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Comparison of papermaking potential of wood and hemp cellulose pulps

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Abstract: *Comparison of papermaking potential of wood and hemp cellulose pulps. The* use of fibre hemp (Cannabis sativa L.) for pulp and paper dates back more than 2,000 years. This technology disappeared, but we have a significant reasons to try to reproduce and improve this technology. The aim of this paper is to present experimental researches, which show that hemp can be successfully used in paper industry and replace wood. This work presents the pulp and paper properties obtained from wood and hemp cellulose pulps. To comply studies were used refined and unrefined pulps. In order to digestion of the raw material used sulfate method, which is the dominant process of digestion in worldwide scale 80%.

Keywords: hemp paper, hemp cellulose pulp, wood, paper properties

INTRODUCTION

The use of hemp fibre and paper dates back more than two thousand years. Until the end of XIX century, 75-90% of all worldwide paper production came from hemp fibre processing. Wastes such as used ropes, sails, clothes, and rags were used in the production, mainly made-up from hemp (or linen). In Ancient China paper was produced mainly from hemp wastes and used fishing nets [1]. Hemp supplied paper for books, bibles, maps, banknotes, securities and newspapers. The Gutenberg Bible, King Jacob Bible, Thomas Paine's pamphlets, and the novels of Mark Twain, Victor Hugo, Alexander Dumas and "Alice in Wonderland" of Lewis Carroll were all printed on hemp paper. Both the US Constitution and the Declaration of Independence were performed on hemp paper, and then copied onto parchment [2].

Wood became a raw material for pulp mill not until XIX century. Industrial revolution brought an increase in demand for paper to such degree, that methods of gaining paper from natural raw materials were developed. The biggest income unfortunately came from exploration of forests. Increasing environmental consciousness of the society appearing in the desire to protect the environment, including forest resources and possibilities of today's technology contributes to the search of alternative raw materials for paper production. Back to the use of hemp in this order seems to be the ideal solution.

Let’s answer the question “why hemp”? This unique plant possesses a lot of advantages. Hemp’s stem is composed in 20% of a fibre, which is the strongest natural fibre in the world [3,4], and is highly valued due to its durability and longevity. 80% of the stem accounts for bast, composed in 50-77% of cellulose [5], which is also a perfect raw material in paper production, and ensures the additional income for producers, due to the fact, that those plants are usually cropped for seeds or fibres. In such a way, paper produced from hemp contains thrice as much cellulose as others, and from one hectare of hemp quadruple amount of paper can be produced, while comparing with one hectare of the forest [6]. Moreover, hemp can be reused just after 4 months of cropping, trees on the other hand require 20-80 years. Farther, hemp paper lasts hundreds of years longer than wood paper, which decomposes and yellows with age. Paper created from hemp resists decomposition and does not yellow with age [7]. Found that, while the hemp paper for hundreds of years is still heavy, 97% of the books which printed on wood paper in the years 1900 – 1937, will be usable for

less than 50 years." Farther, hemp paper does not require toxic bleaching substances. It can be whitened with hydrogen peroxide, so does not poison the waterways with chlorine or dioxins how tree paper mills do [8]. The chemicals involved in making hemp paper are much less poisonous than the chemicals used in making wood pulp paper. In addition, hemp can sterilize soil, kill fungi and weeds and prevent erosion [3,5]. Their roots 10 times better connected subsoil than commonly used for this purpose oats and rye. Research shows that one hectare of hemp absorbs from the ground 0.5 kg of copper, 160 g of lead and much cadmium. Hemp paper can be recycled 7 to 8 times, compared with only 3 times for wood pulp paper.

89% of world paper production is based on wood and only about 11% on non-wood plant fiber [9]. The most paper products from annual plants produce China (about 74%), than India (8%), Pakistan (2%), USA (1.6%), while the rest is divided to the rest of the world. The world hemp paper production was around 120,000 t/year (FAO 1991), which was about 0.05% of the world paper production volume. Only 23 paper mills in the world using hemp fiber. They are located in the USA, UK, France, Spain, Eastern Europe, Turkey, use hemp to produce specialty papers. So far, the hemp fibers are most application to the production of the following types of papers: high-quality specialty papers for writing and printing, archival papers, security papers, filter papers for technical and scientific, insulating papers, greaseproof papers, coffee filter, tea bags, handmade papers, biblical papers and various specialty art papers [2].

High quality of hemp as a raw material will be revealed even more after creation and implementation of the special technology considering production of this pulp. The factor being in favour for the investigation going in such direction will undoubtedly be upcoming raw material crisis on tree market. A very fast increase in paper and cardboard usage will create new possibilities for one-year raw materials, among which, the first place would undoubtedly be occupied by hemp.

THE GOAL OF THE RESEARCH

The aim of the study was conducting the experimental research on hemp as a raw material in paper production and comparison of the characteristics of paper obtained from cellulose hemp pulp and wood pulp, produced in different conditions of the digestion process.

EXPERIMENTAL

The following materials were selected for research: the stems of young plants of hemp and different types of wood – pine, birch, beech, poplar. Wood material was prepared as a chips, while hemp stalks were cut into pieces.

Cellulosic pulp from woodchips and hemp stalks were prepared by the sulfate method. Pulping process was held in a stainless steel reactor with regulation of temperature. The cooking action was conducted at high temperature using a mixture of caustic soda (NaOH) and sodium sulfide (Na_2S).

With the pulps which were obtained in the cooking process were prepared the sheets. To comply studies were used refined and unrefined pulps. Refining were performed in PFI mill in which a single batch was 22.5 g absolutely dry pulp. On PFI mill was performed refining during 1,0 min. Before each refining, pulp was soaked in water for 24 hours.

The next step was a forming sheets of paper on the apparatus Rapid – Koethen. The formation of paper sheets was performed in accordance with PN-EN ISO 5269-2:2001. Each laboratory paper sheets was described by basis weight of 75 g/m².

Following research were performed pulp properties:

- Degree of refining – value which determines the ability of the pulp to dehydration under standard conditions. Measurement of degree of refining was performed using Schopper – Riegler apparatus.

- WRV (water retain value) - it determines the amount of water retained in the pulp. The essence of this method is removal free water from the test pulp (contained between the fibers) and determination content of stopped water (water contained inside the fibers). Water retention within fibers was examined centrifugal method which was developed by Jayme and Rothamel. According to this method the pulp sample is subjected to centrifugation using an acceleration of 3,000 g for 15 min and determining ratio of water to weight of bone dry sample [10].

After performing test sheets, they were conditioned for 24 hours under the following conditions: 23 ± 1°C and 50 ± 2% relative humidity, according to PN-EN ISO 187:1990. Then, done breaking length tests of the paper. Measurement of the breaking length was performed on the tensile testing machine INSTRON 5564, according to PN-EN ISO 1924-1:1998 P.

RESULT

The following results were obtained:

Tab.1 Table of examined properties of pulp and paper

Pulp	**Time of refining [min]**	**Degree of refining [˚SR]**	**WRV (with fines) [%]**	**Breaking length [m]**
Hemp I (cooking in a lower concentration of alkali)	1	51	241	7400
	0	21	-	-
Hemp II (cooking in a higher concentration of alkali)	1	49	245	7800
	0	21	171	3450
Pine	1	15	178	8100
	0	12	126	2500
Birch	1	21	201	9500
	0	14	126	3150
Beech	1	21	186	8450
	0	15	113	2750
Poplar	1	21	214	7200
	0	14	126	1750

CONCLUSIONS

Based on the conducted experiments one may conclude, that the results obtained for the hemp pulp are comparable to the results obtained for the wood pulp. The results also show that properties of paper – breaking length – taken with refined pulp are far better than paper made unrefined pulp.

Therefore, it may be stated, that hemp can be successfully used as a raw material in paper production, after creation of a proper technology and selection of optimal conditions for the operation of the industrial installation producing cellulose hemp pulp.

It has to be emphasised, that conducted experiments were preliminary and experimental, and undoubtedly require elaboration. However, the obtained, based on them, results build the basis for process optimisation and implementation in future in the industrial conditions.

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Streszczenie: *Porównanie potencjału produkcji papieru z drewna i konopnych mas celulozowych.* Zastosowanie konopi (Cannabis sativa L.) do produkcji mas włóknistych i papieru sięga ponad 2000 lat. Technologia ta zanikła, jednak mamy ważne powody ku temu aby starać się ją odtworzyć i udoskonalić. Głównym celem pracy było przedstawienie badań eksperymentalnych, które pokazują, iż konopie z powodzeniem mogą być wykorzystywane w przemyśle celulozowo – papierniczym i zastępować drewno. W artykule przedstawiono właściwości masy oraz papierów otrzymanych z mas włóknistych drzewnych i konopnych. Do wykonania badań wykorzystano masy mielone oraz niemielone. W celu roztworzenia surowców zastosowano metodę siarczanową, która jest dominującym w skali światowej procesem roztwarzania 80%.

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