Volume 2, Issue 12, December - 2024 **ISSN (E):** 2938-3811

RECYCLING PROCESS OF SECONDARY FIBER WASTE

Anvar Abdumajidov
Abdumalik Miratayev
Kholboyeva Aziza
Tashkent Institute of Textile and Light Industy, Tashkent, Uzbekistan
anvarshohv@mail.ru

Abstract
Currently, the demand for environmentally friendly products made from natural resources is increasing sharply. This requires rational use of natural resources, finding new sources of resources and recycling natural resources out of circulation. Taking into account the above, this article is devoted to the results of research on the processing of secondary fibrous waste, that is, waste paper. MC-3 waste paper is a high-quality secondary resource, as it consists of books, magazines and archival papers, but the presence of typography paint in it limits the possibility of using this secondary raw material. The results of the research presented in the article are the conversion of fatty-waxy substances, which are considered as binders of typography paint in MC-3 waste paper, into a soluble state by the alkaline boiling method, and by emulsifying the dissolved binders under the action of surfactants, from the fiber composition. The process of removing oily-waxy substances from secondary fiber waste by making them soluble was checked by the capillarity of the paper samples taken from it, the effect of the alkaline boiling process on the mechanical strength of secondary fiber waste was controlled by the degree of polymerization of the raw material.

Keywords: Waste paper, alkali, typography paint, capillarity and degree of polymerization.

Introduction

In today's world, the use of secondary fibers in the pulp and paper industry is developing rapidly. The main reason for this is the economic advantage of recycling paper products. Researches [1] have developed rational ways of the processes of increasing the physical and mechanical properties of secondary fibers and bringing them closer to the properties of primary fibers.

Using waste paper means saving the main raw material that is cellulose. By processing two tons of waste paper, 6÷8 m3 of wood can be saved. Waste paper recycling means not only saving valuable raw materials, but also saving the environment. Because the paper in the waste room does not pose a direct threat to living organisms, but paper waste burns easily, and as a result, the environment is poisoned by the burning of other wastes around.

Cellulose fibers are subjected to intensive effects of water, pressure and temperature during the papermaking process of the paper casting equipment, as a result of which physico-chemical and structural changes occur. Because of this, these fibers lose some of their papermaking properties. However, the modern technology of processing waste paper and making paper pulp allows them to be "reanimated" in the literal sense. The lost papermaking properties of

Web of Scientists and Scholars: Journal of Multidisciplinary Research

Licensed under a Creative Commons Attribution 4.0 International License.

reanimated fibers are restored by adding high-performance binders to the paper composition. In world practice, the principle possibility of obtaining high-quality paper products containing a significant amount of waste paper, in particular, types of printing paper, has been proven.

In 1960, newsprint production from 100% improved waste paper pulp was started in New York. By 1997, more than 800 improved waste paper pulp production systems were put into operation around the world. The large number of technological schemes requires their division into classes:

1. By the type of technology used to improve the quality of pulp fiber (washing, flotation or a combination of both);
2. According to the number of technological cycles and water use in the corresponding scheme (from one to three).

In recent years, two-cycle systems have been proposed for the extraction of waste paper fiber with improved quality. In addition, there are three-cycle systems for the production of high-quality waste paper pulp from low-quality waste paper. It should be said that all systems have decolorizers, with the help of which contaminated filtrates are cleaned. Purification of filtrates allows them to be reused in production cycles.

The disadvantage of the method is that the ash and paint particles are not completely removed from the mass when waste paper fiber is prepared according to one-cycle schemes based on flotation. In the three-cycle scheme, complete removal of random waste from the mass is achieved.

Dispersion and bleaching in two stages, as well as flotation in the third stage, are unique aspects of the three-cycle production technological scheme.

It should be said that the quality indicators of improved waste paper fiber prepared by the three-cycle scheme from mixed waste paper raw materials of a certain quality office are very similar to the quality indicators of primary fiber (mechanical pulp and technical cellulose). similarity has been determined [2].

In addition to improving the quality of waste paper fiber, economical use of electrical energy and chemicals in the implementation of the technological process is also an important factor [3].

The study of the possibilities of obtaining waste paper mass with improved quality based on the scheme, which includes waste paper processed semi-dry in the disperser instead of the standard wet method, is reflected in the work [4]. Effective conditions for separation of semi-dry waste paper into fibers have been determined. Different parameters of waste paper processed by the semi-dry method than the mass processed by the wet method were determined. The expediency and possibilities of replacing the traditional wet processing of waste paper with semi-dry processing are shown. This allows to significantly simplify the technological scheme of its processing.

Scientists [5] have patented a method of removing impurities from paper pulp. This method involves the removal of large particles, the filtration of fines and the removal of typography ink by flotation. By introducing the eDlP system into the technological process, it allows to automate it, to increase the production efficiency of the system by 10%, to stabilize the

Licensed under a Creative Commons Attribution 4.0 International License.

whiteness indicators, to reduce the amount of waste, to reduce the consumption of chemical reagents and electricity.

In order to evaluate the paper-making properties of the pulp suspension, an indicator that determines the level of water retention can be used. The higher the water holding capacity of the pulp fiber, the higher its paper-making properties. The paper-making properties of waste paper fibers can be improved by hydro-thermal treatment with low concentration alkali. Thanks to hydro-thermal processing, the life of ordinary paper can be extended to 6-7 cycles instead of 4-5 times. This, in turn, has a significant economic effect [6].

In order to expand the possibilities of using secondary fibers in the production of types of writing and printing papers, improving the process of waste paper processing is the main direction of the modern technology of waste paper processing. At the threshold of the 21st century, the share of secondary fibers in the world raw material base for the production of types of printed papers was 10-12%.

In the legislation of a number of Western European countries, North America and Japan, tax incentives are provided for paper production enterprises using waste paper, and the federal legislation of the United States defines certain plans for the production of newsprint using waste paper. Most enterprises in Europe, North America, South-East Asia produce newsprint from 100% waste paper, secondary fibers are included in some types of coated paper [7].

According to the description of the influence of printing papers on consumer properties, waste paper is close to wood pulp. Adding waste paper to the paper composition increases its porosity and therefore decreases its mechanical strength. However, the degree of impact and its description depends on the origin and composition of the waste paper, as well as the composition of the paper mass into which the waste paper is fed. For example, the introduction of waste paper into the pure cellulose mass leads to a decrease in the mechanical strength of the paper, an increase in its susceptibility to dust, and a decrease in the resistance of the surface to abrasion. On the contrary, when adding pure cellulose paper waste to the composition consisting mainly of wood pulp, the mechanical strength indicators increase, the abrasion resistance of the surface is improved, dusting is reduced.

In order to increase the strength of the paper, it is recommended to process the short-fiber fraction with amylase, and the long-fiber fraction with lipase. By adding chemical reagents to the paper pulp, the defects of printed papers containing waste paper can be eliminated. For example, in world practice, the loss of mechanical strength of paper is compensated by the use of hardening polymer compositions, negative situations associated with the presence of printing ink particles dispersed in the mass are eliminated by the use of shielding effects created by the use of special pigments.

In the modern global industry of pulp and paper production, the secondary fiber obtained from waste paper has become competitive in terms of its quality and scope of consumption compared to the primary semi-finished product obtained from wood. Currently, special recycling of waste paper has several challenges. Researches have been carried out on pre-determining and evaluating the characteristics of waste paper pulping by hydromechanical method [8].

Licensed under a Creative Commons Attribution 4.0 International License.

In the researches, it was planned to improve the quality of MC-3 waste paper to produce printing and writing paper from it. It is known that MC-3 waste paper consists of books, magazines and archival papers, and to return it to the main process, it is necessary to remove the typography paint on the surface, decolorize and whiten the mass.

From the analysis of the literature, it was found that it is a multi-component system in the preparation of typography paint. It is required that the printing ink does not penetrate deep into the paper and dries quickly. For this purpose, typography paints are made mainly based on typography fonts. The composition of the paint can be different depending on the purpose for which it is used. For example, when printing a newspaper, liquid paint is used, taking into account the fact that the paint dries quickly, and when printing books, somewhat darker paints are used. In the preparation of all types of typography paints, wood resin and soap are added to the oil. In the literature, the composition of typography paint is given as follows: typography oil - 50 kg, wood resin - 10 kg, black powder - 12 kg, soap - 1 kg, color pigments - 250 grams. It contains oleic oil, which acts as a barrier. In order to extract the typography paint from the waste paper mass, it is first necessary to break up the film-forming component. So, the olif contained in the paint is an oily-waxy substance, and by converting it to a soluble state, it is possible to clean the mass of waste paper from typography paint. It is known that fatty-waxy substances do not dissolve in water, their composition consists of high fatty acids, and they become soluble under the influence of alkali.

Methodical part. The object of this study is MC-3 waste paper. MC-3 waste paper includes books, magazines and archival papers, i.e., typographic ink-storing waste. The degree of polymerization of the raw material and the capillarity of the paper castings obtained from it were selected as quality indicators after the processing of the secondary fiber waste. The degree of polymerization of secondary fibrous waste was determined according to the international standard ISO 1628-1:2009. The capillarity of paper castings was determined according to the international standard ISO 8787-86. According to research methods, the boiling process was carried out in the conditions of an alkaline environment with a pH of 9÷11, at a temperature of 40÷90 ^{o}C, for 20÷90 minutes.

Research results and their discussion. In the research, the waste paper mass was treated in an alkaline environment in order to transfer the typography paint to a soluble state. At the first stage of the process, the paper-waste paper first boils, then absorbs alkali, and at the next stage, a chemical reaction occurs between caustic alkali and fatty substances. At a high temperature, in an alkaline environment, the waste paper swells, and the average size of its pores increases several times, and the diffusion of fatty substances in the typography ink becomes easier. Under the influence of alkali, waxy substances are hydrolyzed and sodium salts of fatty acids are formed.

$$R - COOH + NaOH \rightarrow R - COONa$$

The effectiveness of printing ink removal from waste paper pulp under the influence of alkali was evaluated by the degree of polymerization of the castings made from it.

Licensed under a Creative Commons Attribution 4.0 International License.

For this, the boiling process was carried out in different concentrations of alkali. Based on the results of the experiment, the temperature of the printing ink extraction process from the waste paper mass was taken as 90^0C, and the duration as 50-60 minutes. The degree of polymerization of cellulose and the copilarity of paper casts were checked as indicators of the quality of MC-3 paper. The results of the study are presented in figures 1 and 2.

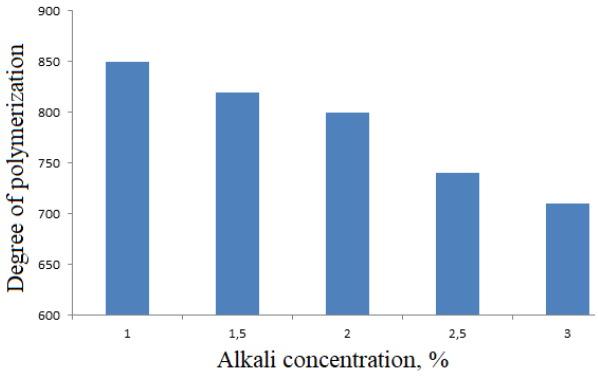

Figure 1. The effect of alkali concentration on the degree of polymerization of waste paper

Note: t= 90^0C; t = 50 minutes

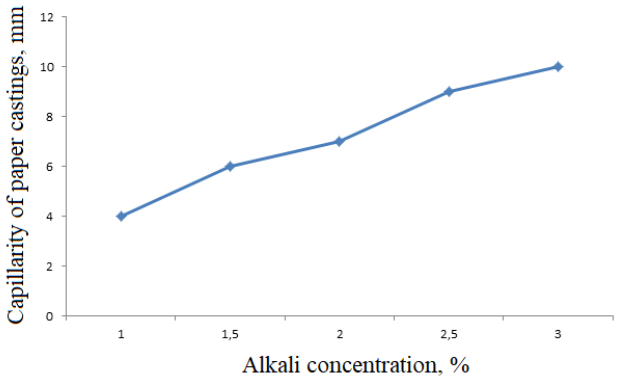

Figure 2. The effect of alkali concentration on the capillarity of paper castings

From the data presented in the table, as the concentration of alkali increases, the degree of polymerization slightly decreases, and capillarity increases. Since increasing the concentration of alkali over 2% led to a sharp decrease in the degree of cellulose polymerization, its amount of 2% was accepted as a suitable concentration.

The increased capillarity of the samples can be explained by the destruction of the film-forming agent in the typography paint under the influence of alkali. The capillary rise of the liquid in the samples occurred as a result of the transfer of oleic-fatty-waxy substances from the paper to the solution as the concentration of alkali increased. It was observed that the degree of polymerization of cellulose was also sharply decreased, while the decomposition of the printing ink was achieved when the concentration of alkali increased. The reason for this is the breaking of hydrogen bonds in the cellulose macromolecule under the influence of caustic alkali at high temperature. Therefore, in order to reduce the temperature of alkaline treatment, the effect of temperature on the process was studied, keeping the concentration of alkali at 2%. The results are presented in figures 3 and 4.

Web of Scientists and Scholars: Journal of Multidisciplinary Research

Licensed under a Creative Commons Attribution 4.0 International License.

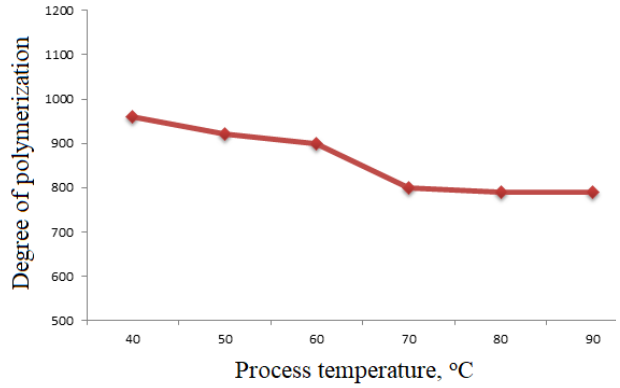

Figure 3. Effect of process temperature on the degree of polymerization of waste paper
Note: C_{NaOH} = 2.0%; t = 50 minutes

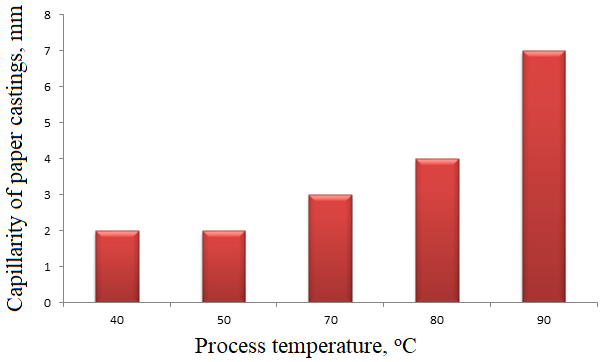

Figure 4. Effect of process temperature on capillarity of paper casts

From the results presented in the table, it is observed that the degree of polymerization of cellulose has a high value at a low temperature of alkaline treatment, but the capillary rise of the liquid in the samples is observed only when the process is carried out at a temperature of 90°C. So, hydrolysis of fatty-waxy substances under the influence of alkali at high temperature has been confirmed. 90°C was accepted as acceptable temperature. Next, the effect of the duration of the process on the efficiency of the printing ink release from the waste paper mass was studied. The results are presented in figures 5 and 6.

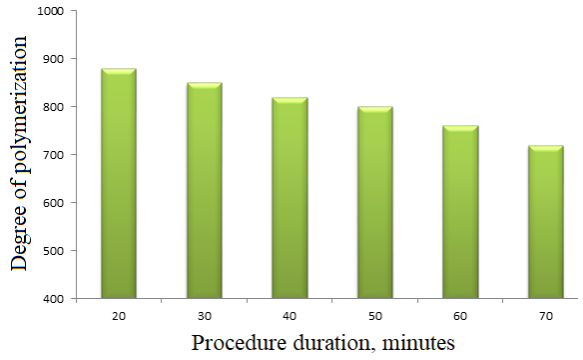

Figure 5. The influence of the duration of the process on the degree of polymerization of waste paper
Note: C_{NaOH} = 2.0%; 90°C

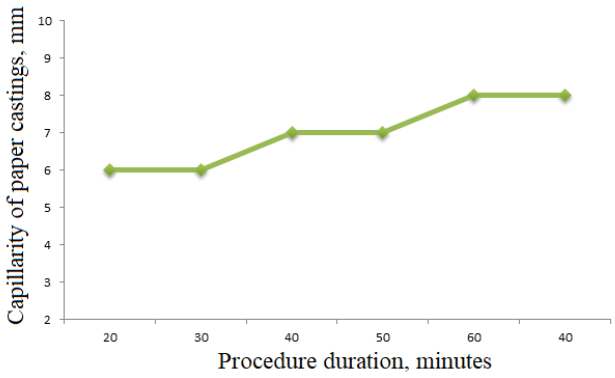

Figure 6. Effect of process duration on capillarity of paper casts

Analyzing the data in the table, it became clear that increasing the duration of the process from 50 minutes leads to a further decrease in the degree of polymerization, but capillarity almost did not change. Due to the fact that the amount of typography ink in the paper samples did not change, the system reached equilibrium in 50 minutes during the transfer of oleic-fatty-waxy substances to the solution in alkaline conditions. Taking into account the above, 50 minutes duration was accepted as an acceptable duration for the process.

Web of Scientists and Scholars: Journal of Multidisciplinary Research

Licensed under a Creative Commons Attribution 4.0 International License.

The given results show that as a result of alkaline treatment of waste paper pulp, the level of whiteness and capillarity of castings decreases with the increase of alkali concentration in the system above 2.5%. The reason for this may be the formation of a hydrophobic layer on the casting surface as a result of the hydrolysis of the oleiferous and fatty substances contained in the typography paint under the influence of alkali, as well as the resorption of the pigment contained in the paint passing into the solution into the fiber. Taking into account the above points, it was considered necessary to add surfactants to the treatment solution. Surfactants facilitate the wetting of the cellulose and the penetration of the solution into the paper. Fat-wax substances, which became soluble during alkaline treatment, are removed from the waste paper mass by emulsification with the help of surfactant. Waxy substances softened under the influence of surfactant gradually turn into spherical microdroplets, break off from the fiber and go into solution.

For this, the boiling process in an alkaline solution was carried out in the presence of different concentrations of surfactant. The results are presented in Table 1.

Table-1 Effect of surfactant's concentration on waste paper quality indicators

Concentration of surfactant, %	Degree of polymerization	Capillarity of paper castings, mm
0.4	780	8
0.6	780	10
0.8	780	12
1.0	780	12
1.2	780	12

Izoh: t= 90^0C; τ = 50, C_{NaOH}=2,0%

At a concentration of 0.8% of surfactant, an increase in the capillarity of the samples was observed, that is, from this concentration, surfactant began to help the separation of the pigments included in the printing inks from the fiber product, as well as the emulsification of fatty-waxy substances from the surface of the fiber. Therefore, adding 0.8% surfactant to the process was deemed appropriate.

It goes without saying that when surfactant is added to the boiling process, the temperature and duration regimes also change. Therefore, the temperature and duration regimes for the process involving surafactants were re-examined. The results are presented in tables 2 and 3.

Table-2 Effect of temperature on the boiling process with the participation of surfactant

Process temperature, ^{0}C	Degree of polymerization	Capillarity of paper castings, mm
30	780	2
40	780	3
50	780	4
60	780	6
70	780	10
80	780	12
90	780	12

Web of Scientists and Scholars: Journal of Multidisciplinary Research

Licensed under a Creative Commons Attribution 4.0 International License.

Table-3 The effect of duration on the boiling process with the participation of surfactant

Duration of the process, min.	Degree of polymerization	Capillarity of paper castings, mm
20	780	8
30	780	11
40	780	12
50	780	12
60	780	12

Tables 2 and 3 were analyzed and a temperature of 80°C and a duration of 30 minutes were accepted as acceptable values for alkaline treatment of MC-3 grade paper waste with the participation of surfactant.

Summary

This research paper presents the results of research on the processing of secondary fiber waste, i.e. waste paper. Since the typography paint does not penetrate deep into the paper and needs to dry quickly, the paints are mainly made on the basis of typography fonts. The composition of the ink can vary depending on the purpose for which it is used, for example, when printing newspapers, liquid ink is used due to the fact that the ink dries quickly, and when printing textbooks and books, a slightly darker gray is used. legs are used. Based on this information, olif in the paint is an oily-waxy substance, and by converting it to a soluble state, it is possible to clean the waste paper mass from typography paint. But since typography ink is insoluble in water, etching alkali was used in research to dissolve the ink. In an alkaline environment, waste paper swells and the average size of its pores increases several times, the diffusion of fatty substances contained in the printing ink becomes easier, and therefore the capillarity of the paper increases. In addition, surfactants were used in order to facilitate the penetration of the treatment solution into the fiber and to emulsify the released fatty-waxy substances. Based on the conducted studies, in order to facilitate the process of separating typography paint from MC-3 waste paper, it was recommended to process it in a 2% NaOH solution with 0.8% surfactant added to the solution at a temperature of 80^{o}C for 30 minutes.

References

1. http://www.pbm.onego.ru/rus/goods/processing_line/mass/2016/
2. www.booksonchemistry.com Rogovin Z.A. “Chemistry of cellulose and its satellites”, 2014
3. A.A. Miratayev, A.A. Abdumajidov. Processing of secondary fiber raw materials used for paper production. Development and innovation scientific online journal. 2022 https://doi.org/10.5281/zenodo.7410406
4. http://www.novosel.ru/mssg207444.htm
5. www.chemicals-el.ru Михайлов Г.М. “Химические свойства целлюлозы и ее применение”, 2017

Web of Scientists and Scholars: Journal of Multidisciplinary Research

Licensed under a Creative Commons Attribution 4.0 International License.

6. Kovaleva O.P., Karavaueva A.A. Modern principles of development of production of paper, cardboard, corrugated cardboard from waste paper raw materials: 11th International Scientific and Technical Conference. May 20-21. 2010: scientific works. M.: MGUL. 2010. p. 53-56.
7. http://www.bummash.ru/koi/goods/celbum/index.html
8. Kononov G.N., Drozdova V.S., Fankovskaya A.A. Effect of mechanical and chemical processing on the properties of removable fibrous semi-finished products of MBS. Westn. Suitable Mr. un-ta lesa, Lesvestnik, 2011 No. 3. p. 136-139.

Licensed under a Creative Commons Attribution 4.0 International License.