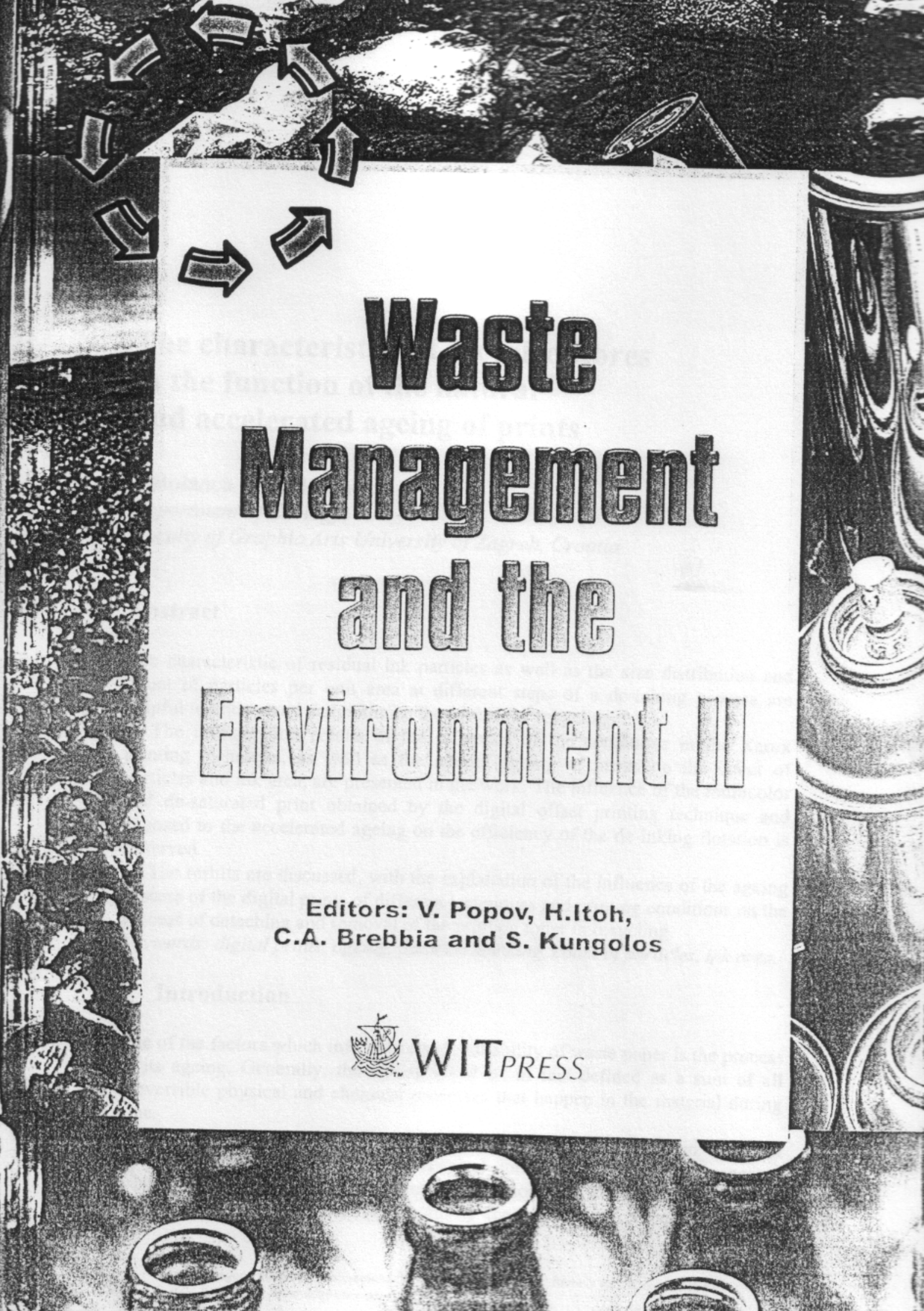

Waste Management and the Environment II

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The characteristics of recycled fibres in the function of the natural and accelerated ageing of prints

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Abstract

The characteristic of residual ink particles as well as the size distribution and count of particles per unit area at different steps of a de-inking process are helpful to understand and optimize the process of recycling.

The investigation results of the influence of the conditions in the Xerox printing technique, as well as the natural ageing of prints on the count of particles and ink area, are presented in the work. The influence of the multicolor and de-saturated print obtained by the digital offset printing technique and exposed to the accelerated ageing on the efficiency of the de-inking flotation is observed.

The results are discussed, with the explanation of the influence of the ageing process of the digital prints of different techniques and printing conditions on the process of detaching and removal of the printing toner in recycling.
Keywords: digital prints, ageing, flotation deinking, count of particles, ink area.

1 Introduction

One of the factors which influence the de-inkability of waste paper is the process of its ageing. Generally, the ageing could be in fact defined as a sum of all irreversible physical and chemical processes that happen in the material during time.

Deterioration in quality of an aged paper can manifest itself in chemical permanence and the decrease in mechanical durability [1]. The permanence of paper or prints depends on the chemical resistance of its components and of the influence of external factors. The durability depends mainly on the physical and

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mechanical characteristics of the raw materials, impact of microclimatic factors such as heat, humidity or radiation and on contamination by ions and gas from the environment and action of micro-organisms [2-5].

Exposure of paper to very short wavelength (254 nm) ultraviolet radiation had induced a post-irradiation effect, which influenced internal and external factors [6]. Result of exposure to visible and ultraviolet radiation of paper is its discoloration effects during and after exposure.

The adsorption of sulphur dioxide by paper as the atmospheric pollutant, depends on many factors [7]. Temperature affects SO_2 absorption. The increase of SO_2 absorption with the increasing temperature is not high, based on chemical reaction kinetics. Transition metal ions presented as soluble salts may increase the sulphur dioxide absorption too. The influence of papermaking additives on SO_2 absorption by paper is noticed. Papers containing rosin, alum, calcium carbonate or mechanical pulp pick up more sulphur dioxide. Atmospheric ozone treatment can enhance the strength properties of mechanical pulp.

The natural ageing process of paper and prints causes the degradation of cellulose. The presence of moisture, oxidative agents and micro-organisms is important in this process and especially the presence of acidic substances. The results in this case are the hydrolysis of cellulose that appears in the shortening of its chain, along with changes in content of crystalline form [8].

Discolouration of a paper may be caused by the formation of chromophores upon ageing as a result of exposure to light and volatile gases [9]. Many volatile compounds, as well as alcohols, ketones, aldehydes, carboxylic acids aromatic and aliphatic hydrocarbons and ethers can be released from paper during the degradation processes, depending upon paper chemical compositions. The role of volatile gases has been studied by Johansson and Lennholm [10]. The migration of volatile degradation products that take place within stacks of paper and the formation of carbonyl compounds has also been followed [11].

Acid catalyzed hydrolysis of cellulose was recognized to be the primary reaction in connection with accelerated deterioration of the paper. For the study of the accelerated ageing of paper new methods are being developed and recently the mathematical model for temperatures was presented by Rychlyet al. [12].

Many authors were occupied with investigations of the recycling efficiency of natural and accelerated aged prints. In this area the reduction of brightness and some mechanical properties of the recycled paper, and change in composition of process water after recycling of waste paper exposed to ageing during the summer months, defined as a summer effect, were studied [13]. The results show that summer effect is due to the ageing and thermal drying of printing inks. This process will lead to the increased ink fragmentation and ink attachment in flotation.

Alkaline and neutral chemical de-inking for treatment of natural and accelerated aged flexographic prints are used [14]. More successful is the neutral de-inking process in correlation with alkaline.

Detachment of printing from different types of aged paper was investigated by Sjostrom and Callmel [15].

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The influence of the natural and accelerated ageing of digital offset prints with liquid toner and different conditions in the printing process in regard to the efficiency of alkaline de-inking flotation has been investigated in this paper. The results of optical measurements and image analysis of handsheet before and after flotation is dependent on the printing substrate grammage and printing process conditions, as discussed.

2 Experimental

The samples of prints were obtained by digital offset printing with liquid toner ElectoInk (Indigo E-Print 1000+ printing machine) and by a digital printing machine with the indirect transfer of the dry toner (Xerox DocuColor 2045). One part of Xerox prints were made with the corotrone voltage on the back side of the paper of 212V and 136V, with corresponding toner fusing on the printing substrate.

In this experiment the test form is designed from standard patterns composed of 210 fields in steps of 5%. The same printing form was used in the printing process. Colour and desaturated prints were made.

Printing substrates were fine art papers and offset papers of 100 and 200 grammages.

One series of prints was naturally aged and the other was age accelerated in the chamber at 80^0C and relative humidity of 65% over the period of 10, 20, 30 and 40 days.

Natural and accelerated aged prints were used in the alkaline de-inking flotation.

In the phase of sample soaking, de-inking chemicals (1% hydrogen peroxide, 0,4% surfactant, 0,2% DTPA, 1% sodium hydroxide and 1% sodium silicate) were added. The consistency of the suspension is 10% in regard to the dry prints. The disintegration stage is 45 minutes. Suspension was diluted to 0,6 % pulp consistency. An optimal level of hardness was maintained in the flotation cell from 200 ppm $CaCO_3$. The flotation time is eight minutes.

The handsheets are made using the laboratory sheet former according to standard method T 205.

For optical measurement X-Rite spectrophotometer with the support of ColorShop program was used. The measuring results are processed by means of a Data Analysis program and technical Graphic Origin Professional.

The residual ink spot size, ink number and ink areas were assessed with image analyses software Spec*Scan (Apogee System Inc., Powder Springs, GA). Scanner optical resolution was set to 600 dots pr inch. The threshold value 100, white level 75 and black level 65 were chosen after comparing computer images to handsheet.

3 Results and discussion

The optimization of the de-inking process is related to the high level of brightness and cleanliness achieved on the recycled fibres. The characteristics of

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the residual ink particles, as well as the size distribution, count of particles per unit area and ink covered area on handsheets obtained at different steps of the deinking process are interesting to understand the mechanisms of de-inking flotation in context of the printing techniques and printing conditions.

The count of particles and residual ink area before flotation of Xerox prints obtained with a corotrone voltage level on the back side of the paper of 212 and 136 V respectively, are presented in figure 1. One part of prints was natural aged before de-inking flotation.

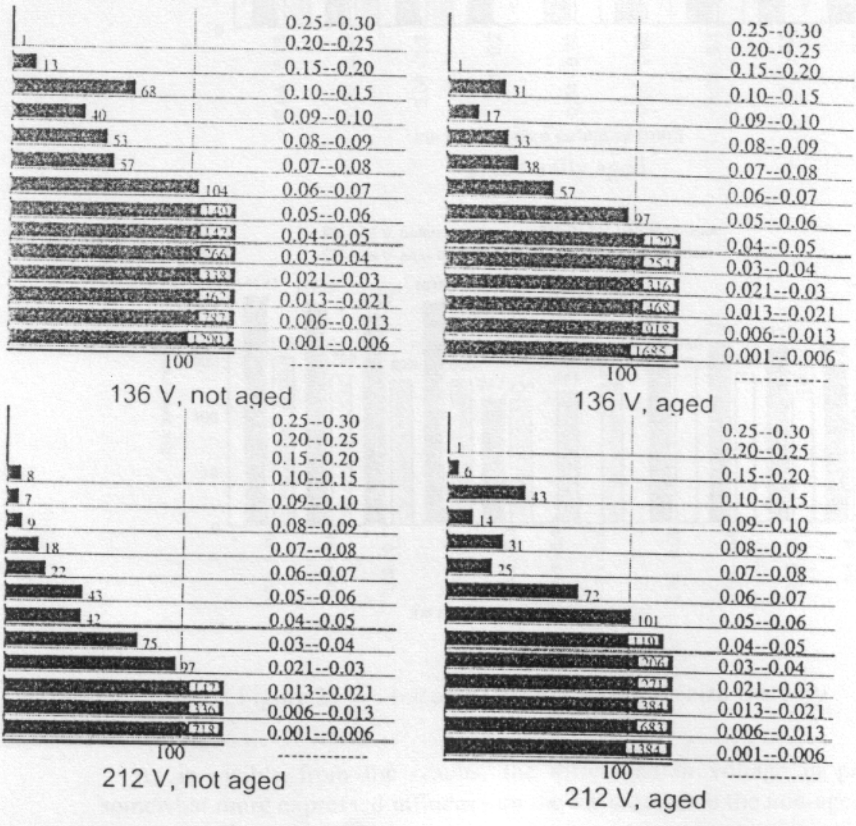

Figure 1: The influence of corotrone voltage on count of particles and residual ink area.

Ink particles were scanned on both sides of handsheets and categorized according to their size. Only ink specks larger than 0.04 mm² (225 μm diameter) were counted, because these represent the lower limit of the TAPPI method. By processing the non-aged prints, a greater number of total ink particles after the disintegration of prints made by lower corotrone voltage (3775, 1522) in relation to the higher, was obtained.

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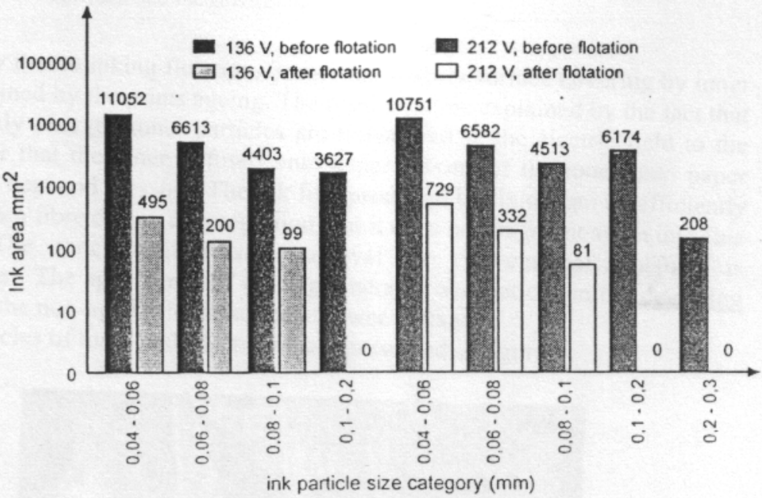
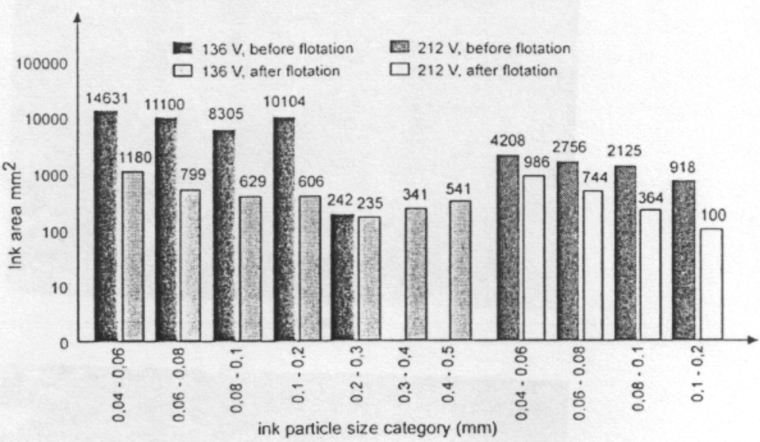
After the flotation of prints naturally aged, the count of particles and ink area in relation to the non-aged ones are decreased. By the disintegration of the aged samples the total number of particles was increased by the processing of prints, obtained by the lower and higher corotrone voltage (4044, 3340). However, the flotation process is more successful in prints after ageing while the size of the voltage in printing has smaller influence in relation to the non-aged print (139, 134).

In figure 2 the residual ink are versus ink particle size category is presented.



a) naturally aged



b) not aged

Figure 2: Ink area versus ink particle size category.

As is visible from the results, the difference in voltage in printing has somewhat more expressed influence on the ink area when the non-aged prints are

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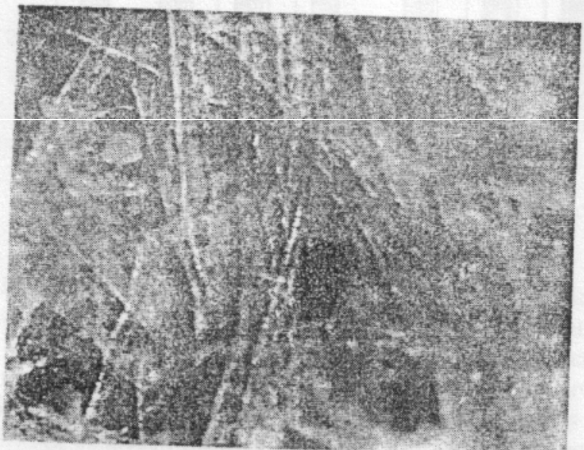
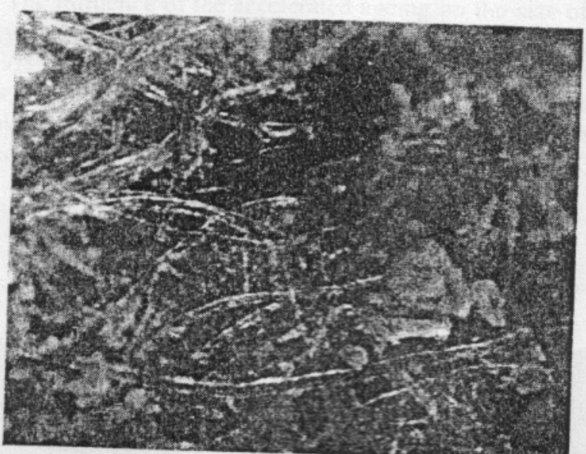
disposed by the de-inking flotation. Somewhat smaller surface covering by toner can be obtained by the prints ageing. The results can be explained by the fact that the positively charged toner particles are transferred in the electric field to the paper. After that the toner is fused onto paper. Fixing of the toner onto paper occurs with heat and pressure. The ink film produced by fixing can be efficiently detached from fibre during disintegration, but it does not fragment again into fine particles. The toner agglomerates removal by conventional flotation is problematical. The appearance of the agglomerates was noticed in the de-inking flotation of the non-aged print obtained at lower voltage.

The particles of toner and ElectroInk are presented in figure 3.



a) Xerox



b) Indigo

Figure 3: Toner and ElectroInk particles after disintegration.

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The shape of the toner and ElectroInk particles as well as the characteristics of their position on the fibres can be seen in the presentation. The particles are flat, some of them are not completely separated from the fibres, which gives them a certain hydrophilic character and which additionally decreases the possibility of good detachment and removal in the flotation process.

The results of the influence of the accelerated ageing on the count of particles and particles area during the recycling process of the colour and desaturated digital offset prints are presented in figure 4.

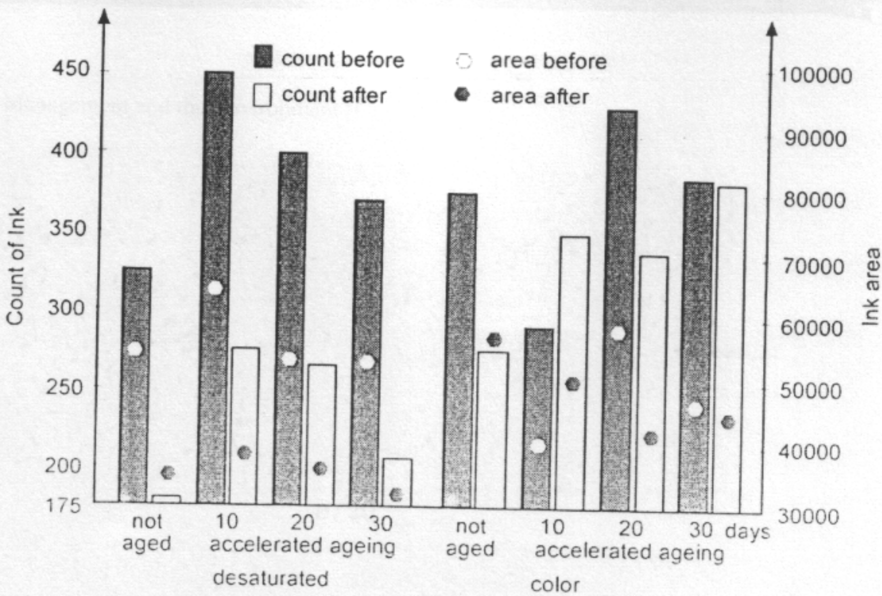

Figure 4: Count of particles and toner area.

By the recycling of the non-aged as well as the accelerated aged desaturated prints smaller count of particles and smaller ink in relation to the colour print was noticed. In the digital offset printing the liquid ElectroInk acts on the area electrostatically and dries very quickly. In the drying process the ElectroInk is laminated into an ink plastic film. The ElectroInk does not penetrate into the paper. All of these influence the form, size and the properties of ElectroInk and the efficiency of the process of de-inking flotation.

The influence of the accelerated ageing on the size of the particles during the recycling of the colour prints is presented in figure 5.

As can be seen from the presented results, the duration of the ageing process has an impact on the particle size of ElectroInk, so that they decrease with time, which influences the efficiency of the recycling process and the quality of the secondary raw material.

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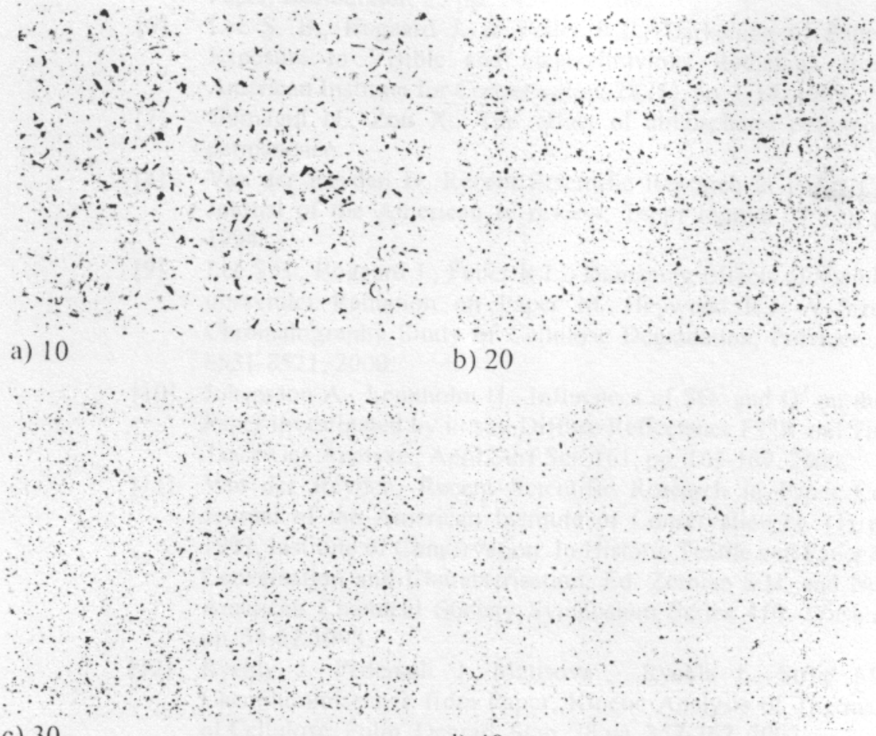

a) 10 b) 20

c) 30 d) 40

Figure 5: The handsheets after disintegration of accelerated aged digital offset prints.

4 Conclusion

On the basis of the investigation results in the frame of the experimental condition, it could be concluded that the influence of the digital printing technique, printing conditions and the processes of natural and accelerated ageing is present on the count of the toner and ElectroInk particles and the ink area during the process of the de-inking flotation.

The influence of the voltage of corotrone in printing with the Xerox technique on the size of the particles and the ink area before and after the flotation is noticed, i.e. the influence on their detaching efficiency. This influence is more expressed in the case of the non-aged print. Better efficiency of flotation is registered at the recycling process of the non-aged and accelerated aged desaturated print in relation to the colour print.

From the investigation results it is seen that during the optimizing of the process of de-inking flotation, except for the well known factors, one should take into consideration the conditions during the printing as well as the time interval to their disposal.

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