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The Effect of Adding Burn Lime and Fresh Lime Variations to The Quality of Lime Mud

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ABSTRACT

Recausticizing units in mill pulp have a major role in converting green liqour into white liquor and produces lime mud as a by-product. In the recuaticizing process there is the addition of calcium oxide. Two types of calcium oxide are used, i.e burn lime and fresh lime. These two types will affect the quality of the lime mud produced. The objective of this research is to identify the effect of variations of addition burn and fresh lime to lime mud quality.The target parameters of $CaCO_3$ content >86%, total alkali <1% and Non-Process Elements (NPE) <2%. The range of combination addition burn lime and fresh is between 0% - 100%. The optimal composition of addition of calcium oxide in the manufacture of lime mud both from a technical and cost perspective is the second variation (75% burn lime and 25% fresh lime). The second variation gives content of CaCO3 86.80%, total alkali 0.1141% and Non-Process Elements (NPE) are P_2O_5 0.4260%, SiO_2 2.4344%, MgO 0.2260%, Fe_2O_3 0.1984% and Mn_2O_5 0 ,0068%. These result are in accordance with the lime mud quality standard.

Keywords: Recausticizing, Lime Mud, Calcium Oxide, Burn Lime, Fresh Lime

I. INTRODUCTION

Today kraft pulping technology still dominates the pulp industry. This Kraft pulping combines heat, chemicals and mechanical treatment in the manufacture of pulp [1]. In the kraft pulping industry, there is a chemical recovery unit which has an important role in reducing the generation of liquid waste and pollutants into the environment [2].

The chemical recovery unit has an important system which produces a cooking solution for the digester. This system is recausticizing plant. This solution comes from recycled inorganic chemicals produced from the recovery boiler and lime kiln [3]. The main function of the recausticizing plant converts Green Liqour to White Liqour by adding lime (CaO). This process decreased the content of Na_2CO_3 and increased NaOH. Another objective of the process is to make sure that the efficiency of carbonate conversion keeping as high as possible [4].

The block diagram of the recausticizing show in figure 1.
Smelt from the bottom of the recovery boiler tank is diluted with weak liquor and produces green liquor.

Green liquor will be converted into white liquor after going through 4 stages of clearence. The first is the opti disc filter, slaker, causticlear and the last is the white liquor disc filter. From all these stages, inorganic wastes are produced [5] namely dregs, grits and lime mud. This waste will be disposed of in landfills. After passing through 4 filter stages, the final product, namely white liquor, will be channeled to the digesting pulp section (figure 1)

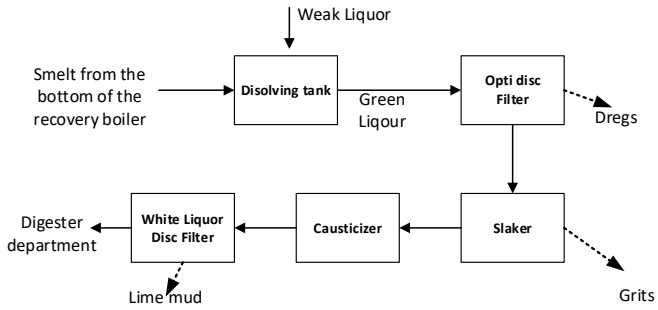

Figure 1 Recausticizing Process Plant

The reaction equation for the slaking process is as follows:

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s) \quad (1)$$

The reaction equation for the causticization process is as follows:

$$Na_2CO_{3(aq)} + Ca(OH)2_{(aq)} \rightarrow 2\ NaOH_{(aq)} + CaCO_{3(s)} \quad (2)$$

The reaction equation for the calcination process is as follows:

$$CaCO3(s) + Heat \rightarrow CaO(s) + CO_2(g) \quad (3)$$

Lime mud is a by-product of the recustization process, most of which is calcium carbonate. Lime mud produced from this process has a fairly high calcium carbonate content of 80%.

In the pulp industry, calcium oxide is used in the recausticizing process which will be reacted with green liquor to produce white liquor and lime mud. Calcium oxide can be produced by the lime mud calcination process in a lime kiln unit. In addition, calcium oxide can also be derived from natural stone calcination.

Burn Lime is a product produced from the calcination process in a lime kiln. Lime kiln is useful for converting calcium carbonate into calcium oxide as in Equation 3. Meanwhile, Fresh Lime or quicklime is a conventional product from the limestone industry [6]. Fresh lime is made by burning lime stone in a calcination furnace.

The type of calcium oxide used can affect the quality of lime mud, so that in the manufacture of the recausticizing process, knowledge is needed about the effect of adding different types of lime (calcium oxide). This is the main reason for research related to the effect of the use of calcium oxide on the quality of lime mud carried out . The parameters of the experimental results that are considered are the value of $CaCO_3$ content, Total Alkali and Non-Process Element (P_2O_5, SiO_2, MgO, Fe_2O_5 and Mn_2O_5). The above is the background for the author to conduct a study entitled "The Effect of Variations in Adding Burn Lime and Fresh Lime to the Quality of Lime Mud". The experimental parameters that are considered are the value of $CaCO_3$ content, Total Alkali and Non-Process Element (P_2O_5, SiO_2, MgO, Fe_2O_5 and Mn_2O_5).

II. METHODS

The preparation stage is the first stage carried out in research. At this stage, preparations are carried out starting from the preparation of raw materials, testing specifications for raw materials, and preparing tools. Testing the specifications of raw materials in the form of burn lime and fresh lime.

The second stage is the implementation stage. The implementation stage is to experiment with making lime mud with a lime mud quality target. In this study, two stages of implementation were carried out,

namely the manufacture of white liquor and lime mud slurry and the treatment stage of lime mud ready to kiln.

In this study, a trial was conducted on the manufacture of lime mud on a laboratory scale using the effective reaction time in previous studies. Making lime mud using burn lime and fresh lime as calcium oxide which will react with sodium carbonate to produce sodium hydroxide and calcium carbonate. Calcium oxide was varied, then the slaking stage was carried out for 20 minutes with the process temperature maintained at 101-104°C and the caustization stage was carried out for 220 minutes with the process temperature maintained at 98-100°C. The lime mud slurry formed will then be added with water with a density of 1.05 kg

TABEL 1
EXPERIMENTAL VARIATIONS FOR MAKING LIME MUD

No	Calcium Oxide (CaO)	
	Burn Lime	Fresh Lime
1	100%	0%
2	75%	25%
3	50%	50%
4	25%	75%
5	0%	100%

The testing stage is the final stage in the research. At this stage, lime mud quality parameters were tested. Among the parameters that are checked are CaCO3 content, Total Alkali and NPE (Non-Process Element).

III.RESULTS AND DISCUSSION

A. Raw Material Test Results

The results of testing the raw materials used will be presented in Table 2 and Table 3 as follow.

TABEL 2. CALCIUM OXIDE PURITY

Sampel CaO	Purity (%)
Burn Lime	74.95
Fresh Lime	89,05

TABEL 3. GREEN LIQUOR COMPOSITION

Parameter	Composition
NaOH	8,39 g/L as Na_2O
Na_2S	34,80 g/L as Na_2O
Na_2CO_3	87,32 g/L as Na_2O
Total Titratable Alkali	130,51 g/L as Na_2O

In this study, testing of raw materials was carried out which aims to determine the content contained in these raw materials. This content will affect the process and the resulting product.

Testing the purity of CaO was carried out to determine the amount of CaO content and impurity particles, the higher the purity of CaO, the smaller the impurity particles, and vice versa. In addition, the purity of CaO is used to determine the amount of lime (CaO) added in the lime mud manufacturing process.

Green liquor composition testing is carried out to determine the amount of alkaline composition contained in green liquor. Because the composition of alkaline green liquor will be used to determine the amount of sodium carbonate which will be converted into sodium hydroxide and calcium carbonate.

B. Lime Mud Test Result

1. $CaCO_3$ Content

The results of the $CaCO_3$ content test aim to determine how much $CaCO_3$ is contained in lime mud, because the amount of $CaCO_3$ content will affect the CaO produced. During the calcination process, the higher the $CaCO_3$ content, sufficient temperature and time, the higher the yield of CaO produced, and the higher the purity of CaO produced. Test results for CaCO3 content will be presented in Table 4 below.

TABEL 4. TEST RESULTS OF THE EFFECT OF ADDITION OF CaO TO $CaCO_3$ CONTENT

No.	Variation		$CaCO_3$ *Content* (%)
	Burn Lime	*Fresh Lime*	
1	100%	0%	85,96
2	75%	25%	86,80
3	50%	50%	90,15
4	25%	75%	92,95
5	0%	100%	97,11

From the above data processing, a graph is obtained regarding the effect of adding burn lime and fresh lime to the CaCO3 content as follows:

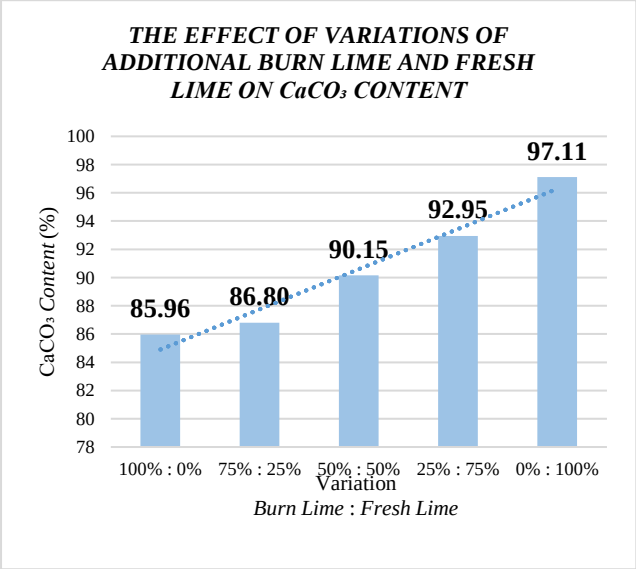

Figure 2 CaCO Content Test Results

The results of the test of $CaCO_3$ levels of lime mud samples with variations of 100% burnt lime and 0% fresh lime are 85.96%. The results of the test of $CaCO_3$ levels of lime mud samples with variations of 75% burnt lime and 25% fresh lime are 86.80%. The results of the test of $CaCO_3$ levels of lime mud samples with variations of burnt lime and fresh lime were 50% each, namely 90.15%. The results of the test of $CaCO_3$ levels of lime mud samples with variations of 25% burnt lime and 75% fresh lime are 92.95%. The results of the test of $CaCO_3$ levels of lime mud samples with variations of 0% burnt lime and 100% fresh lime are 97.11%.

Figure 3 showed that the increase in the percentage value of $CaCO_3$ content with the addition of fresh lime, where the highest percentage value of $CaCO_3$ was obtained with the addition of 100% fresh lime.

It can also be seen in Table 2. that the purity of lime type calcium oxide has a fairly high purity of 89.05%, the purity of this lime can affect the percentage value of the $CaCO_3$ content that will be produced or it can be said that the lime sludge produced will have good quality.

2. Total Alkali

The results of the total alkali lime mud test aim to determine how much alkali content is in lime mud. This test is also carried out to determine the effect of adding burn lime and fresh lime to the total value of alkaline lime mud. The test results for total alkaline lime mud will be presented in Table 5 below

TABEL 5
TEST RESULTS OF THE EFFECT OF ADDITION OF CaO TO TOTAL ALKALI

No.	Variation		Compound (%)				
	Burn Lime	*Fresh Lime*	P_2O_5	SiO_2	MgO	Fe_2O_3	Mn_2O_5
1	100 %	0%	0,57 47	2,68 48	0,24 23	0,23 07	0,00 71
2	75 %	25 %	0,42 60	2,43 44	0,22 60	0,19 84	0,00 68
3	50 %	50 %	0,40 40	1,70 25	0,21 98	0,15 83	0,00 63
4	25 %	75 %	0,34 04	1,65 13	0,20 85	0,14 67	0,00 60
5	0%	100 %	0,17 24	0,87 01	0,17 20	0,03 41	0,00 47

From the data processing above, a graph is obtained regarding the effect of adding burn lime and fresh lime to the total alkali lime mud as follows:

The results of the total alkali test of lime mud samples with variations of burn lime and fresh lime were 50% each, namely 0.1055%. The test results of total alkali lime mud samples with variations of burn lime 25% and fresh lime 75% were 0.0946%. The test results for total alkali lime mud samples with variations of burn lime 0% and fresh lime 100% were 0.0903%. From the test data, the total alkali lime mud sample with various variations has the expected value of 1.0%.

Figure 3 showed that the percent value of total alkali decreased with the amount of fresh lime added, where the lowest percent value of total alkali was obtained with the addition of 100% fresh lime. In addition, the more use of burn lime, the higher the percentage value of the total alkaline lime mud produced

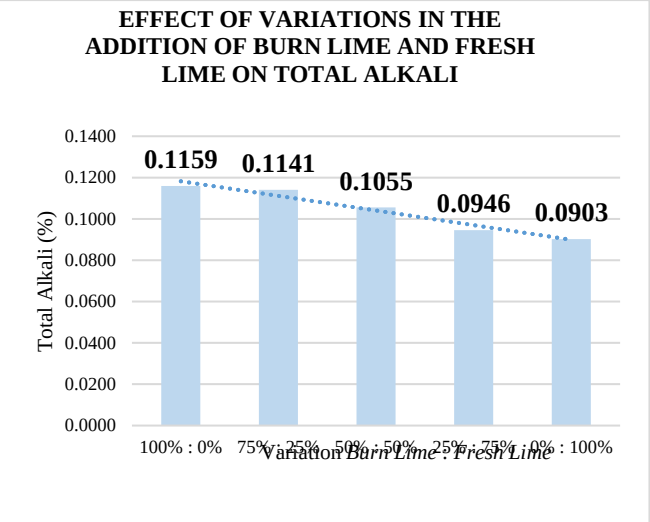

Figure 3 Total Alkali Test Result

The percent value of total alkali indicates that the amount of white liquor or alkali that enters the lime mud. In addition, the high percentage of total alkali will affect the high fuel consumption in the calcination process in the lime kiln. Then from the calcination process will produce large lime, because of the large size of this lime it will cause the inside of the raw lime. As a result of this condition, the lime produced will affect the process of recausticizing. It is known that the recausticizing process and the lime kiln process are part of the chemical recovery process in the kraft pulp industry.

3. Non-Process Elements (NPE)

The results of the Non-Process Element (NPE) test aim to determine how much metal compounds are contained in lime mud. This test is carried out by 2 methods, namely the gravimetry method and the ICP (Inductively Coupled Plasma) method. The test results for total alkaline lime mud will be presented in Table 6, as follows

TABEL 6

NON-PROCESS ELEMENT (NPE) TEST RESULTS

No.	Variation		TotaL Alkali (%)
	Burn Lime	*Fresh Lime*	
1	100%	0%	0,1159
2	75%	25%	0,1141
3	50%	50%	0,1055
4	25%	75%	0,0946
5	0%	100%	0,0903

From the above data processing, a graph is obtained regarding the effect of adding burn lime and fresh lime to the Non-Process Element (NPE) as follows:

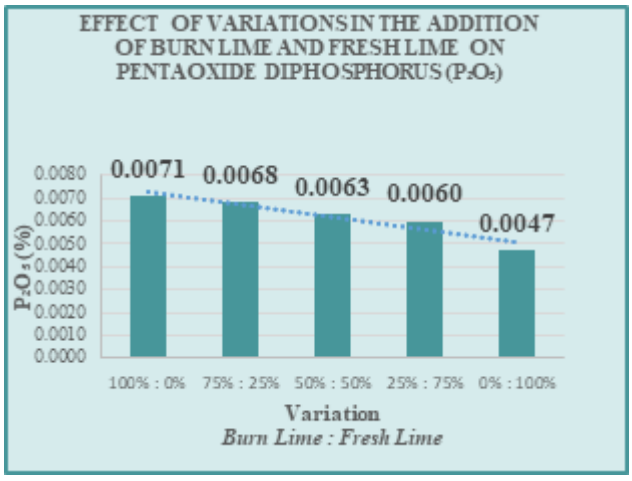

Figure 4 Pentaoxide Disphosphorus (P_2O_5) Test Result

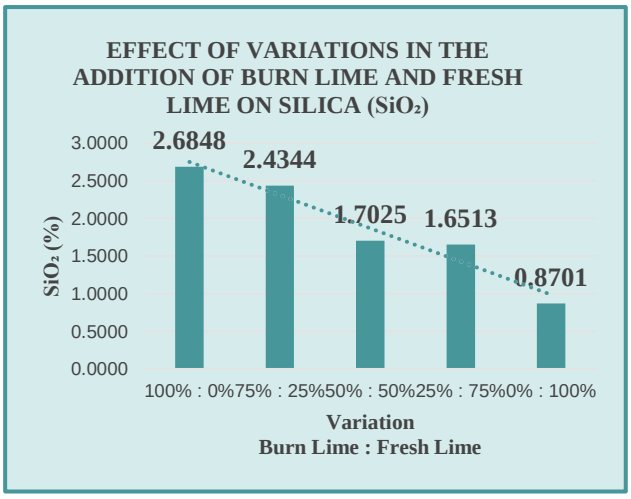

Figure 5 Silica (SiO_2) Test Result

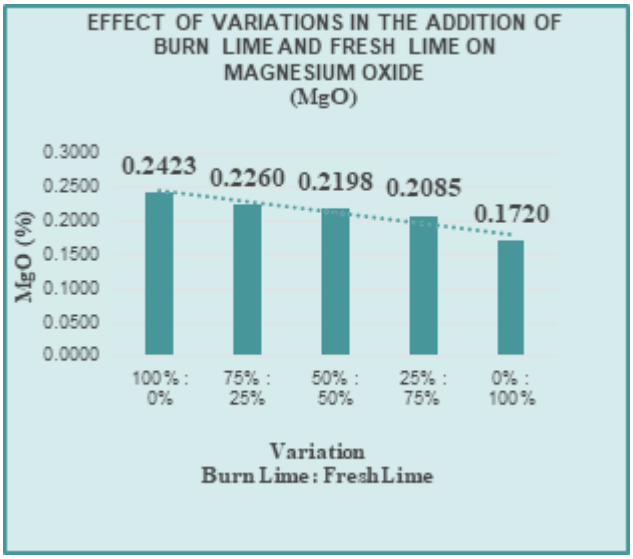

Figure 6 Magnesium Oxide (MgO) Test Result

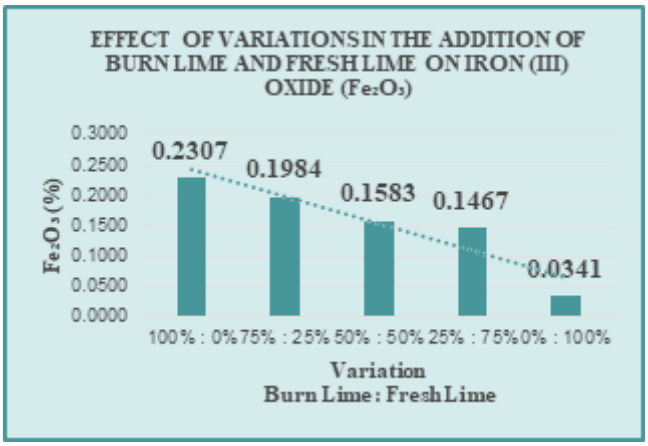

Figure 7 Iron (III) Oxide (Fe_2O_3) Test Result

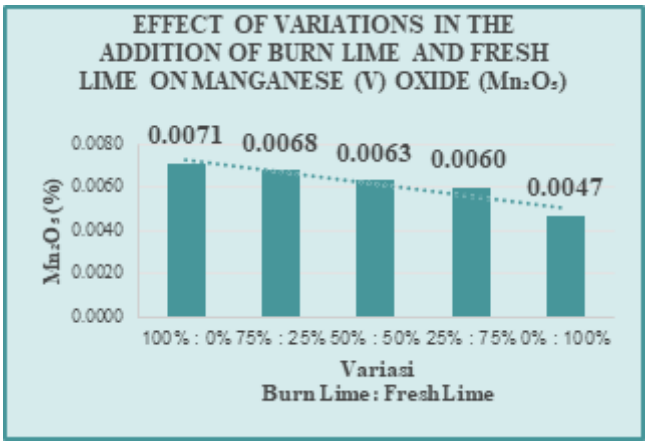

Figure 8 Manganese (V) Oxide (Mn_2O_5) Test Result

Non-Process Element (NPE) is classified as an element / element that is not needed in the process. In other words, NPE can be considered as an impurity in lime mud. This has been state that NPE enters the process through wood, bark, make-up lime, make-up chemical and process water [2].

Figure 4 up to figure 8. showed that the addition of CaO can affect the percentage of Non-Process Element (NPE) contained in lime mud. It can be seen from the figure that there are 5 types of NPE, namely P_2O_5, SiO_2, MgO, Fe_2O_3 and Mn_2O_5. These five types of NPE are impurity compounds that can interfere with the causticizing and lime kiln processes. P_2O_5, MgO, Fe_2O_3 and Mn_2O_5 compounds can be stated as high dead loads in the kiln in the lime cycle process

Figure 4 to figure 8 the percentage of 5 types of impurity compounds contained in lime mud shows that samples with more variations in the use of burn lime can cause the content of the impurity compounds to increase as well.

In addition, it can be seen from Figure 4 up to Figure 8 the graph presented of each impurity compound or NPE decreases along with the less use of burn lime. It can be said that the more use of fresh lime, the lower the NPE content in the lime mud produced. This is because fresh lime is a type of CaO produced from the natural limestone calcination process. This is different from burn lime which is a type of CaO produced from the kiln process, where the process converts calcium carbonate into calcium oxide. So that the quality of fresh lime is better than burn lime.

If the dependent variable is NPE 2%, then the percent SiO_2 with variations in burn lime 100% and variations in burn lime 75%: fresh lime 25% does not meet the desired or specified number, where the percent value for 100% burn lime variation is 2.6848% and the variation of burn lime 75%: fresh lime 25% is 2.4344%.

Figure 4 to 8 shows the percentage of NPE is quite good, where the percentage of the value is much less than 2%.

4. Cost Variasi Kalsium Oksida (CaO)

TABEL 7
COST VARIATION CALCIUM OXIDE (CaO)

No.	Variasi		Total Harga (USD/kg CaO)
	Burn Lime	*Fresh Lime*	
1	100%	0%	**3,2876**
2	75%	25%	**4,8780737**
3	50%	50%	**6,4699427**
4	25%	75%	**8,0608164**
5	0%	100%	**9,6512901**

Table 7 Obtained cost data for variations in the addition of calcium oxide (CaO). Where for each variation of the addition of calcium oxide (CaO) has a different cost value. The quality standards of lime mud used are CaCO content 86%, total alkali 1% and Non-Process Elements (NPE) 2%.

Based on information from the industry where this research was conducted, the burn lime price was 0.04 $/kg CaO and fresh lime was 0.13953$/kg CaO. For variations that use more fresh lime, the costs incurred will also be even greater. The results showed that the good quality of lime mud was found in the increasing composition of the addition of fresh lime. So the optimal composition from the technical and cost perspective is the second variation, where the composition of the addition of burn lime is 75% and fresh lime is 25%.

IV. CONCLUSION

Based on the analysis and discussion of the research data above, it can be concluded as follows.

1. The addition of burn lime and fresh lime will affect the percent $CaCO_3$ content. The more addition of fresh lime composition, the higher the percentage of CaCO3 content produced, namely the addition of 100% fresh lime composition. The percentage of CaCO3 content produced is 97.11%.

2. The addition of burn lime and fresh lime will affect the total alkaline lime mud. The more the addition of burn lime composition, the higher the total alkaline lime mud produced, namely the addition of 100% burn lime composition and the resulting value is 0.1159%. However, the lower the total alkali value, the better the quality of lime mud produced. With the addition of 100% fresh lime composition, the lowest total alkali value was 0.0903%.

3. The addition of burn lime and fresh lime affects the value of Non-Process Elements (NPE). In NPE, the lowest possible value is required, namely the addition of 100% fresh lime composition. The resulting NPE values were P_2O_5 0.1724%, SiO_2 0.8701%, MgO 0.1720%, Fe_2O_3 0.0341% and Mn_2O_5 0.0047%.

4. The optimal composition of addition of calcium oxide in the manufacture of lime mud either from a technical or cost perspective is the second variation, where the composition of the addition of burn lime is 75% and fresh lime is 25%.

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