ISSN No:-2456-2165

The Manufacturing of Laboratory Scale Kraft Pulp from a Mix of Acacia and Eucalyptus Wood Chips

Ni Njoman Manik Susantini
Assistant Professor Pulp and Paper Technology Dept.
Institut Teknologi Sains Bandung
Bekasi, Jawa Barat, Indonesia

Rizki Adi Saputra
Bachelor Degree Pulp and Paper Technology Dept.
Institut Teknologi Sains Bandung
Bekasi, Jawa Barat, Indonesia

Abstract:- This research aims to determine the effectiveness of the use of pins chip mixture of acacia and eucalyptus wood and the optimum condition of the quality of the pulp. The cooking conditions for kraft pulp were alkalinity (17%, 18%, and 19%) and sulfidity were the same in each test (31.28%). Maximum cooking temperature is 160°C for 3 hours, with H-Factor 800. Bleaching of pulp pins chips using three processes, namely D0, EOP, and D1. Pulp properties test consists of physical strength and optical test. The ripening conditions for kraft pulp resulted in a fairly high pulp yield of about 50.93% at 17% active alkaline charge condition, 51.07% at 18% active alkaline charge condition, and 51.42% at 19% active alkaline charge condition. The use of acacia and eucalyptus pins chips was effective enough to produce a fairly high yield with a range of 40-55%, with the lowest kappa number 1.12 and the highest 1.23. The effect of increasing the concentration of alkali is more effective at 19% active alkaline charge conditions, but the resulting viscosity is very low, as well as 17% active alkaline charge conditions are less effective but the viscosity is quite high. The ideal conditions of active alkaline charge are 18% with 50.93% pins chip yield, 720 cm3/g viscosity, and 89.03% ISO brightness. In general, different concentrations of active alkali charge white liquor affect the physical strength and optical properties.

Keywords:- *Pins Chip, Active Alkali Charge, Pulp Yield, Pulp Properties.*

I. INTRODUCTION

Nowadays it knows that pulp is still needed as one of the basic materials in the production of textiles, writing-print media, packaging and tissue. As an illustration, in Indonesia in 2019, the national paper production capacity reached 10.1 million tons and consumption was 6.3 million tons. Despite the global Covid-19 pandemic, global demand for pulp and paper has increased by about 2.1 percent [1]. However, the industry continues to strive to improve the efficiency and quality of pulp in order to meet the standards set by consumers.

Optimization of wood materials is needed because from a piece of wood there is still a large portion that is not utilized. As an illustration, data is taken from Sweden. Data from Sweden in 2000, only about 50% of a wood (sawlog) that will become sawnwood (sawnwood) and a third of it into chips. The details are as in the table 1.

From table 1, it can be seen that the chips that can be processed into pulp are the Large accept chips and Small accept chips. Pin Chips and fines are usually used as fuel for equipment in mills. This research is purposed to optimize the raw material by analyze the using of pin chips for pulp

Table 1 Classification of Pin Chips [2]

Chips' Type	Remark
Oversize chip	*Chips that do not pass on the first screen (45 mm hole)*
Overthick chips	*Chips stuck on second screen (8mm slot)*
Large accept chips	*Chips stuck on the third screen (13 mm hole)*
Small accept	*Chips stuck on the fourth screen*
Pin chips	*Chips stuck on the fifth screen*
Fines	Particles that have passed 5 kinds of screen sizes

The initial stage is mixing pin chips with white liquor solution (Na_2S and NaOH). This stage is called the cooking process. The purpose of cooking is to separate cellulose with extractive substances contained in the cellulose such as lignin. The result of cooking is that the pulp is still brown in color, which is called unbleach pulp.

The next stage is Oxygen delignification. This processes, tradionally, are located between the pulp mill and bleach plant. The Goal is to reduce [3]the lignin content of unbleached pulp before using more expensive bleaching chemicals. Oxygen deliginification can reduce about 30-50% lignin and colored substances from unbleached pulp [4]. In process pulp is mixed with oxygen (O_2) and NaOH. The first objective of Oxygen Delignification is to reduce the use of chemicals in the bleaching stage.

The next step is the bleaching stage. In Indonesia, the pulp bleaching process generally uses the ECF (Elemental Chlorine Free) method. ECF bleaching based on chlorine dioxide is a technology choice for sustainable pulp and paper manufacturing [5]. The ECF bleaching process aims to increase the whiteness of the pulp, by removing residual lignin which is difficult to delignify during the cooking process, so that the pulp has a high brightness stability [6].

ISSN No:-2456-2165

In general, bleaching is carried out in several stages, namely, D0 (ClO_2), E (Extraction), D1 (ClO_2), D2 (ClO_2) [6] (Sirait, 2003). The initial stage of D0 bleaching aims to reduce and degrade lignin. The final two stages, D1 and D2, aim to achieve the target brightness.

In the final stage, the pulp is formed into a sheet called a pulp sheet, before being formed into a pulp sheet, it is tested for the strength properties of the paper and the optical properties of the paper.

Chips that are classified as oversize and overthick will return to the chipper/chip maker to be made into chips that are sized according to the 'accept' classification. Pin chips are usually used as fuel for large-scale power plants such as boilers.

Pins chip raw materials consist of Acacia crassicarpa, Acacia mangium, and Eucalyptus wood. With the pins chip ratio (62.23 : 4.37 : 33.40), the ratio obtained is the field ratio with every 8 hours the condition of the ratio changes, and the ratio of this study was taken at one o'clock in the morning in Indonesia, 11 February 2021.

Cooking pins chip 100% using active alkali 17%, 18%, and 19% was carried out to determine the use of pins chip as a raw material for making pulp so that it can be utilized. This research was conducted to see the effect of variations in active alkaline charge with pins chips as cooking materials and raw materials for pulp production.

II. RESEARCH METHOD

A. *Materials and Equipments*

The materials used in this study were as follows: 100% wood chip pins as the main material. White liquor, chlorine dioxide (ClO_2) and hydrogen peroxide (H_2O_2).

The tools used include analytical balance, measuring cup 250 ml, 500 ml, screen chips, tray, oven, pipette volume 5 ml, 25 ml, Erlenmeyer 300 ml, burette, hydrometer, magnetic stirrer, glass beaker 2000 ml, glass stirring rod , spatula, digester set, stopwatch, screen pulp 325 mesh, screen sumerville, disintegrator, and water bath, ph meter, kappa number tester, viscosity tester, total solid tester, brightness tester, opacity, l*a*b, beater, csf tester, handsheet former, and physical strength tester.

B. *The Method*

The initial stage in the research is the preparation of experimental tools and materials in the cooking process, which consists of 100% pins chips with cooking ingredients using NaOH and Na2S compounds called white liquor. Pins chips consist of wood Acacia crassicarpa : Acacia mangium : Eucalyptus ratio pins chip 62.23% : 4.37% : 33.40%, Cooking pins chip 100% using active alkali 17%, 18%, and 19%. After obtaining the results of the unbleached pulp entering the pre bleaching stage or called the oxygen delignification stage, the pulp is mixed with oxygen (O_2) and NaOH The purpose of this mixing is to reduce the use of chemicals in the bleaching stage and reduce the lignin content. Removal of lignin (delignification) using oxygen is needed to remove residual lignin from brownstock which is the prebleaching stage. The O_2 delignification stage consists of two stages, the initial stage requires a temperature of 980C and 5.5 bar of oxygen pressure, while the second stage requires 1020C and 4 bar of oxygen pressure, each stage requires a waiting time of 30 and 45 minutes with a caustic of 8 Kg/ The bleaching stage consists of 3 stages, namely, initial delignification (D0), extraction (EOP), and final delignification stage (D1). At stage D0 the active chlorine consumption was 28.6 Kg/T, 27.7 Kg/T, 25.9 Kg/T at a temperature of 70^0C with a waiting time of 60 minutes. In the EOP stage, several supporting chemicals such as NaOH and H_2O_2 are needed, with a charge of 10 Kg/T NaOH and 1 Kg/T H_2O_2, the pressure used is about 3.5 bar, the temperature is 85^0C, and the reaction time is 45 minutes. In stage D1, the active chlorine consumption was 15.6 Kg/T, 14.7 Kg/T, and 14.7 Kg/T, respectively, with a temperature of 80^0C, the waiting time was about 150 minutes. In the final stage, the white pulp was tested for paper strength and paper optical properties using the 300 mL CSF method. The paper strength test consists of several tests such as, basic weight, fiber length (length), paper tensile strength (tensile strength), paper cracking power (tearing), paper breaking power (bursting), paper folding strength (folding). , paper thickness (thickness). The paper optical properties test consisted of paper opacity and paper whiteness.

III. RESULT AND ANALYSIS

A. *Result*

The following are the experiment's data

Table 2 Pins chip cooking

ITEM	UNIT	TEST RESULT		
		TRIAL		
		COOKING RESULT		
		AVG	AVG	AVG
AD PULP	g	476,46	473,64	480,54
Kappa number	-	19,32	16,55	15,16
Viskositas	cm^3/g	974	913	854
Brightness	% ISO	31,66	31,93	32,27

ISSN No:-2456-2165

Table 3 Oxygen Delignifikasi

ITEM	UNIT	TEST RESULT		
		TRIAL		
		O2 DELIGNIFICATION RESULT		
		AVG	AVG	AVG
Kappa number stg I	-	12,14	11.60	11,09
Kappa number stg II	-	11,45	11,07	10,47
Brightness stg I	%	44,57	45,27	46,90
Brightness stg I1	%	47,44	47,97	49,83
Viscosity stg I	cm^3/gr	922	884	826
Viscosity stg II	cm^3/gr	910	872	812
Viscosity drop stg I	cm^3/gr	52	29	28
Viscosity drop stg II	cm^3/gr	12	12	14
Viscosity drop total	cm^3/gr	64	41	42

Table 4 D0 stage

ITEM	UNIT	TEST RESULT		
		TRIAL		
		D0 RESULT		
		AVG	AVG	AVG
pH extraction	-	2,14	2,34	2,27
Viscosity	cm3/g	887	853	784
CEK	-	3,99	3,44	3,18
Brightness	% ISO	71,84	73,08	73,60
Residual chlorine	ppm	49,37	30,83	6,24

Table 6 EOP Stage

ITEM	UNIT	TEST RESULT		
		TRIAL		
		EOP RESULT		
		AVG	AVG	AVG
Initial pH	-	12,87	12,81	12,79
End pH	-	12,12	12,09	12,13
CEK	-	2,95	2,75	2,52
Viscosity pulp	cm^3/g	833	809	745
Brightness	% ISO	78,13	78,67	78,72

Table 7 D1 Stage

ITEM	UNIT	TEST RESULT		
		TRIAL		
		D1 RESULT		
		AVG	AVG	AVG
End pH	-	2,03	2,19	2,18
Viscosity pulp	cm^3/g	731	720	707
Brightness	% ISO	89,31	89,03	88,90
Residual chlorine	Ppm	35,6	38,4	58,5

Table 7 Paper Properties Test

ITEM	UNIT	TEST RESULT		
		TRIAL 1	TRIAL 2	TRIAL 3
		PROPERTIES RESULT		
		AVG	AVG	AVG
Freeness	ml CSF	300	300	300
SR	SR	33	32	33
PFI beating	Rev	3420	3731	3854
Basis weight	g/m^2	70,9	75,5	77,0
Thickness	µm	106	107	110
Bulk	cm^3/g	1,39	1,42	1,42
Tearing	mNm^2/g	8,9	8,8	9,6
Bursting	$kPam^2/g$	52,2	4,9	5,1
Tensile	Nm/g	76,0	71,8	72,6
Breaking length	Km	7,751	7,320	7,407
Strech	%	3,1	3,3	3,1
Opacity	%	76,6	76,5	77,3
Porosity	Sec/100ml	10,2	10,1	10,6

B. Analysis

Based on the compilation of test results data listed in the table above, the pins chip is a mixture of acacia and eucalyptus wood with a ratio of acacia crassicarpa : eucalyptus : acacia mangium = 62.23:33.40:4.37. Chip pins affect the yield value produced because as a result, the greater the percentage of use of chip pins, the lower the yield value produced. However, the use of the right active alkaline charge can produce a good pins chip yield and is quite effective in its use. It can be seen that the optimum yield of cooking produced is active alkaline charge sample 19% with yield value of 51.42%, and the lowest is active alkaline charge sample 17% with yield value 50.93%. This study has a fairly high yield value which is influenced by several factors such as fiber loss during cooking, sulfidity, and several other things. This research was conducted with variations of the active alkaline charge of 17%, 18%, and 19%, respectively, to achieve the optimal target for pulping using pins chips.

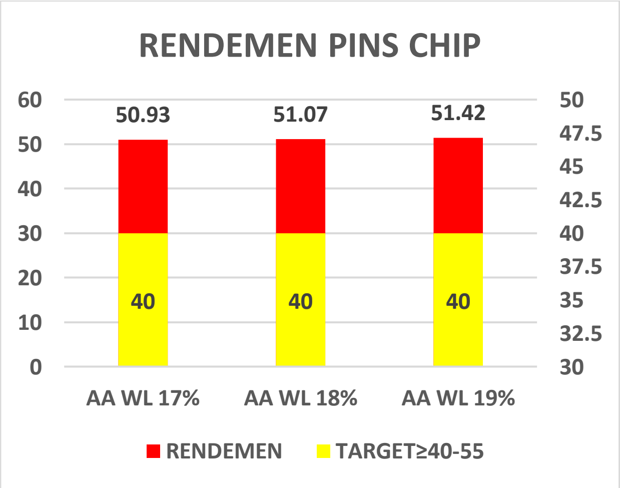

Fig 3.1 Rendemen pins chip

The higher the yield value, the more effective the pulping process. The higher the use of alkaline active charge, the more yield is produced. The yield of pulp produced is quite high at 19% AA WL due to the use of higher AA WL charge so that there is more lignin degradation, but the use of AA WL 17 and 18% also reached the target although not as much as the 19% AA WL yield.

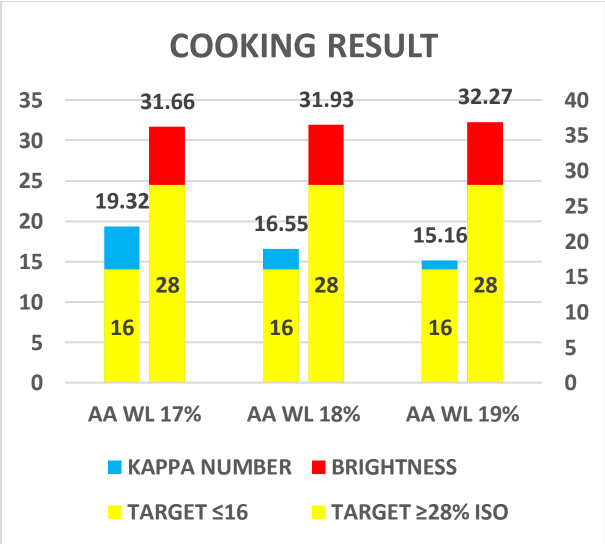

Fig 3.2 The Cooking of Pins' Chip

Pin chip cooking produces a pretty good kappa number, from Figure 3.2 above it can be concluded that the use of AA WL 17% is still very high in achieving the 16-18 target, but at AA WL 18% and AA WL 19% the kappa number has decreased significantly, especially at AA WL 19%. Due to the use of AA WL charge 19% more so that the lignin degraded more than the other two samples. Brightness at 19% AA WL charge is the highest because the low kappa number contains less residual lignin and causes higher brightness.

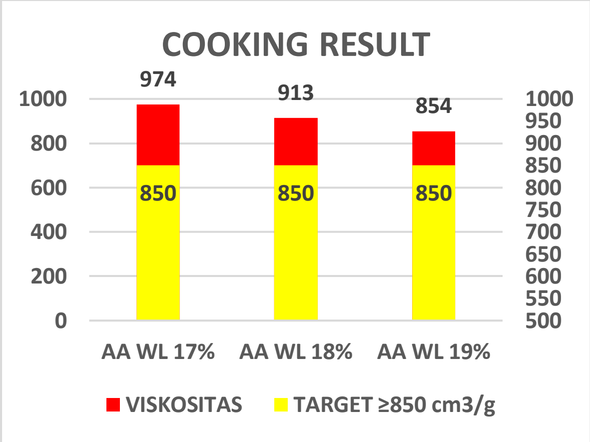

Fig 3.3 Cooking Viscosity

In contrast to brightness, a high kappa number causes a high viscosity because of the effect of the remaining lignin in the pulp. The more lignin contained, the higher the viscosity of the pulp. At AA WL 17% and AA WL 18% the resulting viscosity was higher than AA WL 19%, AA WL 19% experienced a fairly high drop but was still above the specified target.

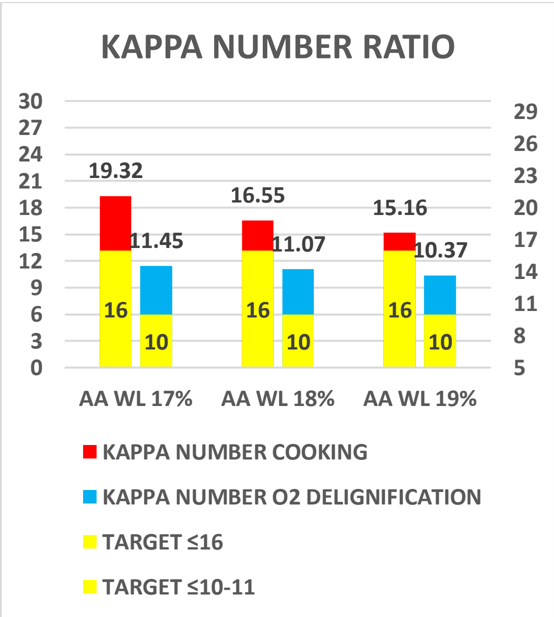

Fig 3.4 The Reduction of Kappa Number

Variations in alkaline active charge also resulted in differences in the value of reducing the kappa number and pulp viscosity. In the O_2 delignification stage, the kappa number reduction was reduced by about 40.74% against the early ripening kappa number in AA WL 17%, while in AA WL 18% the kappa number decreased by about 33.13% and AA WL 19% decreased by about 31.6%, This is because the more the AA WL charge is used on the chip pins, the less kappa reduction is produced.

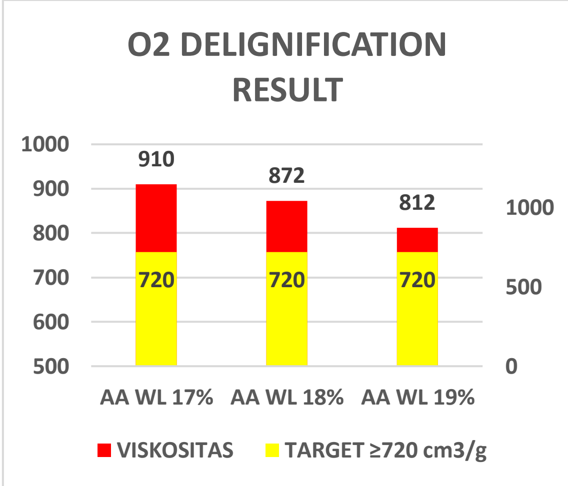

Fig 3.5 The Result of Viscosity O2 delignification

And the drop in total viscosity at 17% AA WL was around 64 cm3/g, at 18% AA WL was around 41 cm3/g and AA WL 19% was around 42 cm3/g, it was found that the drop in viscosity experienced up and down, it can be concluded that the addition of NaOH to AA WL 18% and 19% should be more than AA WL 17%.

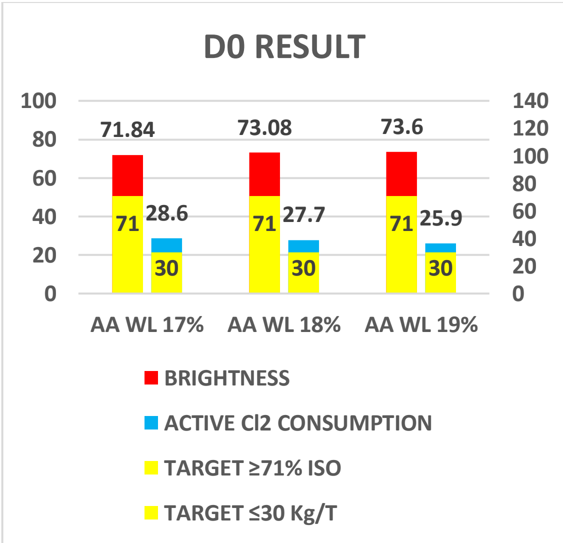

Fig 3.6 D0 Stage

The initial bleaching process (D0) uses active chlorine of 28.6 Kg/T, 27.7 Kg/T, and 25.9 Kg/T, respectively. The high consumption of active chlorine affects the decrease in the value of pulp viscosity and degradation of lignin. The use of AA WL charge at the bleaching stage (D0) affects the active use of chlorine, this is because the kappa number has a greater decrease in AA WL 19%, so that the use of active chlorine consumption is smaller than the other two samples and the viscosity drop is too large, damaging the pulp fiber. . And the brightness of AA WL is 17% smaller than the other two samples because active chlorine consumption focuses on lignin degradation.

ISSN No:-2456-2165

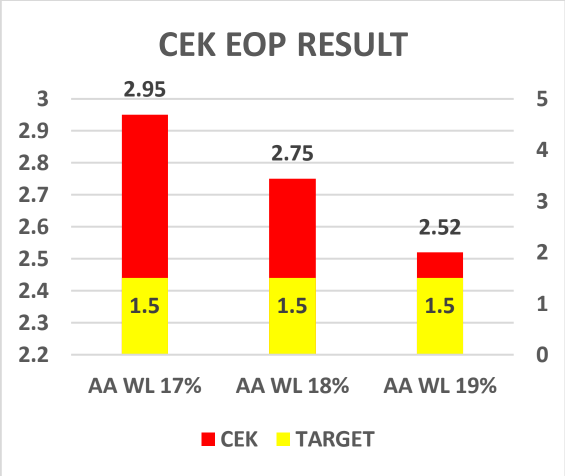

Fig 3.7 CEK EOP stage

The EOP stage is also added with oxygen and peroxide to reduce the bleaching chemical ClO2. The EOP process is a process of extracting the components of degraded lignin, carried out after the first stage of bleaching, the chemical used is a solution of NaOH. The alkaline group replaces the chlorine which makes the lignin dissolved. The CEK values for each sample are around 2.95, 2.75, and 2.52. The CEK target at the EOP stage has not been achieved

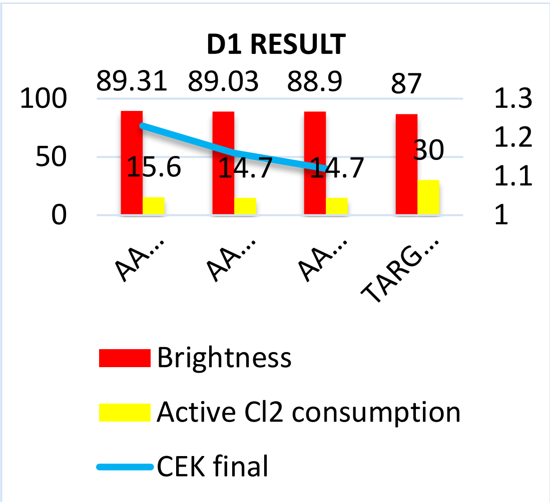

Fig 3.8 D1 stage

Stage D1 is the final stage of bleaching, at this stage the brightness increases significantly at 17% AA WL while in the previous stage (D0) brightness at AA WL 17% below the other two trials, this is because the use of this stage has degraded lignin so that the active use of chlorine focuses on increasing brightness. Meanwhile, in the D0 stage, the brightness of AA WL was 17% smaller, this was due to the low lignin degradation so that the brightness obtained was smaller than the other two trials, and in the D0 stage, active chlorine consumption focused on lignin degradation. In stage D1 the CEK target is around 1.2, so the 17% AA WL trial has not reached the desired kappa target, but the other two trials, namely 18% AA WL and 19% have reached the target.

Each sample requires 4500 revolutions to produce 300 ± 10 mL CSF and a series of physical properties tests are obtained.

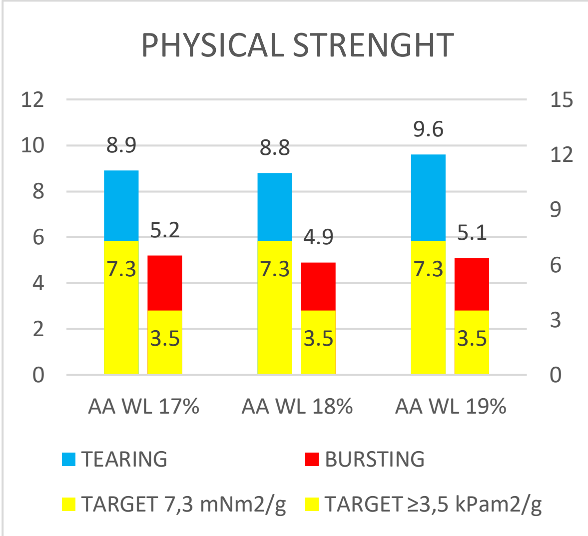

Fig 3.9 Paper Strength

The tearing value on the paper reached more than the target 7.3 Nm2/g and the bursting value 3.5 kPam2/g, this was due to the fibrillation on the paper that continued to increase every time the use of AA WL charge increased. Bursting and tearing are also not affected by active chlorine consumption

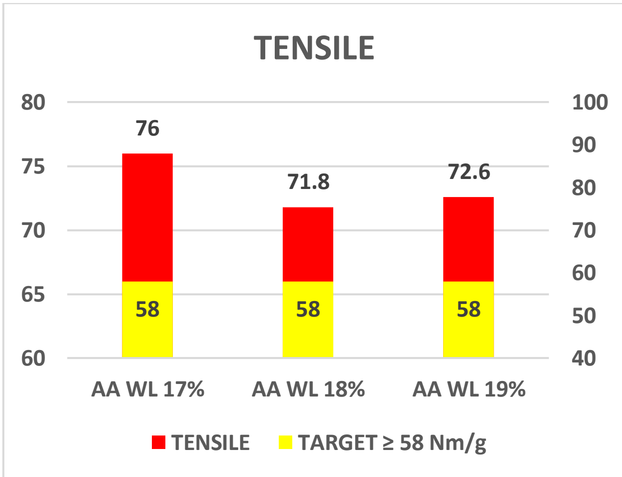

Fig 3.10 Tensile Strength Index

Tensile strength is the maximum resistance of a sheet of paper to the tensile force acting on both ends of the sheet of paper, in units of kN/m. In testing the physical properties of the paper obtained a fairly high value due to the beating process of 4500 rev. These results are combined and the average result is obtained. About 300 mL of CSF produced tensile indexes of 76 Nm/g, 71.8 Nm/g, and 72.6 Nm/g, respectively, the value of active alkali and active chlorine consumption affected the tensile value of paper.

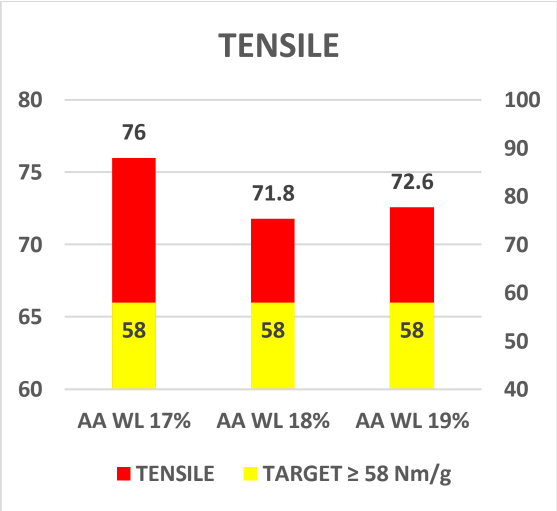

Fig 3.10 Tensile Strength Index

The lower the opacity, the more the interfacial scattering between the air and the fiber, the filler which means the greater the porosity of the paper, the stronger the light scattering ability of the paper, and the easier it is to print. On the other hand, the higher the opacity, the smaller the porosity of the paper, the less scattering of the interface between the air and the fibers, fillers, compounds and coatings. The harder it is for light to pass through the paper, the harder it is for the ink to penetrate the paper.

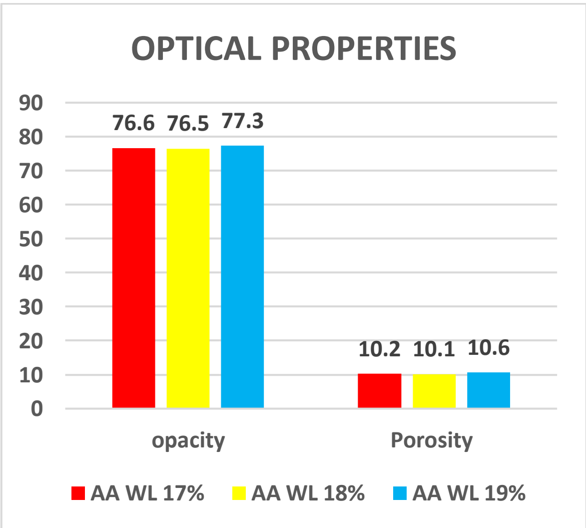

Fig 3.11 Paper Optical Properties

The opacity and porosity of the paper are not affected by the active consumption of chlorine and the cotton factor, this is because the porosity is affected by the length of the fiber and filler material, while the trial does not add filler. And fiber length is affected by fibrillation, active alkali, and wood type.

IV. CONCLUSION

1. The effectiveness of using pin chips can be seen from the amount of yield produced and achieving targets such as kappa number, viscosity, brightness, active use of chlorine, physical strength, and optical properties of paper

2. Based on the test results for making kraft pulp from pin chip pulp as part of the wood, the minimum portion is expected from the chiping process, it turns out to produce a fairly high pulp yield from the cooking process, with an average yield for all variations of active alkali, which is 51.14%, where the yield is 51.14%. the highest is 51.43% and the lowest is 50.93%

3. For the optimum conditions of several variations of active alkali used for the cooking process to determining the strength properties of the pin chip pulp, consumption of active alkali of 18% from white liquor is the best condition, where in this condition the value of the kappa number of cooked pulp is not too high (16.55), the drop in viscosity in the MCO2 process is not too much (4.49%), the total alkaline active chlorine needed in the bleaching process is not too high (42.41 Kg/T) and all strength properties parameters are also high.

REFERENCES

[1]. Septyaningsih, I.,"Kemenperin Tingkatkan Mutu Industri Kertas lewat SDM", Republika.co.id, https://www.republika.co.id/berita/qwonj0380/kemenperin-tingkatkan-mutu-industri-kertas-lewat-sdm, accessed 13 February 2022

[2]. Färlin, A.," Analysis of chip quality and value at Norske Skog Pisa Mill, Brazil",Magister Thesis, Departement of Forest Product, SLU, Sweden, 2008

[3]. Oxygen Delignification, https://imisrise.tappi.org/TAPPI/Products/ELC/ELC-027.9.aspx

[4]. Oxygen Deliginification process, http://www.pulppapermill.com/oxygen-delignification-process/ accessed 14th may 2022

[5]. Pratima Bajpai, Environmentally Benign Approaches for Pulp Bleaching , 2nd ed, https://doi.org/10.1016/B978-0-444-59421-1.00011-9

[6]. Dence, C. W. (1996). Pulp bleaching principles and practice. TAPPI, 812-815.

[7]. Sirait, S. (2003) : Bleaching Module, Training and Development Centre, Porsea, PT. Toba Pulp Lestari. Tbk