

# **PRODUCTION OF CHALK FROM CARBIDE SLUDGE**

*BY*

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93/3716

**A RESEARCH PROJECT REPORT SUBMITTED TO THE  
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OF ENGINEERING & ENGINEERING TECHNOLOGY,  
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THE AWARD OF BACHELOR OF ENGINEERING (B.ENG.)  
DEGREE IN CHEMICAL ENGINEERING.**

**MARCH 2000**

# **CERTIFICATON**

This is to certify that this project work "production of chalk from carbide sludge" which I have found adequate both in scope and quality for the partial fulfillment of the requirement for the award of Bachelor of Engineering degree in Chemical Engineering was presented by Oyelade O. Victoria 93/3716 of **CHEMICAL ENGINEERING DEPARTMENT F.U.T. MINNA.**

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# DEDICATION

This project work is dedicated to my younger ones - Femi, Kola, Gbemi & Seye.

*"The sky is the beginning"*

## **ACKNOWLEDGEMENT**

Hardly anyone receiving an oscar, leaves the podium without thanking all those along the way who have helped towards that moment.

To God be the glory, great things He hath done. Blessed be the name of God forever and ever, to whom belong wisdom & might. He changes times & season, he raises up the poor from dust, he lifts the needy from the ash, to make them sit with princes and inherit a seat of honour. May his name be praised.

It is my great pleasure to express my appreciation to my project supervisor, the Head of Department Chemical Engineering, Dr J. O Odigure for his time and energy spent on reviewing this work, this wouldn't have been possible without his immerse contribution.

I owe a lot to all the lecturers in Chemical Engineering Department, for the knowledge they have impacted.

My profound gratitude goes to my beloved parents Mr. Babatunde Oyelade and Mrs. Yinka Oyelade, for their parental care, morally and financially to see that I attain this level of education, also my younger ones are not left out, Femi, Kola, Gbemi and Seye & my sister Mrs. Nike Adebomi. *"You all mean so much to me"*

Special thanks to my Uncles, Mr. Joel, Mr. Olaolu, Mr. Opeyemi and others for their financial assistance & moral supports.

Words cannot express my appreciation to my guardian Barrister Oluwole Olukunle. I am indebted to his relentless effort morally and financially.

I appreciate Mr. Jide Oladapo, Mr. Peter Egena, Mr. Taiwo OJo, Mr Tikuraaiyesina, Miss Mopayi and Mr. Ejeromedoghene & family.

My gratitude to all staff of Boc Gases Nigeria Ltd, especially Mr. Ogundeji, Mr. Taiwo Ojo, Mr. J. O. Falode & Mr. Ilori for their assistance on this project.

Finally I appreciate my classmates, for their support & encouragement, Chuks, Adinoyi, Isaac, Ochor & Wale. We will meet on top of the ladder.

## **ABSTRACT**

This project focused on investigating the technological feasibility of the production of chalk from carbide sludge.

Carbide sludge was processed into dry lime hydrate by sedimentation, pressing, drying, crushing and sieving. It was observed that the optimum composition for chalk production with carbide sludge is 49.9% of  $\text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$  and 0.2% additives.

The paste was quickly poured into the mould which has been lubricated. The setting time is about 12 minutes. The chalkstick was push out of the cavity using the piston. The drying time is 7hrs at a temperature of ~~120~~<sup>120</sup>°C.

Calculations showed that the dry chalk contains about 25.4% binded water, which is equivalent to 34% of the total water added.

## LIST OF TABLES

- Table 2.1      Typical chemical composition Ca (OH)<sub>2</sub> only basis
- Table 2.2      Bulk density of Ca (OH)<sub>2</sub> vs. percent solid
- Table 2.3      Percent solid vs. available Ca O
- Table 2.4      Analysis of CaCO<sub>3</sub> sample

# TABLE OF CONTENTS

	<b>Pages</b>
TITLE PAGE	i
CERTIFICATION	ii
DEDICATION	iii
AKNOWLEDGEMENT	iv
ABSTRACT	vi
TABLE OF CONTENT	vii
<b>CHAPTER ONE</b>	
1.0.0 Introduction	1
1.1.0 Historical origin	1
1.2.0 Justification	2
1.3.0 Raw Material & Equipment	2
1.4.0 Objective & Motivation	2
1.5.0 Scope & Limitation	3
<b>CHAPTER TWO</b>	
2.0.0 Literature Review	4
2.1.0 Material used in chalk production	4
2.1.1 Gypsum	4
2.1.2 Plaster of paris	4
2.1.3 Calcium Carbonate	5
2.1.4 Lime stone	5
2.1.5 Natural chalk	5
2.1.6 Kaolin	6
2.1.7 Alternative raw material	6



2.1.8	Casting thick suspension	7
2.1.0	Lime sludge as raw material	8
2.2.1	Carbide lime technical data & Availability	8
2.2.2	Production of plaster of paris from lime sludge	12
2.2.3	Production of CaCo <sub>3</sub> lime sludge	13
2.2.4	Reactions of calcium hydroxide	14
2.3.0	Making of chalkstick from hydrate lime	15
2.3.1	Processing of hydrate lime from carbide sludge	15
2.3.2	Casting of hydrate lime	16
2.3.3	Mould for casting chalkstick	16
2.3.4	Binding material	17
2.3.5	Dextrins as binding material	18
2.3.6	Pigments & colourants	20
2.4.0	The great utility of lime	20
2.4.1	Uses in chemical industrial field	21
2.4.2	Uses in Building and construction	22
2.4.3	Uses in field of water softening, sewage & acid treatment	23
2.4.4	Formulas for lime mixtures	26
 <b>CHAPTER THREE</b>		
3.0.0	Experimental work	29
3.1.0	Experimental processes	29
3.2.0	Experimental procedure	30
3.3.0	Flow process	31
3.4.0	Table of result	32
3.5.0	Batch production of 1000kg chalk	33

## **CHAPTER FOUR**

4.0.0 Discussion of results	34
4.1.0 Proposed technology of production	35

## **CHAPTER FIVE**

5.0.0 Conclusion	37
5.1.0 Recommendation	37

<b>Appendix</b>	38
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<b>List Tables</b>	40
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<b>References</b>	41
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## **1.2.0 JUSTIFICATION**

The problem of waste disposal has become so prominent in developed and developing countries. Now and then, Industries are faced with the problem of depositing their waste products. For instance in the generation of acetylene gas by "wet process", carbide lime is obtained as a by-product which has to be disposed. This problem has necessitated finding the possible use of this by-product.

Carbide lime consist about 96.7%  $\text{CaCO}_2$  on dry basis, which can be used for several purposes. Chalk plays an indispensable role in educational development of any Nation. "Education for all by the year 2010" guarantees at least for the next decade a strong demand for chalk. It is found that only in recent times is chalk produced in Nigeria. Most of the chalk consumed are imported. Therefore to complement this, small scale industries on chalk business are springing up as a result of the discovery of row materials in the country. However, there are few chalk business, and machines are very few and the ones available are not cheap to build and operate and sometimes produce poor quality chalks that do not write well.

The need for recycling waste products increase demand for quality chalk led to this project.

## **1.3.0 RAW MATERIAL/EQUIPMENT**

Raw material used could be obtained from acetylene generating plants. They include Boc Gases Phc Lagos. Other raw materials are  $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ , Binders and Pigments. The equipment mainly consists of mould, Drying oven (optional) mixing vessels, stirrer, weighing machine, crusher, screens, sedimentation tank and presser.

## **1.4.0 OBJECTIVES AND MOTIVATION**

The aim of this project is to investigate the technological feasibility of the production of chalk from carbide sludge and also to compare with standard ones for commercial

purposes. The motivation behind this project is the increasing problem of waste disposal in Acetylene generating plants

### **1.5.0 SCOPE AND LIMITATION**

This project involves the processing of carbide lime into dry lime hydrate and the analysis on dry basis. It also involves the production of chalk from lime hydrate. The project also extends to compare output quality with existing ones for commercial purposes.

The limitations encountered in this project is with equipment to test the properties of the chalk produced, and most of the judgments were based on human preference and physical properties.

Very fine particles size would not be obtain.

## **CHAPTER TWO**

### **2.0.0 LITERATURE REVIEW**

### **2.1.0 MATERIALS USED IN CHALK PRODUCTION**

#### **2.1.1 GYPSUM<sup>(2)</sup>**

Gypsum is a soft rock occurring in sedimentary layers, its colour varies from white to grey, pink or brown depending on the nature and the amount of the impurity present.

Gypsum occur in five forms all of commercial value.

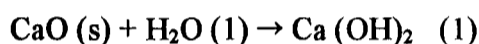
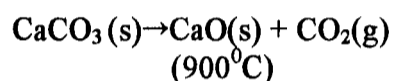
1. **Rock Gypsum:-** The common form is scaly or granular. The plasterboard used by builders is made from this form of gypsum, pressed into layers with paper . This gypsum is also used in the manufacture of plate glass and water based paint.
2. **Gypsum:-** Impure, earthy form, used as fertilizers, particularly for peanut crop of the southern United States.
3. **Selenite:-** Is a transparent crystal form, used for inexpensive jewellery.
4. **Alabaster:** Is a soft, compact, fine grained form of gypsum (calcium sulphate) that is easily carried. Its slightly translucent and it colour usually ranges from white to pink. Alabaster is used to mold status, used as lamp bases, level boxes and other ornamental object. These objects can be made as hard as marble by being subjected to intense heat. Gypsum is anhydrous calcium sulphate with the formula  $\text{CaSO}_4.2\text{H}_2\text{O}$ .

#### **2.1.2 PLASTER OF PARIS**

It is originally made from gypsum fund in Paris <sup>(3)</sup>. Notable producer in Nigeria include Africa mining, limited in north, Maico consultant limited & Karvitex in Lagos. Plaster of Paris is available in the market for direct use. Thus the entrepreneur can decide to buy directly from the place mentioned above or from other producer, or set up his own unit of producing it.

### 2.1.3 CALCIUM CARBONATE <sup>(4)</sup>

This is a white precipitation from limestone or natural chalk. It is mixed with certain organic and inorganic binders, to fashion into chalkstick. Its origin can be traced back to natural occurring chalk. Dimorphous and crystallizing in various form, hexagonal system as calcite (Density 2.7) and Aragonites (Density 292) calcite is the most common form of calcium carbonate, besides occurring in mineral, it forms the calcium constitutes of egg shell and bones (together with calcium phosphate all of which effervescence with acids. A compound of calcium carbonate and magnesium carbonate is dolomite, MgCO<sub>3</sub>, Limestone, chalk and marble are variety of calcium carbonate. On strong heating it forms quicklime, which is strongly basic and is appreciably soluble in water to form an alkaline solution.



### 2.1.4 LIMESTONE <sup>[5]</sup>

This Rock contain chiefly calcium carbonate and a variety of quantities of magnesium carbonate, it also contains argillaceous material (clay containing material silica and iron in smaller quantities. Limestone varies greatly in colour and texture. The texture ranges from dense and hard limestone e.g. marble or travertine, which can be sawed and polish for use as decorative stone. It is an impure deposition of clay and sand.

### 2.1.5 NATURAL CHALK <sup>[5]</sup>

This is a variety of limestone form, from pelagic or floating organism that is very fined grained porous and friable . It is white or very light colour and consist almost entirely of calcite <sup>[6]</sup>. It grain size is so minute that it is amorphous, but actually is a crystalline with high surface area. The best known natural chalks are those of cretaceous exposed in cliff, it is used for cement powders, as soft abrasive and polish, crayons, fertilizer and

## **2.1.8 CASTING THICK SUSPENSION <sup>[10]</sup>**

A thick suspension of chalk batch is made with the following<sup>[10]</sup>

Calcium carbonate	44% by weight
Tale ( 3MgO .4SiO <sub>2</sub> .H <sub>2</sub> O)	3% by weight
Kaolin	3% by weight
Water	50% by weight

The batch is thoroughly mixed and when suspension begin to thicken, it is cast into the mould. As soon as the mixture set, it is compressed in place by bringing down the ejector to exert some pressure, and the chalk is sun-dried.

## **USING PLASTER OF PARIS <sup>[7]</sup>**

A thick suspension can be made using the following

Calcium sulphate ( P.O.P )	47 %
Water	50%
Additive ( coloured and Binder )	3%

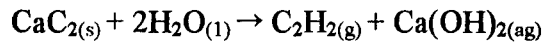
## **2.2.0 LIME SLUDGE AS RAW MATERIAL**

### **2.2.1 CARBIDE LIME TECHNICAL DATA AND AVAILABILITY<sup>[8]</sup>**

Carbide Lime is a by-product obtained in the generation of acetylene gas from calcium carbide. It is variously referred to as carbide sludge, generator slurry, lime sludge, lime hydrate, and other such designations. Carbide lime is better described as by-product of predominantly calcium hydrate from acetylene generation or simply carbide lime.

By-product calcium hydrate is found wherever acetylene is produced from calcium carbide. The calcium carbide employed from the generation of acetylene is manufactured from the reduction of high quality lime by the carbon of the selected cokes in high temperature of carbide electric furnacing process. Production of acetylene (C<sub>2</sub>H<sub>2</sub>) is accomplished by the reaction of calcium carbide and water in properly designed

acetylene generating equipment. In this process, acetylene of the highest purity is obtained from the carbonate of the carbide and the hydrogen of the water. The process also produces the subject carbide lime or by-product calcium hydrate [Ca(OH)<sub>2</sub>], the latter obtaining its calcium from the carbide and hydroxide radical from the oxygen and hydrogen of the water. The chemical equation is given below



Carbide lime is a potential top grade hydrate lime because of the high quality of the original raw materials of the process, and because of the very nature of the electric furnacing and acetylene generation steps through which the lime must pass.

By-product calcium hydrate from acetylene generation is a source of high calcium lime. Its economic and chemical usefulness is potential comparable with that of commercial lime and hydrate lime in all field of agriculture and farming, in building and construction, in industrial and chemical process.

**TYPICAL CHEMICAL COMPOSITION <sup>[8]</sup> TABLE 2.1.1**  
**CALCIUM HYDRATE ANALYSIS**

	( Dry Basis)		Commercial hydrate	
	Acetylene generator		Sample 1	Sample 2
	By-product Hydrate			
	Generator	Pond		
Ca(OH) <sub>2</sub> .....	96.50	92.22	96.44	92.40
Available CaO.....	(73.00)	(69.80)	(72.50)	(69.90)
CaCO <sub>3</sub> .....	1.25	2.82	1.76	3.80
SiO <sub>2</sub> ... ..	1.10	1.46	0.81	1.30
R <sub>2</sub> O <sub>3</sub> (Al <sub>2</sub> O <sub>3</sub> ,Fe <sub>2</sub> O <sub>3</sub> ).....	0.50	2.66	0.38	0.90
Mg(OH) <sub>2</sub> .....	0.25	0.16	0.57	1.40
S.....	0.15	0.17	0.03	1.01
P.....	—	0.01	0.01	0.01
Free carbon.....	0.25	0.25	—	—



## **COLOUR,ODOUR AND FOREIGN MATERIALS <sup>[8]</sup>**

It is to be recognized that carbide lime is a “by product” as produced by the carbide acetylene process, slight variations in chemical analysis and presence of alien matter will exist depending on local conditions at the point of production. The by-product hydrate has a grayish colour and a characteristic acetylene odour as it comes from the generator, this odour passes away with time, but the grayish colour results largely from the very small percentage of combined sulphur contained in the slurry and small amounts of ferrosilicon and carbon.

## **PARTICLES SIZE AND MAGNESIUM CONTENT<sup>[8]</sup>**

Carbide lime is extremely fine in particle size, and usually finer than most commercial hydrate limes. It has a number of advantages, such as

1. **Complete hydration <sup>(8)</sup>**: - That is, freedom from unslaked lime because it is made in many times its own weight of water, while ordinary hydrate lime is made with only a fraction of its own weight of water in order to avoid subsequent drying which is inconvenient and expensive.
2. **Fine state of sub-division or fineness.** In a published test <sup>(8)</sup> of dried carbide lime, 99.9% passed through 300um mesh sieve, in another series of test, 92 to 98% passed through a 325um mesh sieve, while ordinary commercial hydrated lime does not show as good a percentage through a 200um mesh sieve. This extreme fineness is caused by the nature of formation from calcium carbide. The acetylene on liberation has a tendency to crack or break open ordinary fine grains of lime into still smaller particles. The heat and excess water in the generation also present ideal conditions for the production of very fine particles of hydrated lime. The finer subdivision is particularly valuable, where carbide lime is used in the chemical, industrial and construction fields of usage.
3. **Low Magnesium Content:-** There is only a trace of magnesium present because the lime originally used in making calcium carbide must be extremely low in magnesium. Low magnesium and high calcium are the resulting magnesium products dissolved very

readily in water, while calcium product are insoluble and can easily be removed by precipitation.

4. **Price:** Users of hydrated lime can in many instances effect a saving of one third to one half of their present expenditure for lime, by arranging to secure carbide lime from a nearby acetylene generating plant. A very high grade of by product-hydrated lime can be purchased at attractively low prices.
5. **Bulk density vs Percentage Solids <sup>[8]</sup>:**- The following are typical weight ratio and density data of carbide lime at various percentages of solid content based on a specific gravity of solid of 2.14.

**TABLE 2.2 BULK DENSITY VS PERCENTAGE SOLID**

Solid content (%)	Weight ratio, lb carbide lime per lb available CaO	Density lb per gallon
10	14.4	8.8
20	7.3	9.3
30	4.8	9.9
40	3.6	10.6
50	2.9	11.4
60	2.4	12.3

- 6 **Percent Solid VS Available CaO.** The available calcium oxide content of carbide lime is often the gauge by which its value or usefulness is measured. By-product calcium hydrate has a higher available calcium oxide content than many high grade commercial hydrate limes. The following are typical data relating percent solids of carbide lime per ton of available CaO.

**Table 2.3.0 [8]**

<b>Solids Contents (%)</b>	<b>Available CaO gal. Carbide lime per Ton</b>
10	3,300
20	1,560
30	960
40	670
50	510
60	400

7. **Handling and Pumping-** Pumping of carbide lime has been demonstrated to be feasible in the solid concentration as high as 40 percent. Carbide lime with a solid content in the range of 50-60% is amenable to digging and truck hauling. Tank truck or car haulage of lesser solid content slurries has been demonstrated satisfactorily.

**Handling and Transportation-** Water slurries of carbide lime, containing up to 40 % solids by weight, are fluid enough to be pumped satisfactorily with standard type centrifugal pumps. At about 50% or more solid content, the concentration reached by prolong pond settling, the consistency of the carbide lime is that of a fairly firm putty which can be handled effectively by digging with power shovels. Carbide lime in the intermediate 40-50% solid content semi-fluid state can either be fluidized for pumping by adding water or be further concentrated to a putty firm enough for shoveling by continued settling and decanting.

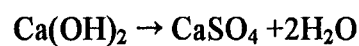
8. **Fineness vs Settling:-** In spite of the fineness of carbide lime particles size, the solid of a slurry are generally many times faster settling than the solid of a water lime mixture made directly from burned lime. This difficulty can be overcome by using a surge tank with agitator in most cases. If the later method proves inadequate under certain process conditions the difficulty may be overcome by

grinding wet slurry in a colloid mill. When so treated, it is known that the slurry can be held in storage tanks for a week or more without appreciable settling and in addition is less apt to clog valves or lines of a pumping system.

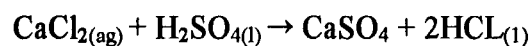
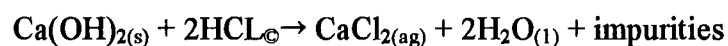
### 2.2.2 PRODUCTION OF P.O.P FROM LIME SLUDGE <sup>[9]</sup>

Plaster of Paris (P.O.P.) can be produced synthetically from carbide sludge, which is one of the materials used in chalk production carbide sludge which consists of mainly of calcium hydroxide and the early impurities such as charcoal (Carbon) and Sand that come from carbide ore.

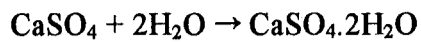
There two methods of synthesizing the P.O.P. from carbide sludge. The direct and indirect method. In the direct method, the sludge is reacted straight away with dilute sulphuric acid. The equation for the reaction is given thus-



This  $\text{CaSO}_4$  is also known as synthetic gypsum. The other method is known as indirect method. This involves first converting the calcium hydroxide to calcium chloride which is highly soluble in water which through filtration enable the separation of all impurities present and the resultant clear solution is reacted with dilute hydrochloric acid. The equation of the reaction is given thus:-



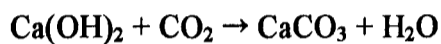
The precipitated calcium sulphate is washed cleaned of hydrochloric acid and first dried to gypsum. The calcium sulphate of the indirect method was found to be in the purest form. This calcium sulphate can be dried to gypsum and roasted to plaster according to the reaction



This roasting process is known as calcination and the method used in calcining will determine the type of product obtained. If the gypsum is crushed to smaller sizes and heated in a kettle with 30% solution of calcium chloride harder materials suitable for manufacturing porcelain, ceramic is produced<sup>[4]</sup>

### 2.2.3 PRODUCTION OF $\text{CaCO}_3$ FROM LIME SLUDGE<sup>(12)</sup>

Calcium carbonate can be produced synthetically from carbide sludge, which is one of the oldest materials used in production of chalk.



This experiment is performed by dissolving the dried and grained  $\text{Ca(OH)}_2$  in water, and stirring continuously until the required solution is obtained. Depending on the quantity of  $\text{CO}_2$  to be used for reaction. For example, 12.5 kg of grinded sludge is dissolved with 130 litres of water and 7.5kg  $\text{CO}_2$  filled inside a cylinder is bubbled into the solution. A precipitate of  $\text{CaCO}_3$  is obtained with when dried contains over 88%  $\text{CaCO}_3$ . About 98% of the water used is recovered which shows that water does not take part in the reaction.

An analysis of the sample is given below

**TABLE 2.4 ANALYSIS OF  $\text{CaCO}_3$  SAMPLE<sup>(10)</sup>**

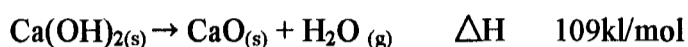
PARAMETERS	PERCENTAGE
Calcium Carbonate $\text{CaCO}_3$	88.82
Calcium Hydroxide	1.48
Silical carbon ( as impurities)	3.06
Ferrous ( as $\text{Fe}^{2+}$ )	0.26

## 2.2.4 REACTIONS OF CALCIUM HYDROXIDE<sup>[8]</sup>

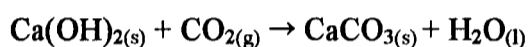
- \* Calcium hydroxide  $\text{Ca(OH)}_2$  can be obtained from calcium oxide by the reaction of  $\text{CaO}$  with water.



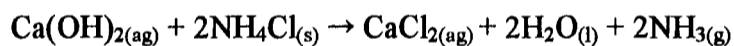
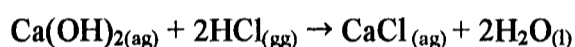
- \* Calcium oxide or quicklime can be obtained from calcium hydroxide by heating at a temperature of  $309^{\circ}\text{C}$



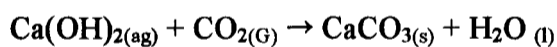
- \* Calcium hydroxide is used to neutralize acidic soils, soften hard water.
- \* It is used to produce mortar which is an important building material formed by mixing calcium hydroxide with sand and water. The water evaporates and the mixture sets hard. The setting process takes place because calcium hydroxide absorbs  $\text{CO}_2$  from the air and thus converted to calcium trioxocarbonate(iv)



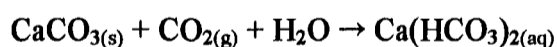
- \* As a base, Calcium hydroxide is a weak base, reacting with acids, acidic oxide and ammonium salts.



- \* If carbonate is bulked through water, calcium-trioxocarbonate(iv) is precipitated.

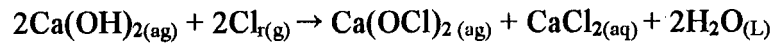


- \* The precipitate will disappear if more  $\text{CO}_2$  is bubbled through the solution. Calcium hydrogen trioxocarbonate (iv) is formed which is soluble.



- \* With chlorine<sup>[8]</sup>

If chlorine is bubbled through a cold saturated solution of calcium hydroxide, calcium -oxochlorate (bleaching powder) is formed.



(Bleaching powder)

### **2.3.0 MAKING OF CHALKSTICK FROM HYDRATED LIME**

#### **2.3.1 PROCESSING OF HYDRATED LIME FROM CARBIDE SLUDGE**

In the generation of acetylene from calcium carbide, the later reacts with water in a “wet” generator, to produce a slurry of calcium hydroxide (hydrated lime). The solid concentrate from the wet generation is between 10 –12%. It is possible to concentrate this slurry to about 30 – 40% solids by decanting or by the use of mechanical thickener. 45 – 55% solid center produced by prolonged pond settling. Commercial operations have demonstrated that slurry can be concentrated satisfactorily up to 60% solid in a centrifuge. Experimental tests have indicated that drying of 60% solid to a moisture content of 1-3% can be accomplished in a flash drier without excessive carbonate formation. <sup>(8)</sup>

Commercial operations has further demonstrated that 60% solid hydrate can be calcinated in a rotary klin to produce a high quality calcium oxide of unusual reactivity; the product is inherently of extreme fine particle size and may be produced either in agglomerated or briquette form. <sup>(8)</sup>

Dilute or concentrated slurry can be dried effectively by mixing it with quicklime. The surplus water in the carbide lime slurry slakes the quicklime such that the percent solid of the resultant mixture is appreciably increased even to the extent of achieving commercially dry hydrate. This is accomplished in a process consisting essentially of a slurry tank with manually controlled discharge, a quicklime feeder and a mixing tank or hydrator. The quicklime hydration develops considerable heat, which acts to vaporize some of the water and volatile impurities of the carbide lime <sup>(8)</sup>. The resultant hydrated lime product is completely free from sulphide & objectionable odour and is amendable to

further processing as to improvement or physical sizing and hence it is suitable for various end uses in chemical, industrial, building or agriculture field.

For this project, decanting method is selected because of the easy simplicity and low cost.

### **2.3.2 CASTING OF HYDRATED LIME**

Hydrated lime is mixed with plaster of paris and water at room temperature. The mixture is thoroughly stirred, to ensure complete mixing and removal of air bubbles. It is poured immediately into the mould as soon as mixing is completed because it sets fast and will form a solid crust of any shape it finds itself.

The grain fineness, operating temperature, amount of stirring determined how fast the mixture sets. Another vital determinants of the setting time is the presence and amount of chemical substances which acts as retarder (slows down the reaction eg Animal glue) or accelerator (speed up the reaction eg Aluminum Allum); potassium sulphate ( $K_2SO_4$ ) and Ammonia sulphate ( $(NH_4)_2 SO_4$

It takes about 15 minutes for the mixture to set. The setting time also depends on the ratio of hydrated lime to plaster of paris, because plaster of paris has a stronger binding property. Accelerators can be added to increase the setting time, but some accelerators have some bad features which makes them undesirable <sup>(8)</sup>.

### **2.3.3 MOULDS FOR CASTING CHALKSTICK <sup>(10)</sup>**

The type of mould used in casting chalkstick will determine the surface roughness and smoothness of the chalk. Moulds can be made from metal, plaster of paris, lime mortar etc. The surface feature of the mould is very important because it determines the type of chalkstick that will be obtained since it takes the shape of the mould. When wooden moulds are used, heavy oil may be used as a thin layer to prevent sticking. For metallic mould, lubricant is necessary especially for plunger surfaces.



A cheap lubricant is made by mixing hard oil and some other oil, which contain stearin, palm oil or olive oil could be used. There are now also new chemicals, which can be used as lubricating agents or parting agents to separate the object from the mould. One of such is methyl – phenyl silicon fluids <sup>(10)</sup>.

It is possible to use a “gang mould” namely a large mould with a number of holes in a line each hole being a mould for a single chalkstick, here the casting slip is poured rapidly into the individual moulds and the excess can be removed from the mould by a simple movement of blade or knife. Such device could be held firmly in position in a machine, having a group of plunger operated vertically to push the chalksticks upward <sup>(10)</sup>

## **COMPRESSION MOULD**

They are machines having metal mould equipped with two vertical plunger for each chalkstick mould. With the bottom plunger in place, the mould is filled with the chalk – paste, and as soon as the mixture sets, it is compressed in place by bringing down the upper plunger to exert pressure of several hundreds Newton per square metre of Area. The upper plunger is then released and the chalkstick is removed by being pushed upwards by means of lower plunger. The mould part are lubricated and the entire operation repeated.

### **2.3.4 BINDING MATERIAL**

#### **ORGANIC BINDERS <sup>(11)</sup>**

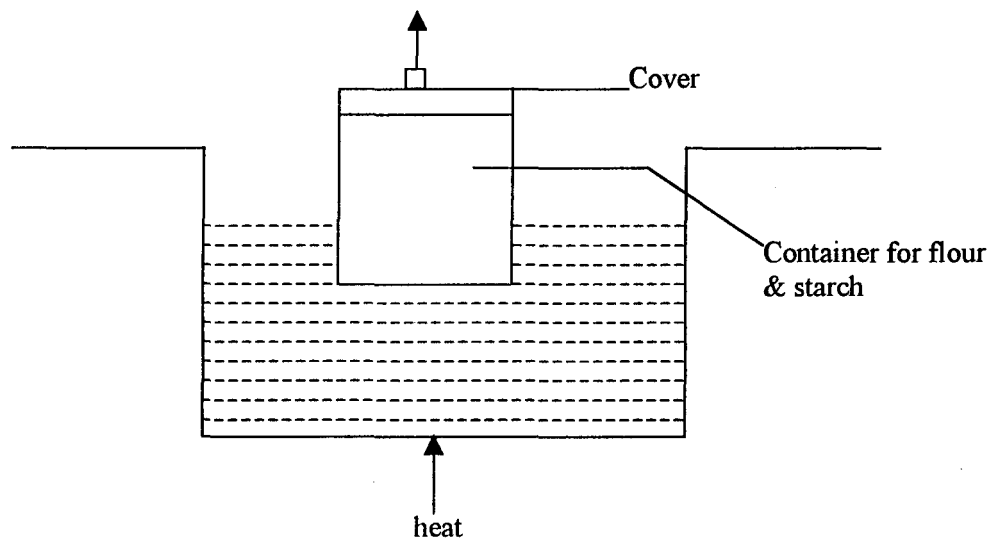
Organic binder can be employed in making of chalkstick by two processes, (extrusion and pressing). The binder put the chalk particles together and hold them in place to form consolidated and compact solid mass in the finish shape.

There are numerous natural occurring & synthetic organic binders, <sup>(11)</sup> they include:

- (a) Flour (extrusion and pressing)
- (b) Starch (extrusion and pressing)

has formed, the container should be removed from the water bath and allow to cool at room temperature. <sup>(9)</sup>

For the formation of best structure the gel should be aged overnight before use. If the paste is kept for sometimes, it is necessary to add preservatives, to prevent the formation of mould, which accompanies deterioration of the paste. Keeping the paste in a cool place or in a refrigerator will help prolong it's usefulness. Concentrated ammonia water not only acts as preservative but also aid in development of plasticity <sup>(9)</sup> but, however, ammonia is not absolutely necessary as phenol or benzoic acid may be used as preservative. Below are formula process that have been used.



(a)	Wheat flour paste	By weight %
	Weight flour	2.5 – 5.0
	Water	95.5 – 95
	Ammonia Conc.	<u>2.0</u>
		100
(b)	Corn starch paste	By weight %
	Corn starch	2.5 – 5.0
	Water	97.0 – 94.5
	Vinegar 5% Acetic acid	<u>0.5 – 0.5</u>
		100

reasonably by expected to result from the systematic research and experimental work now being carried on in the matter of lime and its properties”.

By-product calcium hydrate from acetylene generators is always a potential source of high calcium lime because of its high reactivity and fine particle size.

Whenever lime or hydrated lime is used there is a potential possibility that carbide lime will satisfy the need for the oxide or calcium.

#### **2.4.1 USES IN CHEMICAL – INDUSTRIAL FIELDS <sup>(8)</sup>**

- (i) Carbide lime for bleaches: Bleaching powder or bleaching solution is made from slaked lime or milk of lime and chlorine. Carbide lime gives a good source of milk of lime for this purpose.
- (ii) Carbide Lime As Dechlorinating Agent: Milk of lime is used as a dechlorinating agent in the manufacture of trichloroethylene, perchloroethylene, ethylene oxide, ethylene glycol, and other organic chemicals. By-product calcium hydrate has been successfully used in a plant manufacturing trichloroethylene, its use in the production of ethylene glycol has been proved by test.
- (iii) Carbide Lime for Pulp and paper Manufacture:- There are many uses for lime in the pulp & paper industries. Rags for the manufacture of paper are cooked in a digester under steam pressure with lime or with lime and soda ash. The standard quicklime for use in cooking rags must contain at least 90 per cent quicklime [(CaO) A.S.T.M.C<sub>45-25</sub>]. By-product calcium hydrate, easily meeting this purity requirement, is a good source of lime for this use.
- (iv) Carbide Lime For Paint & Vanish Manufacture: Paint and varnish manufacture requires the use of lime. It is used to neutralize the acids and clarify varnish and as a resonate in paints. Consistent with the removal of alien particles, carbide lime should be a suitable source of lime for this purpose.

- (i) **Carbide Lime in the Aluminum Industry:** Dry carbide lime, as a replacement for virgin lime, is used extensively and successfully in the aluminum industry. It is used in conjunction with soda ash, as a causticising agent for the wining of alumina from bauxite.
- (ii) **Carbide Lime in the Leather Industry:-** In the leather industry lime is used in the depletion (hair removing) process. The skins are soaked in vats containing milk of lime, arsenic sulphide, sodium sulphide and sometimes sodium hydroxide. The lime should contain a minimum of 85% CaO and have a low iron content. By-product calcium hydrate is a good material for this use.

Carbide could also be used in metallurgical fields, carbide lime for by-product coke plants, for glass manufacture.

### **2.4.3 USES IN FIELD OF WATER SOFTENING, SEWAGE AND ACID TREATMENT. <sup>(8)</sup>**

- (i) **Carbide Lime for water softening** Lime, or a mixture of lime and soda - ash, is used extensively for softening . When water contains considerable quantities of bicarbonates and sulphates of calcium and magnesium it is hard. The bicarbonates produce what is termed "temporary hardness" when excess lime is added, the bicarbonate form carbonates which are much less soluble in water and a precipitate is formed which is removed by filtration. Carbide lime, can be used for all or part of lime used for the softening of water. By direct pumping of the slurry to water treating vats substantial saving in costs of lime and labour of handling lime in acetylene generators assures that it is completely and properly slaked. With respect to this particular quality requirement it would therefore follow that by-product calcium hydrate meets full requirements for use in the building industry in place of other forms of lime.

Physical properties of the hydrate such as plasticity, sand carrying capacity, strength when mixed with sand, time of set, and color are equally important properties to consider for building industry uses. By-product calcium hydrate of desired water content, generally meets these requirement except perhaps were colour is critical factor, according to A.S.T.M specification C<sub>5</sub> - 59 for lime structural purposes, the chemical composition must conform to the following

CaO minimum	75%
CaO, plus MgO, minimum	95%
Silica Iron, etc maximum	5%
CO <sub>2</sub> Content, maximum	10%

By - product calcium hydrate will meet the above specifications and has also been found satisfactory as to particle size.

- (iii) **Mortar Using Carbide Lime:** Mortar is made by mixing lime putty with sand and water. The lime putty is made from quicklime or hydrated lime. By - product calcium hydrate, properly concentrated, is high quality lime putty. The quality of mortar depends on the method of its preparation as well as the characteristic of the lime. A high calcium lime properly burned (by - product hydrate is of this character) yields the greatest volume of mortar per weight of materials.

Proper slaking has more to do with the mortar slaking properties of a lime than any other single factor. By - product calcium hydrate is unusually well slaked because it is made in many times, its own weight of water and considerable time usually elapses between the time of discharge from the generator and its use in mortar. Because of its extreme fineness & complete hydration, mortar made with carbide lime spreads more smoothly with less effort and has much "pull" to it as the average grade of high magnesium hydrated lime, while it has the added advantage of greater density and more lasting resistance to weather conditions.

#### **(iv) USE IN THE FIELD OF AGRICULTURE <sup>(8)</sup>**

Soil conditioning: Lime is applied to land extensively in the form of hydrate lime and limestone. It serve primarily as a corrective conditioner and secondarily to supply plant-food. By - product calcium hydrate from acetylene generation is a satisfactory liming agent and is not difficult to distribute on the land when of a satisfactory degree of dryness.

Soil is a complex material possessing varying chemical, biological and physical properties. The effect of lime on soils varies with the character of the soil. Lime applied to the soil accomplishes the following benefits.

- (i) Neutralization of soil acidity
- (ii) Promoting the activity of beneficial bacteria and depressing injurious soil organisms
- (iii) Replenishing the supply of calcium
- (iv) Improving the texture of the soil
- (v) Hastening the decay of organic matter and the formation of Nitrate.
- (vi) Acting as a germicide in killing certain soil borne organisms.

#### **2.4.4 FORMULAS FOR LIME MIXTURE <sup>(8)</sup>**

- (i) **Lime Sulphur Spray:** Lime sulphur, one of the best fungicides for trees, is prepared by heating sulphur with milk of lime.

Direction for making 50gal. of lime sulphur spray are as follows:

Sulphur (wetttable)	8lb
Carbide lime	3 gal.
Calcium arsenate	80z
Water	40 gal.

(approximately 50% solid)

### Formula B

- (1) Mix 20 lb of 50% solid carbide lime to a creamy consistency with water.
- (2) Dissolve 1lb of carbonate of soda in 1/4 gal of boiling water.
- (3) Soak in cold water for at least 8 hours 1/4 lb of common glue and 1lb of rice flour, then thoroughly dissolve the glue mixture in 3/4 gal more water in a double boiler mix (1) with (2), then add (3).

### Maryland formula

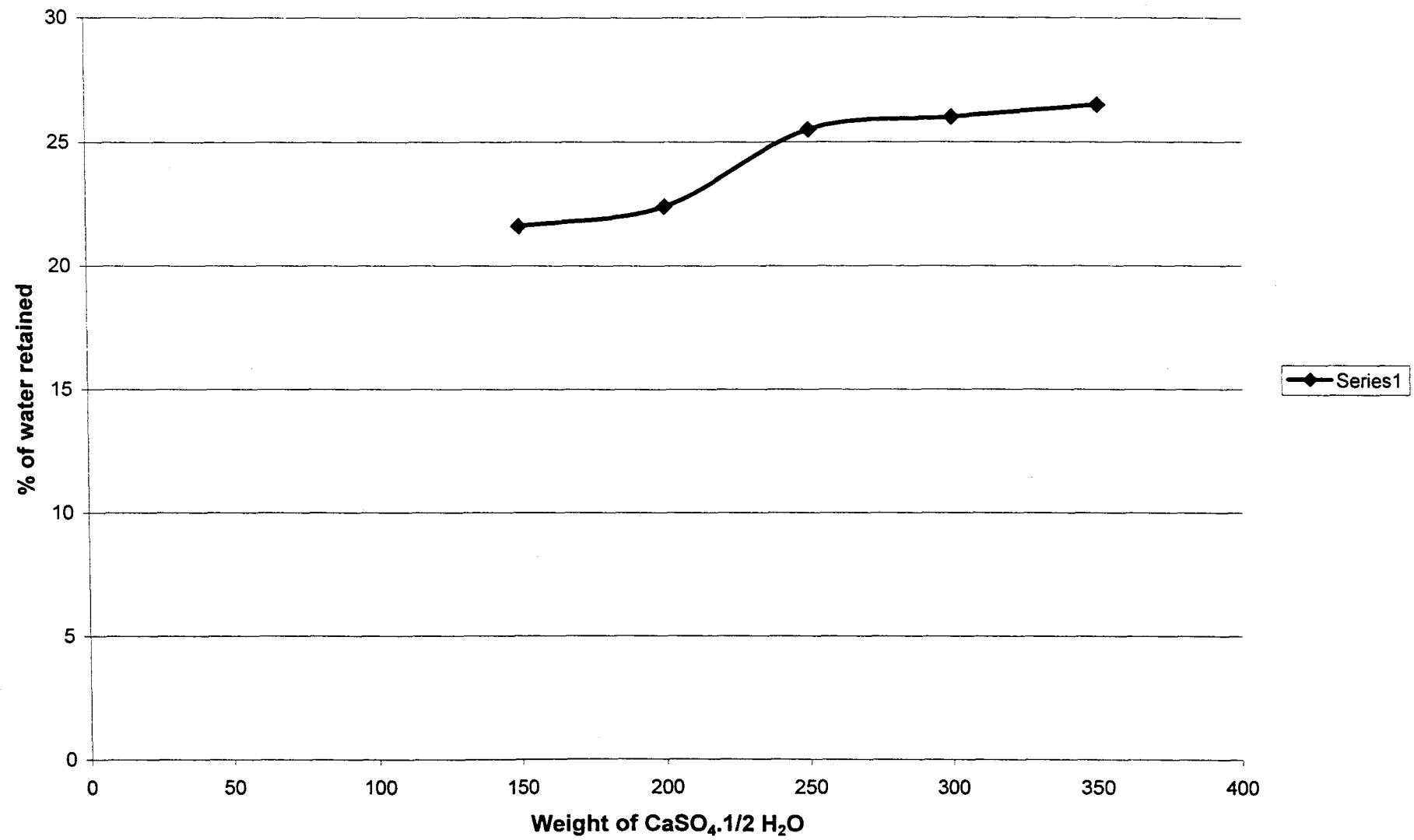
The following formula is used quite universally in the making of exterior white wash. This wash may be slightly brown in colour but whitens after application.

Hydrated lime	1/2 bag
Common salt	6 lb
Molasses	1 pint
Ground alum	3O <sub>2</sub>
Hot water	10 gal

### Advantages of additives to whitewash formulas

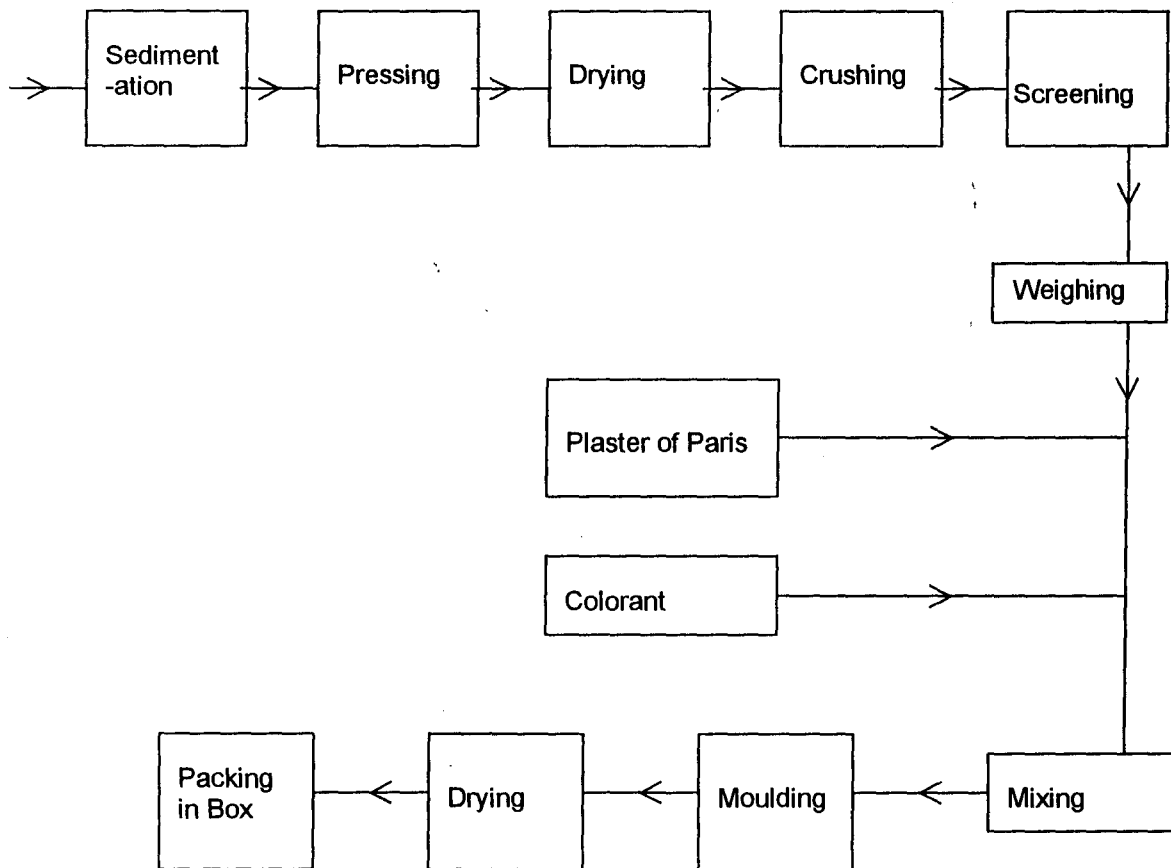
Alum prevents its rubbing off, flour paste will also prevent it rubbing off but zinc sulphate must be used as preservative. Molasses cause lime to penetrate wood & plaster better. One pint of molasses to 5 gal of whitewash is generally considered sufficient. A solution of silicate of soda or water glass, makes what is commonly referred to as "fire proof cement" of whitewash.

Fig 3: Graph of % water retained vs weight of  $\text{CaSO}_4 \cdot 1/2 \text{H}_2\text{O}$





### 3.3 CONCEPTUALIZED FLOW PROCESS FOR CHALK PRODUCTION FROM LIME SLUDGE.



#### 3.4.1 TABLE OF RESULT

Very high .....	<<<
High.....	<<
Low.....	>>
Very low.....	>>>
Average.....	<

#### BEST OUTPUT REQUIREMENT

Writability – Very high (>>>)

Hardness - Average (>)

**TABLE 3.1 OUTPUT QUALITY**

CaSO <sub>4</sub> . ½ H <sub>2</sub> O (kg)	150	200	250	300	350
Ca (OH) <sub>2</sub> (kg)	250	250	250	250	250
Writability	<<<	<<	<<	>>	>>
Hardness	>>	>>	>	<<	<<<

**3.4.2 RESULT OF THE EXPERIMENTS ARE PRESENTED IN TABLE 3.2 AND 3.3**

**TABLE 3.2.0 OVEN – DRIED (AT 120<sup>0</sup>C FOR 7HRS)**

WEIGHT IN KILOGRAMS						
SAMPLE	Ca(OH) <sub>2</sub>	CaSO <sub>4</sub> .1/2 H <sub>2</sub> O	WATER	WEIGHT ON DRYING	WATER CONTENT ON DRYING	% WATER RETAINED
A	250	150	400	510	110	21.60
B	250	200	450	580	130	22.40
C	250	250	500	670	170	25.50
D	250	300	550	743	193	26.00
E	250	350	600	816	216	26.50

**TABLE 3.3 SUN – DREID (20 HRS AT ATMOSPHERIC TEMPERATURE)**

<b>WEIGHT IN KILOGRAMS</b>						
<b>SAMPLE</b>	<b>Ca(OH)<sub>2</sub></b>	<b>CaSO<sub>4</sub>.1/2 H<sub>2</sub>O</b>	<b>WATER</b>	<b>WEIGHT ON DRYING</b>	<b>WATER CONTENT ON DRYING</b>	<b>% WATER RETAINED</b>
A	250	150	400	511	111	21.70
B	250	200	450	578	128	22.10
C	250	250	500	672	172	25.60
D	250	300	550	741	191	25.80
E	250	350	600	816	217	26.40

### **3.5.0 BATCH PRODUCTION OF 1000KG OF CHALK**

#### **MATRIAL & SPECIFICATION**

Ca (OH) <sub>2</sub>	372.5 kg
CaSO <sub>4</sub> . 1/2 H <sub>2</sub> O	372.5 kg
Water	745 kg
Pigment	<u>2.5</u>
	<b><u>1492.5 kg</u></b>

## **CHAPTER FOUR**

### **4.0.0 DISCUSSION OF RESULTS**

Processing of carbide sludge into dry lime hydrate gave a dry powder, which is grayish in colour, not very white, as lime obtained from other processes. This is as a result of impurities such as combined sulphur present in the slurry (Table 2.2.1).

#### **EFFECT OF METHOD OF DRYING**

It was observed that the sun-dried chalk had a brighter appearance than the oven-dried chalk, this is a result of slight conversion of  $\text{Ca}(\text{OH})_2$  to  $\text{CaCO}_3$ .

At a temperature of  $120^\circ\text{C}$  drying time is 7hours and 20hrs when sun-dried.

In most commercial application, the chalk is usually oven-dried to save time.

#### **EFFECT OF $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ ON BINDING STRENGTH**

The setting (time taken to form crust) decreased with increasing concentration of  $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ . The percentage water retained is indicative of the binding strength, for higher concentration  $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ , to  $\text{Ca}(\text{OH})_2$ , more water was retained and for the range of values taken, it was highest at 26.5% water and at lower  $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$  (21.6%) indicating that higher compositions of  $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$  favour water retention. (Table 3).

In most commercial application, employ the use of  $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$  because of its strong binding property and whiteness. ( )

#### **EFFECT OF $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ ON HARDNESS**

It was discovered that as the concentration of  $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$  increases, the hardness of the chalk increases and writability decreases. Equal fractions of  $\text{Ca}(\text{OH})_2$  &  $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ , was found to be optimum.

From literature, when  $\text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$  is used as sole raw material in chalk production, retarders are added to minimize the rate of hardening of the chalk. ( )

### **EFFECT OF PARTICLE SIZE**

Binding property of chalk depends on the particle size, it was observed that as the particle size increased the binding property decrease. Optimum particle size will be determined by comparing the cost of size reduction to output quality. A sieve size of 300mm was used.

### **EFFECT OF PIGMENTS**

The use of large quality of pigments yielded bad result, smaller quantities are preferable. The most type of pigment use are White lead, Zinc oxide and lithophone (White) and lead chromate, iron oxide of transition metals (colour) A small percentage of about 1% is used in most commercial production of chalks. ( )

#### **4.1.0 PROPOSED TECHNOLOGY OF PRODUCTION**

- (a) The dry lime hydrate powder should be pulverized.
- (b) A chalk-making machine should be used.
- (c) Could be sun-dried to reduce cost (about 20 hrs).

#### **THE PROCESS SHOULD COMPRISE**

- 1 Measurement of clear water
- 2 Measurement of Dry lime hydrate and plaster of Paris
- 3 Stirring
- 4 Injection of moulding agent
- 5 Drawing of chalk from designated grams.
- 6 Transfer of drawn chalk on shelf for drying, and
- 7 Transfer of chalk to the place for drying and maturing consumption of clean water and dry solids for 500 pieces of chalk dryer.

H<sub>2</sub>O, 2, 350g - per dryer

Ca (OH)<sub>2</sub>, 1175g - per dryer

CaSO<sub>4</sub>. ½.H<sub>2</sub>O, 1175g - per dryer

8. Transfer of semi-finished goods, after completion of drying for the finishing process.
9. Packaging- packaging in cartons after the packaging of 100 pieces to case and
10. Transfer to the shipping section in the warehouse for storage as finished goods and shipment.

### **DESCRIPTION OF CHALK MAKING MACHINE**

Model: M-600

The school chalk-making machine contains 600 round brass tubes for chalk molding.

One mold will produce 600 pieces of chalk at about 15-20 minutes.

This machine is manipulated manually, no electric fuel are necessary.

Machine dimension: L.39" W.24" H.34 ½"

Net weight: 220kgs

Accessories:

For each set of school chalk making machine

Oil brush 1 piece

Brass scrapper 1 piece

Oil box: 1 piece

Wooden drying trays (for sunlight drying) 3 pieces.

#### ***Raw Materials.***

1. Dry Powder 2.7kg/per mold/ 600 pcs of chalk. (Equal weight of Ca(OH)<sub>2</sub> and CaSO<sub>4</sub>. ½.H<sub>2</sub>O)
2. Water-soluble pigment for making colour chalks.
3. Mold releasing agent: Mineral oil mixed with vegetable oil.

**Drying method: By sunlight about 20hrs, or By drying oven about 7hrs.**

## **CHAPTER FIVE**

### **5.0 CONCLUSION**

Chalk can be produced from hydrated lime among other materials such as  $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ ), accelerator and retarders.

The particle size determined to a great extent the quality of chalk and best result can obtained by pulverizing the carbide lime.

The chalk when compared with standard ones had good writability & hardness. However, the finest of the chalk is poor compared to the standard ones, this is due to the limitation encountered.

### **5.1 RECOMMENDATION**

1. The paste should be mixed thoroughly to avoid formation of air bubbles, which lead to breakages.
2. Should not be allowed to dry inside the mould, otherwise removal becomes difficult.
3. Corrosions resistant material should be used in construction of chalk mould, to obtain clean and white chalk.
4. Lubrication must be carried out prior to pouring the paste in the mould for easy removal of chalk.
5. Mould surface should be kept clean after used.

## APPENDIX

### CALCULATIONS

#### (1) CALCULATION OF PERCENTAGE OF WATER RETAINED

Given,

$$\text{Weight of water} = 400\text{g}$$

$$\text{Weight of Ca (OH)}_2 = 250\text{g}$$

$$\text{Weight of CaSO}_4 \cdot \text{H}_2\text{O} = 150\text{g}$$

$$\text{Total weight} = 800\text{g}$$

$$\text{Final weight} = 510\text{g}$$

$$\text{Weight of water dehydrate} = \text{Total weight of mixture} - \text{final weight}$$

$$800 - 510 = 290\text{g}$$

$$\text{Weight of water retained} = 400 - 290$$

$$= 110\text{g}$$

$$\% \text{ of water dehydrated} = \frac{290}{400} \times 100 = 72.5\%$$

$$400$$

$$\% \text{ of water retained} = \frac{110}{400} \times 100 = 27.5\%$$

$$400$$

$$\% \text{ of water retained in chalk} = \frac{110}{510} = 21.6\%$$

$$510$$

% Water retained in B, C, D & E are obtained to be 22.4%, 25.5%, 26.0% & 26.5% respectively.

### DENSITY

$$\text{Weight of 20 pieces of chalk} = 17.5\text{g}$$

$$\text{Volume of 20 pieces of chalk} = 12\text{cm}^3$$

$$\text{Density} = \frac{17.5}{12}$$

$$= 1.46\text{g/cm}^3$$



## BATCH PRODUCTION OF 1000kg CHALK

1000kg of mixture = 670kg of chalk

xg “ “ = 1000kg of chalk

x = 1492.5 kg.

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