DEINKING OF WASTE OFFSET PRINTED PAPER BY THE USE OF ENZYMES

ОБЕЗМАСТИЛЯВАНЕ ЧРЕЗ ИЗПОЛЗВАНЕ ЕНЗИМИ НА ОТПАДЪЧНА ХАРТИЯ С ОФСЕТОВ ПЕЧАТ

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Abstract. *Recycled waste paper is a raw material for the paper industry. One of the most important processes in the recycling of waste paper, for the ability to print, is deinking. One perspective and ecological method for implementing that is the flotation process with enzymatic treatment. The aim of this study is to investigate the deinking of secondary fibrous material, obtained from waste paper, by flotation of offset printed paper by the use of different types of enzymes - lipase, cellulase, amylase, xylanase, on the process of deinking by flotation. In this research are being investigated various proportions of enzymes, and combinations thereof with surfactants. Their ability of deinking is calculated. As a result the treatment of the secondary fibers with the enzymes, improves the papermaking properties. The improved recovery papermaking properties of secondary fibers by the effect of enzymes, is able to increase the number of cycles of use of waste paper and to improve some parameters of the paper produced from secondary fiber. The optical properties of the obtained deinked fiber material are investigated and the possibilities for its usage in the composition of various types of paper and paperboard.*

Keywords: WASTE PAPER WITH OFFSET PRINTING, SECONDARY FIBROUS MATERIAL, ENZYMATIC DEINKING, FLOTATION

1.Introduction

The use of recycled fiber material for the production of paper and paperboard has a significant share of solving the problems of environmental protection and saving energy by reducing energy costs. The increased usage of waste paper is supported by the strengthened measures in environmental law in many countries, rising prices of energy, water and the territory for waste storage. The need for waste paper in the manufacturing process of various paper and paperboard types in the world will continue. Recycled waste paper is one of the most important raw materials for the paper industry. It represents about 50% of fibrous raw material used in the production of paper and paperboard. [1,2]

Traditionaly the deinking of waste paper, by alkaline chemicals and surfactants, leads to contamination of the waste water and high price for their treatment. One perspective method for the deinking of waste paper by flotation method is enzymatic treatment, leading to a modification of the cellulose fibers. The improved regeneration properties of the secondary fibers is capable of increasing the number of cycles of usage of waste paper and of improvement of some parameters of the paper produced from secondary fibers. Among the advantages of enzymatic deinking is the neutral pH of the suspensions, also less consumption of chemicals, reducing energy costs, improving recycling of the fibers. According to their specificity enzymes attack the surface of the fibers or the ink and the main mechanism is based on the weakening of the link fiber-ink removal of fiber. The positive effect of the enzyme can be explained by the destruction of the binders in the printing ink by hydrolysis and de-polymerization.[3-5]

The aim of this experiment was to study the de-inking of waste offset paper by flotation with the usage of different enzymes. The used waste paper is 70 g/m^2, with offset printing. The used enzymes are lipase, cellulase, amylase, xylanase and surfactants. The waste offset printed paper is subjected to a feathering flotation in the presence of enzymes. After the flotation a paper samples were obtained.[6]

2. Materials and methods

For straightening out the interactions the following materials and methods were used.[7]

- Waste Paper - 70 g/m^2, with offset printing.
- Reagents:
• Lipase - Lipase, Biovet Joint Stock Company
• Cellulase - Cellulase
• Amylase - BAN, Novo
• Xylanase - Xylanase, Biovet Joint Stock Company
• Surfactant - Tween 80, Sigma Aldrich

The waste paper with offset printing is subjected to a slushing in laboratory vertical pulper, then in a disintegrator at a concentration of 2%. The de-inking of the paper suspension is carried out by flotation with enzymes in the flotation cell. From the deinked fiber suspension paper samples are obtained in laboratory paper machine Rapid Köthen. The optical and physical-mechanical properties of paper samples are examined. The deinking ability is observed following the equation:

$$\text{Deinking ability} = \frac{B\ treated - B\ untreated}{B\ untreated} . 100$$

$B_{treated}$ - brightness of the treated sample, %

$B_{untreated}$ - brightness of the untreated sample, %

3. Experimental

The composition of the suspensions for the flotation and the obtained paper samples are shown in Table 1.

Table 1: *Composition of the samples*

Name of sample	Waste Paper, g	Surfactant %	Lipase %	Cellulase %	Amylase %	Xylanase %
Surf. 0,3	70	0,3	-	-	-	-
Surf + L 0,1	70	0,3	0,1	-	-	-
Surf.+ L. 0,3	70	0,3	0,3	-	-	-
Surf.+ Cell. 0,1	70	0,3	-	0,1	-	-
Surf.+ Cell. 0,3	70	0,3	-	0,3	-	-
Surf.+ A. 0,1	70	0,3	-	-	0,1	-
Surf.+ A 0,3	70	0,3	-	-	0,3	-
Surf + X 0,1	70	0,3	-	-	-	0,1
Surf + X.0,3	70	0,3	-	-	-	0,3
Surf.+L+Cell+ A+X ,[0,1]	70	0,3	0,1	0,1	0,1	0,1
Sample without Surf.	70	-	-	-	-	-

1. Microscopic analysis

The results from the microscopic analysis of the waste offset paper are shown on Fig.1 and Fig.2 It is well visible, that the composition of the paper is from 85-90% bleached hardwood pulp from beech and oak wood and 10-15% of bleached softwood pulp from pine and spruce wood.

Fig.1 *Microscopic picture of fiber from beech hardwood pulp*

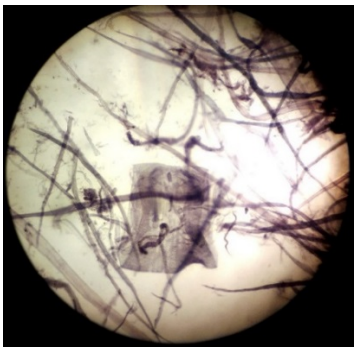

Fig.2 *Microscopic picture of fiber from oak hardwood pulp*

2. Study the degree of Brightness of the paper samples.

The degree of Brightness of the samples is presented on Fig. 3. From the figure it can be concluded that the brightness is increased in all the samples after the process of flotation. For all the examined samples with different consumption of the enzymes, the brightness increases with the increasing of the concentration of the enzymes in the suspension. The lowest results of improving the brightness of the samples are obtained during the flotation of the suspension with the enzyme amylase. The best results for the brightness of the samples are achieved in the sample flotated with the combination of four enzymes, due to the synergistic effect of the enzymes.

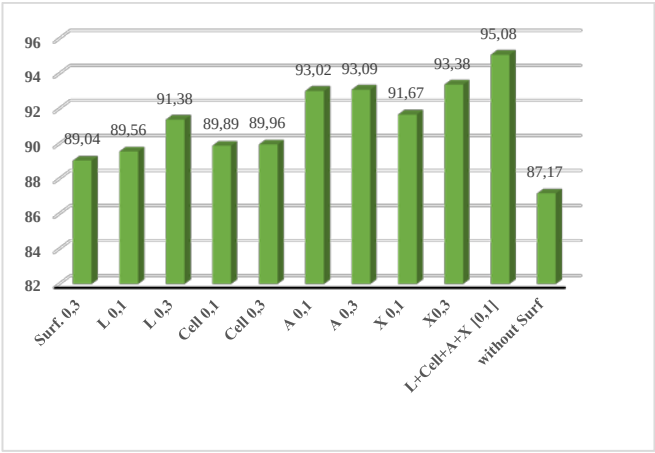

Fig. 3 *Degree of brightness in ISO Brightness of the samples [%]*

3. Study the degree of opacity of the paper samples.

On Fig.4 is shown the second examined optical property of the paper samples. It is visible that there is no significant change for this parameter. Better results are obtained when flotation is carried out with enzymes lipase, cellulase and xylanase with consumption of 0.1%. The lowest values are obtained with the 0.3% xylanase.

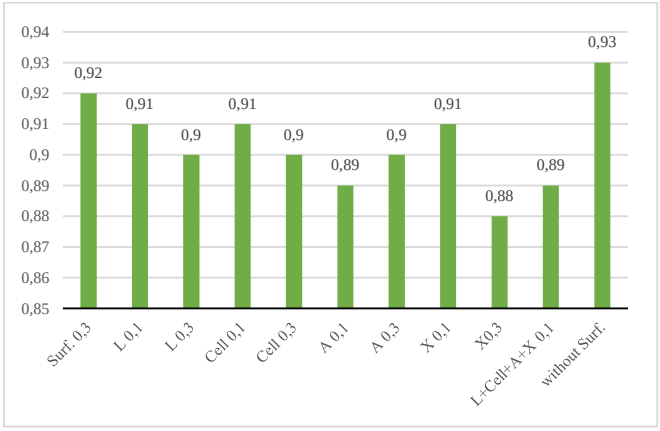

Fig. 4. *Opacity ISO 2471:2000 [%]*

4. Physical-mechanical properties of paper samples

4.1 Tensile strength

This parameter depends primarily on the amount and strength of the bonding forces between the fibers in the finished paper sheet and according to the results, shown on Fig.5, the enzyme cellulose with consumption of 0,3 % gave the highest increase of this parameter according to the paper samples without enzyme.

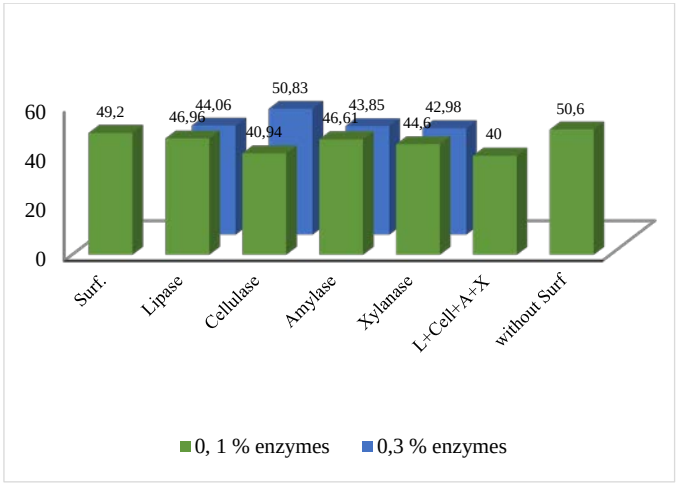

Fig. 5. *Tensile strength of the paper samples [Nm/ g]*

4.2 Burst resistance

The burst resistances of the paper samples are shown on Fig.6. This parameter depends primarily on the structure of the obtained paper samples, there for practically the consumption and the type of the enzyme for the flotation of the suspensions does not change the burst resistance of the paper.

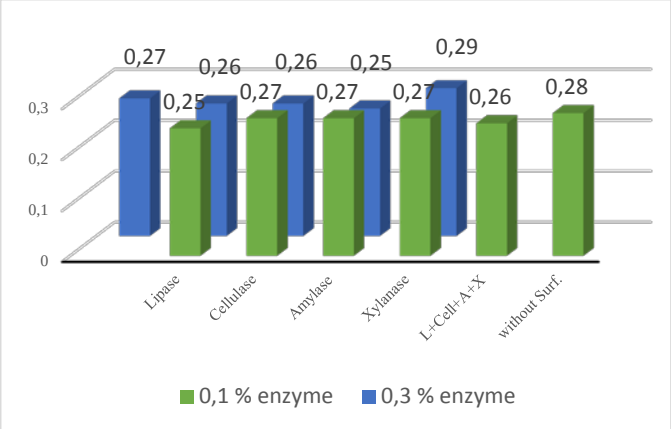

***Fig. 6**. Burst resistance of the paper samples [KPa.m^2/g]*

4.3. Tear resistance

The parameter tear resistance depends primarily on the strength and the nature of the fibers, which formed the obtained paper. As it is shown on Fig.7 the lowers effect of the flotation, over this parameter, is when using the enzyme cellulase, xylanase and the combinations of four enzymes. Most likely, this is due to the shortening of the cellulose chain and the length of the fibers.

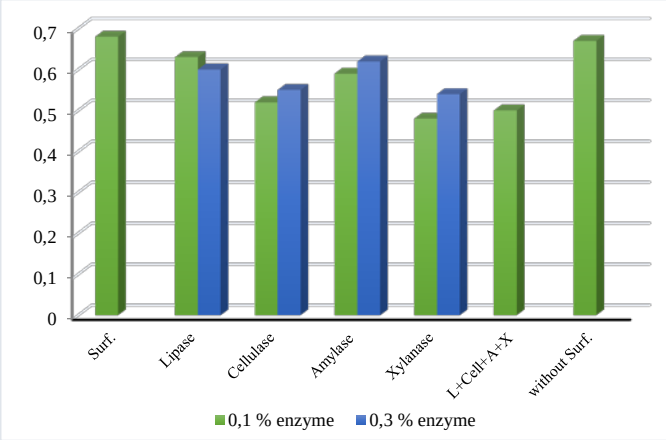

***Fig. 7**. Tear resistance of the paper samples [mNm2/g]*

5. Deinked ability

The results of the calculated deinking ability are shown on Fig.8. All the samples are with positive deinking ability. Lowest deinking ability has the enzyme lipase with consumption of 0.1% - 0.58%. With the increasing the enzyme consumption, the positive effect over the deinking ability is enhanced. Most significantly, it is observed when is used the enzyme lipase (0.58%-4.87%) and xylanase (2.95%- 4.87%). With best deinking ability is the sample which is in combination with the four enzymes - 6.78%. For the samples treated only with one enzyme, it is visible that most effective is the enzyme amylase. The samples treated with the enzyme lipase and xylanase is observed same deinking ability at a concentration of 0.3%.

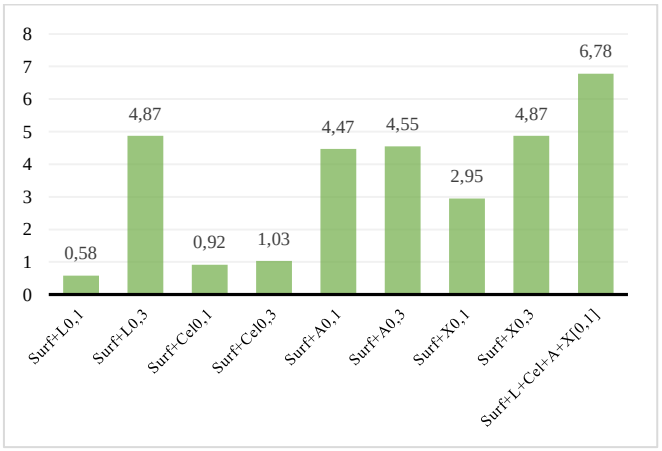

***Fig. 8.** Deinking ability, %*

4. Conclusion

On the basis of the experiments, which were carried out through the deinking of waste paper with offset printing, by flotation in the presence of enzymes - amylase, cellulase, xylanase, lipase, and combinations of them with surfactants, we can make the following conclusion: The results show that the usage of different enzymes do not change significantly the physical-mechanical properties of the paper, although the best results are obtained with the enzyme amylase at a consumption of 0,1%. The study over the optical properties of the paper samples shows that the highest values for the brightness are obtained during the flotation with a combination of the four examined enzymes. The obtained and examined secondary fibrous material can successfully be used in the composition of various types of paper.

5. Referenses

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