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THE EFFECTS OF SODIUM HYDROXIDE CONTENT ON MECHANICAL AND PHYSICAL PROPERTIES OF RICE STRAW PAPER

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ABSTRACT

Paper demand increases day by day according to current needs and requirements. This condition can affect to uncontrolled felling of trees and the occurrence of unbalanced ecosystem problems. Therefore, a study was made alternatively to use other resources to produce papers. Sodium hydroxide in different content for rice straw paper was studied to know its mechanical and physical properties. Preparation for paper sample process involves several important steps such as the provision of raw materials, preparation of pulp (absorption process, digesting process, rinsing process and mixing process) and sample preparation process (filtration process and drying process). The percentage of NaOH used for each sample are 5%, 10%, 15%, 20%, and 25% to varies the NaOH contents of the paper samples and see the effect of the chemical addition different in producing rice straw paper. Testing procedure including tensile, folding endurance, surface roughness, water absorption and FESEM test were implemented according to prescribed standards to see the different in its mechanical and physical properties of rice straw paper. The results showed that increasing the percentage of NaOH will decreases the surface roughness and water absorption rate. Also, the specimen surface when increasing NaOH indicates that the paper has improved fiber structure with fine arrangement to each other. With this, the addition of NaOH are seen to be able to improve fiber properties as well as strengthen ties between the fibers. The results also showed that the J25 using 25% of NaOH has highest tensile strength and folding value.

Keywords: rice straw paper, sodium hydroxide.

INTRODUCTION

Cellulose is the main ingredient needed to make paper. Before this, paper has been produced from resources mainly found in wood. Until now wood is needed in extremely large quantities to produce paper. The widely use of paper affects the production of paper every year and this caused a lot of felling trees and causing deforestation. Recently, many studies used various fibers as substitution for paper main materials. Some of the fibers are banana leaves, pineapple leaf fiber, kenaf fiber and others. These fibers are often used as a cellulose in making paper. Rice straw fiber was chosen to replace the main ingredient of wood fiber as it is often thrown away without recycled or reproduced.

Paper can be classified as a substance that is thin and flat or a crossing network between cellulose fibers bonded to one another. Furthermore, the paper comprised of thin sheets must be made of glass fiber in which each constitute a separate unit. Each paper has certain properties, in which these qualities important to distinguish the different types of paper. In producing a paper, the process can be divided into three parts, namely manufacturing pulp (pulping), material preparation and producing paper.

In the pulping process, wood will be cut into small wood chips or chips using the cutting machine (chipper). After that small wood chips or chips will be cooked (digesting) in the boiler at a particular temperature stage to destroy the wood chips. From the process, it will produce a waste material called fly ash or dust particles. The cooking process should be done continually to get uniform pulp results (Lesmono, 2005).Chemicals that are often used to break the bonds of cellulose fibers are sodium hydroxide (NaOH) and sodium sulphite. Cellulose also can found in wood, cotton, hemp and other plants (Jalaludin, Rizal. S, 2005). The study showed chemical composition of some is highest in rice husk compared to other lignocellulose biomass like straw, bagasse and bamboo. Pulp bleaching or also known as bleaching processes for obtaining and bright white paper.

In materials preparation process, the process of making the pulp and papermaking are combined. In this process, namely pulp short fibers will be filtered and cleaned and smoothed. Long fiber pulp will only be smoothed. Then, both pulps will be mixed and cleaned using chemical anti-foam and anti-septic. Once ready, this will undergo a screening process for making paper (Nurhayati and Mahmudin, 2012).

In producing paper, pulp will be dissolved in water to form a slurry or a viscous solution that can be pumped through the machine. As a result, this process produces a paper in a sheet form. Then the paper will be suppressed using press machine and dried using steam. Finally, the paper will be wound up on the machine calendar until generating a roll of paper. (Nurhayati and Mahmudin, 2012).

There are three different types of pulping process including mechanical pulping, chemicals pulping and semi chemicals pulping. For mechanical pulping the main process are thermo-mechanical pulping (TMP) and mechanical pulping (SGW) process or also known as ground wood process. The process required range of steam temperature between 110 ˚C until 130 ˚C for 2 to 5 minutes (Holiks, 2006). For chemicals pulping, two main process are used involving pulp alkali processes and acidic sulphite process. In chemicals pulping, raw materials were cooked with appropriate chemicals in an aqueous solution at high temperature and pressure. The aim of this process

is to get rid of lignin and cellulose and hemicellulose left in a state of good fiber (Smook, 1994). Meanwhile for semi-chemical pulping determined through a two stage process pulp by combining chemical pulping process for producing some of the bonding material and refining lignocellulose fibers to enhance mechanical pulping process. According Navaee-Ardeh *et al*. (2003) rice straw has a chemical composition having an ash content of 11.35%; 30% lignin and hemicellulose 58.65%.

In order to improve the quality of paper, chemicals needed as a function of binder or also known as filler (filler) or binder agent. These materials have strong mechanical properties of paper and can increase the strength during steeping (Fengel and Wegener, 1995). NaOH serves as a medium separator between lignin and cellulose or can also be identified with the process of degrading lignin. This study was conducted to see the results of the paper produced from rice straw fibers comparable to different NaOH contents.

The objective of this study was to investigate the production of paper using rice straw with varies sodium hydroxide (NaOH) and studying different mechanical properties via testing of tensile, folding, surface roughness, water absorption and physical texture observation using FESEM machine. This initiative is a move to diversify the raw material for producing paper.

SAMPLE PREPARATION AND TESTING

Sample preparation of rice straw paper involves the process for raw materials preparation, pulp and sample specimens.

For raw material preparation, the rice straw after harvested is taken and dried under the sun. Rice straw is dried for about a week to ensure rice straw dried very well. After that, the dried rice straw ready to be cut by using a shredder. Rice straw is slowly fed into the shredder so that the cutting process can proceed smoothly.

For producing pulp, the process is divided into four important process including soaking, cooking, rinsing and grinding process. The blended rice straw will be weighed and measured mass of NaOH according to the parameters set at 5%, 10%, 15%, 20% and 25%. Then both substances were mixed and soaked for 12 hours. After that, straw fibers are cooked for 2 hours as shown in Figure-1. This immersion objective is to remove lignin, hemicellulose silica, and the pith of the fiber in order to have a better impregnation between the fibers and the matrix as well as increasing fiber surface roughness in order to have better interaction.

After cooling it for a while, rice straw fiber goes through the process of rinsing to remove the effects of NaOH and impurities in the fiber. Next stage of the grinding process, the amount of water used per 1 litre and grinding is made within the range of two times for 2 to 3 minutes to produce a smooth pulp as shown in Figure-2. The next process is the formation of rice straw fiber paper where it will go through a screening methodas shown in Figure-3. Paper that has been filtered as shown in Figure-4 and was hung out to dry. The time taken for the paper to dry was about 5 hours.

Figure-1. Preparation process.

Figure-2. Grinding process.

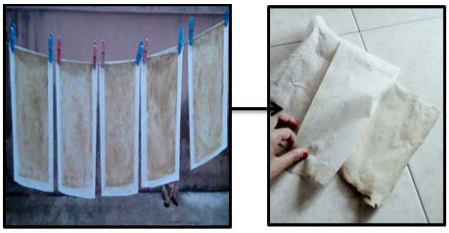

Figure-3. Screening process.

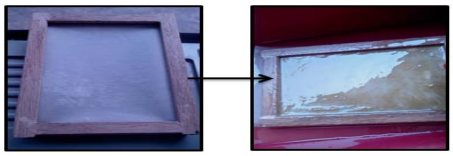

Figure-4. Drying process.

After obtaining straw paper, the paper will be cut according to the standard size for the sample tests which will be carried out. The mechanical tests executed for samples of rice straw fiber paper were tensile test, folding endurance, the surface roughness and water absorption test. These tests were carried out to determine the mechanical properties of materials before they are used in an application. For physical exam, the test performed is the surface roughness, water absorption and "FESEM" test using equipments as shown as Figure-5, 6, 7, and 8.

Figure-5 shows schematic diagrams for tensile test and samples specimen. Folding endurance tests as shown in Figure-6 was conducted to assess the durability of paper folding withstand the maximum. In addition, it is used to estimate the ability of a paper to resist bending rate applied repeatedly to the fold. Meanwhile surface roughness and water absorption test machine were shown in Figure-7. Testing of surface roughness is an important parameter where quality of printing paper relies on the structure of the paper surface. Thus, the paper surface whether in fine or coarse texture is a critical feature to be determined in this test. As shown in Figure-8, FESEM test

known as Field Emission Scanning Electron Microscope was done to look at very small topographic details on the surface of the entire material.

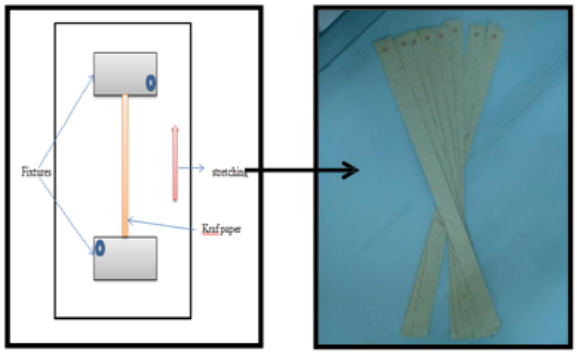

Figure-5. Tensile test schematic diagram for sample and real specimen.

Figure-6. Folding endurance test.

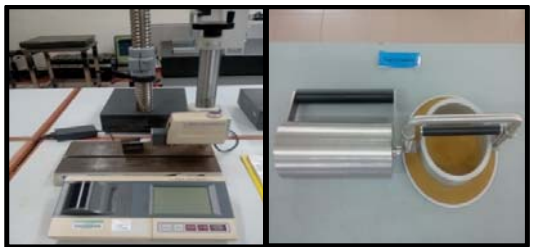

Figure-7. Surface roughness testerand water absorption.

Figure-8. Field emission scanning electron microscope(FESEM).

RESULT AND DISCUSSIONS

The result of for the test conducted was acquired and analyze based on different testing. Figure-9 shows each specimen tested have different stress value. J5 specimens showed the highest reading of 26.4 N / mm^2, followed by J10, J15 and J25 respectively of 3.61 N / mm2, 4.16 N / mm^2 and 3.96 N / mm^2. J20 has lowest value of 2.8 N / mm^2. This specimen shows J5 stronger because the fiber structure can withstand before break or fracture. Air cavities or high porosity will give a lower strength when a force is applied.

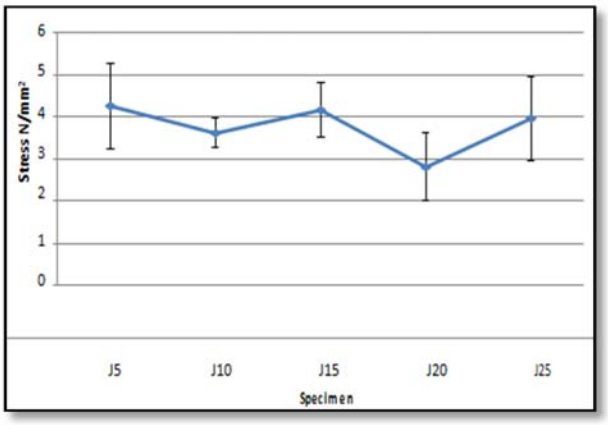

Figure-9. Tensile strength for all specimens.

From Figure-10, it shows that J25 specimen has a good level of folding with ability of 8 times fold before failure. The lowest level specimens of folding capabilities are J10 and J15 which failing to 5-fold. With this, the fibers in specimen J25 is better in folding endurance compared with other fibers. Fibers having high flexibility properties would fulfill the pores easily and can touch other fibers closely. This makes extensive contact area and the number of bonds between the fibers increases. Then, the resulting paper will become closer and its density will be higher.

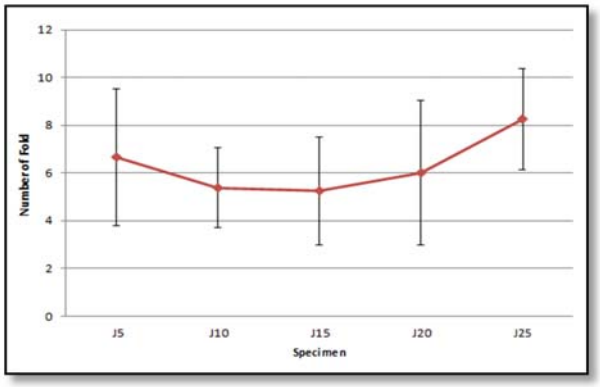

Figure-10. Folding endurance result.

Figure-11 shows the results of surface roughness against all specimens. The best surface roughness is J25 with Ra value 6.09. Most rough surface is J5 with Ra value is 7.34. Paper surface structure is important in assessing fineness or roughness of the paper texture. Surface roughness is also important to be determined as it can give suitability as printing and writing paper.

For the final test in water absorption test, results in Figure-12 shows the water absorption rate is the lowest in specimens J25 of 0.033 compared to other specimens. The water absorption rate is highest where the specimens J5 absorption is 0.073. Each specimen takes immersion for 120 seconds. The results show straw fiber in samples J25 has closer fibers composition and compact compared to other specimens resulted in low absorption rate

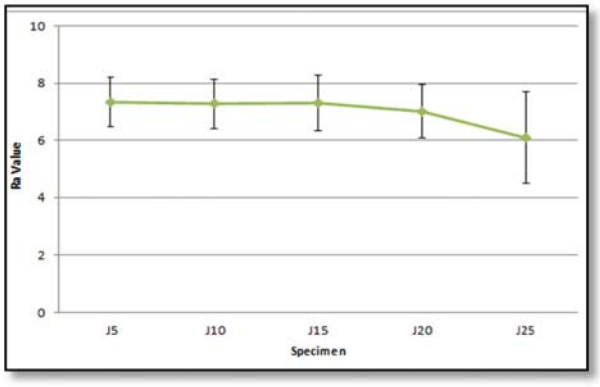

Figure-11. Surface roughness result.

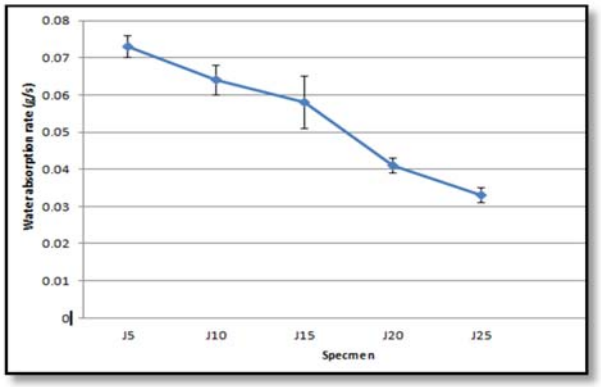

Figure-12. Water absorption results for all specimens.

At magnification of x500 micrometers, long fiber and less porosity can be seen (Figure-13). It can be concluded that J25 specimens have a high stress value. Moreover, the enlargement of x1000 micrometer, J25 has long fibers and a very good structure compared to other fibers of the specimen.

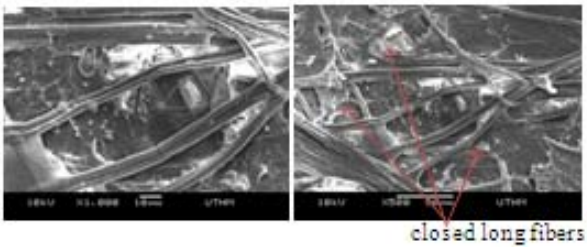

Figure-13. Surface texture magnification using FESEM.

Table-1. Overall results.

Specimens	Stress (N/mm^2)	Number of folding	Ra value	Water absorption (g/s)
J5	**4.26**	6	7.34	0.073
J10	3.61	5	7.29	0.064
J15	4.16	5	7.31	0.058
J20	2.8	6	7.01	0.041
J25	3.96	**8**	**6.09**	**0.033**

The overall results shown in the Table-1. It shows that specimens J25 with 25% NaOH have tensile strength, surface roughness and value of folding endurance at 3.96 N / mm^2, 6.09µm and 8 respectively, have good comparable properties rather than others specimen. While for water absorption rate is 0.033 g / observations on the specimen surface indicates a finer fiber structure and are arranged closer to each other. With this, the use of NaOH can improve fiber properties as well as strengthen ties between the fibers.

CONCLUSIONS

This study was conducted to determine the effect of a percentage NaOH content of rice straw fiber in the mechanical properties of the produced paper. Different percentage NaOH content used on rice straw fibers include 5%, 10%, 15%, 20% and 25%. The results showed different percentage NaOH content influences the mechanical properties and physical materials. However, the percentage content of J25 NaOH is best compared with J5, J10, J15 and J20. The main features that should be included in the production of paper is good tensile strength and can withstand tearing. Moreover, it should also have a low water absorption rate and can withstand folding endurance. All these features can be seen and identified through testing that has been done on the rice straw fiber.

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