

PRODUCTION OF GUN POWDER USING  
MADAR AS A SOURCE OF CHARCOAL

BY

NDAGANA LADAN

(89/1143)

DEPARTMENT OF CHEMICAL ENGINEERING  
SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY  
MINNA.

A PROJECT SUBMITTED TO THE  
DEPARTMENT OF CHEMICAL ENGINEERING  
SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY,  
FEDERAL UNIVERSITY OF TECHNOLOGY,  
MINNA, NIGERIA.

IN PARTIAL FULFILMENT OF REQUIREMENT  
FOR THE AWARD OF DEGREE IN CHEMICAL ENGINEERING  
B.ENG. (Hons).

DECEMBER, 1998.

CERTIFICATION.

This report has been read and approve as meeting the requirement of the department of chemical engineering in the school of engineering and engineering Technology Federal University of technology Minna for the award of bachelons of engineering BENG (Hons) Degree in chemical engineering.

Mr. Akiwale Akinbode.

*Akiwale Akinbode*

Date

.....14/12/98.....

Dr. J.O Odigure Msc ph.D MNSE  
Head of Department

Date

.....

External Examiner

Date

.....

Dean School of engineering  
and engineering technology

.....

DEDICATION.

I dedicate this work to my father late Mohammed Ladan and my mother Mrs. Fatima Ladan Shabakaji.

## ACKNOWLEDGEMENT.

My sincere thanks goes to almighty allah, who has made it possible for me to conclude this work. I wish to express my appreciation to my brothers Moha'd Gana and Moh'd F. Ladan whose financial and moral support has sustained me throughout my stay in the University. I wish to thank my Supervisor Mr. Akiwale Akinbode for his effort to the success of this project.

I appreciate my gratitude to my class mate Mallam Ismail Isah Rikoto whose endrmous contribution to the success of this work can not be over looked, and to my brother Ibrahim Hassan who has encourage me through out my course. Finally I am grateful to my class mates in chemical engineering department.

## TABLE OF CONTENTS

Little page.....	(i)
Certification .....	(ii)
Dedication .....	(iii)
Acknowledgement .....	(iv)
Abstract .....	(v)
Table of content .....	(vi)
	<b>PAGE</b>
<b>CHAPTER ONE</b>	
.000 Introduction.....	1-3
.100 Back ground of studies .....	1-2
.200 The objection of study.....	2
.300 Method and scope.....	2
.400 The relevance of study .....	3
<b>CHAPTER TWO</b>	
.000 The Literature review .....	4
.100 History of Gum powder.....	4-5
.200 Black powder and its raw material classification .....	5-6
.300 The raw material .....	6
.310 Potassim nitrate .....	6-9
.320 Sulphur .....	9
.330 Charcoal .....	9-10
.331 Effect of carbonization temperation and Griding on the composition of charcoal .....	11-12
.400 The buring properties of the black powder .....	12-16
.500 The milling of the ingredients .....	17
.600 Finishing .....	17
.700 Safety in black powder .....	18
	<b>PAGE</b>
<b>CHAPTER THREE</b>	
3.000 The experimetal .....	19
3.100 The equipment for the experiment .....	19
3.200 The raw materials .....	19
3.210 Carbonization of the wood .....	19-20
3.300 The experimetal procedual .....	20
3.400 Testing .....	20
	<b>PAGE</b>
<b>CHAPTER FOUR.</b>	
4.000 The Results .....	21
4.100 Calculations .....	21
4.200 Tables of results .....	22
4.300 Graph of rate against particle size .....	23

CHAPTER FIVE

5.000	Design project .....	24
5.100	Introduction .....	24
5.200	Flow sheet of the production process .....	25
5.300	Material balance .....	26-27
5.400	Power requirement by Crushers & ball mill .....	28
5.500	Detail design of Ball mill .....	29
5.510	Determination of material requirement .....	29
5.520	Choice of Grinding mill .....	29-33
5.530	Capacity and power requirement .....	33
5.600	Material for construction .....	34
5.700	Costing of equipment .....	34-35
5.800	Safety consideration .....	35

CHAPTER SIX.

	PAGE	
6.000	Discussion of Results .....	36-37

CHAPTER SEVEN

	PAGE	
7.000	CONCLUSION, RECOMMENDATION, NUMENCLATURE	
7.100	Conclusion and recommedation .....	38
7.200	Numeclature.....	39
7.300	References .....	40
	Appendix .....	41

## ABSTRACT.

This project focused on the production of gun powder using Madar tree as a local source of raw material, other material used in the mixture are potassium nitrate and sulphur.

The wood from madar tree was carbonised using muffle furnace at a temperature of 500°C. The carbonized charcoal and sulphur were mill separately. The three component were then mixed together at a proportion of 67.2%, 21.3% and 11.5% for potassium nitrate sulphur and charcoal respectively, water was added to maintain 1-1.5% moisture content, depending on the quantity to be produce. This helps to incorporate potassium nitrate in to the mixture, the mixture was mill with mortar and pestle. During of mixture was done on sunlight or natural sun, which finally mill to obtained require fines.

Diameter of particle size ranging 25, 20, 15, 10 and 5mm were Tested for the rate of explosion. After testing it was dicovered that 5mm diameter of particle size gives high rate of explosion, which indicate that fine powder increase the reactivity of solid and best for gun powder.

## CHAPTER ONE

### 1.0.0 INTRODUCTION

#### 1.1.0 BACK GROUND OF STUDY

Gun powder or black powder as the name implies is black in colour with irritating smell. It was known centuries B.C by replacing oxygen with solid to obtain a better power ratio after notice that, there are small amount of power available for explosive involves gaseous at any given volume.

Gun powder was originated in china by a franciscan order ROGER BACCON in 13 century. The manufacture of Gun powder started in 14th century in Britain and by 18th century was introduced to Nigeria. This powder is a mixture of combustible materials, There are, of three types viz. potassium nitrate, Sulphur and charcoal. Hence, it is defined as a mixture of combustible material readily ignited even in complete absence of air and burn very rapidly therefore could simply mean a substance which in its self capable of producing a quantity of gas under high pressure and being able to produce this gas so rapidly under certain condition that the surround are subjected to a strong dynamic.

The commonly used Gun powder has the composition of 75% by potassium nitrate, 10% by sulphur and 15% by charcoal. The potassium nitrate and sulphur are locally available in the market in their pure state or could be prepared. While charcoal is obtained from woods such as willow, hamp, elders, poplar or hazel usually found in the forest or could be alternatively obtained from cassava stem, calabash, and maize cobs (commonly used by local hunter).

The origin of Gun powder has a number of advantages to the developed and developing countries. Among its advantages include the use of Gun powder in small proportion for the production of rockets, in military fields, in mining centers and by the local hunters. The ready availability of its raw materials make its economical valuable for use.



The method is limited on size distribution of finishing grain. Further effort may be made to incorporate powder with water proof to avoid shutt failure at low temperture

1.40

THE RELEVANCE OF STUDY

This project is prepare to produce a Gun powder at cheaper rate to meet the high demand by the local hunter as a result of the incresing in population and they are not get asses to the modern wipound for fighting against wild animals.

arms. Table 2.2 show an example of such powder. While for type 2. It is must burn vigorously so as to give an effect as close as posible to detonation. It consist either of grains with a density of 1.8 or compresses cylindrical pellets with a density of 1.35-150 and a central peforation [6]. According to Andreyew [5] black powder may buring at a pressure low than atmospheric and dependence of the rate of buring on the pressure may be expressed by the equation  $U=72p^{0.24}$  (2.1) where U is a linear rate of buring in cen/min and P the pressure in atmosphere.

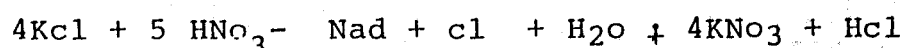
The component of black powder are clasify in to phosophore and anxoplosives atcording to Whrop and Handrick [5] The primary source of black powder  $KNO_3$  is a phosophores and other additives as auxoplosive. According to these Authours. A phosophores has been define as a group of atom which is capable of forming explosives compound on introduce into hydrocabon. While group which do not then selve produce properties but may influrence others in the same way as that of auxochromic group vary the colour intensity and shade of the dye are called anxoplotives.

### 2.30 THE RAW MATERIAL.

### 2.31 POTASSIUM NITRATE.

The primary source of Gun powder is potassium nitrate. It is obtaiable from nature deposits in hot counties for example in ceylon, egypt, mexico, India, Iran and some areas of the USSR. It occur thereas the result of the microbiological oxidation of organic nitro compounds and of the reaction of the product with the alkaline component of the soil. On being refered by cystallization such saltpetre was used for the manufacture of black powder

Still another method for the preparation of  $\text{KNO}_3$  directly from  $\text{KCl}$  and nitric acid was used recently. Reaction process at temperature between  $55-85^{\circ}\text{C}$  according to the approximate equation.



-(2,6)

Potassium salt petre prepared by any of these methods is refined i.e. it is recrystallized from water by a method chosen in accordance with the impurities known to exist in the product. Crystallization is facilitated by great difference in solubility of potassium nitrate at high and low temperature. It is ten times more soluble at  $100^{\circ}\text{C}$  than at  $10^{\circ}\text{C}$ .

Potassium nitrate saltpetre for the manufacture of black powder must be of high purity. The technical specification for the synthetic product according to the U.S.R.S standard (Gost 1939 to 43) is summarized in table 2.3 below.

Requirement	CLASS	
	1	2
Appearance	White crystals	White crystals
Minimum content of $\text{KNO}_3$	99.80	99.00
Max content of moisture %	0.10	0.20
Max content carbon as $\text{K}_2\text{CO}_3$	0.03	0.10
Max content of $\text{H}_2\text{O}$ insoluble substance %	0.03	0.05
Max content of substance insoluble in $\text{HCl}$ acid %	0.04	0.04
Max content of chloride calculated as $\text{NCl}$ %	0.005	0.02

Table 2

The technical specification for synthetic  $\text{KNO}_3$  used in the manufacture of black powder (Gost 1939-43).

Potassium saltpetre manufactured from chilian saltpetre may also contain potassium perchlorate and potassium iodate which are very detrimental since they increase the sensitiveness of black powder to friction and impact. A great many explosions which have occurred during the manufacture of black powder have been ascribed to the

black powder. It must be soft, but not resinous and should be prepared from white light and porous wood [15]

For the purpose of this project the source of charcoal is limited to madar plant calotropic proceral. The use of this plant was not only based on the characteristic mentioned above but also in addition, its content a waste product and often irritating and poisonous substance so that it causes inflammation [17]

**CARBONIZATION:-** Before carbonization, the wood must be debarked and into pieces that could be fed into a sheet of iron retorts approximately 1m diameter and 1.5 by 3m long. One end of which is closed with an air tight lid and the other fitted with an off take for the gaseous products of distillation. These products are usually burnt since it is not worth while recovering them. The combustion of CO is particularly important, otherwise it may poison the atmosphere. The retorts are heated by passage of electric current.

The carbonization lasts for 3-8 hours depending on the construction of the furnaces and retort. The temperature and the types of material to be carbonized. After carbonization the retorts are taken out of the furnace and allowed to cool down (with the off take closed) the charcoal is removed from the retort when it is cold. Hot charcoal easily ignites. The charcoal should not be milled until after at least 24 hours from the removal time since charcoal which is too fresh may catch fire during milling. The effect of temperature of carbonization on charcoal are shown in table 2.3 below.

Types of Charcoal	Temperature of carbonization (°C)	content of carbon (c) %
Cocoa (red)	140-175	52-54
" Brown	380-350	70-75
" Black	350-450	80-85

Three types of charcoal are obtained depending on the temperature of carbonization.

### 2.341 THE EFFECT OF CARBONIZATION TEMPERATURE AND GRINDING ON CHARCOAL.

The best structure of carbon required for the manufacture of black powder is aromatic structure and this is achieved during heating to a temperature above 300°C. The aliphate structure are breaks down in to aromatic ring through weaker and disappearance of the bound by hydrogen 33000cm from the water present 16140cm and bound between carbon and hydroxyl group.

The determination of aromatic ring in charcoal are extensively work on by different people such as Juctiner whom oxidized various types of coal including charcoal using various oxidizing agent such as potassim per maganate in an alkaline medium and nitric acid. On such oxidatism of charcoal obtained by carbonzation of wood at 1000 mellitic acid in a yield of 25% by weight results under similar condition flurene give mellitic acid in yield of about 45% while hexactly, benzene yield almost exclusively carbondioxide with out mellitic acide. Also this structure of carbondioxide with has definetly provide by infra-red spectroscopic analysis carried out by T.urbanski, Ostrowski and vitanowski,

The effect of grounding on charcoal provide the break of the bounds of unpaire electros which are polymers of coñvalent bound to a free radicals. These radicals considerable influnce the properties of black powder. The concentration of these free radicals considerably depend on temperature of carbonization.



Charcoal here implies a component with variable properties, not a specific chemical. Hence, depending on the method by which the charcoal is prepared powder with various properties could be obtained. As early as 1848 this attracted the attention of violette who prepared different types of charcoal in a retort by employing different temperature of carbonization as shown below.

Table 2.4

Temperature of carbonization (°C)	Colour of charcoal	Yield %	composition of charcoal.		
			Nto	% C	H
280-300	Brown	34.00	21.90	73.20	4.3
250-400	Black	28.31	-	77.81	-
1000	Black	18.00	14.10	82.00	2.3
1250	Black	18.00	9.30	88.1	1.4

Effect of temperature of carbonization on the charcoal composition.

The relation between the ignition temperature of charcoal and the carbonization temperature of wood are show below.

Table 2.5

Temperature of carbonization (°C)	Ignition temperature of charcoal (°C)
260-280	340-36
270-350	36-370
432	Ca-400
1000-1500	600-800

This shown that the power of powder containg black charcoal is greater because is less hygroscopic. Hence the powder from it is less hygroscopic ([6])

#### 2.40 THE BURNING PROPERTIES OF THE BLACK POWDER.

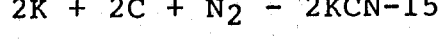
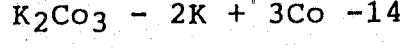
For a long time attempt have been made to explain why three non explosive substance viz potassiumnitrate, sulphur and charcoal, when combined together should form an explosive mixture. It was particularly incomprehensive that binary mixture of potassim nitrate and charcoal or with sulphur should be non explosive or only poorly if so due to the difficults in elusidate since reaction involved the solid pharse.

So that  $1/3$ ,  $1/4$ ,  $1/4$  and the rest  $1/24$  of the powder decompose according to the equation respectively.

Much later K.A. Hoffmann resumed work on the mechanism of explosion of black powder. On examining the mixture, he found that the reaction in black powder starts above the melting point of sulphur at approximately  $150^{\circ}\text{C}$  with a reaction between hydrogen present in charcoal and sulphur. Hydrogen sulphur thus formed reacts at temperature between  $285^{\circ}\text{C}$ - $290^{\circ}\text{C}$  with potassium nitrate to yield  $\text{K}_2\text{SO}_4$ . Heat is then emitted and  $\text{KNO}_3$  were course to melt [8]

The increment of sulphur for the purpose of this project is to produce a powder with low initial decomposition and explosive temperature on the bases that;

- i. Sulphur intensifies the sensitiveness of mixture to impact. A mixture of  $\text{KNO}_3$  and charcoal does not explode while a mixture of  $\text{KNO}_3$  and sulphur decompose when struck by a 21g weight falling from 45-50cm on the other hand a mixture of  $\text{KNO}_3$ , charcoal and sulphur is exploded by a 2kg weight from a drop of 70-80cm.
- ii. It counteracts the formation of carbon monoxide in the product of explosion  $\text{CO}$  and  $\text{KCN}$  occurs in the product of decomposition of a mixture of  $\text{KNO}_3$  with charcoal, due to the reaction of charcoal with  $\text{K}_2\text{CO}_3$ .



On the other hand, in the presence of sulphur a reaction with  $\text{K}_2\text{SO}_4$  takes place.  $\text{K}_2\text{SO}_4 + 2\text{C} - \text{K}_2\text{S} + 2\text{CO}_2 - 16$

- iii. Sulphur reduces the initial decomposition temperature for instance a mixture of 2mole of  $\text{KNO}_3$  and 3g atoms of carbon (in the form of 71% charcoal) decompose at  $320^{\circ}\text{C}$  and explode at  $357^{\circ}\text{C}$  while the same mixture but 1gram of sulphur decompose at  $310^{\circ}\text{C}$  and explode at  $450^{\circ}\text{C}$ .

The latest studies of H. Thomos quote the following figures for normal "Gun powder G 12" [5]

Table 2.7

Potassim nitrate	75.3%
Sulphur	10.3%
Charcoal	14.4%

While for this project the composition of the Black powder are as shown below.

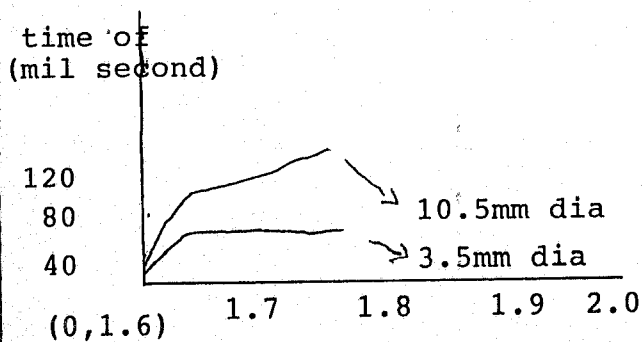
Table 2.8

Potassim Nitrate	67.20%
Charcoal	11.50%
Sulphur	21.30%

This powder were proportionaly as above base on the masses of the component that gives the completely buring of the powder. To avoid unreacted deposition that could be found on the side of the gun bore barel which may block the hole to the ignition cap and result in shatt failure if not regularly washed.

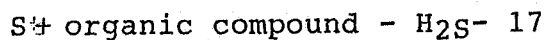
The normal Gun powder has the following charateristic heat of explosion is  $735 \pm 15$  Kcal/kg at a moisture content of 0.85% and  $740 \pm 15$  Kcal/kg at dry place according to Kast, the volume  $V_0$  is 280 L/kg; the specific pressure (f) is 2800m and the temperature of explosion (t) is  $2380^{\circ}\text{C}$  while the specific gravity of Gun powder may vary within the limit of 1.50-1.80 depending on it intended use. Its appearent density is 0.900-0.980.

The reaction between the time of buring of black powder and density for grain 3.5-10.5mm dia are shown below.

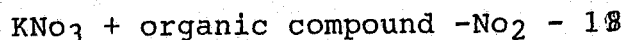




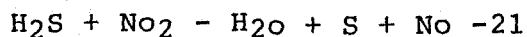
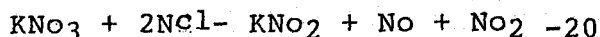
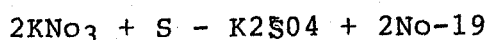
Finally, the mixture of the 3 component at the proportion above decompose at  $290^{\circ}\text{C}$  and explodes at  $311^{\circ}\text{C}$ . The black wood and Bowden formulate the following mechanism for the ignition and burning reaction of black powder. First sulphur react with organic substance present in charcoal.



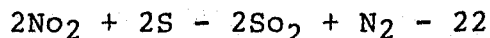
Almost simultaneously, salt petre reacts with these compound



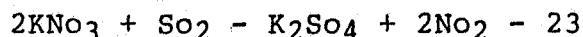
The follow reaction may also occur.



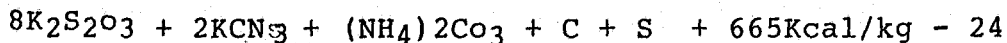
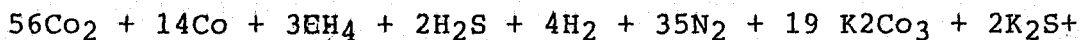
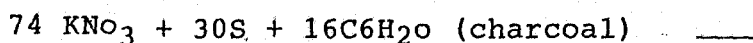
Reaction (last) proceeds until all the hydrogen sulphide is used up when  $\text{NO}_3$  appears and begin to react with the still unconsumed sulphur according to equation below.



The sulphur dioxides so formed may immediately react with potassium nitrate.



According to Black wood and Bowden, the chief reaction when powder begin to burn is the oxidation of charcoal by potassium nitrate from a comprehensive analysis of the product of explosive of black powder Kast derived the following equations.



The heat of explosion and gas volume naturally depend on the decomposition of the powder. Noble and Abel in the work quoted above gives the following figures.

Table 2.6

Black powder	composition			Heat of explosion Kcal/kg	Gas volume vcm <sup>3</sup> /g
	$\text{KN}^{\circ}\text{O}_3$	Sulphur	charcoal		
course grained	75.00	10.00	15.00	726.00	274.00
Fined graine sport- ting.	75.00	10.00	15.00	764.00	241.00
Blasting	62.00	16.00	22.00	516.00	360.00
Cocoa powder	80.00	2.00	18.00	837.00	198.00

2.500

### THE MILLING OF THE INGREDIENTS.

The manufacture of black powder consist thoroughly mixing andd well milled of ingredient to obtain the required particular size and density (fast burring black powder is fine grained while the slower burring types has larger grains~~s~~ of higher density the manufacture consist of the following operation.

- i. Milling of the ingredient
- ii. Mixing of the ingredient
- iii. Pressing
- iv. Corning and finishing (drying, polishing and screening).

The method of manufacture depend upon the trend of development tradition in a give factory of country and for the purpose of this project pressing is done by the stone.

2.600

### FINISHING

The powder from the milling is then finished, this consist mainly of polishing, drying and grading the grains depend on the required structure.

**POLISHING:-** The grains have an irrigrular and rough surface which prevent them from flowing strecly and from filling aspace with out voids, so that their density is rather low. To over come this the proces of polishing were employed and it takes places as follows. At first, the work is carried out with the side door closed so that the powder retains enough moisture to facilitate the process. After a few hours 0.1 to 0.5% of grapl~~ite~~ is added to the charge and polished for several more hours. The graphite fills the pores in the surface of the grains and coat with a thin large giving then characteristic of brightness.

**GRADING:-** Finally the polishing dried powder is finally graded by sieving out the dust through revolving or the types of vibrating sieves often, hand sieving and commonly used for this purpose. The sieve frames are made of wood to avoid the danger of friction and impact.

The manufacture of black powder is one of the most dangerous in the production of explosive, shelter for the work should be set up in the vicinity of each building. There are huts covered with earth at the side of the operating building. If the building have three stout walls, the shelter may be located behind one of them. Doors and windows should be large to gives plenty of light.

Electric cables should be carried in steels conduit on the extension of the walls. In candescent lamps inside the building should be recessed in to the wall and protected by safety glass(7)

The three component was then mill together in a mortar and water was added to maintain a moisture content of 1 to 1.5%. The mill of the three component was carried out for 1½ hour to insure proper incorporation of potassium nitrate in to charcoal. The mill cake after 90 minute was removed and dried using infrared light.

The dried cake was broken by pressing used stone in to finished grain and the gains was sieve in to 25, 20, 15, 10 and 5mm diameter particles size with the respectively sieving diameter.

3.40

#### TESTING

The testing of the powder was carried out in two stages in the first stage, 0.5% of the ungraded powder produced was measure and test for the heat of explosion used a calorimeter of bomb heat capacity 120.86 (KJ), surrounded by water of mass 1.2kg and heat capacity 4.184 kg/g.k and a change of 23.9°C was observe when it burns.

While, in the second stage 0.04 of each from the respectively particle size diameter was measure and spread over 1.50 centimeter long of iron sheet and was spark, the time taken for each particle to explode was measure and was used to calculate the rate of explosion at each particle diameter. The result of the testing were show on chapter four.

The identification of these raw material could be through their physical properties such as colour, structure and observation of certain characteristics. The potassium nitrate and sulphur could be identified through their colour and structure, sulphur as a yellow cylindrical rod and  $\text{KNO}_3$  in a fine ground silverish colour. While charcoal as a black stuff material from slow burning of wood usually from a white light and porous wood.

The use of potassium nitrate serves as a primary source that gives the powder an explosive characteristics. Other additives such as sulphur as a catalyst and charcoal as a base compound as catalyst and are of significant importance. Although, the source of charcoal has no limit to those mentioned above but may also be obtained from any other plant base on the same characteristic and this forms the base of this project.

1.20

#### THE OBJECTIVES OF STUDY

The objectives of this project could be summarized as follows. Despite that this powder utilizes sulphur &  $\text{KNO}_3$  as its base, the aim is

- i. To produce the same type of Gun powder but from a different source of charcoal. And with different proportionality of ingredient.
- ii. To determine the particle size that will give a high rate of explosion.

1.30

#### METHOD AND SCOPE.

The method and scope of this project involves milling of the 3 compounds together in mortar using pestle. Water is added throughout the process to maintain moisture content of 1 to 1.5% to reduce ignitions and incorporation of  $\text{KNO}_3$  into charcoal. The result cake is broken by pressing using stone to increase intimate contact of the ingredients and improve strength and burning properties of the powder.

41 part	Salt petre
29.5 part	charcoal
29.5 part	sulphur.

Table 2.1

It was not until the invention of the fire arms that the manufacture and use of black powder really began to develop up to the present day.

The first published reference to use of black powder in mining was the paper read to the royal society in London by Sir R. Moray in 1665. He referred to "a way to break easily and speedily the hardest rock" according to the same paper. The method was invented by Dusson in France from that time the use of explosive for various engineering operations such as mining, road building, dam building, land improvement etc began. Became general, black powder are employed in the manufacture of safety fuse in which the cores consist of black powder and the use of gun powder for rain making by D.A Dauris. The change consisting of 15g of black powder plus 1.5% of silver iodide and sand by balloon in to a cloud where they are exploded by a time fuse the particles of silver iodide thus released act as nuclei on which the water vapour is in a rain cloud coagulate to fall as rain drops.

In Great Britain, the manufacture started in 14th century and by the 10th century was introduced in to Nigeria and later became over shadowed by high explosives in 1833 to 1846.

## 2.20 THE BLACK POWDER AND ITS RAW MATERIAL (CLASSIFICATION)

There are in fact, two types of black powder classified according to their intended uses.

Type 1 for filling fuse.

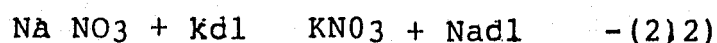
Type 2 for blasting charges.

The difference between the two types lies mainly in their different rate of burning. For type 1, the rate of burning should be as high as possible and is achieved by making the grains of powder of the density as low as possible. Examples of such are powder used in small

In great Britain for instance until relatively recently, the only source of potassium nitrate was salt petre from India.

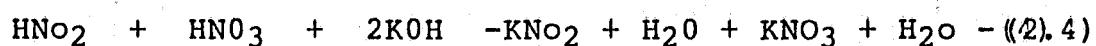
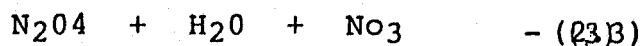
At one time potassium saltpetre was also obtained from manure wood ash. Here potassium nitrate forms as a result of microbiological processes followed by reaction with potassium carbonate. Description from various periods of history may also be found that refer to the collection of salt petre from the walls of cellars situated in the vicinity of stables. In this way for instance, salt-petre was acquired in Poland for the manufacture of black powder during the insurrections of 1830 and 1863 [7].

From the middle of the nineteenth century potassium nitrate began to be manufactured from Chilean salt petre containing 20-35%  $\text{NaNO}_3$  10-90% and afterwards subjected to an exchange reaction.

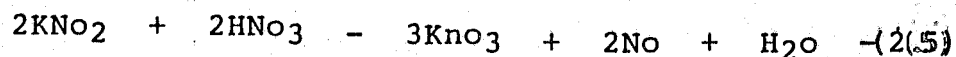


Reaction 2 is conducted in an aqueous solution at a temperature of  $100^\circ\text{C}$ . It takes the desired course due to the poor solubility of NaCl at this temperature. The sodium chloride is then precipitated and the reaction therefore shifts to the right. The potassium nitrate so obtained was termed converted saltpetre. Another method of manufacture of  $\text{KNO}_3$  was based on double decomposition with potassium carbonate [8].

At present, reaction 2 is most frequently used to obtain potassium nitrate although the sodium nitrate used is now of synthetic origin. Another method now employed consists in the treatment of potassium carbonate or caustic potash with nitrogen dioxide. The course of the reaction is:



A mixture of potassium nitrite and potassium nitrate is heated with nitric acid to oxidize nitrite to nitrate.



pressure of these salts in salts petrealt petre, although, it has been ascertained experimentally that small admixtures of  $KClO_4$  increase the sensitives of black powder to impact and friction. Never the less, for the sake of safety potassim nitrate manufacture from chillias saltpetre must not contain perchlorates and iodates in analytically detectable quantities other wise should be remove through method of purification before used [(5)].

However, for fasts and easily production of black powder potassim nitrate could be readily purchase from the market in its purest town.

2.32

#### SULPHUR

For the manufacture of black powder the sulphur used should be of higher puriffy, refined by distillation, crude sulphur (which usually contain 2.5% of impuriffie) is distilled from retorts heated to a temperature of  $400^{\circ}C$ . The recieves should be maintained at a temperature above  $115^{\circ}C$  ( $120-130^{\circ}C$ ) i.e above the melting point of sulphur ( $114-115^{\circ}C$ ). Under these condition, the distillate condenses to liquid which is then cast in to stickes or blocks. This is the only form of sulphur suitable for the manufacture of black powder. If the reactive temperature is lower, the sulphur distilled from the refort condences as flowers of sulphur which always contains a little  $S^{O2}$ , and even traces of  $H_2 S^{O4}$ . (the substance is easily oxidized to its large surface area). Sulphur is this form is therefore slightly hygroscopic and acidic and is unsuitable for the manufacture of black powder.

Unlike potassim nitrate, sulphur could also be found readily available in the market and this is the only easist way of obtaining sulphur for fasts manufacture of black powder (3)

2.33

#### CHARCOAL

The Ignition temperature of charcoal highly after the Ignition temperature of the black powder and so also the type of the wood used as a source of charcoal. It is very important to select a suitable types of wood for the manufacture of the charcoal used in



## CHAPTER THREE

### 3.00 THE EXPERIMENTAL

#### 3.10 THE EQUIPMENT FOR THE EXPERIMENT

- i. The Electric furnaces
- ii. Mortar and pestle
- iii. Electronic weighting balance
- iv. Sieving of 25mm dia, 20, 15, 10 and 5 diametre.
- v. Stop watch.
- vi. Stone.

#### 3.20 RAW MATERIALS

- i. Wood (From madar colotopic proceral)
- ii. Sulphur
- iii. Potassim nitrate.

#### 3.21 CARBONIZATION OF THE WOOD.

The wood from madar calotopic proceral was deback and cut into 0.8-25m long. The cut pieces was feed to the sheet of iron retorts of 1m diameter and 1.5-3metres long of a furnaces with one end close and other fitted with an off taken for the gascous products of distillation. The furnace was then switch on and the retort heated by the electric current to a temperature of  $450^{\circ}\text{C}$  to  $1000^{\circ}\text{C}$  and was maintain at this temperature for a period of 3 hours the retort was taken out and allowed to cool for 24 hours.

#### 3.30 THE EXPERIMENTAL PROCEDURE

The cystals of sulphur and the charcoal was first ground in to powder seprately used mortar and pestle. 32 grains of sulphur and 17.4 grams of charcoal was measure from the samples of each respectively used electric weighing balance. The two sample were mill together in mortar used pestle for 30 minute 101gram of  $\text{KNO}_3$  was measure and added to the mixture and mix throughly with rod like wood.

CHAPTER FOUR

4.00

THE RESULT

The percentage of sulphur =  $\frac{\text{Amount of sulphur}}{\text{total amount of mixture}} \times 100\%$

$$= \frac{32 \times 100}{150.40} = 21.3\%$$

Percentage of charcoal =  $\frac{17.4 \times 100}{150.4} = 11.5\%$

Percentage of  $\text{KNO}_3$  =  $\frac{101 \times 100}{150.4} = 67.2\%$

The heat of explosion is give by  $H_u = H_b D_T + h_w M D_T$

where  $h_b$  = heat capacity of the steel bomb in calorimetre =  $120.86 \times 10^3 \text{JK}$

$h_w$  = heat capacity of water =  $4.184 \times 10^3 \text{J/gk}$

$m_w$  = mas of water = 1.2kg

$D_T$  = change of temperature =  $48.9 - 25 = 23.9^\circ\text{C}$

$$H_u = 4.184 \times 10^3 \text{K/g.k} \times 1.2 \text{Kh} \times 23.9^\circ\text{C} + 120.86 \times 10^3 \text{ J/K} \times 23.9^\circ\text{C}$$

$$= 3008.6 \times 10^3 \text{kJ}$$

$$= -719.06 \text{ Kcal/kg}$$

The rate of explosion  $U = \frac{\text{distance covered}}{\text{time taken}}$

$$\text{for 25mm dia} = \frac{1.5}{0.038 \text{min}} = 39.47 \text{cm/min}$$

$$\text{" 20mm} = \frac{1.5 \text{cm}}{0.023 \text{min}} = 65.20 \text{cm/min}$$

$$\text{for 15mm} = \frac{1.5 \text{cm}}{0.013 \text{min}} = 115.38 \text{cm/min}$$

$$\text{for 10mm} = \frac{1.5 \text{cm}}{0.005 \text{min}} = 300.00 \text{cm/min}$$

$$\text{for 5mm} = \frac{1.5 \text{cm}}{0.004 \text{min}} = 312.500 \text{cm/min}$$

The rate of explosion with particles sixes are.

Table 5.1

Particle size (mm dia)	Mass (g)	distance covered (cm)	Time taken (min)	rate of explo sion (cm/mm).
25.00	0.04	1.50	0.0380	39.470
20.00	"	"	0.0230	65.200
15.00	"	"	0.0130	115.380
10.00	"	"	0.0050	300.000
5.00	"	"	0.0048	312.500

The composition of the powder produces.

Table 5.2

Component	Composition by mass (g)	Composition by percertage (%)
Potassium nitrate	101.00	67.20
Sulphur	3.00	21.30
Charcoal	17.40	11.50

The heat of explosion of the powder was found to 719Kcal/kg exodemic because heat is release to the surrounding.

## CHAPTER FIVE

5.100

### DESIGN PROJECT

5.100

### INTRODUCTION

The production of Gun powder has a number of process of which different machine are employed. The charcoal and sulphur are usually found with large particle size and for intermitely contact of the ingredient these are reduce to the smallest posible size each to provide effective chamilal reaction.

The two component are crushed or grinding seperatly using any size reduction machine such as crushers. The crushed sulphur and charcoal are then mixed with  $KNO_3$  which is already, in its fine particle size in a mixer thoroughly. The mixture of the 3 component are then send to the ball mill. There the component come together and the chmical reaction takes place between the component such as iron exchange reaction.

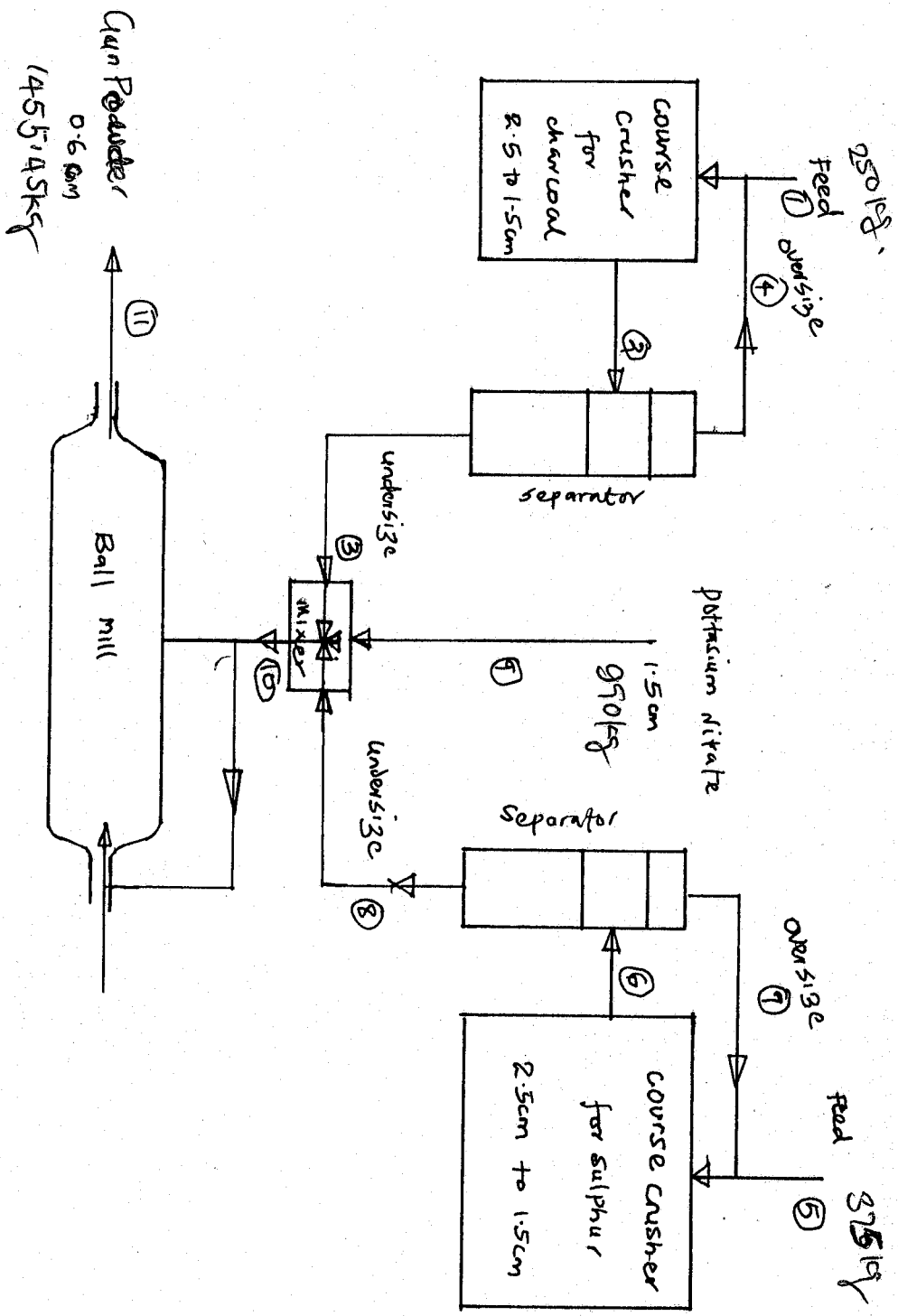


FIG 5.20

Flowsheet for Production of gun powder

Material in = material out + loss Basis 250kg/hr of charcoal  
Balance over charcoal crusher.

Stream (1) = 250kg of charcoal.

Stream (1) = stream (2) + loss

loss = 1% of stream (1)

stream (2) =  $250 \frac{-1}{100} \times 250$

= 247.5kg

Initial particle size = 2.5cm

final particles size = 1.5cm

If 80% of the crushed charcoal is the under size = 1.5cm

20% of the crushed charcoal is the over size = 1.5cm

Undersize stream (3) =  $\frac{80}{100} \times 247.5\text{kg} = 198\text{kg}$

Over size stream (4) =  $\frac{20}{100} \times 247.5\text{kg} = 49.5\text{kg}$

Balance over sulphur crusher (The ratio of the three component are 10:3:2 potassim sulphur and charcoal respectively.)

Since stream (3) = 198kg

stream 8 =  $\frac{3}{2} \times 198\text{kg} = 297\text{kg}$

If stream (8) = 80% of stream 6

then stream (6) =  $\frac{1}{0.8} \times 297 = 371.25\text{kg}$

stream (6) = stream 8 + stream (7)

stream (7) = stream (6) - stream (8)

=  $371.25 - 297$

= 74.25kg.

Stream (5) = stream (6) + loss

loss = 1% of stream (5)

stream (5) =  $371.25 + \frac{1}{100} \text{ stream (5)}$

stream (5)  $\times \frac{99}{100} = 371.25$

stream (5) =  $\frac{100}{99} \times 371.25 = 375\text{kg}$

Particle size = 2.5cm 601.5cm

$$\begin{aligned}\text{Amount of stream (9)} &= 10 \times \text{stream (3)} \\ &= 5 \times \text{stream (3)} \\ &= 990\text{kg.}\end{aligned}$$

Balance over mixer

$$\begin{aligned}\text{stream (10)} &= \text{stream (9)} - \text{loss. loss} = 1\% \text{ of stream (9)} \\ &= \text{stream (8)} - \text{loss. loss} = 1\% \text{ of stream (8)} \\ &= \text{stream (3)} - \text{loss. loss} = 1\% \text{ of stream (3)} \\ &= 990\text{kg} - \frac{1}{100} \times 990 = 980.1\text{kg of KNO}_3 \\ &+ 297 - \frac{1}{100} \times 297 = 294.03\text{kg of sulphur} \\ &+ 198 - \frac{1}{100} \times 198 = 196.02\text{kg of charcoal}\end{aligned}$$

with particlesize = 1.5cm

Balance over Ball mill

$$\begin{aligned}\text{Stream (11)} &= \text{stream (10)} - \text{loss. loss} = 10\% \text{ of each stream} \\ &= \frac{980.1}{100} - \frac{1}{100} \times 980.1 = 970.3\text{kg of KNO}_3 \\ &+ 294.03 - \frac{1}{100} \times 294.03 = 291.09\text{kg of sulphur} \\ &+ 196.02 - \frac{1}{100} \times 196.02 = 194.06\text{kg of charcoal}\end{aligned}$$

with particles size = 0.6cm

Then the amount of gun powder produces is equal to

$$\begin{array}{r} 970.30 \\ 291.09 \\ 194.06 \\ \hline 1455.45\text{kg.} \\ \hline \end{array}$$

POWER REQUIREMENT

The power requirement by charcoal crusher is given by

$$P = 0.3162 W_{i_c} \sqrt{\frac{1}{D_{pb}}} - \sqrt{\frac{1}{D_{pa}}}$$

where P = Power requirement.

$W_{i_c}$  = working index of charcoal = 11.37kw/ton

$D_{pb}$  = particles size of the product (mm)=15

$D_{pa}$  = particle size of the feed (mm)=25

$$P = 0.209 \text{ Kw.}$$

The power requirement by the sulphur crusher is given by

$$P = 0.3162 W_{i_s} \sqrt{\frac{1}{D_{pb}}} - \sqrt{\frac{1}{D_{pa}}}$$

where  $W_{i_s}$  = working index of sulphur = 11.5kw/ton

$D_{pb}$  &  $D_{pa}$  are the same as for charcoal.

$$P = 0.211 \text{ Kw}$$

Power require by the ball mill is given by

$$E = [ (1.64L - 1) k + 1 ] [ (1.64D) ^{25} E_2 ]$$

where L = inside length of the mill (m) = 1.8m

D = inside Diameter of the mill (m) 0.9m

$E_2$  = power require by 0.6 by 0.6m Laboratory mill over 1.5m long.

$$E = 52336.02 E_2 \text{ Kw}$$



## 5.20 BALL MILL DESIGN (DETAIL DESIGN)

This ball mill is to be design to mill 250 kghr of charcoal with 8 working hour planned per day.

## 5.21 DETERMINATION OF MATERIAL REQUIREMENT

The production of gunical powder is a continous process. The anual productivity of the technological line is calculated as;

$$G = Q - tq - 5.1$$

Where  $q$  = productivity of reactor mill kg/hr = 250kg/hr

$t$  = planned working hour per year =  $8 \times 365$  hr

$Q$  = Annual productivity =  $8 \times 365 \times 250 =$

$G = 8760 \times 250 \text{ kg/hr} \times 2920 \text{ kg}$

$= 2190000 \text{ kg} - 730000 \text{ kg}$

$= 1460000 \text{ kg.}$

## 5.2.2 CHOICE OF GRINDING MILL

The factor deterring the size of the grinding ball are finess of material being ground and maintance cost for the ball charge. Acoarse feed requires a larger ball than fine feed, a relation has been proposed.

$$D_b^2 = Kxp - 5.3$$

where  $D_b$  = Diameter of the ball cm

$x_p$  = size of coarse feed particle cm = 2.5cm

$K$  = guidability costant = 90

$$D_b = \sqrt{90 \times 2.5} \\ = 15 \text{ cm}$$

The critera by which the ball action in mills of various size may be compared in the concept of critical speed at which the centrifugal force on the ball in contact with mill sheet and the height of its path equals the forces on it due to the gravity.

For ball mill, the critical ( $N_c$ ) and working number of revolution are determine as follows.

$$N_c = \frac{42.3}{\sqrt{D}} - 5.4$$

$$L = 2D - 5.5$$

where D = Diameter of the mill (m)

L = length of the mill = 1.8m

$$D = \frac{1.8 \text{ cm}}{2} = 0.9 \text{ m}$$

$$N_c = \frac{42.3}{\sqrt{0.9}} = 44.5 \text{ cm}$$

$$N = 0.76 N_c = \frac{32.15}{\sqrt{D}} = 33.84$$

For grinding using small balls.

$$N = (0.71-0.70) N_c = \frac{0.423}{0.95} = 0.445$$

The maximum ball diameter ( $D_b$ )

$$D_b = 283 \sqrt[3]{d} - 5.6$$

where d is the maximum diameter of coarse feed to the mill  
= 4cm

$$D_{bmx} = 283 \sqrt[3]{4} = 44.4 \text{ cm}$$

Actual mill speed is equal 75% of critical speed for dry grinding

$$= 0.75 N_c = 33.39$$

The weight of grinding ball in the mill (g) in kg is determine using

$$g = \frac{ND^2L\phi\rho}{4} = 0.785 D^2P\phi - 5.7$$

where D = internal diameter of the mill in (m) = 0.0009m

L = mill length in = 0.0018m

$\phi$  = coefficient of loading = 0.3

of = ball density  $\text{Kg/m}^3 = 0.0048 \text{ Kg/m}^3$

of =  $0.785 \times (0.9)^2 \times 0.0048 \times 0.3$

= 1.0742 second compartment

$$\begin{aligned}
 g &= 0.785 \times (0.9) \times 0.0043 \times 0.45 \\
 &= 0.00358 \times 0.45 \\
 &= 1.61g \text{ first compartment.} \\
 of &= 0.00358 \times 0.27 \\
 &= 0.967g \text{ third compartment}
 \end{aligned}$$

The number of revolution per minute can be calculated as

$$\begin{aligned}
 n &= \frac{8}{\sqrt{D}} (50 + 2) \quad -5.8 \\
 &= \frac{8}{\sqrt{0.95}} (5 \times 0.45 + 2) \\
 &= \frac{8}{\sqrt{0.95}} \times 4.25 \\
 &= 35.79 \text{ first compartment.}
 \end{aligned}$$

$$\begin{aligned}
 n &= 8.42 \times (5 \times 0.3 + 2) \\
 &= 29.47 \text{ Second compartment}
 \end{aligned}$$

$$\begin{aligned}
 n &= 8.42 \times (5 \times 0.27 + 2) \\
 &= 28.21 \text{ third compartment.}
 \end{aligned}$$

The specific loss of milling balls and limiting material per 1Kg of grinded material can be calculated as

$$P = P_s \frac{0.04}{kg} \quad -5.9$$

where  $P_s$  = specific loss of grinding ball use in grinding of 1kg of powder kg/kg = 0.25kg for ball.  
 $K$  = coefficient of grindability = 90  
 $q$  = grinding finess = 0.8cm

$$P = 0.25 \times 0.04 / 90 \times 0.8 = \frac{0.01}{72} = 1.39 \times 10^{-4}$$

$$\text{The mill productivity } Q = 6.4 \sqrt{D} (P/V)^{0.8} \text{ qkn } -5.10$$

where  $n$  = coefficient of powder utilization for closed loop = 1.1  
 $= P$  open loop = 1.  
 $q$  = specific productivity kg/kd hr  
 $k$  = corective coeffecient for grinding finess = 0.85  
 $v$  = mill internal volume  $m^3 = \frac{\pi D^2}{4} L = 1.145 m^3$   
 $p$  = mass of the mill grinding ball (kg)  
 $= 0.967 \text{ kg} \times 10^{-4} \quad 1.61 \times 10 \times 10 \text{ kg} \text{ and } 1.074 \times 10^3$

For particle size of 20-25mm material to be grinded at ventilation air velocity of 0.3m/s Act velocity = 0.7m/s the mill productivity increases 15-20%

$$Q = 6.4m (0.95) 0.0003 \times 250 \times 1.1$$

$$= 4.41 \text{ third compartment}$$

$$Q = 6.4m (0.95) 0.0046 \times 250 \times 0.85 \times 1.1$$

$$= 6.54 \text{ first compartment.}$$

$$Q = 6.4m (0.95) 0.0033 \times 250 \times 0.85 \times 1.1$$

$$= 4.74 \text{ second compartment.}$$

Electric motor powder consumption (N) required to rotate the mill it given by

$$N = \frac{0.2pDn}{n_p} ns \quad -5.55$$

where P =mass of grinding ball (kg) = 0.001074, 0.00161 and 0.000967.

D =mill diameter (m) =0.9m

n = number of revolutions per minute = 35.79, 29.47 and 28.21

$n_p$  =mechanical coefficient of usefull work done considering loss due to friction and starting  $n_p = 0.85$

$n_s$  = coefficient of increase in powder due to starting initial =1.1

$$N = \frac{0.2 \times 0.00161 \text{ kg} \times 0.9 \text{ m} \times 35.79 \times 1.1}{0.85}$$

$$= 1.34 \times 10^{-2} \text{ first compartment}$$

$$N = \frac{0.2 \times 0.0001074 \text{ kg} \times 0.9 \text{ m} \times 29.47 \times 1.1}{0.85}$$

$$= 7.4 \times 10^{-3} \text{ second compartment.}$$

$$N = \frac{0.2 \times 0.000967 \text{ kg} \times 0.9 \text{ m} \times 28.21 \times 1.1}{0.85}$$

$$= 6.35 \times 10^{-3} \text{ third compartment}$$

Then, productivity of the ventilator during grinding (v) m<sup>3</sup>/hr

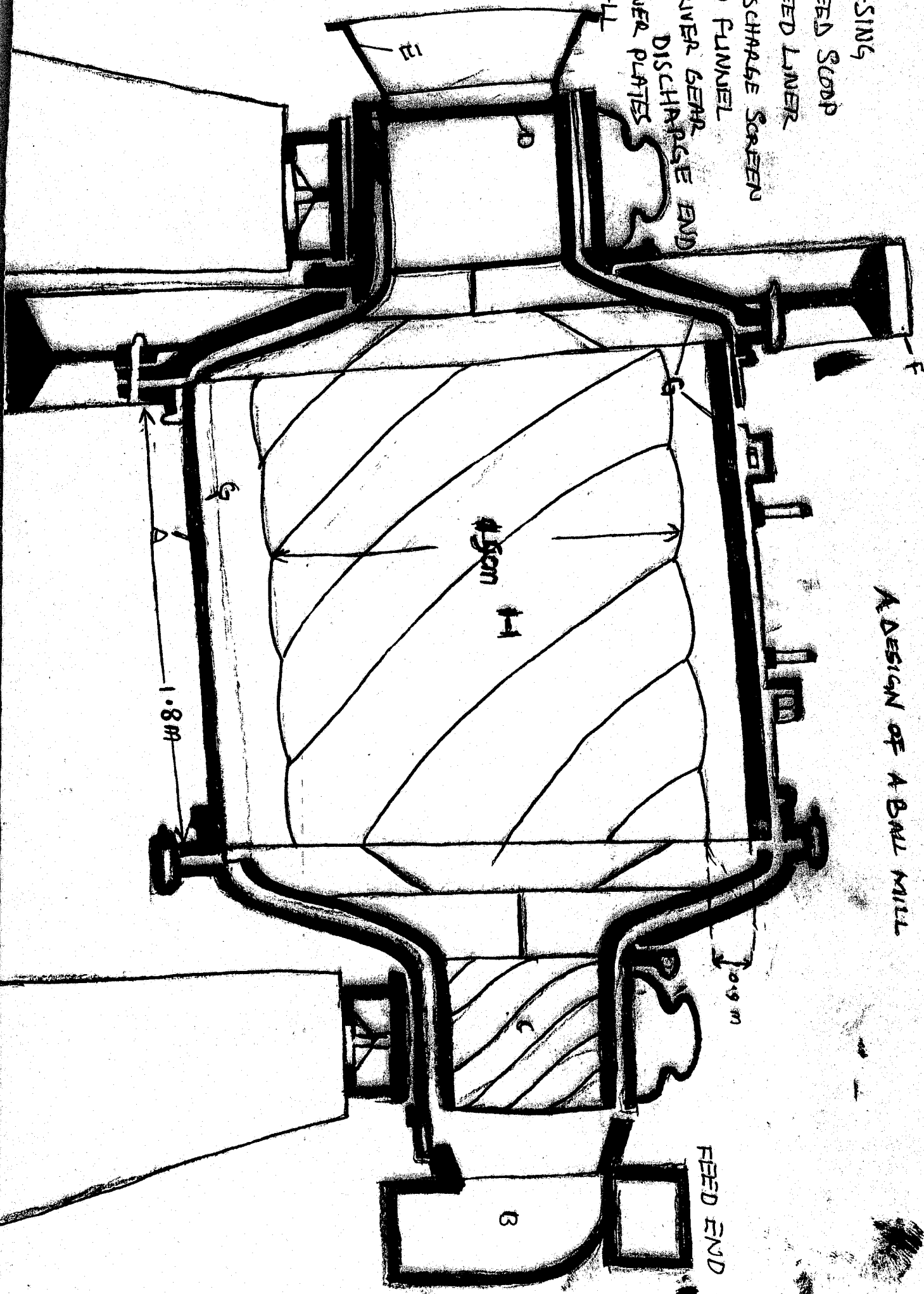
$$V = 2818 D^2 (1-\phi) wkn - 5.12$$

where W =velocity of ventilation air =0.3m/s

$K_n$  =coeffiecient of air draght = 2

A DESIGN OF A BALL MILL

A	CASING
B	FEED SCOPP
C	FEED LINER
D	DISCHARGE SCREEN
E	FUNNEL
F	DRIVER BEAR DISCHARGE BAND
G	LINER PLATES
H	BALL



Many factors have to be considered in selecting materials for construction but for chemical process plant the overriding consideration is usually the ability to resist corrosion strength, and easily to operate. It should be a material that will give lowest possible cost over the working life.

Material of construction should therefore be of great mechanical strength as with stand vibration stress, But longitudinal or axial, it should be one that is not susceptible to deformation under any condition unless its life time is exceeded. Availability of standard should also forged steel, cast.

The Grinding balls can be made of forged steel balls generally give optimum wear characteristics. Balls vary considerably in hardness with soft balls having Brinell hardness in range of 350 to 450 and hard balls having hardness in excess of 700 the cylindrical or conical shell is made of cylindrical steel shell.

COSTING OF EQUIPMENT

Equipment costing can be obtained from the relation below.

$$C_e = CS^N - 5$$

where  $C_e$  = purchased equipment cost in (£)

$$S = \text{constant} = 1600$$

$$N = \text{index} = 0.4$$

$$\text{Rate} = \text{₦}125 \text{ to } \text{₦}1$$

The costing of the crusher for charcoal  
the characteristic power parameter is

$$0.209 \text{ Kw}$$

$$C_e = 1600 (0.209)^{0.4}$$

$$\text{₦} 855.42 = \text{₦}106,927.28$$

The costing of the crusher for sulphur

The characteristic power parameter

$$\text{is } 0.211 \text{kw}$$

$$C_e = 1600 (0.211)^{0.4}$$

$$= \text{EQ } 958.68 = \text{N}107335.14$$

The costing of ball mill

The characteristic size parameter is  $134.00\text{cm}^3$

$$C_e = 1600 (134)^{0.4}$$

$$= \text{EQ } 11347.11$$

$$= \text{N } 1,418639.10$$

5.800

#### SAFETY CONSIDERATION

Any organisation has legal and moral obligation to safeguard the health and welfare of employer and the general public. Good management practices need to ensure safe operation will also ensure effecient operation.

Manufacture process are to sure extent hazardous, but in chemical process, the application of sound engineering practices that risks are reduced to acceptable level.

The most likely hazard expose to the employee by mill plants are dust explosion, and noise. Release of dust to the atmosphere and people working around the plant, ways of minimising such dust should be considering during the design of ball mills. Noise is also harzard to health by exposure to high level of noise can cause permanent damage to hearing. At lower lever noise distraction and cause fatigue.

Industrial sound meter include a filter net work to give the meter the respose that correspond roughly to that of human error and attention should be given to noise level when specifing and when laying out the plant.

## CHAPTER SIX

### 6.00 Discussion of results

Despite that Gum powder can be produce from any Light. White, and porous wood as sources of charcoal was utilized to produce this powder, of which it almost have the same characteristic as normal powder. However, it was found that the mass proportion of the component that provide completely burning of the powder was the same with the relative masses of the components of the mixture but for carbon is a little high. The excess amount correspond to the masses of its impurities (oxygen and hydrogen) and this gives us or corresponding to 67.2%  $\text{KNO}_3$ , 21.3% sulphur and 11.5% of charcoal.

The most important characteristic of a good Gum powder is to have a relatively low of heat of explosion this is highly achieve on test for its heat of explosion and was found to be -719 Kcal/kg which was abit higher than that of normal powder (-735 Kcal/kg) by 16 Kcal/kg. Although, this might be as a result of calorimeter use to takes the measurement and that of normal powder was calculated from the heat capacity of stack gases of the produce of decomposition.

The comprehensive analysis of the grain of the powder produce base on 5unit interval, it was seen that the grain of the powder do not burn by parallel layer but all over the mass of charge of their particles size is lower than 15mmdia. Above this, there exist a parallel layer burning of the powder and the burning time depend on the grains size. The particles Size of 5mm shows a faster rate of burning of about 312.50cm/min while that of 25mm has a slow burning effect (burning by parallel layer) of about 39.41cm/min.

This observation was also was plotted using rate against particle size and was notice on the graph from particle size above 15mm their exist a parallel layer burning and below it a non parallel burning. This characteristic tend to reduce as the size change below 10mm (from 15 to 10mm the change in rate was 184.62cm/min and from 10 to 5mm it was 12.5cm/min. Then, apoint may be reach of which any attempt decrease size further may eventually gives a negative rate. This properties was in correspondance with the observation made of normal powder of which the rate of 3.5mm is high than that of 10.5mm particle size.

In scale up, production in chapter five, it was found that for every 250kg/m feed of the charcoal 297 kg and 990 kg of sulphur and potassium nitrate are require base on the ratio of 2:3:10 respectively to produce 1455.45kg of the Gum powder. The power require by the sulphur crusher was 0.002kg higher than that require by the charcoal crusher be cause of difference in the working index of the materials and that ball mill has the highest power requirement and therefore has the highest cost.

.../2..



## CHAPTER SEVEN.

### 7.00 CONCLUSION, RECOMMENDATION, NUMENCLATURE AND REFERENCE.

#### 7.10 CONSLUSION AND RECOMMENDATION.

This project was carried out to explore posible way of manufacture Gum powder from local raw materials. The characteristic indicated that charcoal from madar calotropic proceral has high inflamenable property for Gum application. The result and other analysis shown that, the Gum powder can not withstand high pressure rathersplosions will result. Therefore, a moderate drying temperature below  $60^{\circ}\text{C}$  is recommended for a good powder and raw material should of highly pure, as impurity may increase sensitive to fri ction impart.

moreover, different ratio of the component of the powder may be use to determine the best composition that will give the best properties when ever different application is required. The content of sulphur is high to reduce the dager of carbonomoxide form and release when little amount are used. While charcoal is low to avoid unreacted deposition of carbon on the barel after shutting. This result shows that gun<sub>2</sub> produce posses excellent properties that are needed in most of our Guns. And that the particle size between 15 to 10mm die should always be used when ever employed.

However lack of availability of datas was a mojour constraint to this research project. Some of the important propaties of this powder were not determine as a result. Therefore I recomanded that effort should be made to provide datas needed in this areas of research. Further research should be to incorporate Gun powder with water proof to avoid shut failure at low temperature dur to its deliquence behaviours.

For scaling up production of this powder any amount of initial feed of charcoal may be use and other proportions determine from the ratio of 2:3:10 for charcoal sulphur and  $\text{KNO}_3$  respectively and that the size of a ball mill and other parameters are a function of length of the mill and diameter of the feed particles only.

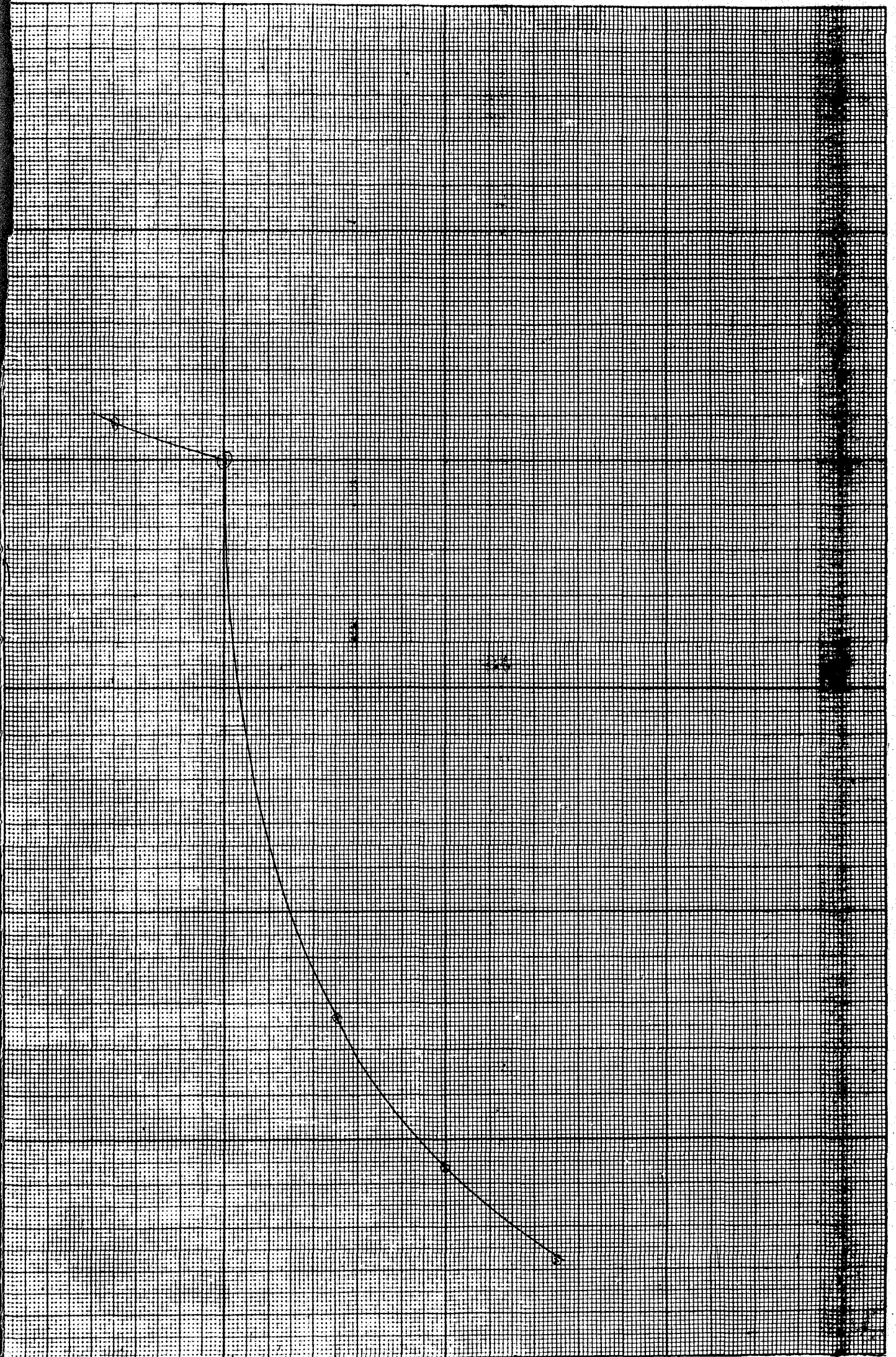
Therefore, I recomanded that for any readjustment after fabri cation should be restrict to either length of the mill of the diameter of the feed particles. Therefore this shows that the high the diameter of the feed particles the bigger is the diameter of the ball.

.30 REFERENCES.

- ) T.urbanski, chemistry and technology of explosive Vol I
- ) Sybol parkes, cyclopedia of chemistry mc Grain Hill
- ) Sfordham, High explosive and propellants 2 revised edition
- 4) T. Urbanski, chemistry and technology of explosive Vol II
- (5) " " " " " " " " Vol III
- (6) " " " " " " " " " IV
- (7) A.C. Du Botary for degree standent fifth edition
- (8) N.L. Glnkan, General Chemistry Vol 2
- (9) M. Hughes, Physical chemistry.
- (10) David A. Tillman, Amaded J. Rossi, Miham D. kitto wood combustion principle processes and economic.
- (11) Rene Descartes, principe de la philosophie elsevier Amsterdam (1644)
- (12) T. Gay Lussac, Rapponts de la comite des pondre at sulpetre 1823
- (13) M. Cherreuil according to R. E scales
- (14) Andrew Noble and F. Abel pril trans toy soc 165.
- (15) J.D Black wood and F.P. Bowden Proc. Roy Soc.
- (16) Perry chemical engineering hand book 6th Roberth Perry bongreen.

## 7.20 NOMECLATURE

Db	=	Diameter of the ball (m)
Wi	=	Working index
E <sub>z</sub>	=	Power use by 0.6 by 0.6cm laboratory mill under the same condition
Nc	=	Ball critical revolution (rpm).
Xp	=	Size of coarse feed particles (cm).
N	=	Ball mill working Number (rpm).
O	=	Coefficient of loading.
Hu	=	Useful heat released (kcal/kg).
Cp	=	Specific heat capacity (kj/g).
Ac	=	Heat loss from stack gases (kj/g).
HHv	=	Higher heat value (kcal/kg).
	=	Ball density (kg/m <sup>3</sup> ).
D	=	Mean inside diameter of mill (m)
L	=	Inside length of the mill (m)
H <sub>2</sub> <sup>o</sup>	=	Heat of vaporization of water. (kj/g)
C	=	Carbon.
K	=	Potassium
S	=	Sulphur.
N	=	Nitrogen.
O	=	Oxygen.
hw	=	Heat capacity of water (kj/gk).
mw	=	Mass of water.
hb	=	heat capacity of bomb (kj).
m <sub>T</sub>	=	Total mass (g).
V <sub>T</sub>	=	Total volume (cm <sup>3</sup> ).
DT	=	Change in temperature.
Hp	=	Enthapy of product (kcal/kg).
U	=	Rate of explosion (cm/min).
T	=	Temperature (°C).



4 8 12 16 20 24 28 32 36 P.N.O. CONCEPT 20

Scale to base  $\rightarrow$  2 unit.  $\rightarrow$  particle size