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PLENARY LECTURE:

PREFACE

The 23rd DAAAM International Symposium on Intelligent Manufacturing and Automation took place at the University of Zadar, Croatia, between 24th and 27th October 2012.

This proceedings contains 276 refereed papers from 605 authors presented at the 23rd DAAAM 2012. In the DAAAM proceedings since first symposium in 1990 we published papers from 7713 authors.
The papers discuss all aspects of modern manufacturing and automation and are presented in following sections: Algorithms, Artificial Intelligence, CAX, Computer Integration, Control, Cutting Tools, Design, FEM, Invited Lectures, Knowledge, Management, Manufacturing System, Mechatronics, Methodology, Methods, Modeling, Optimization, Poster section, Robotics, Simulation, Technical Solutions, Technology and Trends

We wish to thank the Scientific, Program and Review Committee members who did an excellent job in reviewing papers and providing feedback to the authors.

Finally, we wish to thank all the authors who submitted papers, making this conference possible, and the authors of accepted papers for updating their papers with care and patience during the lengthy production of these proceedings.

Special thanks to Festo company for support of our activities and support of young researchers and scientists in the form of Festo Prize and Festo scholarships for the participants of the 1st DAAAM International Doctoral School, which was held parallel to the symposium and interacted positively each other.

We would like to thank the rector, management and all those nice colleagues from the University of Zadar for their excellent support in the organization of 23rd DAAAM International Symposium and the 1st DAAAM International Doctoral School.

Zadar, 2012-10-26

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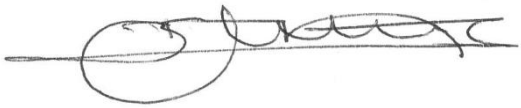

Branko Katalinic

IMPRESSUM
2012

Verba volant, littera scripta manet. [In English: Words fly away; written letters remain.]

Who is in the field, and not in the DAAAM he/she does not exist.
(Jyri Papstel 1996)

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Make Harmony between Technology and Nature, and Your Mind will Fly Free as a Bird
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ECOLOGICAL SUSTAINABILITY OF THE SHEETFED OFFSET PRINTING

BOLANCA MIRKOVIC, I[vana]; MAJNARIC, I[gor] & BOLANCA, S[tanislav]

Abstract: *The basic directions of the ecological sustainability of the sheet fed offset printing are in the area of the application of the renewable and recycled raw materials for the production of the printing materials, in the decrease of the energy consumption, the usage of the energy from the renewable sources and in the production without waste; or if the waste was formed that it could be used in the same production or in another one. The analysis of the life cycle assessment offset printed matter has shown all the importance of the recycled paper usage in relation to the usage of the paper made from the virgin fibres and with it the possible influence on the quality of the environment. The main object of these investigations is the contribution to the explanation of the mechanism of the deinking flotation of prints made with the ink based on mineral oils and prints with greater share of the renewable raw material. Some prints were exposed to moist heat ageing before recycling. The brightness of handsheet, number and area of specks and chromatic coefficient in relation to the ink formulation and the conditions of the moist heat ageing of prints are discussed.*
Keywords: *sheetfed offset printing, renewable raw material, recycling, specks, CIE a* and b**

1. INTRODUCTION

One of the most important challenges of the modern production is transforming the general aims of the sustainable development into the concrete meaning of the concept and the inclusion of the ecological demands in the process of the general management [1].

It is necessary to point out the interdisciplinary character of the postulates of sustainability which comprises the area of economy, ecology and society [2]. The economists are interested into the growth and influence of the micro-economy, (e. g capital cost, operating cost, profitability, investments) and macro-economy(e.g. value added, taxes paid and other investments). Ecologists are occupied by the integrity of the ecological system (raw material, energy, emissions to air, water, land, environmental impacts e. g. global warming, ozone depletion, acidification, human toxicity, eco toxicity, summer smog, eutrophication). Sociologists are interested in justice and security for all the members (provision of employment, health and safety, public acceptability).

To provide the detailed information about the environmental aspects and potential environmental impact of the sheet fed offset printing, the life assessment methodology can be used [3-5]. Studies with product life cycle assessment on printed matter are relatively new and they include the investigation as follows.

LCA analyzes the environmental aspects and potential impacts across the product from cradle to grave including raw material acquisition, production, use, end of life treatment, recycling and final disposal [6].Life cycle assessment can help in identifying the opportunities to improve the environmental performance of products, selecting relevant indicators, help for the purpose of strategic planning and applying for an eco-label [7-11].The methodological development in LCA has been strong and some areas have been an intense methodical development. Developments concerning databases and input, output and hybrid LCA have to be mentioned [12].

The four phases of LCA are made according to the ISO 14040 standard [7]. They are: goal and scope definition, inventory analysis, impact assessment and interpretation.

The goal definition of an LCA includes: the reason for carrying out the LCA, the audience to which the results are intended to be communicated. The scope definition has to have the goal of the research.

In the scope definition of an LCA, the following items should be described: the product systems, the function of product, the functional units, the product system boundaries, allocation procedures, types of impact and methodology of impact assessment, data requirements, data quality requirements, assumptions, limitations and type of critical review[7]. The functional unit is the basis for comparison between all inputs and outputs.

In the system analysis in the area of graphic technology the functional unit of one tone of the produced material is more frequent than the number of impressions [3, 4, 13, 14].

Life cycle inventory LCI is the second phase of the LCA study. This phase gives information about the inputs from environment to the researched system and the outputs to the environment from the system. Concerning the LCA sheet fed offset printing for phases: the inner sheets cover and papers, chemicals, material, fuels in printing, direct emission from printing, energy and transport, the LCI data were investigated: greenhouse gas emission, NO_x, SO_2, particulate matter, volatile organic compounds and emission into water [15-17].

In the life cycle impact assessment LCIA, the results of the inventory analysis are linked to specific environmental damage categories. The elements in LCIA

phase are: selection of impact categories, category indicators and characterization models, assignment of LCI results – classification, relative to a chosen reference calculation of category indicator results – characterization, calculating the magnitude of category indicator results relative to a chosen reference information dataset – normalization, sorting and ranking of the impact categories – grouping, converting and possibly aggregating indicator results across impact categories using numerical values based on value choices – weighting [7, 8].

The impact assessment methods which were used in the investigation in the area of printing were: Eco-indicator 95, CLM, Recipe, Impact 2002 + and EDIP 97. The limited number of LCA´s on offset prints has been produced [18]. The results from Dalheilm and Axelsson, Axel Springer Verlag AG, Stora and Canfor point to paper as the dominanting contributer to the potential environmental impact from LCA of the offset printed matter [3,4].Dominating role of paper is in the energy impact categories of global warming, acidification and nutrient enrichment. In Axel Springer Verlag AG, Stora, Canfor study includes the chemical related impact categories by using Ecoindicator 95 methodology and CML method, impact or midpoint approach [4].

The following impact categories were included in the assessment according to the ReCiPe method (offset printing, newspaper, magazine): climate change - greenhouse gasses, acidification – So_x and NO_x, eutrophication- nitrates and phosphates, photochemical oxidant formulation- hydrocarbons and NO_x, particulate matter formulation, mineral resource depletion, fossil fuel depletion [18, 19].The results show that when considering the time from cradle to grave, the solid waste amount of about 345 kg is produced per tonne of newspaper [18].

In the study of Larsen and coauthors the assessment criteria used are defined in the impact category made in the EDIP method, and include: global warming, ozone depletion, acidification, nutrient enrichment, photochemical ozone formulation, chronic human toxicity via air, acute eco-toxicity in water, hazardous waste, nuclear waste, slag and ashes and bulk waste [20].

The life cycle assessment found that the sheetfed offset printing process (52%) was the largest contributor to the environmental impact of most printed materials, more than the impact of paper (31%) and ink (17%) together [20]. In term of the resource usage, paper is still dominant at 48% [20]. The environmental impact can be reduced with approximately 16% by using recycled paper instead of virgin paper. The scope of the Moberg at al. study was printed and the tablet e-paper newspaper from an environmental perspective [21]. Several different environmental impact categories were assessed; resource used (renewable, nonrenewable and total) acidification, climate change, eutrophication, photochemical oxidant formation, ozone depletion and toxicity [21].

Results show that the most significant phase of the life cycle for both product systems was the production of the paper and the tablet e-paper device respectively. In the same paper, ICT sector was started to give rise to 500 Mtonne CO_2 emissions /year globally [21].

Specific focus in LCA study of the Vercalsteren at al. was on newspaper (coldest offset) and periodical (heat set offset)[22]. The functional unit was 1 m^2 printed matter. Impact categories were included in the assessment according to the ReCiPe method and CML. The environmental profile was dominated by the production of the paper (80%-99%) [22];the contribution of the production of ink and printing was much lower and nearly insignificant. Comparison of the environmental impact of newspaper and periodical was different mainly due to the large impact of paper production (newspaper 100% recycled, periodical 100% virgin paper) and printing, coldset offset (newspaper) requires much less energy than the heat set offset (periodical)[22].It is known that in the recycling process of papers, deinkability of the furnish depends on the ink setting, printing processes, on the nature and amount of ink in prints and on the paper grade [23- 25]. The deinking effectiveness is influenced by the chemical characteristic of the vehicle and by drying mechanisms of the ink [26-28]. Ink, they set by penetration of the vehicle into the uncoated structure of paper, can be rubbed off from the surface of the fibers in a deinking process. Inks which contain more vegetable oil, binders or varnishes lead to faster ink drying and lower rub off [29].

From the presented critical overview of the literature in the area of life cycle assessment of the offset printing the importance of the usage of the recycled paper in regard to the virgin paper is visible and with it the possible influence on the environment.

The problem statement in the area of ecological sustainability of the sheet fed offset printing comprised in this work is in the domain of the renewable raw materials and the recycled fibers for production of ecologically more suitable graphic materials. These investigations are a part of the project, which includes phases of the printing process through the life cycle assessment, following the important factors of the print quality together with the ecological characteristics. The investigation goal is the contribution to the explanation of deinking process mechanism in relation to the material composition, printing principle and ageing conditions of prints as well as the characteristics of the recycled fibers. The results are applicable in the development of the printing materials new formulation and in the domain of deinking flotation. This is the direction of the continuation of our investigation.

2. EXPERIMENTAL

For the print preparation the sheet fed offset printing machine Heidelberg was used. The printing form contained different printing elements: standard CMYK step wedge in the range from 10-100% tone value, standard ISO illustration for the visual control, textual positive and negative microelements, wedges for determination the grayness and the standard wedge with 378 patches for production of ICC profiles. In printing the two commercial inks were used, one was based on the mineral oil and the other contained the greater share of the renewable raw material. The samples were made on the uncoated paper with the characteristics as presented in the Tab. 1 and Tab.2.

Kind of paper	Grammage g/m²	Caliper mm	Brightness %	Opacity %
Uncoated paper	80	0.08	103.5	92

Tab. 1. Characteristics of the printing substrate

Paper	L*	a*	b*
Non aged	94.0	0.21	-0.61
Moist heat aged	93.0	0.09	-2.99

Tab. 2.L*a*b* values for the printing substrate

The life cycle of the sheet-fed offset printed matter is presented in Fig. 1.

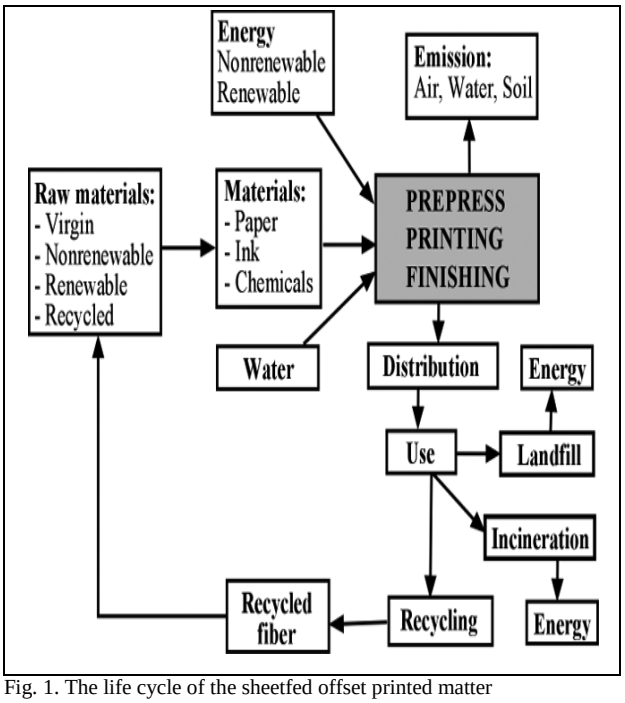


Fig. 1. The life cycle of the sheetfed offset printed matter

According to the INGEDE method 11p before paper recycling, the samples had to be exposed to accelerated ageing at 60^0C for 72 hours [30]. According to the same statement these ageing conditions correspond to 3-6 months of natural ageing.

The aim of our project is to find out how the accelerated ageing (the moist heat ageing without light and xenon arc light at determined temperature and relative humidity) in relation to the natural ageing influences on prints on different papers and with different ink compositions, especially those with unsaturated oils, resins or other oxidable component in the ink components.

A part of the answer to the above set question is given by this work. Because of that, before the recycling process, the prints were exposed to the moist heat accelerated ageing with increased temperature and humidity without the influence of the light according to the standard ISO 5630-3 1996, which was used for paper [31]. The samples were moist heat aged for 4, 8 and 12 days.

According to Debeljak and Gregor Svetec the 24 daily expositions to the described conditions should be equivalent to 100 years of natural ageing [32].

The prints were recycled by the method of the alkaline chemical deinking flotation, described in details in the quoted work [33]. The handsheets were made using the laboratory sheet former, according to standard method T 205 [34].

For determining ISO brightness of the recycled fibers the spectrophotometer DataColor, Elrepho 450X was used [35].

Specks number and area were assessed with image analysis software Spec*Scan, Apogee System [36]. This system was utilizing the scanner to digitize the image. Threshold value (100), white level (75) and black level (65) were chosen after comparing computer images to handsheet.

3. RESULTS AND DISCUSSION

The investigation results of the influence of the sheet fed offset printing technique, paper surface, ink type, ageing of the prints on deinkability are presented in this work.

The brightness of handsheet made from the fibers after the disintegration and after the flotation of prints on uncoated paper with the ink based on mineral oils (S_1) and the one with the increased share of the renewable raw material (S_2)is presented in Tab 3. In the recycling process the non aged prints were used as well as the moist heat aged ones, aged for 4, 8 and 12 days.

Samples	Brightness % Non aged	Brightness % Aged 4 days	Brightness % Aged 8 days	Brightness % Aged 12 days
S_1 after disint.	76.06	74.05	73.62	73.13
S_1 after flot.	79.21	77.89	76.01	75.99
S_2 after disint.	73.42	70.94	70.70	69.61
S_2 after flot.	75.05	72.23	72.01	71.27

Tab. 3. Brightness of handsheet made from recycled fibers from aged prints

The results show somewhat greater brightness of handsheet made from the recycled fibers of ink based on mineral oil (79.21%) in relation to the ink with greater share of renewable raw material (75.05%).Greater difference in handsheet brightness made from recycled fibers of the non aged print with the ink based on mineral oil in relation to the one obtained from the fibers of the non aged print with the ink based on greater share of the renewable raw material is achieved. The difference increased by the print ageing which were used for recycling (brightness on aged prints, ink mineral oil – non aged prints, ink renewable raw material= 3.64, brightness aged prints, ink mineral oil – aged prints, ink renewable raw material= 4.72.

The effectiveness of deinking can be estimated by image analysis of handsheet made from the recycled fibers. In Tab. 4. the specks number/m^2 and area mm^2/m^2 of handsheet are presented.

Specks number/m^{2}on handsheet made from the recycled fibers of the non aged print with the ink based on mineral oil is for 342889 specks lesser in relation to

the one with the ink based on greater share of the renewable raw material.

The ageing process influences the specks number/$m^2$of handsheet. Number of specks/m^2on handsheet made from the recycled fibers of the non aged print $S_1$is lesser for 277984 specks in relation to the

Samples	Non aged	Aged 4 days	Aged 8 days	Aged 12 days
S_1 after flot. Speck numb./m^2	243474	364736	378033	521458
S_1 after flot. Speck area mm^2/m^2	1120	1929	1971	2404
S_2after flot. Speck numb./m^2	586363	886510	10657121	1062863
S_2after flot. Speck area mm^2/m^2	4247	7496	7318	7409

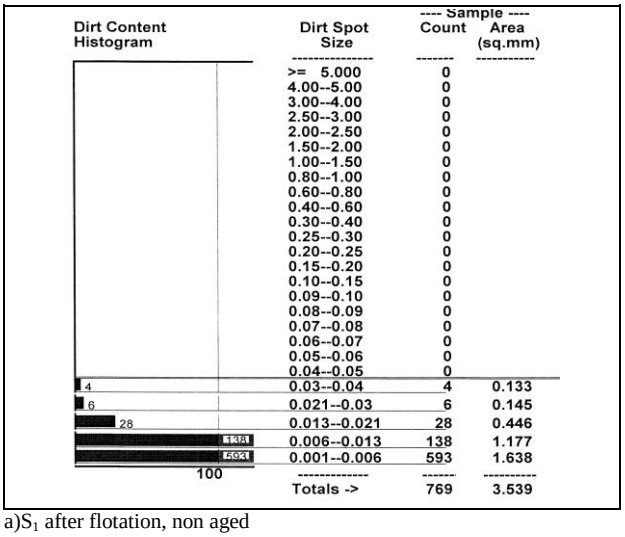
Tab.4. Number and area of speck on handsheetu made from the recycled fibers

handsheet moist heat aged for 12 days. This difference is greater in the case of the sample S_2 and it is 277984 specks.

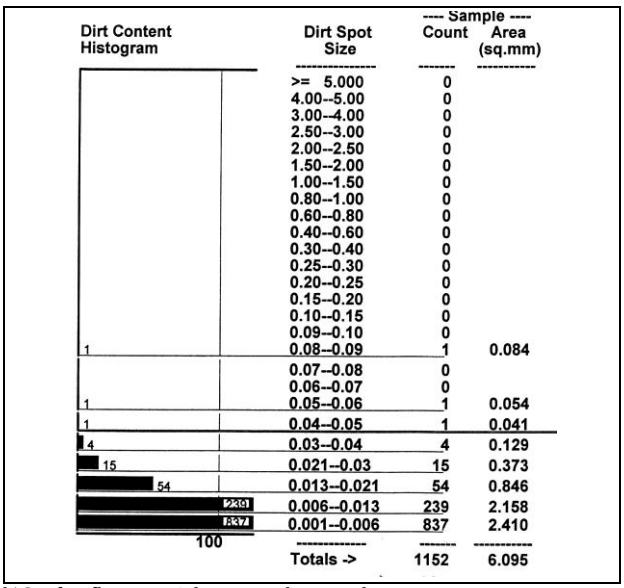
Speck area mm^2/m^2, for S_1 non aged sample in relation to S_1 aged for 12 days is lesser for 3327 speck area mm^2/m^2. By print ageing the earlier described trend appears (S2non aged, speck area mm2/m2 – S1 non aged, speck area mm2/m2 = 3327, I (S2 aged 12 days, speck area mm2/m2 – S1 aged 12 days, speck area mm2/m2 = 5005.

In Fig. 2 the speck number and area within the size classes on the scanned handsheet from 0.003158 m^2 are presented

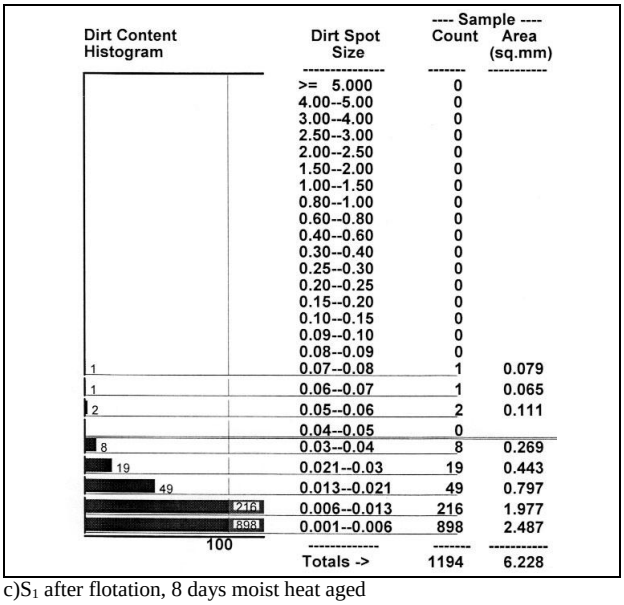
On handsheets made from the recycled fibers of the prints S1as well as S2there is the greatest number of specks in the smallest size class 0,001-0,006 mm 2 (S1 non aged 593, S2 non aged 1185) By ageing of prints the number of specks on handsheet increases. However the mentioned characteristic of the speck distribution within the classes continues.



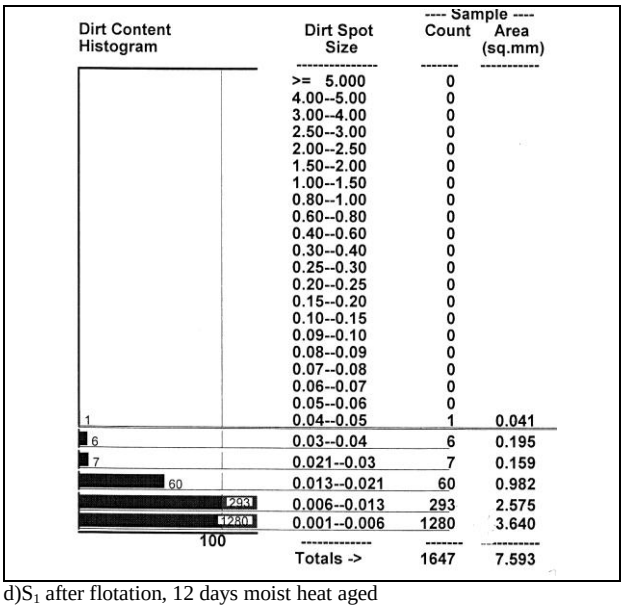
a)S_1 after flotation, non aged



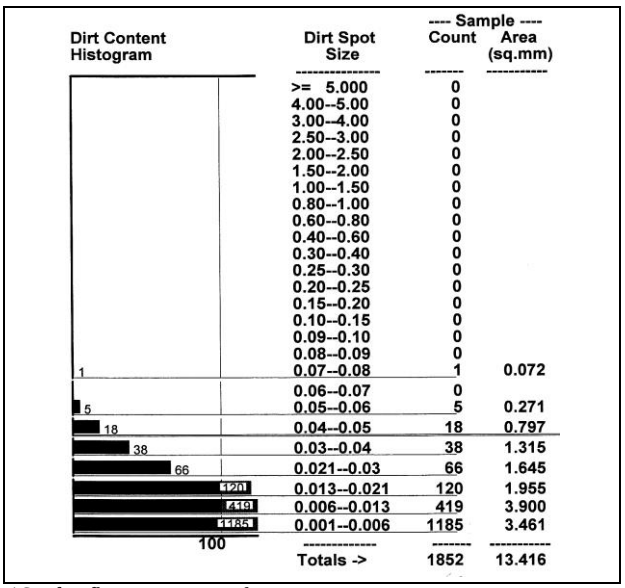
b)S_1 after flotation, 4 days moist heat aged



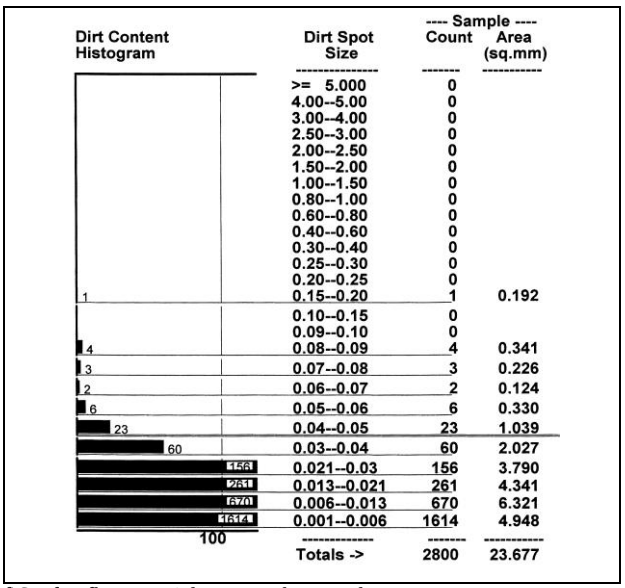
c)S_1 after flotation, 8 days moist heat aged



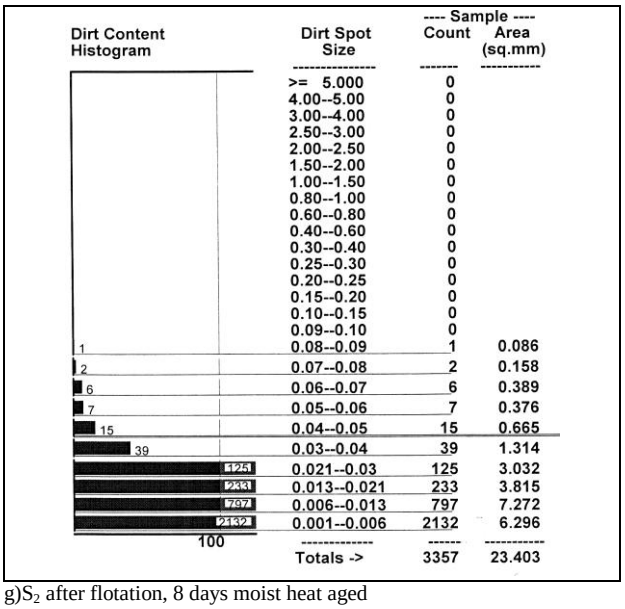
d)S_1 after flotation, 12 days moist heat aged



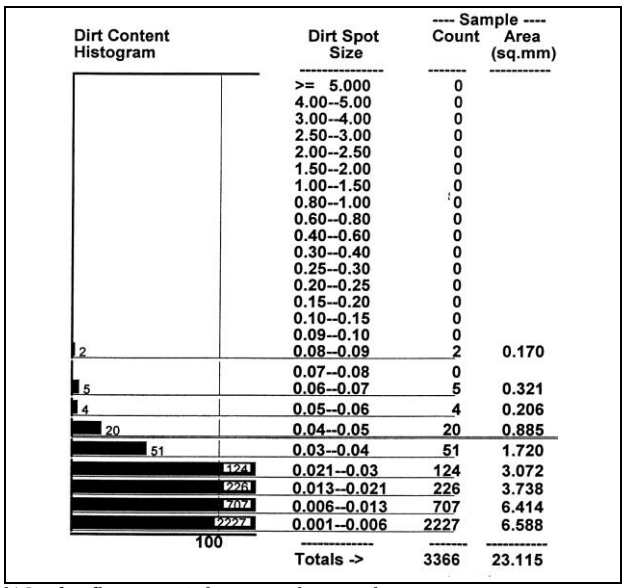
e)S_2 after flotation, non aged



f)S_2 after flotation, 4 days moist heat aged



g)S_2 after flotation, 8 days moist heat aged



h)S_2 after flotation, 12 days moist heat aged

Fig.2. Specks number and area set in size classes for the scanned handsheet surface from 0.003158m^2

Earlier mentioned characteristic of the speck distribution within the size classes is as follows: sample S_1, print 12 days aged, size class 0.001-0.006, contain 1280 specks; class 0.006-0.013 contain 293 specks; class 0.013-0.021 contain 60 specks. The sampleS_2 in the same conditions and classes contains 2227, 707 and 226 specks . Area of specks on handsheet obtained by processing, on aged S_1 sample in relation to the aged one for 4 days, for the class 0.001-0.006,increases for 0.77mm^2 and in relation to 14 days aged print it increases for 2.0 mm^2. In the same conditions with the sample S_2 the area of specks on handsheet will increase for 2.54 mm^2, that is 3.08 mm^2.

In Tab. 4the chromatic a* (represents color position in red-green area) and b* data (represents color position in yellow-blue area) of handsheets made from the fibres after the disintegration for non aged prints S_1 and S_2, and moist heat aged ones are presented. Greater difference of chromatic a* values of handsheet made from the fibers after disintegration of printsS_1 in relation to S_2can be seen. Handsheets obtained from the fibers of prints with the ink with greater share of the renewable raw material are colored red as it can be seen by the shift of their chromatic value a*. For handsheets obtained by floated fibers with the commercial ink based on mineral oil the shift is made towards the achromatic area. It is characteristic for the sheet fed offset printing that in the formulation of the ink the oxidable components are necessary. The drying mechanism comprises the processes of absorption, evaporation and oxidation.

Samples	Non aged	Aged 4 days	Aged 8 days	Aged 12 days
S_1 a*	1.33	1.64	1.71	1.69
S_1 b*	-3.20	-3.59	-4.01	-4.20
S_2 a*	3.21	3.98	4.02	3.99
S_2 b*	-3.98	-4.63	-4.45	-4.72

Tab. 5. CIE a* and b* values of handsheet made from the fibers after the disintegration of prints S_1 and S_2

In the case of print ageing the oxidation process does not stop by print drying. This process further continues and the problem can be in ink detachment and specks. Except that the aged sheet fed offset detachment presents

difficulties, because the uncoated paper is used in this case and ink print is directly fixed onto the fibers surface.

4. CONCLUSION

One of the basic directions of ecological sustainability of sheet fed offset printing is in the area of the application of the renewable and recycling raw material for the production of graphic materials and ecologically justified disposal of the used prints. Based on the investigation results of the influence of sheet fed offset printing technique, paper surface, ink type and moist heat ageing of prints on deniability, the following can be concluded. By ageing of prints, depending on the composition of the printing substrate ink formulation and the drying mechanisms of prints connected with the principles of the printing technique, the oxidation of some ink components appears which then causes the strong attachment of the ink onto fibres.In the process of deinking flotation just the presence of the unsaturated vegetable oils can cause greater ink detachment problems and specks as well as the shift of the chromatic a*value towards the greater values, which causes coloring. The obtained investigation results are the contribution to the knowledge which is applicable for new formulations in the direction of ecological sustainability of the offset sheet fed printing which is the goal of our further investigations.

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