The Colorimetric Properties of the Deinked Pulp from Digital Prints

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Abstract

Optical properties of handsheet during deinking flotation of prints from digital and conventional offset printing have been observed in this paper. The prints for processing were made on web digital offset printing machine with six colors and on two models of sheet fed digital offset machines with four colors on different printing substrates. The investigation results show that the model of the printing machine in the same technology can have effects on the size of particles and on the optical properties of handsheet. The quality of deinking pulp and the efficacy of the ink removal in relation to the optical parameters such as brightness, reflectance in the determined area of wave lengths and color have been discussed in this work.

Introduction

Recycled fibers are a most important raw material in paper production. The treatment of recovered paper stars with the separation of non-paper components, and is followed by the separation of the printing ink from prints.

Deinking is a process for detaching inks from fibres using chemical and mechanical conditions, and is followed flotation process for removal the printing inks particles.[1] Flotation is the most common method used. The efficiency of mentioned process depends on many factors like: type of printing technique, kind of the printing ink, properties of the substrate, climatic conditions during the life cycle of prints and ageing process of prints.[2,3]

Printing inks which drying by polymerization (oxidative drying and radiation curing), are difficult to remove from the fibre. Examples are ultraviolet inks and varnishes which break up in disintegrator in particles too big to float. In addition, their cross-linked surface makes them resistant to attachment by collector chemicals.[4] Particle sizes of water based flexo inks after disintegration are too small for flotation. In addition it is hydrophilic and cannot agglomerate with collector chemicals.[5]

Toners from some digital prints detach in flat plate-like structures and are too large to be removed by flotation.[6,7] Removal of plastics, coating binders, contact adhesive and hot melts is important, because these materials can cause problems in the paper production and later in printing process.

Letterpress printing inks is easy to remove from prints. To process these prints effectively into bright pulps a combination of different method is necessary such as flotation after ink particle fragmentation and detachment by dispersing or kneading.[8] Rotogravure prints make with toluene based ink is easier to deink than offset printed paper. Deinking of coated paper is more successful than uncoated substrate.

Generally, paper and board are used for printing, finishing and for packaging applications.

Recently, the increase in recovery rates of waste paper will require a consumption increase of recycled fibres in higher quality grades such as magazine and office paper for non impact printing.

The important characteristics of secondary raw material are those which influence the printability and the runability of paper and quality and durability of the end product. Paper properties may be classified into those affecting surface, optical and strength characteristics.

The surface characteristics of paper depend on factors which include nature of the fibres and their treatment during production. Some important strength properties include tensile strength, burst strength and tear resistance. Recycled fibres have lower strength properties than virgin paper.[9] The reduction in swelling and the loss of fibres flexibility after drying diminish the strength potential of recycled fibres. Contaminants to occur in recycled pulps (stickies) and age degradation also contribute to the reduced strength of recovered fibres.

Some optical properties of handsheet obtained after the chemical deinking flotation of digital offset prints are presented in this paper.

Experimental

Multicolored prints made in conventional and digital offset printing technique were used for recycling. In the first case the printing was performed on the sheet fed Heidelberg printing machine. For the production of prints in offset digital technique, different models of Indigo E-Print machines were used, such as: rotary digital offset machine Galos DO 330 with six ElectroInks, sheet fed digital offset machine 1000 + and TurboStream with four ElectroInks in both cases.

Prints used in recycling are made on different printing substrates of the same grammage. The used printing substrate were offset paper (sample a) and both side coated paper for digital printing (samples b).

In the recycling process alkali chemical deinking was used. The conditions in the recycling process of prints are presented in table 1.

Table 1. Condition of pulping and flotation.

Parameter	Pulping	Flotation
NaOH %	1,0	-
H_2O_2 %	1,0	-
Water glass %	2,0	-
DTPA %	0,2	-
Surfactant %	0,4	-
Consistency %	10,0	0,6
Time min	45	8
Temperature ^{0}C	40	30

The handsheets were made using a laboratory sheet former, according to standard method T 205. The optical properties of handsheet were determined by using the ISO standard methods. For determining the number and size of the remainder ElectroInk and conventional offset ink particles the image analysis was used, according to TAPPI standard method.

Results and Discussion

The first impression of a paper is its color, whiteness and gloss. The parameter frequently used for study of mechanism of deinking flotation of different kind of prints in particular conditions and to evaluate the optical quality of deinked pulp is the spectral reflectance factor R_{457} used as ISO brightness.

Figure 1 presents the brightness of the handsheets before and after flotation of prints made by different kind of digital offset printing machine in relation to the handsheets made by conventional offset sheet fed machine.

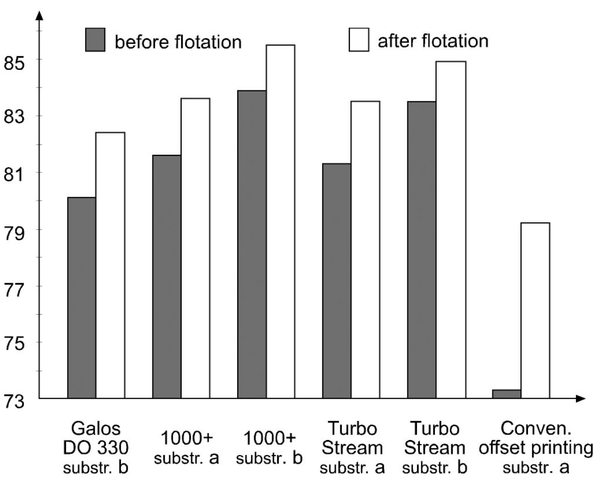
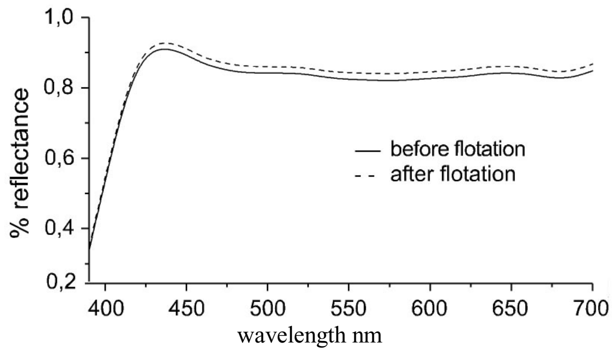


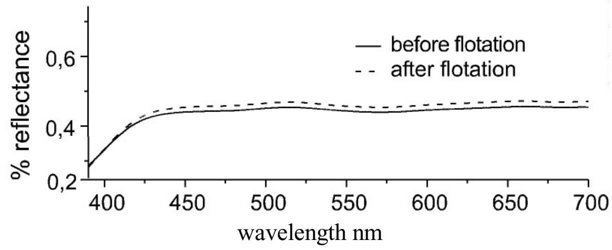
Figure 1. Brightness of handsheets before and after flotation

The measuring results show that the brightness of handsheet is influenced by the printing technique, kind of the digital offset printing machine as well as the kind of substrate. The smallest value of brightness is measured for handsheet obtained by the recycling of prints from conventional offset machine. However, in this case the greatest brightness growth is obtained, when handsheets before and after flotation are compared. The smallest differences in brightness can be noticed with handsheets made by the recycling of prints from the web digital printing machine in relation to the sheet fed digital offset printing machine. Except that somewhat greater values of brightness are obtained in those cases when specially coated paper designed for digital printing was used for printing. It is interesting in these cases that the differences between the upper and lower side of handsheet are smaller than the usual ones, usually the upper side is about two points brighter for the flotation method.

Figures 2a and 2b present the reflectance curves of handsheet before and after flotation obtained by the processing operation of prints from digital offset with the machine 1000+ on the substrate b (figure 2a) as well as the prints from conventional offset on the substrate a (figure 2b).



(a) digital offset printing - substrate b



(b) conventional offset printing - substrate a

Figure 2. Spectral reflectance curves for various handsheet

Handsheets made after disintegration of prints from digital offset printing with the machine 1000+ on the substrate b show the reflectance growth. Reflectance increase is present in the areas of smaller wave lengths, which is a characteristic of the original substrate used in printing. It could be thought that it is the consequence of the addition of optical whitening during the manufacturing of original paper. Handsheet after flotation has the increased reflectance along the whole measuring area of wavelengths. The growth of handsheet reflectance after flotation shows its slightly improved characteristics by this process. Handsheet made after disintegration and flotation of prints from the conventional offset printing on the substrate has somewhat different trend of the reflectance curve in relation to the sample described before. The reflectance values are about 45% with a slight growth from smaller to greater wavelengths. In this case one can notice a strong influence of the original substrate used in printing.

Generally speaking for other investigated sample series, the influence of the original printing surface and less of other varying parameters is recognizable.

Possibility to evaluate colored samples from the recycled paper processing operation is to determine their color. Figure 3 presents a*/b* plot for handsheet after disintegration and after flotation.

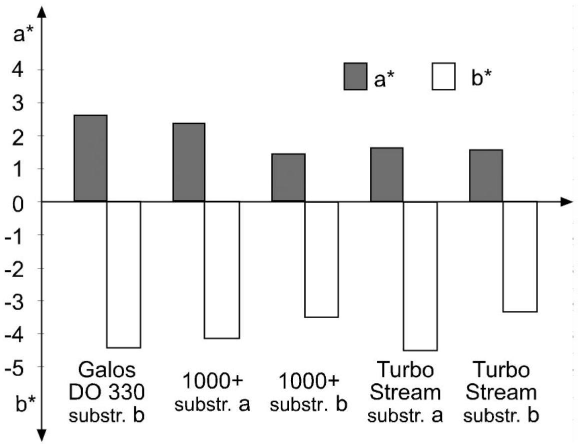


Figure 3. a/b* plot for handsheets from digital offset prints after flotation*

As it can be seen from the presentation, according to the measuring criteria in CIE color system, the inking of handsheet after flotation does not differ much in series. The greatly colored handsheet is obtained by recycling the prints from web digital offset printing in the experimental conditions.

Interesting parameter for study the removal of color from prints including the aspect of the usage possibility of the recycled fiber for the production of fine graphic paper is the definition of the white and very near white paper. White or near white paper are those that have the following L*a*b* values: L*>84 and $(a^{*2} + b^{*2})^{1/2}$<10, according to TAPPI Test Method T524. These results are presented in figure 4 including all the handsheets before and after flotation.

From the presented results one can se that the stages of the used process of deinking flotation had little effect on color. This means that while the deinking process can remove inks it has little effect on dyes. In the experiment used hydrogen peroxide did not display enough color stripping function as it was expected.

The method of image analysis is useful for recording optical inhomogeneities. Generally, these are dirt specks including ink particles in the handsheet. Figure 5 presents only a part of results, those which can explain to the best the influence of the incoming materials on the successfulness of the studied processes.

General characteristic of the results presented in figures 5a and b is the presence of greater number of bigger particles of ElectroInk in one case as opposed to the presence of numerous very tiny particles of conventional offset ink on handsheet after pulping in another case. This fact can serve in explanation of relative weak efficacy of flotation, which on the other hand is confirmed by the presented results of some optical characteristics of handsheet before and after recycling.

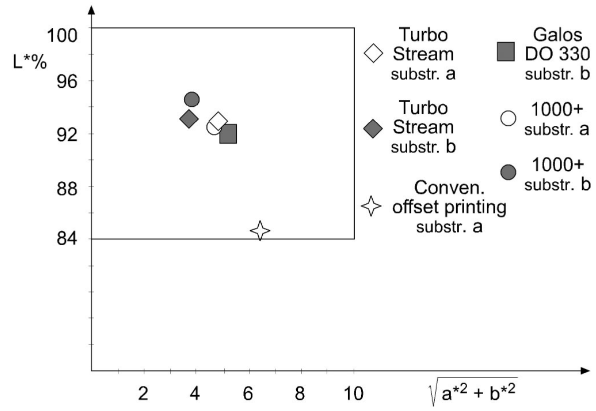
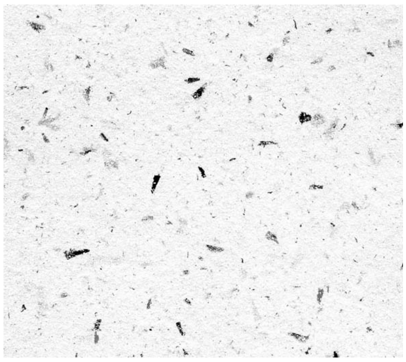
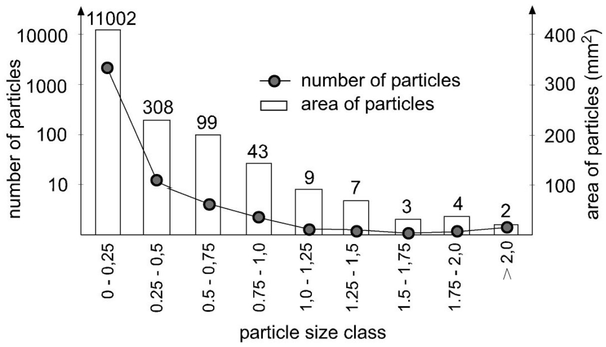
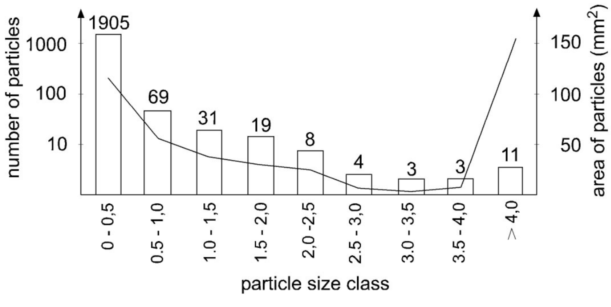


Figure 4. Lightness versus chroma





(a) handsheet after pulping of prints from web digital offset machine and substrate b



(b) handsheet after pulping of prints from conventional offset machine and substrate a

Figure 5. Size distribution of dirt particles after pulping

The reason for such particle distribution can be looked for in the principles of the used printing techniques, some details in which the machines for digital offset printing mutually differ as well as in characteristics of the used substrate

As it is known, the principle of the digital offset printing is identical for all the models of these machines. However, there is the difference between this technique and the classical offset in drying the prints, which can be the cause of appearance of great particles on handsheet. In digital offset printing the ElectroInk is laminated into an ink-polymeric film, and the peeled off blanket is applied to the paper with help of transfer foil. This occurs for each color. In conventional printing the ink binds with the paper. The ElectroInk dries to a film for the blanket before it reaches the substrate and does not penetrate into the paper.

It is also known, that there are differences in details among the digital indigo technique machine models of the digital indigo technique. The differences among the series 1 and 2 are in the application of binary Ink Development Technology in the last one. In the mentioned technology there are the inking rollers which transfer ink onto the base cylinder in one layer. In this case the developer units are separated for each ink which results in greater working speed of the machine. There are also differences in the second transfer of ElectroInk in dependence on the machine model. The sheet fed machines use multyshot technology, which means that the sheet of paper repeats its way until all the colors are printed. Such a process can not be performed in web printing. In web digital printing machine oneshot technology is used which means that the colors are put one above another on the transfer roller and not on the printing substrate. In this case all the colors are transferred on the printing substrate at one time.

Better results can be obtained by mixing smaller part of digital offset prints with the conventional ones in the determined conditions of conventional deinking flotation or by using the enzymatic deinking.[11,12]

Conclusion

On the basis of the obtained investigation results one can conclude that in the pulping process the prints from digital and conventional offset printing technique give different size and shape of ElectroInk particles in relation to the conventional offset inks. The ElectroInk particles are too big in order to be removed successfully by the conventional process of chemical deinking flotation. The characteristic shape and size of particles reflect on investigated optical properties of handsheet before as well as after flotation. There is correlation between the particle size and brightness. Specially in processing of prints from digital sheet-fed technique on the coated paper designed for digital printing, the greatest particles are obtained and the brightness has the same trend. The slow increase of reflectance curve of handsheet after flotation shows somewhat improved properties of the secondary raw material. In this segment greater influence of the original substrate is noticeable. In the experimental conditions the process of deinking flotation has slightly effect on color. All the tested samples satisfy the criterion of white or near white substrate.

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Biography

Ivana Bolanca, B.Sc. in chemistry junior researcher at the Chair of Ecology Engineering. She is attending postgraduated study on the Faculty of Graphic Arts. Area of her scientistic work is ecology and her special interests are in mechanisms of paper ageing and recyclation.

Ph.D. Zdenka Bolanca is a full professor and the head of the Department for Ecological Engineering at the Faculty of Graphic Arts, University of Zagreb. She teaches several undergraduate and postgraduate courses at Faculty. She is engaged in the scientific research related to the processes and materials of graphic technology especially paper recycling and its properties. She is the head of research project of the Ministry of Science and Technology of Croatia. Professor is the associated member of Engineering Academy of Croatia.