INCREASING THE EFFICIENCY OF DEINKING FLOTATION OF INDIGO PRINT

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The recycling process of the paper waste consists of four main processes:

- **disintegration** - preparation of the cellulose suspension of the waste paper in which the ink/toner particles are dispersed,
- **deinking cellulose suspension** by separating and removing the dispersed particles of ink/toner from the cellulose suspension,
- **bleaching the cellulose suspension** after deinking and
- **treatment of the processed water**.

In the paper industry two basic deinking processes are used:

(1) **flotation deinking**, selective process in which by blowing the air through the cellulose suspension in the flotation cell the particles of ink/toner collected in the form of froth, are removed and

(2) **wash deinking** where the particles of toner are removed from the cellulose suspension by washing them in great quantities of water.

1. Eksperimental part

1.1. Preliminary investigation of the processing possibility of sample in chemical agents otherwise used in deinking flotation

samples: unprinted substrate,

digital offset print,

conventional offset print

chemical agents: distilled water,

NaOH (pH=10),

H_2O_2 (pH=10),

enzyme preparation (α-amilase from *Porcine Pancreas*)

1.2. Chemical deinking flotation

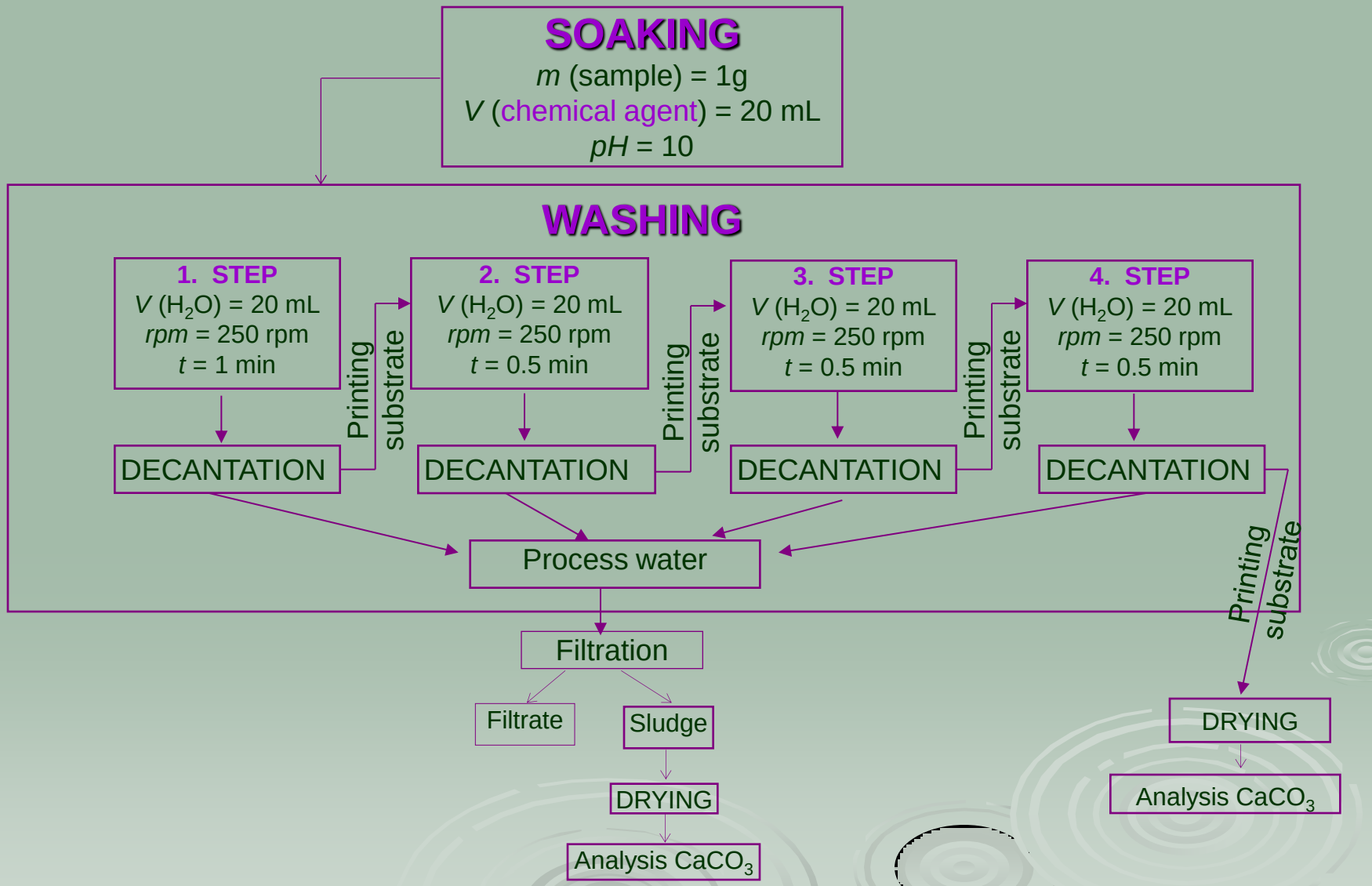
1.2.1. Deinking flotation without the sample pre-processing

1.2.2. Deinking flotation with the sample pre-processing

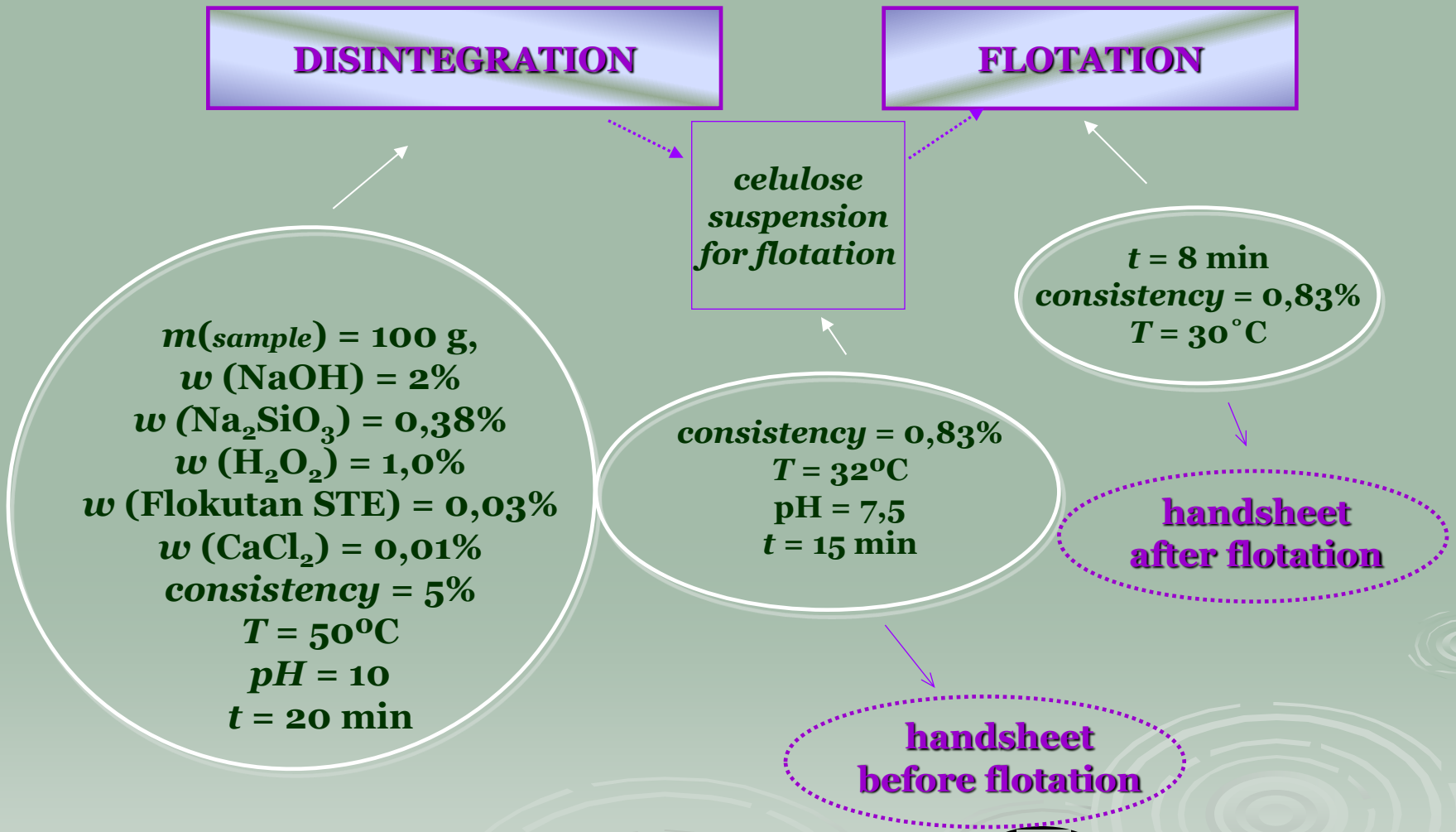
samples: digital offset print,

conventional offset print

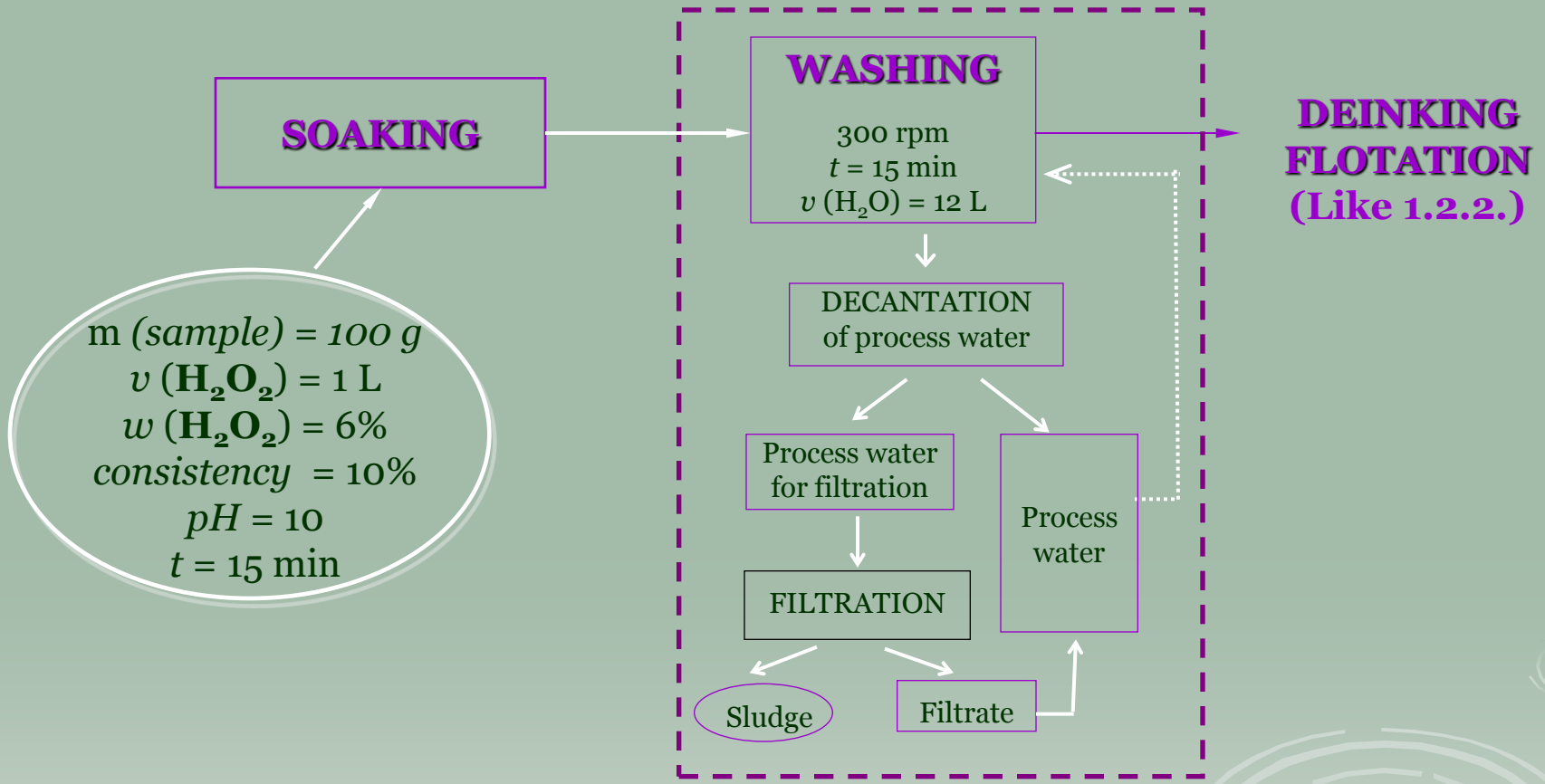
1.1. Preliminary investigation of the processing possibility of sample in chemical agents otherwise used in deinking flotation



1.2.1. Deinking flotation without the sample pre-processing

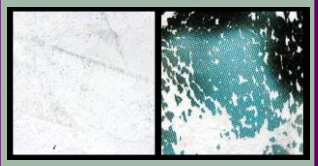
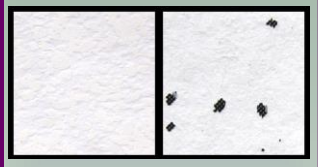
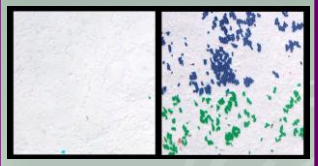


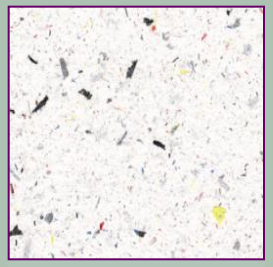
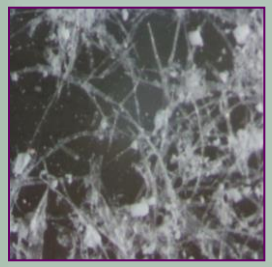
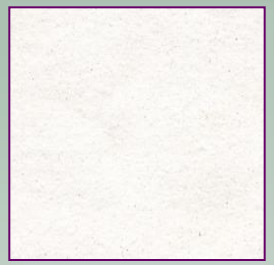
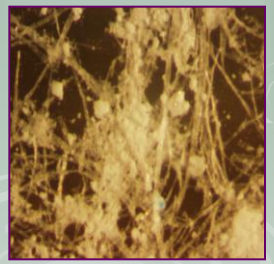
1.2.2. Deinking flotation with the sample pre-processing

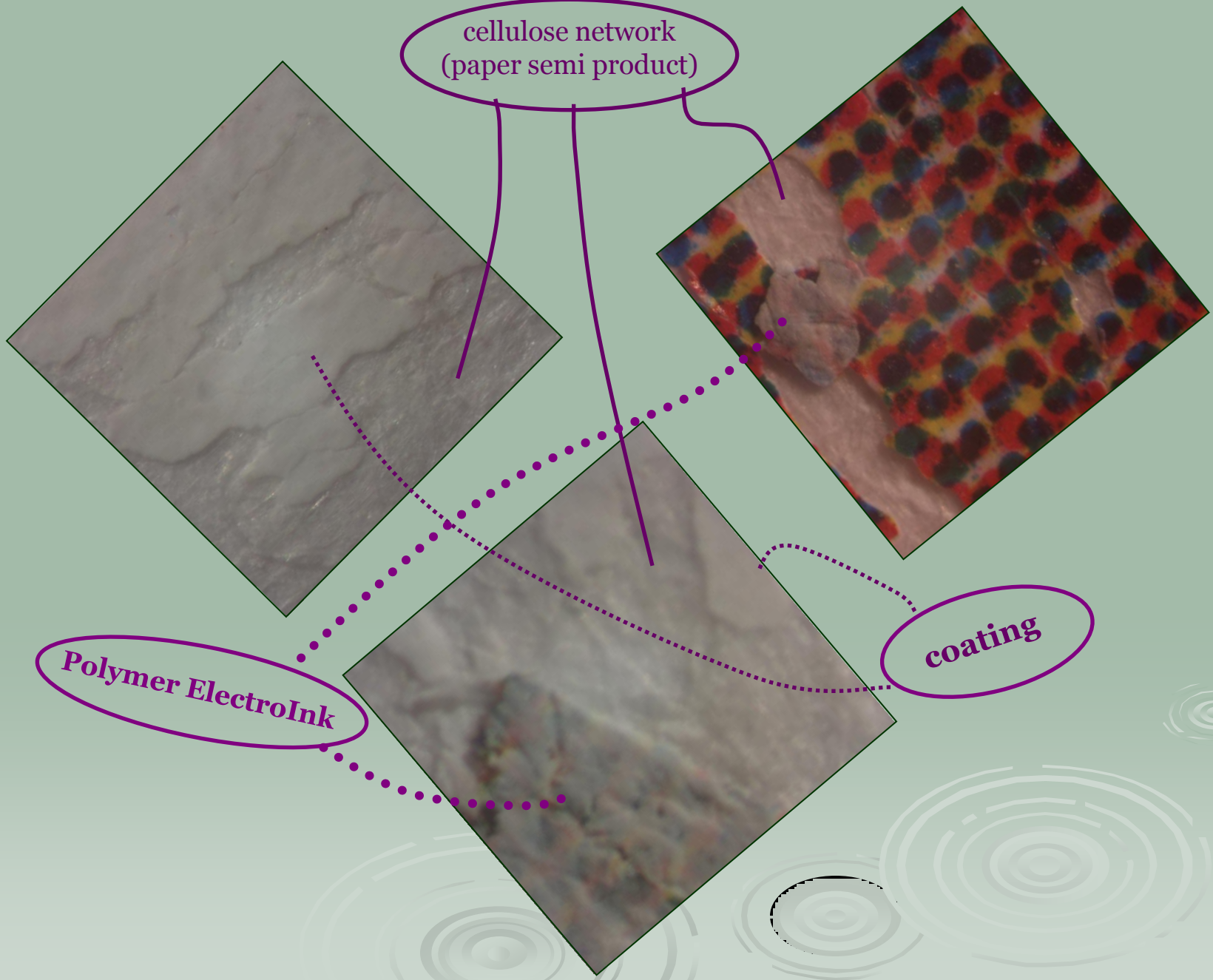


2. Results

Sample:	H_2O_2		NaOH		Distilled water		Enzyme preparation	
	Mass loss, %	w($CaCO_3$), %	Mass loss, %	w($CaCO_3$), %	Mass loss, %	w($CaCO_3$), %	Mass loss, %	w($CaCO_3$), %
Unprinted supstrate	31.6	16.5	27.5	20.1	23.2	22.0	14.8	28.7
Digital offset print	30.4	19.4	18.6	28.8	13.8	33.2	11.5	34.3
Conventional offset print	25.7	30.8	12.5	33.1	11.1	34.1	9.2	35.8

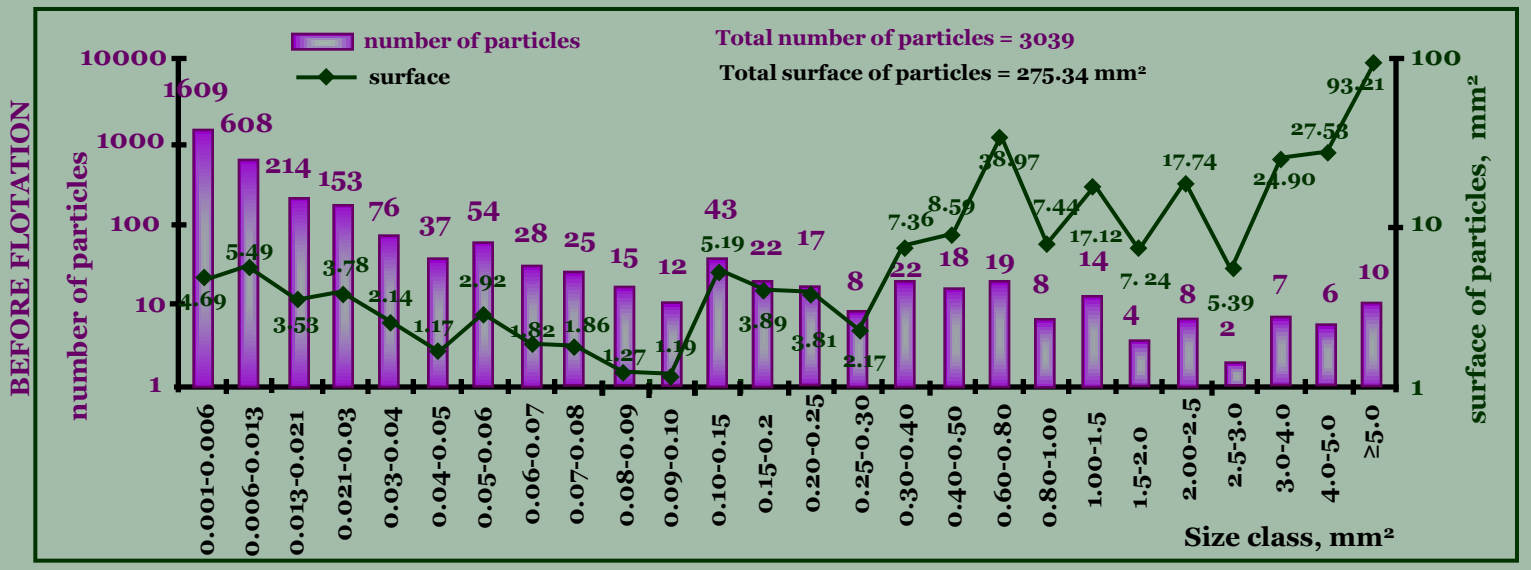
$c(H_2O_2)$, mol L^{-1}	Unprinted substrate		Digital offset print			Conventional offset print		
	Mass loss, %	$w(CaCO_3)$, %	Sample appearance	Mass loss, %	$w(CaCO_3)$, %	Sample appearance	Mass loss, %	$w(CaCO_3)$, %
0,016	26,5	15,3		25,3	23,5		19,3	32,0
0,032	31,0	15,9		30,4	19,0		25,7	29,3
0,064	35,0	15,3		32,0	15,0		26,1	25

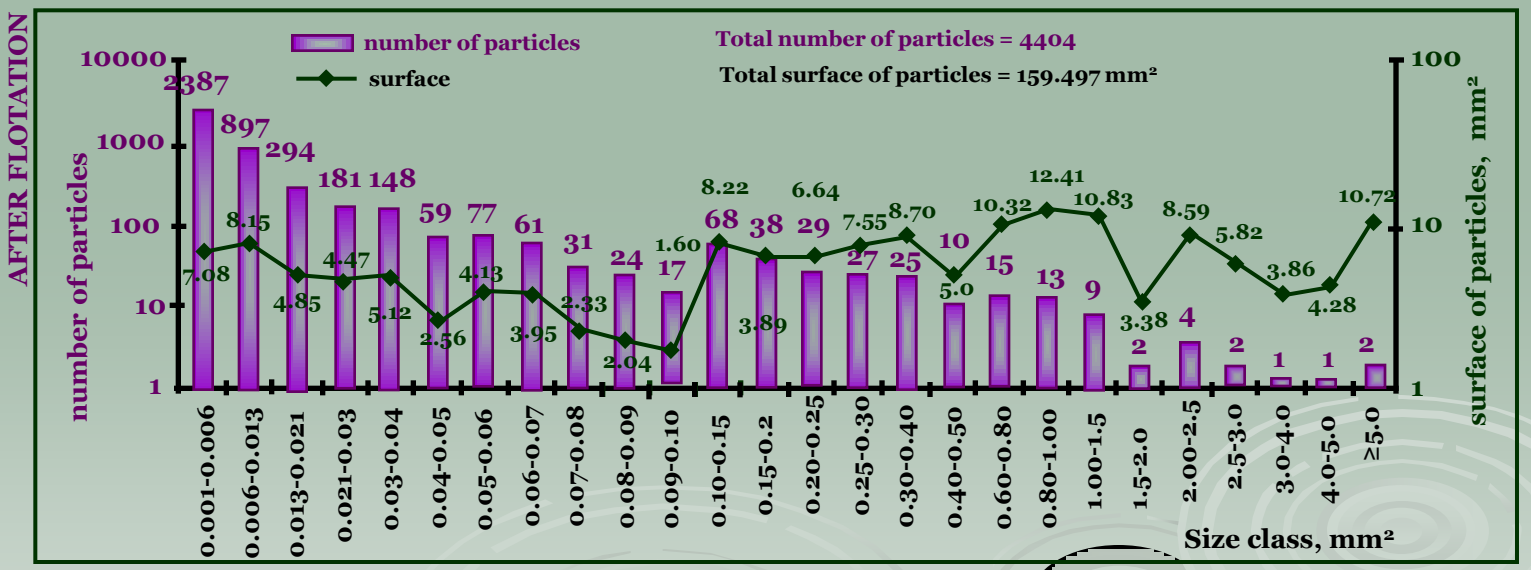
Offset print	Handsheets:						
	Before flotation			After flotation			
	Handsheet appearance	Total number of particles	Total area of particles, mm²	Handsheet appearance	Total number of particles	Total area of particles, mm²	Handsheet appearance taken with the electronic microscope, magnification of 60x,
Conventional		5274	44,30		159	1,47	
Digital		3039	275,41		4404	159,50	

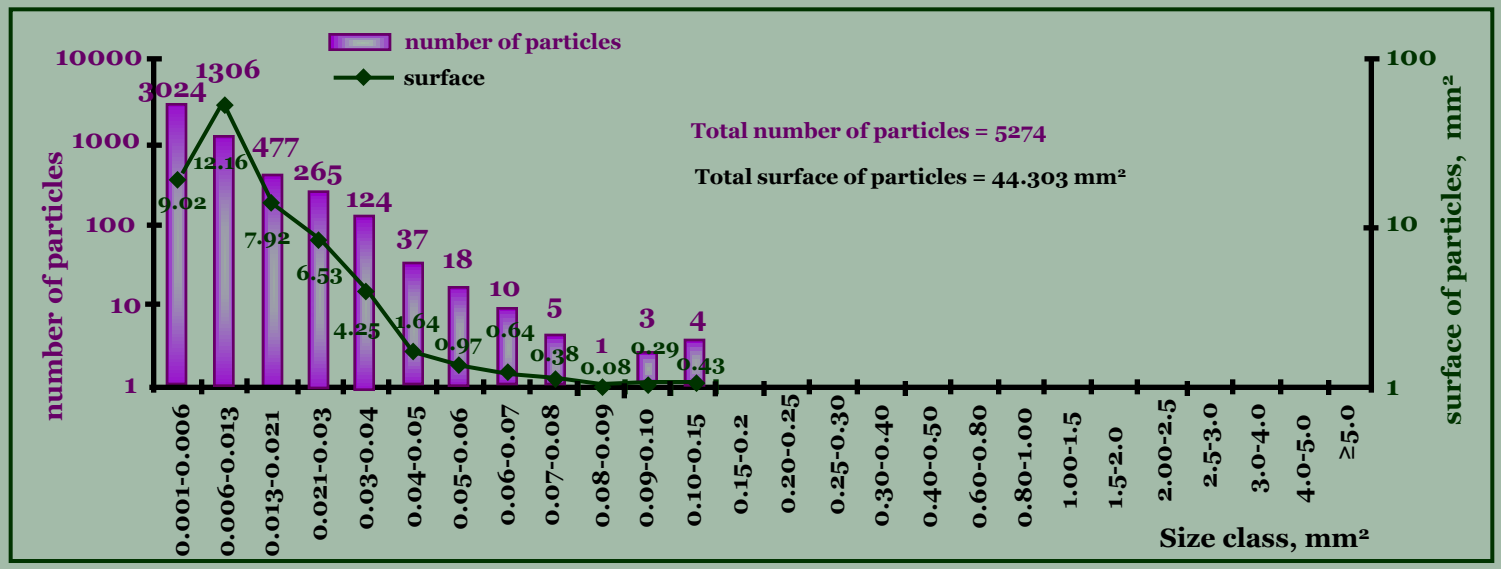

cellulose network
(paper semi product)
Polymer ElectroInk
coating

Polymer ElectroInk particles detached by pre-processing

DIGITAL OFFSET PRINT






number of particles
surface
Total number of particles = 5274
Total surface of particles = 44.303 mm²
number of particles
surface of particles, mm²
Size class, mm²
0.001-0.006
0.006-0.013
0.013-0.021
0.021-0.03
0.03-0.04
0.04-0.05
0.05-0.06
0.06-0.07
0.07-0.08
0.08-0.09
0.09-0.10
0.10-0.15
0.15-0.2
0.20-0.25
0.25-0.30
0.30-0.40
0.40-0.50
0.60-0.80
0.80-1.00
1.00-1.5
1.5-2.0
2.00-2.5
2.5-3.0
3.0-4.0
4.0-5.0
≥5.0

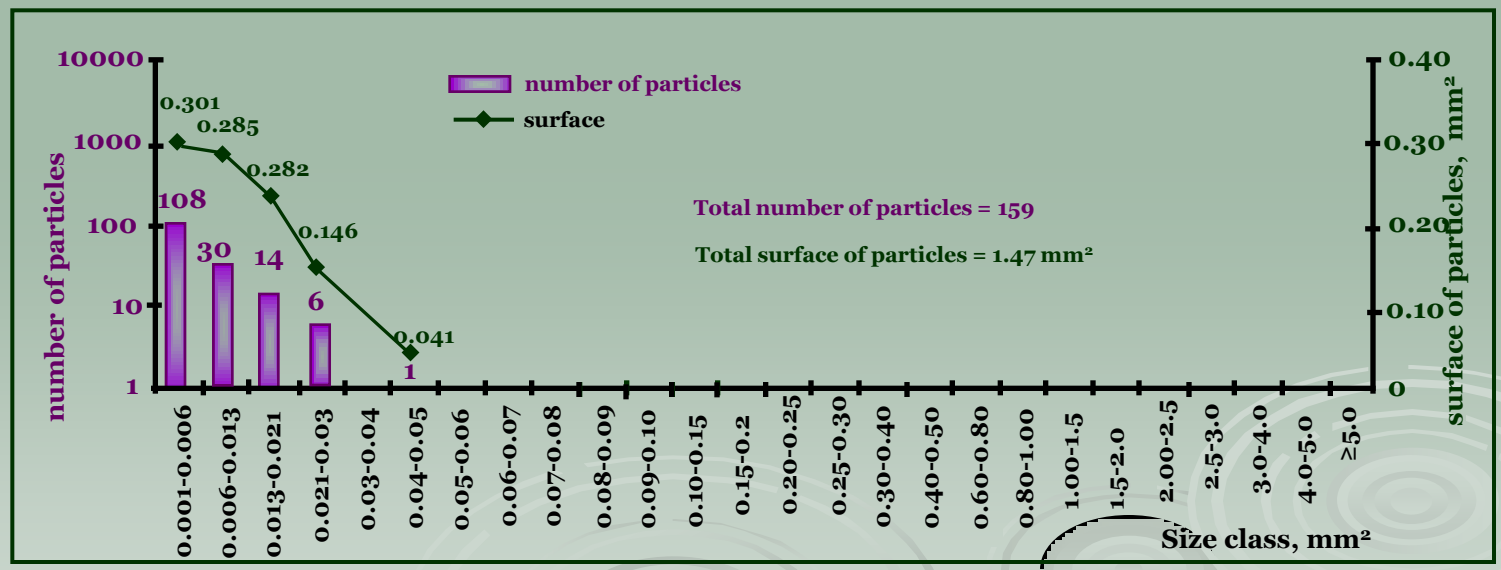
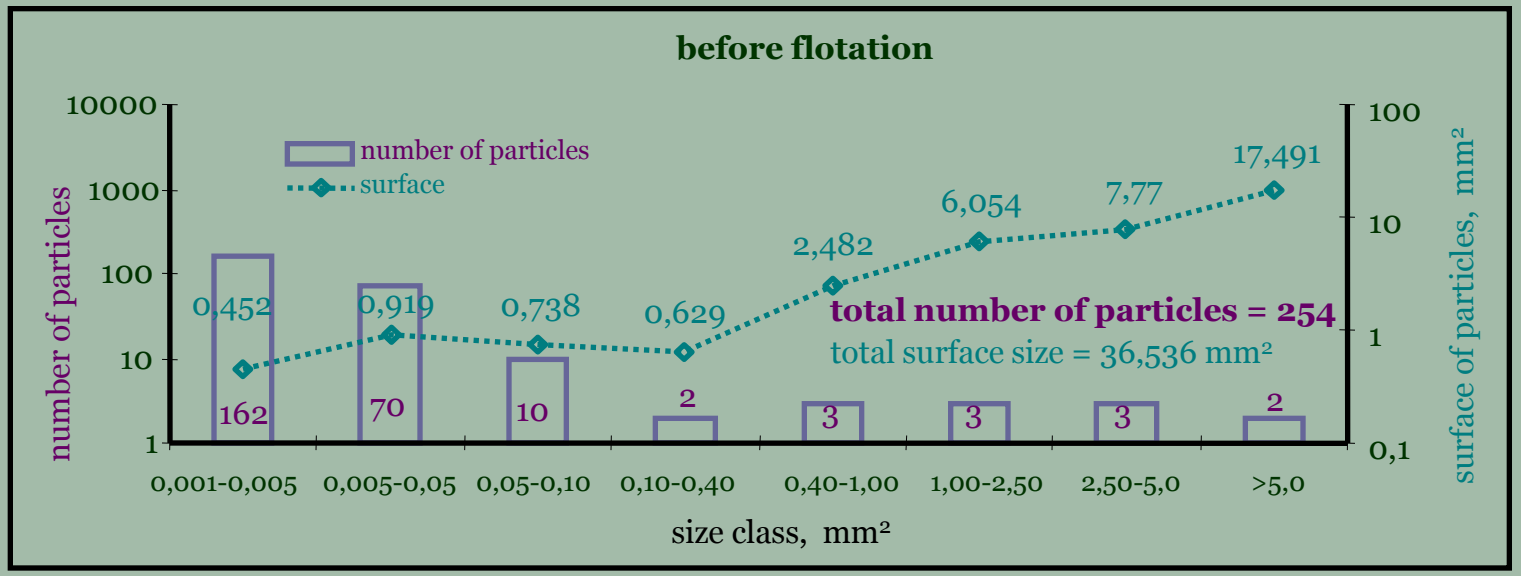
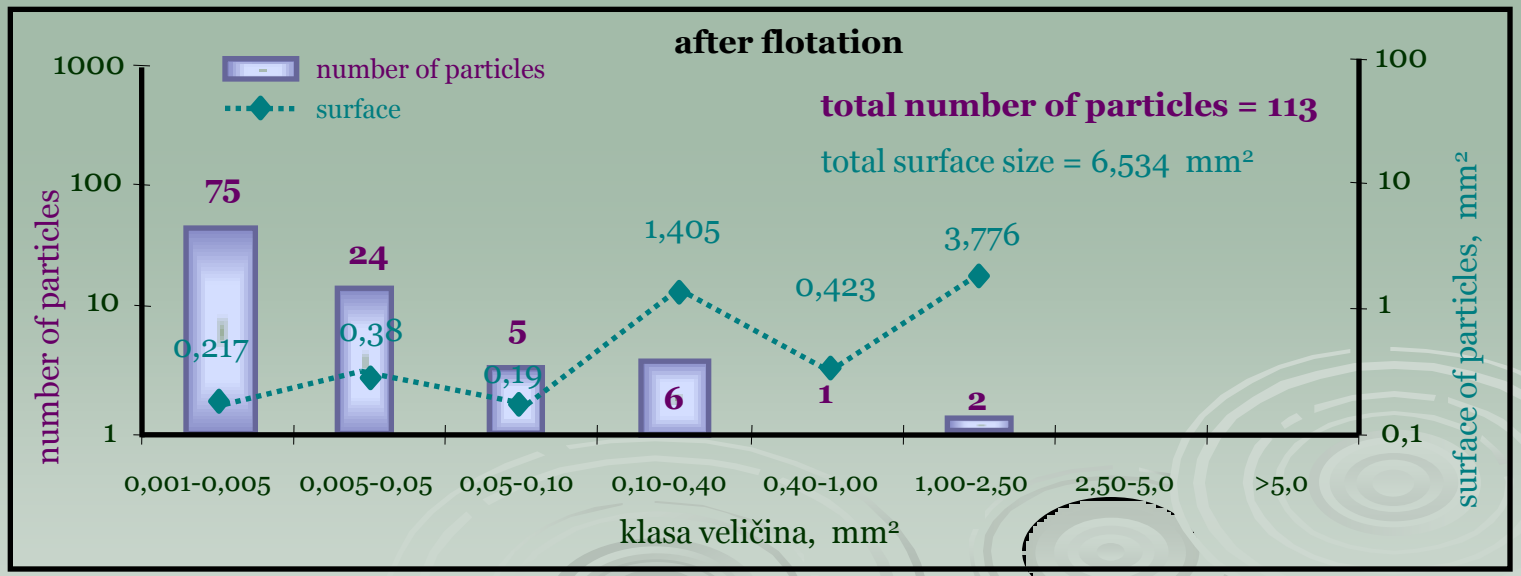
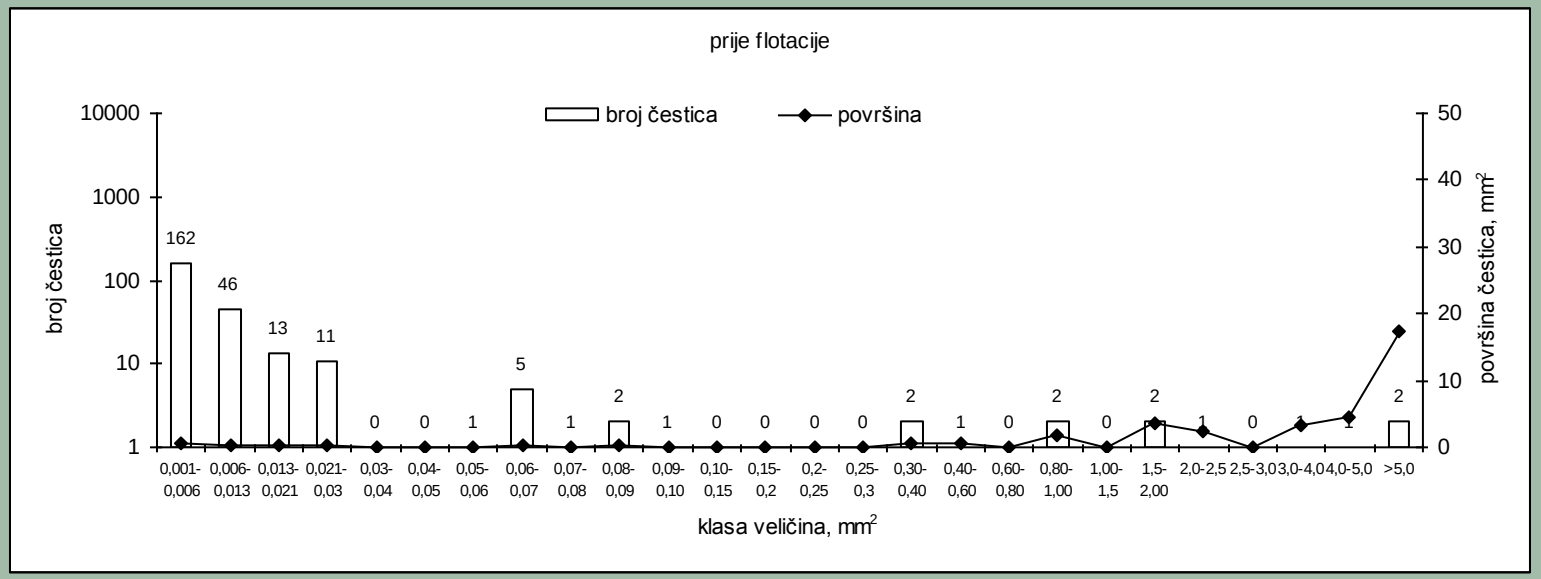
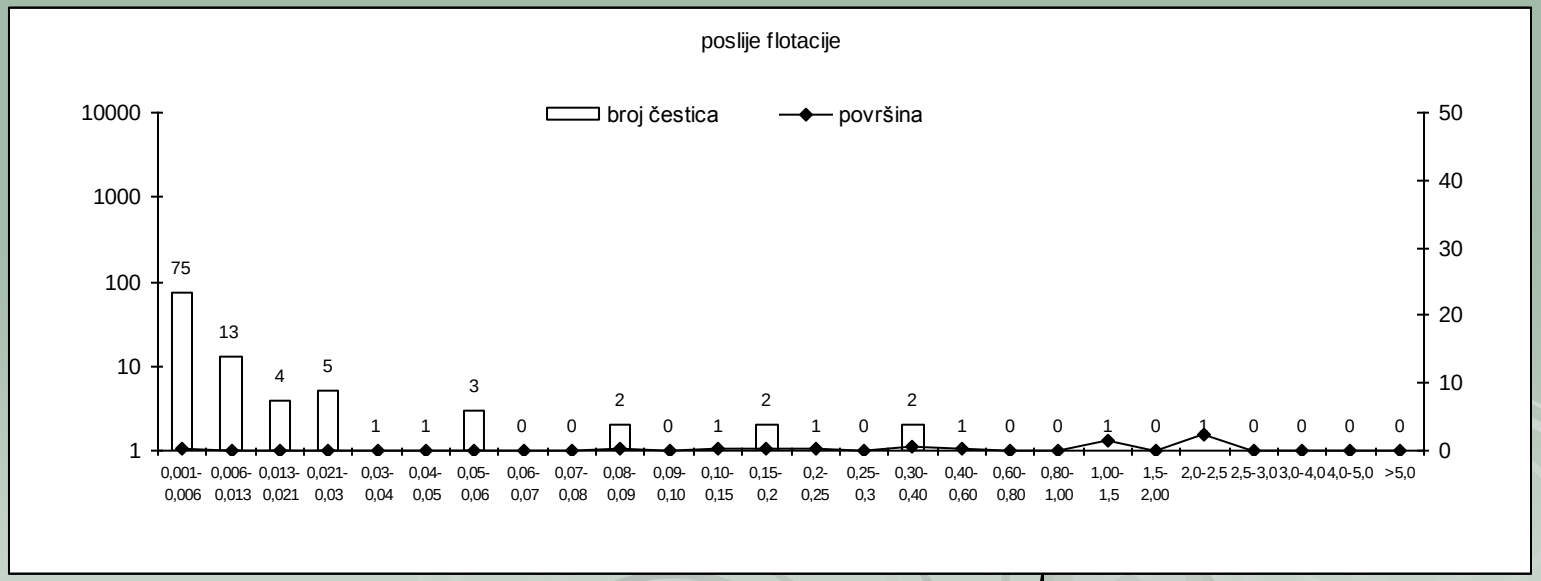

number of particles
surface
Total number of particles = 159
Total surface of particles = 1.47 mm²
number of particles
surface of particles, mm²
Size class, mm²
0.001-0.006
0.006-0.013
0.013-0.021
0.021-0.03
0.03-0.04
0.04-0.05
0.05-0.06
0.06-0.07
0.07-0.08
0.08-0.09
0.09-0.10
0.10-0.15
0.15-0.2
0.20-0.25
0.25-0.30
0.30-0.40
0.40-0.50
0.60-0.80
0.80-1.00
1.00-1.5
1.5-2.0
2.00-2.5
2.5-3.0
3.0-4.0
4.0-5.0
≥5.0

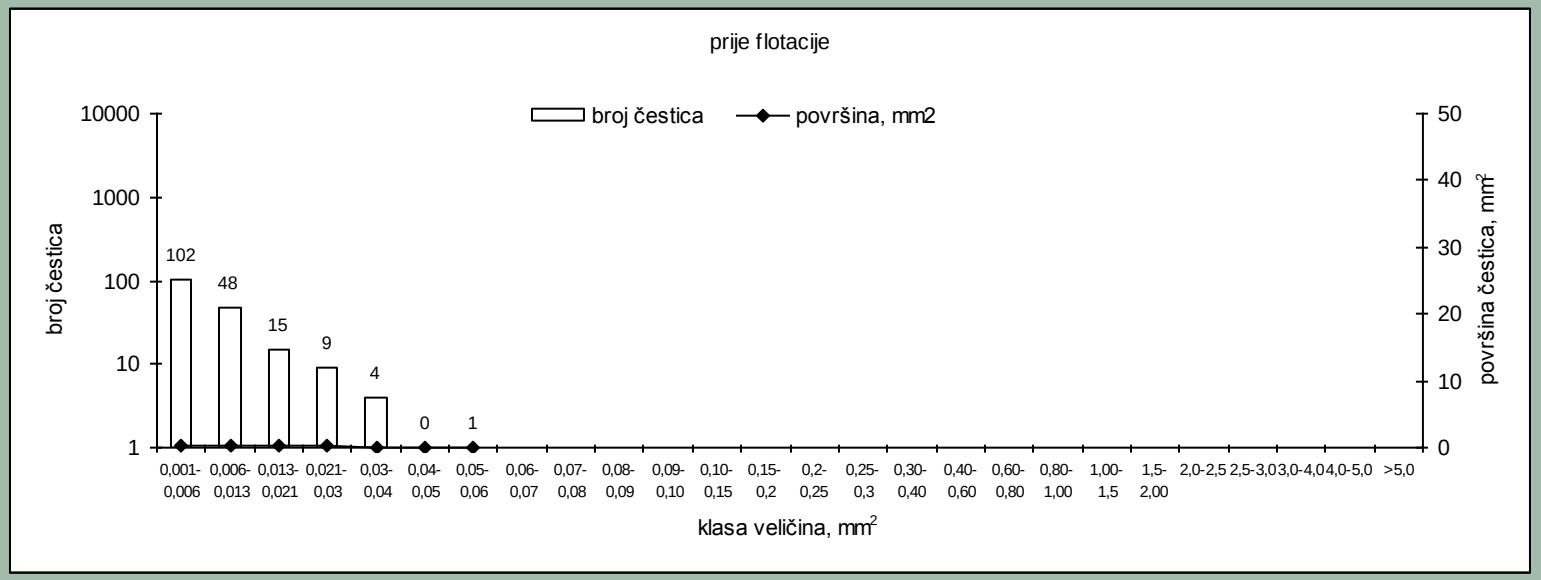
Image analysis of handsheets **(with the pre-processing of sample)**

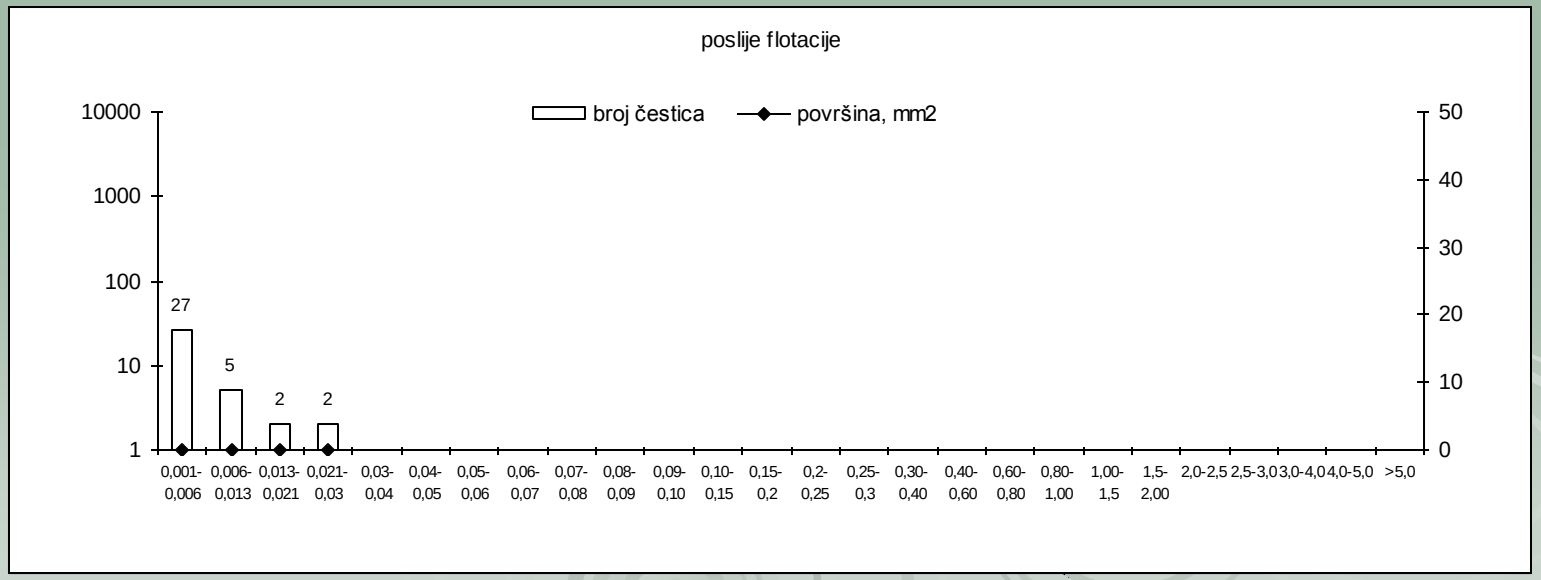





prije flotacije
broj čestica
površina
broj čestica
površina čestica, mm2
klasa veličina, mm2
10000
1000
100
10
1
50
40
30
20
10
0
162
46
13
11
0
0
1
5
1
2
1
0
0
0
0
2
1
0
2
0
2
1
0
1
1
2
0,001-0,006
0,006-0,013
0,013-0,021
0,021-0,03
0,03-0,04
0,04-0,05
0,05-0,06
0,06-0,07
0,07-0,08
0,08-0,09
0,09-0,10
0,10-0,15
0,15-0,2
0,2-0,25
0,25-0,3
0,30-0,40
0,40-0,60
0,60-0,80
0,80-1,00
1,00-1,5
1,5-2,00
2,0-2,5
2,5-3,0
3,0-4,0
4,0-5,0
>5,0


poslije flotacije
broj čestica
površina
10000
1000
100
10
1
50
40
30
20
10
0
75
13
4
5
1
1
3
0
0
2
0
1
2
1
0
2
1
0
0
1
0
1
0
0
0
0
0,001-0,006
0,006-0,013
0,013-0,021
0,021-0,03
0,03-0,04
0,04-0,05
0,05-0,06
0,06-0,07
0,07-0,08
0,08-0,09
0,09-0,10
0,10-0,15
0,15-0,2
0,2-0,25
0,25-0,3
0,30-0,40
0,40-0,60
0,60-0,80
0,80-1,00
1,00-1,5
1,5-2,00
2,0-2,5
2,5-3,0
3,0-4,0
4,0-5,0
>5,0


prije flotacije
broj čestica
površina, mm2
broj čestica
površina čestica, mm2
10000
1000
100
10
1
50
40
30
20
10
0
102
48
15
9
4
0
1
0,001-0,006
0,006-0,013
0,013-0,021
0,021-0,03
0,03-0,04
0,04-0,05
0,05-0,06
0,06-0,07
0,07-0,08
0,08-0,09
0,09-0,10
0,10-0,15
0,15-0,2
0,2-0,25
0,25-0,3
0,30-0,40
0,40-0,60
0,60-0,80
0,80-1,00
1,00-1,5
1,5-2,00
2,0-2,5
2,5-3,0
3,0-4,0
4,0-5,0
>5,0
klasa veličina, mm2


poslije flotacije
broj čestica
površina, mm2
10000
1000
100
10
1
50
40
30
20
10
0
27
5
2
2
0,001-0,006
0,006-0,013
0,013-0,021
0,021-0,03
0,03-0,04
0,04-0,05
0,05-0,06
0,06-0,07
0,07-0,08
0,08-0,09
0,09-0,10
0,10-0,15
0,15-0,2
0,2-0,25
0,25-0,3
0,30-0,40
0,40-0,60
0,60-0,80
0,80-1,00
1,00-1,5
1,5-2,00
2,0-2,5
2,5-3,0
3,0-4,0
4,0-5,0
>5,0

Conclusions

By processing the digital offset prints in the different chemical agents the impurities particles are detached from the printing substrate. The greatest detaching and impurities removal was obtained in alkaline solution of hydrogen peroxide.

Flotation deinking is not a successful process for removing the particles of polymer ElectroInk from the cellulose suspension of Indigo print.

Effectiveness of deinking flotation is increased with pre-processing of Indigo prints in alkaline solution of hydrogen peroxide. By soaking and washing Indigo print a considerable amount of impurities particles are removed. A part of residual impurities in pre-processed samples is removed by flotation.

Removal of impurities by pre-processing in handsheets before and after flotation decreases the number of ElectroInk particles and the share of ashes, and improves their mechanical properties.

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