DANUBE ADRIA ASSOCIATION FOR AUTOMATION & MANUFACTURING
DAAAM International Vienna
DAAAM Baltic

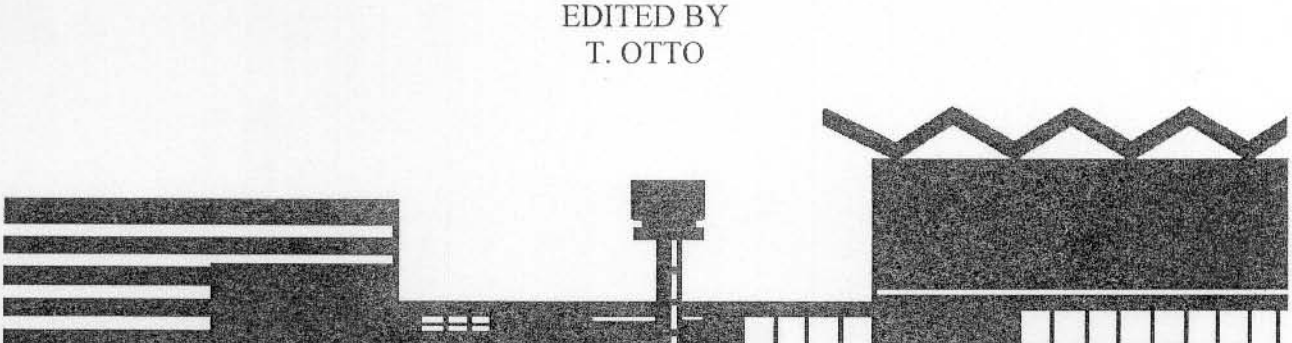
PROCEEDINGS

OF THE 8^{TH} INTERNATIONAL CONFERENCE OF DAAAM BALTIC
INDUSTRIAL ENGINEERING
19-21^{st} APRIL 2012, TALLINN, ESTONIA

ORGANIZED UNDER THE AUSPICES
OF DAAAM INTERNATIONAL VIENNA

in co-operation with:
BALTECH Consortium
Estonian Academy of Sciences
Federation of Estonian Engineering Industry
Association of Estonian Mechanical Engineers

EDITED BY
T. OTTO



TALLINN UNIVERSITY OF TECHNOLOGY

The Chairman of DAAAM Baltic Scientific Committee expresses special personal thanks to Professor Branko Katalinic for encouraging to organise and for advising during the organisation of the conference. Also special thanks for the support during the organising the conference to the following persons: A. Hermaste, K. Karjust, E. Jürves, R. Kulbas, I. Veldi, M. Randmaa, A. Napp.

EDITORS' NOTE

This publication was reproduced by the photo process, using the soft copies supplied by their authors. The editor and the DAAAM Baltic are not responsible either for the statements or for the opinion expressed in this publication.

Proceedings of 8th International Conference of DAAAM Baltic INDUSTRIAL ENGINEERING
Editor T. Otto
19–21 April 2012, Tallinn, Estonia

ISBN 978-9949-23-265-9

Additional copies can be obtained from the publisher:
DAAAM Baltic, Tallinn University of Technology, Ehitajate tee 5, 19086 Tallinn
Estonia

Phone: +372 620 3257
Fax: +372 620 3250
E-mail: daaam@ttu.ee

OÜ·INFOTRÜKK

Foreword

Over the past years, DAAAM-Baltic has been an international forum for researchers and engineers to present their research results in the areas of industrial engineering, manufacturing and automation. It provides an avenue for discussion and exchange of new ideas addressing new techniques and methods for product development and manufacturing engineering.

This DAAAM-Baltic-2012 conference in the DAAAM-Baltic Conference series will continue the mission of the DAAAM, which is to give for young and active scientists of the Baltic Sea region an opportunity to introduce their works and find partners.

The main idea of starting DAAAM-Baltic meetings was to organize regional conferences of DAAAM International events (DAAAM – Danube-Adrian Association for Automation & Manufacturing). DAAAM International is association for international scientific and academic cooperation in the fields of intelligent automation and modern production. DAAAM-Baltic is organized in Estonia every second year. Estonia has been represented as a member of International DAAAM Committee since 1994. In year 2012 we have 8th Conference of DAAAM-Baltic and 16 years of history of publishing the Proceedings. The Proceedings of DAAAM-Baltic are included in Web of Science of Thomson Reuters.

The Conference addresses the issues of managing globalization in the internet age. Its scope ranges from design engineering, production engineering, production management, materials engineering to mechatronics and system engineering, with an emphasis on innovative practices, to ensure that the focus of the conference is on learning, networking and generating new ideas. We emphasize importance of European initiatives towards Factories of the Future and technology platform Manufuture, and hope to give our contribution by bringing scientists, entrepreneurs and industry specialists together for exchange of future visions based on scientific research and case studies.

In 2012 we received about two hundred proposals from 16 countries. Over a hundred participants from 12 countries take part in the Conference. All proposals have been carefully selected and full texts of presentations peer-reviewed to address key topics of the conference. 130 papers were selected to present orally. Part of proposals were rejected on the grounds of either not being appropriate for the areas that DAAAM-Baltic covers or being of rather narrow and specialized nature.

We wish to thank all authors, referees, members of the Organizing Committee and Program Committee, as well as supportive organizations for their efforts which made this conference possible. DAAAM-Baltic would not be possible without contributions from members of the scientific community of the Baltic-Sea region.

We look forward to a very exciting and stimulating conference, and hope that you will join us in next DAAAM-Baltic in 2014.

Tallinn; April 2012

Tauno Otto
Chairman of the Scientific Committee DAAAM-Baltic 2012

Steering Committee

Tauno Otto - *chair*

Kristo Karjust

Rein Küttner

Aadu Paist

Leo Mõtus

Mart Tamre

Renno Veinthal

International Program Committee

M.Airila (FIN)

J.Balic (SLV)

F.Boór (HUN)

S.Bockus (LIT)

J.Brnić (CRO)

M.Eerme (EST)

L.Hagman (SWE)

H.Jähn (GER)

T.Karaulova (EST)

B.Katalinic (AUT)

T.Kjellberg (SWE)

P.Kulu (EST)

P.Kuosmanen (FIN)

J.Lavrentjev (EST)

I.Liiv (EST)

V.Mironov (LAT)

J.Martikainen (FIN)

S.Ottosson (SWE)

J.-G.Persson (SWE)

D.Polize (SUI)

P.Pukk (SWE)

V.Reedik (EST)

J.Riives (EST)

A.Schulz (LAT)

F.Sergejev (EST)

A.Siirde (EST)

M.Veveris (UK)

A.Voet (BEL)

A.Zawada-Tomkiewicz (POL)

CONTENTS

8th International DAAAM Baltic Conference
"INDUSTRIAL ENGINEERING
19-21 April 2012, Tallinn, Estonia

RECYCLING OPTIMISATION OF THE ELECTROPHOTOGRAPHIC PRINTS

Bolanča Mirković I., Majnarić I., & Bolanča S.

Abstract: *The research results of the temperature influence of the offset cylinder in electrophotography with the liquid ElectroInk on the effectiveness of the recycling process of prints have been presented in the paper. By the temperature increase in the domain from 125 – 145^{0}C the increase of specks area after pulping appear which then influences their elimination in the flotation process. On the other hand by the increase of temperature the increase of gamut volume of prints appears, i.e. the greater reproduction quality. In the paper the results have been discussed in relation to the principle of electrophotography with the aim of their application in the field of graphic materials development and the ecological sustainability.*

Key words: recycling, coated paper, electrophotography, image analysis, gamut

1.INTRODUCTION

The digital printing contributes to sustainable development [1]. These printing techniques, in regard to some conventional printing techniques has advantage in fewer influence on environment mainly due to faster make ready and the absence of plate making and its related chemicals, materials, emissions and wastes. The poor deinkability of ink jet and liquid toner electrophotography especially of the former formulations is the biggest environmental challenge of digital printing [2,3].

The recycling of waste paper in relation to the production of virgin paper influences the consumption of water (25%) and energy (40%), decreases the pollution of the process water (35%) and air (70%), preserves the woods and has the positive economic effect [4].

Deinking is a process for detaching and removing printing inks to improve optical characteristics of pulp and paper using recovered printed material [5]. Deinking plants have several unit operations: pulping, screening, cleaning, washing and/or flotation, dispersion, bleaching, effluent treatment and sludge disposal. Pulping in a deinking plant involvs defibering which is accomplished mechanically, and deinking by a combination of chemical, mechanical and thermal action [6]. The most ink detachment is achived by the addition of chemicals during the defibering operation in the pulper.

Several chemicals are added to the pulper: sodium hydroxide, sodium carbonate, sodium silikate, soapps of fatty acids and surfactants. Bleaching chemicals may be added in the pulper or later in the process, or both [7]. The type and concentration of these chemicals will be a function of the waste paper characteristic to be deinked, the type of separation equipment used to eliminate the contaminants from the pulp slurry and the nature of the end–product [8].

High consistency pulpers used due to the savings in the chemicals, steam, and electrical energy and reduced pulping time [9]. Removal of the detached ink particles then use flotation.

The effectiveness of the deinking

process itself depends on numerous factors. The following ones have to be mentioned: the kind and quantity of chemicals used in different phases of the process as well as the chemical and physical conditions of the system such as pH value, consistency of fiber suspension, defibering time and the hydrodynamic factors of the flotation process [10].

The other influential factors are: the size, shape and the surface properties of the dispersed ink particles, the air volume and the size of the air bubbles have special importance for the effectiveness of deinking flotation. The effectiveness of the process depends on the ability of the printing ink adherence on air bubbles and the strength of this bond in order to prevent their detaching and rebinding to the cellulose fibers [5]. The surfactants stabilize the air bubbles. The surface of the air bubble and the ink is hydrophobic, while the cellulose fibers are hydrophilic.

The main problem of such a complex process is the effectiveness of the printing ink detaching or the toner detaching from the cellulose fibers, removal of the ink particles from the suspension as well as the purification of the waste water. In the described problems, the majority of authors researched the hydrodynamic factors of the process and the influence of chemical and physical conditions of the system on the process effectiveness, while the influence of the conditions in printing process haven't been studied much.

The previous investigations have proved the bad effectiveness of print recycling made in the technique of indirecte electrofotography with liquide toner ElectroInk [11]. ElectroInk appears to produce big specks after pulping, wich to be difficult to eliminate in a flotation deinking plant. The new generation of ElectroInk produces smaller specks after pulping. Specks wich are effectively broken up by dispersion, are flotable in a second flotation loop [12]

The results in this article is a part of the project in which the influence of the conditions in indirect electrophotography (scorotrone, voltage, laser strength, offset cylinder voltage, concentration of the liquid toner etc) on effectiveness of the prints recycling has been researched. Number and area of specks on handsheet made from fibers after pulping and flotation of prints obtained by the change of the working temperature of the offset cylinder at the first transfer of the liquid ElectroInk has been presented.

In order to get the ability - for the prints obtained in the defined conditions of the offset cylinder temperature - to control the print quality and the total information scope on ink (tone, saturation lightness) which is possible to reproduce on the given medium 2D and 3D gamut are presented in the work.

The paper is the contribution to the explanation of the influence of the conditions in electrophotography in the domain of deinkability and it can have the application in the area of the printing materials production and in the design of graphic products taking into consideration the postulates of the sustainable development.

The continuation of our investigations includes the creation of statistical models in the direction of optimisation of the recycling processes of the prints and in the domain of the new graphic material formulation.

2. EXPERIMENTAL

¶

The prints made on digital offset machine Turbo Stream HP Indigo were used for analysis. 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 greyness and the standard wedge with 378 patches for production of ICC profiles and 3D gamut.

ElectroInk of the third generation and the special paper for digital printing, Splendogel EW Soho were used for printing. This paper is coated and it has high brightness grade and its basic characteristics are presented in the table 1.

Parameter	Method	Value
Basis weight	ISO 536	160g/m^2
Caliper	ISO 534	0,170 mm
Brightness	ISO 2470	93%
Roughness (Bendtsen)	ISO 8791/2-90	57,5ml/min
Water absorption (Coob)	ISO 535	38,49 g/m^2

Table 1 Characteristics of the paper Splendogel EW Soho

Samples were prepared so that the working temperature of the offset cylinder was changed as follows: 125^0 C, 130^0 C, 135^0C, 140^0 C and 145^0C.

For spectrophotometric analysis use X-Rite SwatchBook and ColorShop 2,6 application. From ICC profile with the use of MONACO Platinum program the gamut of prints is established.

For print recycling the method of alkaline chemical deinking flotation was used, which was described in details in the previous work [13]. The handsheets were made using a laboratory sheet former, according to standard method T 205.

For determining ISO brightness of the recycled fibres the spectrophotometer DataColor, Elrepho 450X was used. Specks number and area were assessed with image analysis software Spec*Scan, Apogee System. This system is utilizing scanner to digitize image. Threshold value (100), white level (75) and black level (65) were chosen after comparing computer images to handsheet.

3. RESULTS AND DISCUSSION

As indicator of reproduction quality of prints obtained by the temperature change of the offset cylinder in the process of indirect electrophotography, two-dimensional and three-dimensional reproduction gamut are shown on fig.1.

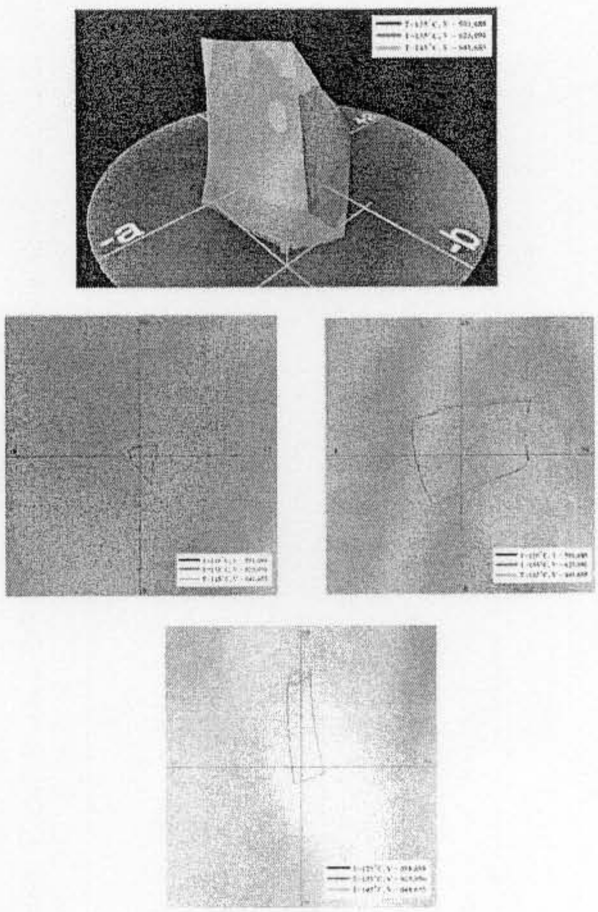


Figure 1. Gamut of print, obtained by using temperature offset cilindre from 125^0 C, 135^0C and 145^0 in indirect electrophotography printing

The greatest reproduction gamut was achieved at the temperature of 114^0C and the smallest one at the temperature of 125^0C.

Sample	V CIE L * a * b * CCU
T=125^0C	591.688
T=135^0C	623.096
T=145^0C	641.655

Table 2. Volumes of gamut V CIE L * a * b * CCU

The gamut increase is not linear with temperature, but it is more expressed in the lower area from 125^{0}C to 135^{0}C. The characteristic cross-sections show that the greatest change of tones is in the medium part of gamut. The temperature increase of the offset cylinder influences the increase of the tone values which have high value on +b coordinate, i.e. in yellow tones. At 125^{0}C the yellow ink adheres weaker on the printing substrate. Except that, by the increase of the temperature the decrease of the tone colours appear, which have high value on the coordinate -b (green). At the reproduction of the darker tones there are not greater changes.

Figure 2 represents the distribution of the number and area of specks in 26 classes with the size from 0.001-0,006 to <=5 for the handsheet made from the fibers after pulping and after flotation.

Dirt Content Histogram

Dirt Spot Size	Sample Count	Sample Area (sq.mm)
>= 5.000	1	10.652
4.00--5.00	0	
3.00--4.00	0	
2.50--3.00	0	
2.00--2.50	3	6.624
1.50--2.00	3	5.181
1.00--1.50	7	8.344
0.80--1.00	3	2.656
0.60--0.80	4	2.559
0.40--0.60	11	5.471
0.30--0.40	9	3.163
0.25--0.30	8	2.242
0.20--0.25	8	1.731
0.15--0.20	11	1.935
0.10--0.15	11	1.355
0.09--0.10	4	0.376
0.08--0.09	6	0.504
0.07--0.08	8	0.608
0.06--0.07	18	1.170
0.05--0.06	15	0.817
0.04--0.05	11	0.487
0.03--0.04	19	0.656
0.021--0.03	21	0.522
0.013--0.021	42	0.708
0.006--0.013	109	1.011
0.001--0.006	314	0.978
Totals ->	646	59.751

a)T=125^0 C, after pulping

Dirt Content Histogram

Dirt Spot Size	Sample Count	Sample Area (sq.mm)
>= 5.000	0	
4.00--5.00	0	
3.00--4.00	0	
2.50--3.00	0	
2.00--2.50	0	
1.50--2.00	1	1.647
1.00--1.50	3	3.919
0.80--1.00	0	
0.60--0.80	4	2.862
0.40--0.60	2	0.968
0.30--0.40	2	0.640
0.25--0.30	5	1.367
0.20--0.25	8	1.830
0.15--0.20	4	0.676
0.10--0.15	7	0.875
0.09--0.10	0	
0.08--0.09	4	0.335
0.07--0.08	2	0.145
0.06--0.07	5	0.332
0.05--0.06	4	0.213
0.04--0.05	2	0.093
0.03--0.04	10	0.357
0.021--0.03	5	0.122
0.013--0.021	13	0.233
0.006--0.013	22	0.195
0.001--0.006	89	0.256
Totals ->	192	17.065

b) T=125^0 C, after flotation

Dirt Content Histogram

Dirt Spot Size	Sample Count	Sample Area (sq.mm)
>= 5.000	3	22.645
4.00--5.00	1	4.434
3.00--4.00	2	6.665
2.50--3.00	1	2.616
2.00--2.50	4	8.629
1.50--2.00	5	9.237
1.00--1.50	7	8.690
0.80--1.00	4	3.396
0.60--0.80	7	4.894
0.40--0.60	18	8.771
0.30--0.40	6	2.065
0.25--0.30	8	2.167
0.20--0.25	5	1.177
0.15--0.20	16	2.740
0.10--0.15	19	2.281
0.09--0.10	3	0.281
0.08--0.09	6	0.496
0.07--0.08	10	0.754
0.06--0.07	9	0.590
0.05--0.06	9	0.487
0.04--0.05	15	0.665
0.03--0.04	24	0.815
0.021--0.03	20	0.516
0.013--0.021	30	0.516
0.006--0.013	90	0.814
0.001--0.006	337	0.970
Totals ->	659	97.312

c) T=135^0 C, after pulping

Dirt Content Histogram

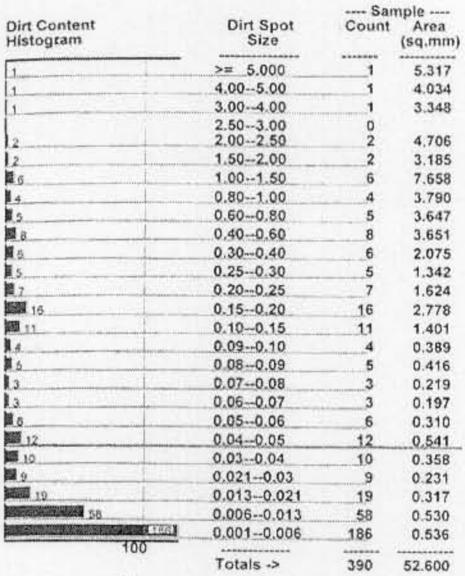
Dirt Spot Size	Sample Count	Sample Area (sq.mm)
>= 5.000	0	
4.00--5.00	0	
3.00--4.00	0	
2.50--3.00	1	2.993
2.00--2.50	0	
1.50--2.00	1	1.932
1.00--1.50	1	1.176
0.80--1.00	3	2.597
0.60--0.80	6	4.260
0.40--0.60	4	1.987
0.30--0.40	4	1.355
0.25--0.30	5	1.303
0.20--0.25	2	0.434
0.15--0.20	2	0.371
0.10--0.15	9	1.116
0.09--0.10	1	0.097
0.08--0.09	2	0.163
0.07--0.08	3	0.226
0.06--0.07	4	0.269
0.05--0.06	3	0.163
0.04--0.05	3	0.138
0.03--0.04	5	0.170
0.021--0.03	10	0.254
0.013--0.021	22	0.364
0.006--0.013	44	0.405
0.001--0.006	110	0.332
Totals ->	245	22.104

e)T=135^{0}C, after flotation

Dirt Content Histogram

Dirt Spot Size	Sample Count	Sample Area (sq.mm)
>= 5.000	4	60.491
4.00--5.00	4	17.882
3.00--4.00	2	6.493
2.50--3.00	1	2.514
2.00--2.50	1	2.346
1.50--2.00	3	4.884
1.00--1.50	8	9.909
0.80--1.00	7	6.224
0.60--0.80	8	5.584
0.40--0.60	16	7.815
0.30--0.40	8	2.830
0.25--0.30	6	1.665
0.20--0.25	10	2.251
0.15--0.20	6	1.030
0.10--0.15	16	1.849
0.09--0.10	4	0.378
0.08--0.09	7	0.606
0.07--0.08	5	0.389
0.06--0.07	7	0.457
0.05--0.06	13	0.679
0.04--0.05	6	0.258
0.03--0.04	12	0.398
0.021--0.03	23	0.568
0.013--0.021	43	0.715
0.006--0.013	88	0.835
0.001--0.006	333	0.932
Totals ->	641	139.982

f) T=145^0 C, after pulping



g)T= 145^0 C, after flotation

Figure 2. Results of the image analysis of handsheet obtained by the recycling of electrophotographic prints in relation to the temperature of the offset cylinder

The results show that the effectiveness of removing the specks decreases by the increase of the offset cylinder temperature.

On electrophotographic machines with liquid ElectroInk in the fourth phases is the first ink transfer. It is performed over the offset cylinder. By the activation of Pre Transfer Erase (PTE) the process of ink transfer begins. The emanation with PTS neutralizes the photoconductor surface which results in the possibility of discharging the negatively charged ink from the photoconductor on the positively charged transfer cylinder.

Sample	Number of specks removed by flotation [%]	Area of specks decreased by flotation [%]
T=125^0C	70,3	71,4
T=130^0C	63,7	79,6
T=135^0C	62,8	77,3
T=140^0C	37,2	58,2
T=145^0C	39.2	61,6

Table 3. Flotation effectiveness

In the first transfer the ElectroInk is brought into contact with the heated rubber blanket. At high temperature the Isopar evaporates which results in the change of the physical state of ElectroInk. From the liquid state the ElectroInk changes into the paste state.

The part of Isopar can be regulated in the paste ElectroInk by adjusting the temperature of the offset cylinder.

The second transfer follows, in which the ElectroInk on the transfer cylinder and the paper on the printing cylinder have to be brought in contact. In this contact the Isopar forms a thin oil layer among the pigment particles and the rubber blanket. The toner particles are pressed into the cold paper and the rest of Isopar evaporates completely.

In the contact of the toner particles and the paper there is the attraction by electrostatic forces as well as between molecular Van der Waals ones.

The described principle and the change of temperature in the defined area leads to the increased number and surface of specs in the phases of the pulping prints as it is presented in the table 4.

The results of the speck area in the table 4 and in the figure 1 explain the badly effectiveness of flotation in relation to the temperature of the offset cylinder. In the flotation is effective in the 10 to 100 µm range [14,15].

Sample	Total number of specks $>=0.04mm^2$	Total number of specks $>=5mm^2$	Area for specks >=5m m^2
T=125^0C	141	1	10,652
T=130^0C	148	2	12. 839
T=135^0C	158	3	22.645
T=140^0C	161	3	30.588
T=145^0C	142	4	60.491

Table 4. Number and the area of specks >=5 mm^2 after pulping in dependence on temperature of the offset cylinder

4. CONCLUSIONS

Based on the results of the image analysis of handsheet obtained from the fibres from the pulping process it can be concluded that by the increase of the offset cylinder temperature in the area from 125-145^{0}C the number and the surface of specks increase. The increase of the number of great specs was estimated, as well as of those in the area >=5mm^2. This is the cause of the worse flotation effectiveness which decreases with the increase of temperature from about 70% to 30%.

On the other hand, by the increase of the offset cylinder temperature in the investigated interval the gamut volume increases for about 49.967 space units which points at the greater reproduction quality.

Knowing that the indirect electrophotography printing is a complex process, with six separate, synchronous phases, the needs and characteristics of the graphic material, along with a number of factors in the field of chemical deinking flotation should be considered. In the further research the experimental design will be used and statistical models will be created to obtain information about optimising processes in the direction of environmental sustainability in this area.

5. REFERENCES

[1] Viluksela P., Pihkola H., Behm K., Wessman H., Pajula T., Changes in sustainability due to technology development in selected printing processes. In: Advances in Printing and Media Technology. Edlunds N., Lovreček M., (Eds.) IARIGAI, Darmstadt, 2008

[2] Bolanča I., Bolanča Z., Majnarić I., The Influence of the Digital Printing of Packaging on the Characteristics of the Recycled Fibers Proceedings on Internationale Digital Printing Conference, Amsterdam, (2005), 100

[3] Carre B., Deinkability of ink jet prints: a new challenge to solve, 3rd CTP Research Forum Recycled Fibres, Grenoble, 30-31 January 2001

[4]Recycled paper facts, http://beterpaper.nimg.com (29.02.2012.)

[5] Renner K., Deinkability of printing inks in: Recycled Fiber and Deinking, G□ttsching L., Pakarinen H., (Eds) Fapet Oy, 2000

[6] Fabry B., Pulping and ink detachment, 8th ATC Deinking, Grenoble, 29-31 May 2007

[7] Ayala C., Bleaching of deinked pulp, 8th CTP/PTS Advanced Deinking Training Course, Grenoble, 2007

[8] Theander K., Chemistry studies on surfactant properties relevant to flotation deinking, Vetenskap Och Konst, Stockholm, 2003

[19] Koffinke R.A., High-consistency slushing effective in deinking, contaminant removal, *Pulp and Paper*, 2004, **58**, 58-61

[10] Lassus A., (2000) Deinking Chemistry, In: Recycled Fiber and Deinking, Göttsching L., Pakarinen H., (Eds.), 241-266, Fapet Oy, ISBN 952-5216-07-1, Jyväskylä

[11] Fisher A., Digital prints-not all of them are deinkable, Ingede Seminar, Septembar, 2008, Vienna

[12] Ayala, C., Carre B., Recent progress in the deinking of HP-INDIGO prints, PTS/CTP Deinking Symposium, 2006

[13] Bolanaca Mirkovic I., Bolanca Z., (2005), Optical properties of deinked pulp, Journal of Imaging Science and Technology, 49(3) (2005)284-292

[14]McCool A., Silveri L., Removal of specks and nondispersed ink from a deinking furnish, *Tappi J.,* 1987, **79** (11)75-78

[15]Moss, C.S., Theory and reality for contaminant removal curves, *Tappi J.* 1997, **80,** (4), 6

6. CORRESPONDING ADDRESS

Assis.Prof.PhD. Ivana Bolanča Mirković
University of Zagreb, Faculty of Graphic Arts, Getaldićeva 2, 10000 Zagreb, Croatia, ibolanca@grf.hr