounds, and savings of resources are the main ecological reasons which benefit the change of the heat set offset ink composition. However the question of deinkability of heatset inks based on vegetabile oils remain. The oils are capable of a certain amount of oxidative crosslinking which might actually impede ink removal.

Figure 4 presents the numerical value of deinkability - DEM (lab) of prints from the conventional ink and vegetable based ink, immediately after the printing and prints aging.

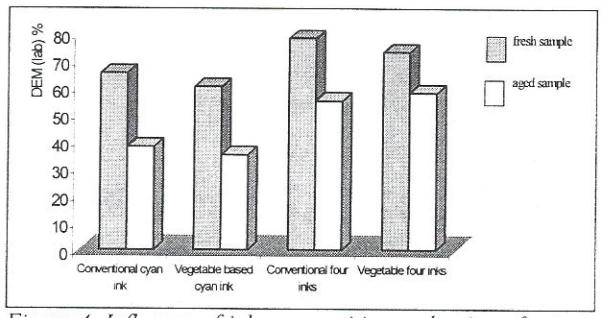

Figure 4. Influence of inks composition and aging of prints on DEM

Results shows that the kind of oil used in the ink preparation does not noticeably influence its removal in the deinking flotation.

Probably the resin, which binds pigment with printing substrate influences the deinkability to a larger extent. The reactions in which oils can participate, plastization or cross linking do not decrease the ink removal in the deinking flotation.

The distribution of particles after flotation for the prints with the conventional heatset ink and the vegetable based ink is presented in figure 6. Number of ink particles per unit surface after deinking flotation, in the case of vegetable based inks, is somewhat greater at smaller particle size classes.

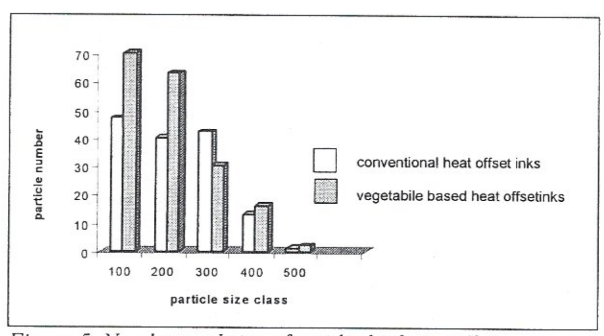

Figure 5. Number and size of residual ink particles

In general, since the eye can see ink particles 40 μm and larger in size, all the particles in this size range will be visible in a handsheet after flotation. Particles below 40 μm cannot be individually resolved, but they absorb light and contribute to grayness to paper (handsheet). The particles below 10 μm will reduce the visual quality of the finished paper.

As the non-printing techniques are more and more present, it is interesting to observe the influence of the mixed samples (20% laser printing samples) on the mechanism and efficiency of deinking flotation.

Figure 6 presents the flotation deinking efficiency by particle size class for sample, which contents offset sheet fed prints and sample which contents offset sheet fed prints and 20% laser prints.

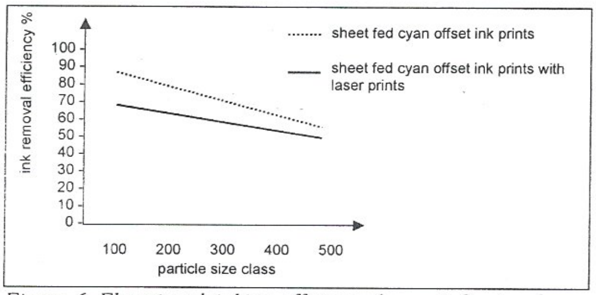

Figure 6. Flotation deinking efficiency by particle size class

Smaller ink removal efficiency is noticed by mixed samples with laser prints. The toners during the laser printing process are polymerized in the formation of larger particles, which make fibers chemically bonded to and physically trapped in the toner particles. The oxidation creates a polarity at toner surface and makes flotation more difficult. During repulping, some toner particles are detached from fibre, there are still some fibres bonded to them. Both effects make the toner particles more hydrophilic and in such reduce efficiency in the flotation deinking.

CONCLUSION

The oil based offset cold and offset heat inks are hydrophobic and should be possible to detach and separate them from hydrophilic cellulose fibres by flotation. Environmentally motivated trend is a substitution of the mineral oil in offset inks with the vegetable one. It is particularly interesting with heat set inks, because except the resource saving by using greater ratio of renewable resources, the quality of air is increased by decreasing the emission of volatile organic compounds. The mentioned pollutants are risky on the working place concerning health and safety. Except that in the outer atmosphere, under certain meteorological conditions in the presence of some other pollutants such as nitrogen oxides can lead to photochemical reactions. The products of these reactions are for environment detrimental compounds from the photooxidans group.

From the ecological aspect, the question concerning the influence of greater ratio of vegetable oil on deinking flotation efficiency remains, as the possible process of waste disposal, i.e. usability of prints.

The investigation results of the efficiency of deinking flotation of prints with vegetable based offset cold inks show point at similar brightness of handsheet, made from fibres after flotation in comparison with the conventional ink. The obtained values do not satisfy the term white or near white papers. In the case of deinking of prints with vegetable based offset heat inks, somewhat smaller numerical values of deinkability DEM (lab) were obtained and somewhat greater ration of residual particles on handsheet was noticed in relation to the conventional inks. Generally, the difficulties in deinking of prints with vegetable based inks in the conditions of experiments were not noticed.

The case when a certain ratio of laser prints is added to offset inks is completely different. The difference in size and 0outlook of particles is noticed and the ink removal efficiency appears in relation to offset prints. Problems in deinking flotation of prints containing laser prints are caused primarily by polymerization and oxidation in the printing process. The polymerization causes a strong chemical and physical bonding with cellulose fibres and oxidation creates greater polarity at the toner particle surface.

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