

Study on Manufacture of Paper Sheet from Rice Straw

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Abstract: This study is based on finding environment friendly economical process for manufacturing of paper sheets. Rice Straw an agro residue based fibrous raw materials has been used for paper manufacturing. The chemical properties of pulping process such as (Kappa number and Residual Alkali) were measured. The mechanical properties such as (breaking length, tensile strength, thickness and double fold) of paper sheets were measured. In the present work, different concentration of sodium hydroxide were varied as (4%NaOH, 6%NaOH, 8%NaOH), liquor to straw ratio of (8:1), temperature at 170°C and cooking time 1hr and holding time 30min are cooked with digester. The experimental results show that the concentration of sodium hydroxide (6%NaOH), reaction temperature 170°C and cooking time 1hr and holding time 30min. The physical properties of paper sheet are not consistent the standard limiting value, the prepared paper sheets were produced to use the shopping bag. Therefore, strength results are very important in this process. The mechanical properties of paper sheets for 6%NaOH was consistent with the standard limiting value because tensile strength and breaking length results were very acceptable limit. This study will provide a process for manufacturing of paper sheets which can be used in place of plastic bags.

Keywords— Rice Straw, Soda Pulping Process, Paper Sheet, Sodium Hydroxide, Sodium Silicate

1. INTRODUCTION

Rice is the major cereal crop of Myanmar, covering an area of about 40 million hectares, the largest area under any crop. Rice-Straw is abundantly available almost throughout Myanmar the harvest as an agro-residue [1]. The farmers like to get rid of this residue at the earliest by burning in the open fields in order to prepare the field for the next crop [2]. Rice straw burning in agricultural fields is serious environment pollution. Rice straw is available abundantly after harvest and as a consequence creates disposal problem. The wood pulp from other sources is comparatively expensive to support local paper production [3]. Nan-wood based raw materials can be applied as an effective substitution forever decreasing of forest wood resources especially in the most Asian countries [4].

Rice straw is an abundant and easily available raw material in Asian countries as it is produced in almost equal quantities during grain production and can be procured by paper mills at a lower cost [5]. In this study, rice straw was cooked with soda pulping process at 170°C and 1 hr. The effect of cooking variables such as cooking time, temperature and sodium hydroxide concentration were examined on the pulp properties. After that the best result of the paper produced from rice straw comparable to different liquor ratio. The objective of this study was to investigate the production of paper using rice straw with sodium hydroxide (NaOH) and studying physical and mechanical properties of paper sheet.

2. MATERIALS AND METHODS

2.1. Materials

In this work, rice straw and chemicals were used as raw materials. Rice straw were collected from Kyauktan Township. Sodium Carbonate (analytical grade) and sodium hydroxide (analytical grade) were used in preparation process.

2.2. Methods

In producing a paper, the process can be divided into three parts, namely manufacturing pulp (pulping), material preparation and producing paper. The pulping processes of rice straw have mechanical pulping process (ground wood process, Refiner mechanical process, Thermo-mechanical process, etc) and chemical pulping process (Soda process, Kraft process, sulfite process, etc). In this study, soda pulping process is chosen because process control is relatively easy and cooking chemicals are not expensive and then spent chemicals can be recovered.

In this study, rice straw was cut into small pieces of (1 to 3 cm) with knife. Rice straw was cleaned, and washed with water to remove adhering soil and dust. To remove the silica, rice straw was treated for 30 min in a 15% solution of sodium carbonate (Na_2CO_3) at 100°C. After the removing of silica from rice straw, liquor to straw ratio(V/W) 8:1 was cooked with 4%, 6% and 8% sodium hydroxide (NaOH), reaction time 1hr and reaction temperature at 170°C. For quick digesting and consistent pulp two knives containing beater was used. The beating was carried out until the pulp consistency was held between 80-100g/m² in beater and SR was between 40 to 60. To smooth out of the pulp, cylinder mold press with rollers was used. Traces of water in pulp were removed with tetron cloth sheet by pressing. And then, the wet sheet was dried at 110°C by sheet former machine. Finally, the smooth product of paper was obtained.

Liquor to straw ratio(V/W) 8:1 was various with 4%, 6% and 8% sodium hydroxide (NaOH) and reaction time 1hr, (holding time 15min, 30min and 45min) to prepare the paper sheet in order to determine the best results of the experimental conditions. The prepared paper sheets were cut into specimens of suitable dimension for the determination of physical and mechanical properties. The processing steps were described in Figure 3.2 and 3.3.

Preparation of Paper from Rice Straw

The schematic diagram of preparation of paper making from rice straw is shown in Fig.1.

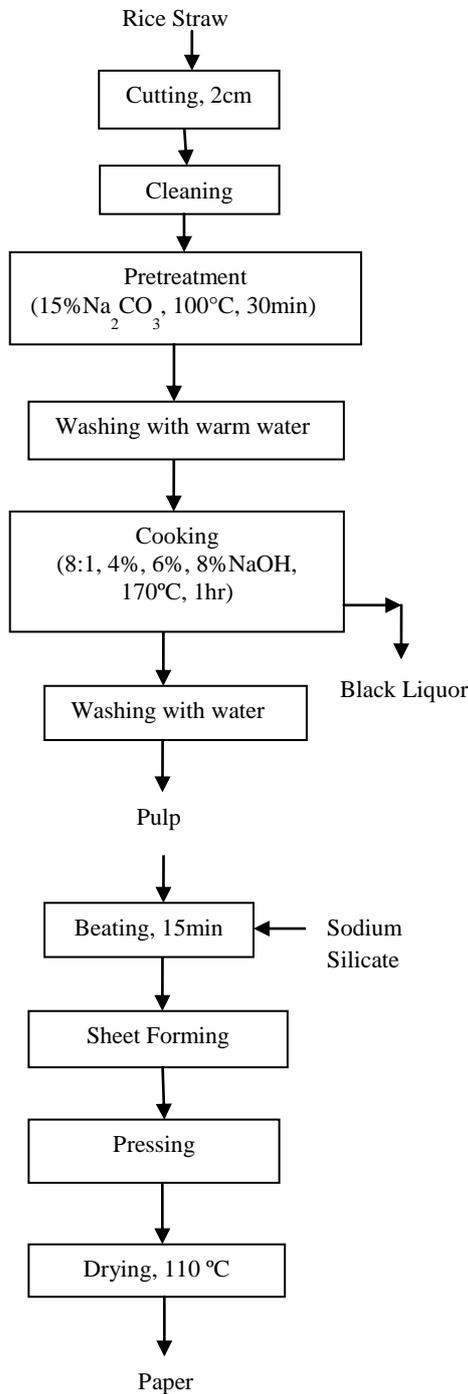


Figure 1. Flow Diagram of Process of Paper Sheet from Rice Straw

(i) Cutting Process

Rice straw was cut into small pieces of (1 to 3 cm) with knife.

(ii) Cleaning Process

Rice straw was cleaning with tap water to remove other impurities.

(iii) Soaking Process

Rice straw was soaked for 30 min in a 15% solution of sodium carbonate (Na_2CO_3) at 100°C .



Figure 2. Digester

(iv) Cooking Process

After the removing of silica from rice straw, the mass ratio of NaOH solution to straw 8:1 was cooked with (6%NaOH, 8%NaOH, 10%NaOH), reaction time 1hr and reaction temperature at 170°C .



Figure 3. Digester

(v) Beating Process

For quick digesting and consistent pulp two knives containing beater was used. The beating was carried out until the pulp consistency was held between $80\text{-}100\text{g/m}^2$ in beater and SR was between 40 to 60. After that, 1% sodium silicate was mixed in the beater for better quality of strength.



Figure 4. Hollander Beta

(vi) Sheet forming Process

To smooth out of the pulp, cylinder mold press with rollers was used. Traces of water in pulp were removed with tetron cloth sheet by pressing. The wet sheet was dried at 110°C by sheet former machine. Finally, the smooth product of paper was obtained.



Figure 5. Sheet Former

3. RESULTS AND DISCUSSION

3.1. Determination of Produced Pulp Properties

Kappa Number, Residual alkali (RA), and Yield percent are determined as shown in Table 3.1.

Caustic %	Yield (%)	Kappa No.	(RA), g/L
4% NaOH	42	24	0.2
6%NaOH	46	18	9
8%NaOH	34	13	1.16

Liquor to Straw Ratio (8:1) and Holding Time (30min)

The results of chemical properties of pulp were described in Table 4.3. It was shown that the kappa number was the best result from caustic percentage (6%NaOH) because the resulting pulp showed the less amount of lignin. The two remaining of caustic percentage at 4%NaOH and 8%NaOH have the amount of 24 and 13. The result of caustic percentage 4%NaOH was described the incomplete condition of cooking time and the other 8%NaOH was described the over complete condition of cooking time. The amount of residual alkali in the black liquor was reused to the chemical reaction. The best of yield percentage was described the 46% at 6%NaOH cooking process.

3.2. Determination of the Mechanical Properties of Paper Sheet

The mechanical properties of tensile strength, folding, breaking length are determined as shown in Table 3.2.

Properties	4% NaOH	6% NaOH	8% NaOH
Double Fold , time	5	3	7
Brightness,%	56.2	46	43.6
Opacity, %	144	86.1	92
Moisture, %	10.8	8.1	11.2

Thickness, mm	0.190	0.18	0.186
Smoothness, sec	374.5	430	252.2
Breaking length, m	1786	6013	2381
Tensile Strength, KN/m	1.4	4.9	1.9
Ash content, %	14	9.7	15

Liquor Ratio (8:1) and Holding Time (30min)

It was shown that the physical and mechanical properties are described in Table 3.2. Although the physical properties of paper sheet are not consistent the standard limiting value, the prepared paper sheets were produced to use the shopping bag. Therefore, strength results are very important in this process. The mechanical properties of paper sheets were liquor to straw ratio (8:1) was standard limiting value because tensile strength and breaking length results were very acceptable limit.

The Liquor to Straw ratio (8:1), reaction time such as soaking time 30 min at 100°C and cooking time (1hr+30min) with 6%NaOH at 170°C and then beating time 15 min. After the beating process, 1% sodium silicate was mixed into the beater for better quality of pulp and good tensile strength. And then liquor ratio (8:1) reaction time such as soaking time 30 min at 100°C and cooking time (1hr+30min) with (4%NaOH, 6%NaOH, and 8%NaOH) at 170°C and then beating time 15 min. After liquor ratio (8:1), reaction time such as soaking time 30 min at 100°C and cooking time (1hr+15min, 30min, and 45min) with 6%NaOH at 170°C and then beating time 15 min. Among then, the liquor ratio of (8:1), 6%NaOH and holding time (30min) is the best result of in this study. The best pulp of chemical properties results had yield of 46%, kappa number of 18 and residual alkali of 9g/L. The best paper sheet had 46% of brightness, breaking length of 6013 m. Some physical properties had not conformed to the limiting standard. But the prepared paper is shopping bag. Therefore physical properties result is acceptable value.

4. CONCLUSION

In this study, Paper were used in the preparation of rice straw at 170°C temperature, cooking time at 1hr and holding time at 30min, and NaOH concentration (4%, 6%, 8%). Experimental conditions set up with liquor to straw ratio (8:1) by using digester is studied in order to obtain the best results of the paper sheet product.

The best results were rice straw at 170°C temperature, cooking time at 1hr and holding time at 30 min, and NaOH concentration 6% from the liquor to straw ratio (8:1). The best yield at 46%. Pulp strength was higher because ash content can be dropped to acceptable level with longer holding time.

Prepared paper was tested for brightness, opacity, smoothness, double fold, thickness, breaking length and tensile strength. These properties of paper sheet prepared in the laboratory were quite satisfactory for its application. When it was soaked and cooked with sodium carbonate and sodium hydroxide, its yield was best the paper of brightness, breaking length and tensile strength at the accepted pulp yield of 46% of oven dried raw material. Breaking length of paper sheet is obtained 6013m by using liquor to straw ratio (8:1), at 170°C temperature, cooking time at 1hr and holding time 30 min, and 6%NaOH.

Viewing from this study, it was observed that the use of rice straw to paper sheet give the encouraging result. The fact

to consider was how to make the natural rice straw fibers compatible enough with the chemical. In orders to develop paper were better mechanical properties.

Additive of sodium silicate having good tensile strength, very high opacity, good brightness and good surface properties can be used in a number of industrial and domestic applications of environment friendly packaging materials and decorative laminates.

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