DESIGN, CONSTRUCTION AND TESTING

OF

A MECHANICAL OPERATED SIEVES

BY
SABA TAUHID
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A PROJECT IN THE DEPARTMENT OF AGRICULTURAL ENGINEERING

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DEDICATION

To my mother & entire family for the moral & Financial Support.

ABSTRACT

The mechanically operated sieve for sifting granulated and powdery materials was designed, constructed and test. The materials consist of two sieve of different mesh sizes. (i.e mesh number 10 & 20) and a retaining tray of the bottom. The size stock can be tilted between 0° to 35° with the horizontal. The system is gyrated by rotating the handle the motion is then transmitted to the crank through the plain bearing and converted into reciprocating motion by the connecting rod, thus gyrating the whole system and an average velocity of 0.34m/s. The machine was tested on gani corn flour and yam flour at the capacity of about 5kg/min. For each material and results obtained show the particles sizes relationships and the fines modules as 0.96, 0.57 and 0.16 respectively. Testing on cornflour also give the machine effectiveness of sieve as 84.5%. Other qualities of the machine include portability and versatility in sieving operation.

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Special acknowledgment to the entire member of Late Saba Kutigi's family and also my friends for their supports and encouragement throughout the academic period.

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LIST OF SYMBOLS

µM	-	Micrometer
MM	-	Millimeter
DPC	-	Particle cut diameter
A	-	Area (CM^2)
B	-	Breath (CM)
L	-	Length (CM)
H	-	Height (CM)
	-	Angle of the crank mechanism
r	-	radius
W	-	Angular velocity
V	-	Linear velocity
A	-	Angular acceleration
µ	-	Coeffient of friction
	-	Angle of internal friction
	-	Diameter
%	-	percent

1.0 CHAPTER ONE

1.1 INTRODUCTION

Sieve is a vessel with method or perforated bottom for sifting. Sieve has a very wide range of applications in the farms, houses, laboratories and industries. They are employed for cleaning and grading in post-harvest crop processing, for particles classification in food technology and industries and for materials sampling processes in laboratories.

With the post harvest crop processing, the sieves are mostly designed to clean grains before and sometimes after milling/shelling process. This is aimed at removing foreign materials and thus increasing the nutritional market value of the harvested or threshed crops. Most equipment used for this purpose are referred to as sieve separators or sieve cleaners, and they are in corporated with a blower, as such they are mostly powered by motor. This is a very vital factor in the selection of equipment, for it may cost more than the actual process machine (Carruthers, 1985).

In the food processing industries, such as the flour mills, it is very much desirable to obtain the fineness particle size for flour. This is because it maximizes the amount of flour extracted from wheat or corn. As such the milled grains are passed through various sieve sizes and the fineness particle are collected for use as flour, while the coarser in size which could not pass through the sieves are returned for further size reduction or alternatively as food material for animal feed (Kent, 1985).

Similarly, in most African houses, milled grains are sifted with the use of sieve before the fine particles are used for making meals. This types of meals include "towon dawa" (sorghum flour meal), "towon masara" (maize flour meal), "albo" (yam flour, "Gari" (cassava flour), soya beans powder etc.

For laboratory use, most samples eg soil, are usually sieved by the used of standard sieves before further analysis is carried out. As a result, the use of sieve in all aspect of live is unlimited.

This mechanically operated sieve, which is the theme of discussion is more or less a plan sifter, consisting of two sieves, set at a slight angle to the horizontal and oscillating in the lengthwise direction. The sieving unit comprises of three section which becomes progressively coarser in size of mesh from head to tail. The top sieve is of larger mesh of 1.6mm diameter, retains the coarser size particles; the next sieve is of 0.8mm diameter and the last compartment is a wooden try which retain the fineness particles.

The mixture to be sieved is fed in at the top through the hopper and falls by gravity from the first sieve to the next and finally to the wooden tray, as the whole assembly gyrates in a vertical plane. Due to the tilting of the sieve and the gyrating movement of the whole unit, the particles that could not be sifted immediately, will flow and if not sifted after passing through the length of the sieve, it will be discharged on the collecting tray. If need be, the discharges at the trays of the two sieves can be grinded and sieve again by passing it from the top. This is to maximize the amount of fine particle (flour) from the milled grain.

The oscillating motion of the sieves is caused by the manual rotation of the crank shaft. This rotation by hand is converted into a reciprocating motion by the connecting rod, thus transmitted in the sieving unit as rectilinear motion which facilitates the flowing and sifting of the particles to be sieved. The provision of interchangeable sieves of different sieves of different sizes and the adjustable angle of sieve tilt from the horizontal, enable for replacement of sieve as well as setting to any desirable angle between $0^o - 35^o$. Hence the mechanically operated sieve is capable of sifting different types of flour and other dry granulated materials.

1.2 OBJECTIVE

The main objectives of carrying out the design, construction and testing aof a mechanically operated sieve are as follows:

i) To design a sieving machine that can accept a mixture of solid particles of various sizes and separte the particle into three fraction sizes.

ii) To meet all requirements necessary for the separation of solid particles basically granulated materials and flours.

iii) To produce a sieving machine which will be an improvement over the manual (i.e local method) sieving. The mechanically operated sieve is aimed at reducing the drudgery associated with local method of sieving and rather a continuous process instead to batch method.

iv) To produce a sieving machine which will be easy to operate, and cost effective. The machine should be an alternative to very expends imported sieving machine. Thus is should be produced at an affordable cost.

v) To carry out testing of the machine to ascertain the performance and effectiveness of sieve.

1.3 Justification of work: Considering the frequent need and the importance of good sieving, relative to other processing work, and the cost of procuring an imported standard sieving machine, it becomes necessary to design and construct a machine from locally available materials that will meet the expected standard.

The project work therefore involves selection of materials to meet all design requirements, designing to achieve effective sieving, constructing according to specifications and testing to evaluate the performance of the machine. Perhaps, with little modification the machine will meet the requirements to enable for mass production.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Preambles:

Solid materials in general are more difficult to handle than liquids, vapors or gases. Frequently it is necessary whatsoever to separate the components of the solid mixture into individual fractions. The faction may differ from each other in size, in phase or in chemical composition. Thus crude products may be purified by removing from it the impurities, two or more products in a mixture can equally be separated. A number of methods have been invented for accomplishing such separations and several unit operations are devoted to them.

The procedures for separating the components mixtures, fall into two classes. They are:-

i) diffussional operations – which involves phase changes or transfer of material from one phase to another.

ii) Mechanical separation – which are useful in separating solid particles or liquid drops. This is the main topic of this project.

2.2 Mechanical separations:

Mechanical separation methods are applicable to heterogeneous mixture, which are primarily particle large than 01mm. The techniques are base on physical differences between the particles, such as size, shape or density. They are applicable to separating solid from gases, liquid drops from gases, solid from solid and solid from liquid. The two general methods used in mechanical separation are, the use of sieve, septum or membrane, such as screen or filter; and the utilization of differences in the rate of sedimentation of particles or dope as they move through a liquid or gas. Emphasis will however, be lied on the former method.

General mechanical separation can be grouped into four. Viz: Sedimentation Centrifugal separation, filtration and Siezing. (Sarle, 1983). Sedimentation is use in liquid-liquid or liquid-solid separation; if centrifugal force is applied to increase the rate of sedimentation, the method is referred to as centrifugal separation; filtration on the other hand is only applicable to liquid-solid separation; and the classification of solid particles is often accomplished by sieving.

2.3 Sieving and sieving equipment:

Sieving is a method of separating particles according to size alone. It involves classification of mixture of particles based on particle size into fractions of narrow size range. This was supported to be first practiced by the Egyptians in the earliest centuries (Allen 1981). The early sieves were made of trays or pans with nail drilled holes to separate grains like rice, maize, wheat etc from stones, chaffs and strains by winnowing. With development, domestics sieve came into use. It is usually, made of round metal plate or soft wood, with wire mesh bottom, later on plastics rubber with perforated bottom were also use for the same purpose of separating or obtaining fine particles from milled grains. The procedure involve in this method of sieving is laborious (Murdock, 1979).

By 1910, the Tyler sieve was originated and later adopted by the united state Bureau of standards. This Tyler sieve is most frequently used for placing granular materials with minimum dimension range of 3.125mm to 0.0725mm approximately (Henderson, 1976). Presently, the Tyler sieves is used as a basis for sizing all screened materials used in processing. The sieves characteristics are given in table 1 below, which constitute a normal set.

Mesh No. Openings To inch	Diametre, of wire in	Size of Actual	Opening Approx
-	0.148	1.05	1
-	0.135	0.742	¾
-	0.105	0.525	½
-	0.092	0.371	3/8
3	0.070	0.263	¼
4	0.065	0.185	3/16
6	0.036	0.131	1/8
8	0.032	0.093	3/32
10	0.035	0.065	1/16
14	0.025	0.046	3/64
20	0.0172	0.0328	1/32
28	0.0125	0.0232	-
35	0.0122	0.0164	1/64
48	0.0092	0.0116	-
65	0.0072	0.0082	-
100	0.0042	0.0058	-
150	0.0026	0.0041	-
200	0.0021	0.0029	-

Source: Henderson (1976)

Note: Inch = 25mm.

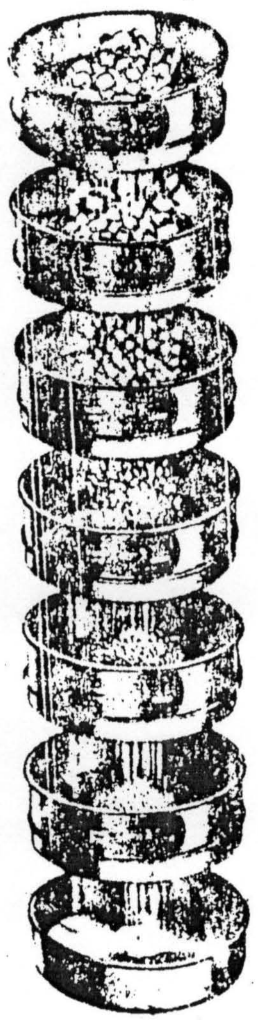
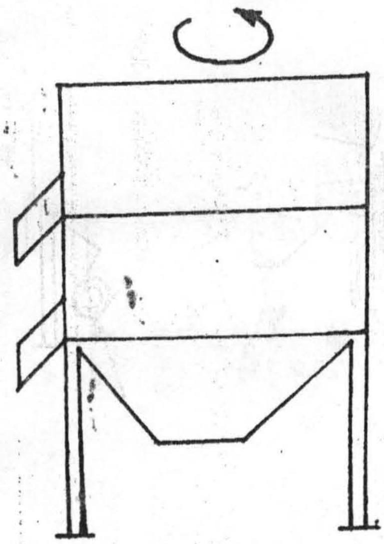


Figure 1:Tyler Sieves for classifying granular materials.

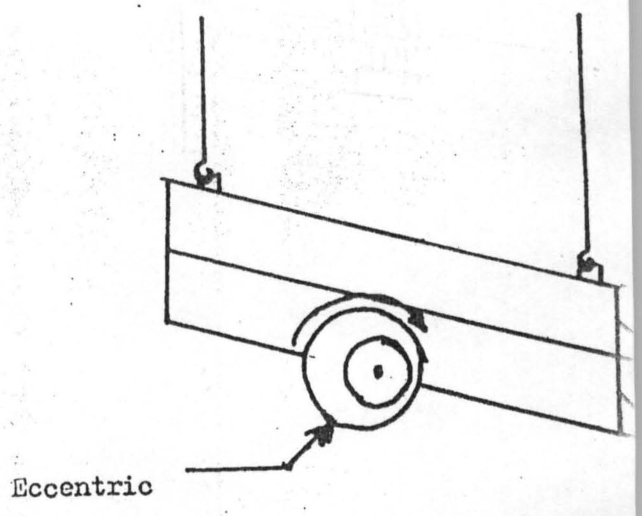
Figure 1: Tyler Sieves for classifying granular materials.

Industrial sieves are made from woven wire, silk or plastic cloth, metal bars, perforated or slotted metal plates or wires that are wedge-shaped in cross-section, various metals are used with steel and stainless steel the most common. Standard sieves range in mesh size from 100mm to 400 mesh and woven metal sieves with openings of as small as 1mm are commercially available. The separation in the size range between 4 mesh is referred to as "fine sieving". But sizes smaller than 48 mesh are considered ultra fine".

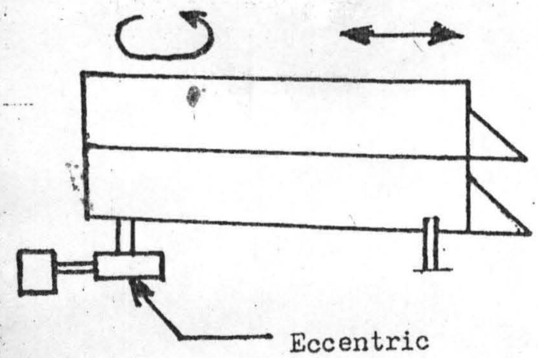
Many varieties of sieves (other wise known as screens) are available for different purposes, but a common feature in most screen is that particles drop through the openings by gravity, nonetheless, in few designs they are pushed through the sieve by brush or centrifugal force. Coarser particles drop easily through large openings in a stationary surface, but with fine particles the sieve must be agitated either by shaking, gyrating or vibrating it mechanically or electrically (Brennan, 1969). Typical screened motion are illustrated in figure 2.



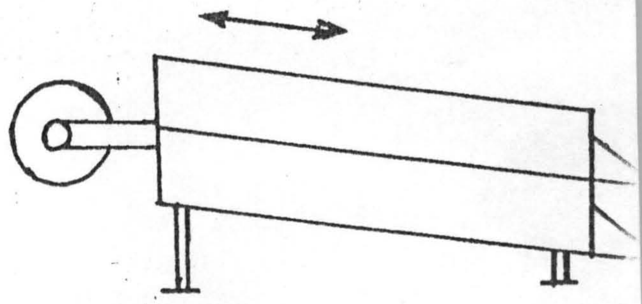
yrations in horizontal plane;



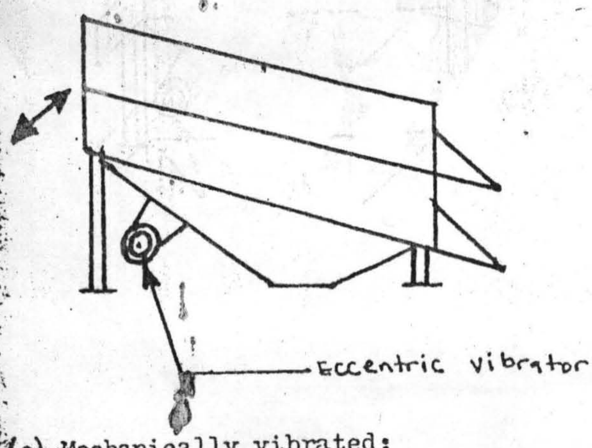
(b) gyrations in vertical plane



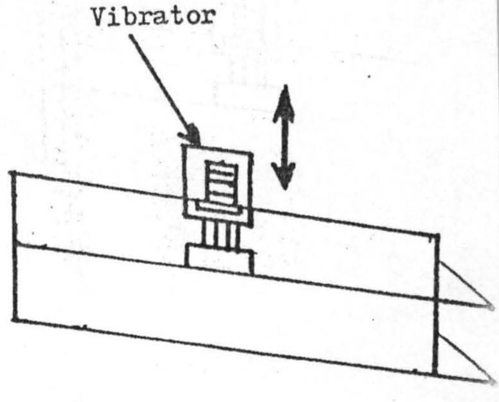
) gyrations at one end, shaking at other;



(d) Shaking;



(e) Mechanically vibrated;



(f) Electrically Vibrated

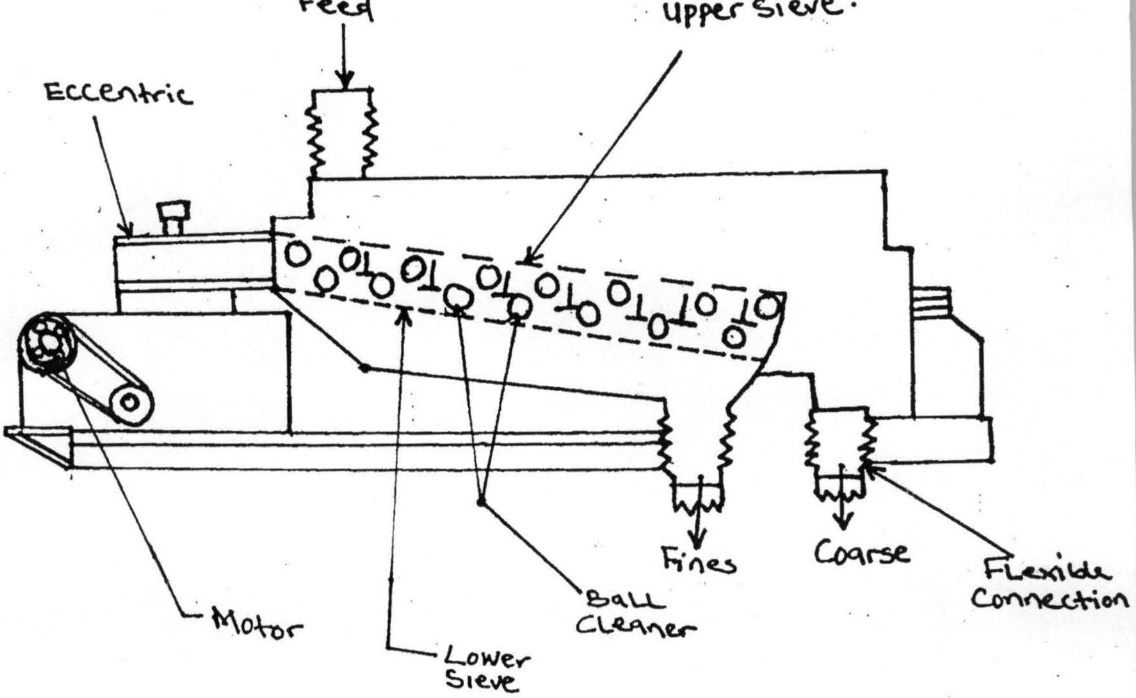


Figure 3:   A horizontally gyrated sieve

Emphasizing on gyrating sieves, in nearly all sieves which produce sized fractions, the coarse material is removed first and the fines last. The horizontally gyrated flat sieves is on the machine for carrying out sieving operation, (see figure 3). The machine contains several decks of sieve, on above the other, held in a box or casting. The coarsest sieve is at the top and the finest at the bottom, with suitable discharge ducts to permit removal of the several fractions. The mixture of particles is dropped on the top sieve, and the sieves with the casing are gyrated to sift the particles through the sieve openings.

Feed

Upper sieve.

Eccentric

Fines

Coarse

Flexible
Connection

Ball
Cleaner

Motor

Lower
Sieve

Figure 3: A horizontally gyrated sieve.

In another design, for example the vertically gyrated sieve, the casing is inclined at angle between 16^0 and 30^0 with the horizontal. The gyrations are in a vertical plane about a horizontal axis. This is caused by an eccentric shaft set in the floor of the casing half way between the feed point and the discharge. The sieves are rectangular in shape and fairly long, typically 45: 120cm to 150: 420cm. The speed of gyration and the amplitude of throw are adjustable, as is the angle of tilt. One particular combination of speed and throw usually gives the maximum yield of desired product from a given feed (Fourt, Etel, 1960). The rate of gyration is between 600 to 1800rpm; the motor size is 1 to 3hp.

2.4 Application of Sieves:

As a household utensil the wire screen of the sieve may be coarse or fine depending on one's choice of a sifter. It is used for sifting flours and other ingredients. The sieve is held in one hand and the sifting mechanism operated by the other, or one hand may both hold and sift. Such a method is very efficient, but it allows for only batch sifting and is very laborious when large quantity is to be sifted (Peet, 1979).

In the food industry, impurities larger or smaller that the grain are removed by screens of perforated metal, the sieves are mounted in a frame which is caused to move horizontally, or nearly so, by gyrating or reciprocating motion. The third type of sieve motion used in food processing is the Rexman motion: One end of the Sieve reciprocates while the other end gyrates. It is claimed that the apertures of the screen become less clog with this type of motion (Kent, 1983). After grinding, the mixture of particles is again passed through sieve or set of sieve this is to classified the particles into fraction of narrower particle size range. Names of particular sieving p[rocesses include: Scalping –

sieving to separate the breaker stock from remainder of a break grind; dusting, bolting, dress-sieving flour from the coarser particles; grading – classifying mixtures into fractions of restricted particle size range. When grading flours, flour stream with the lowest ash yild are now as "patent" flour and are rated, high grade. Other industries such as fertilizer companies, powder companies, cement companies etc make use of sieves in the production processes other areas of application of sieve include soil and chemical laboratory.

2.5 Ideal and actual sieves.

The obkjective of a sieve is to accept a feed containing a mixture of particles of various sizes and separate it into two fractions, an under flow that is passed through sieve and an over flow that is rejected by the sieve. Either one, or both, of these streams may be required product.

An ideal sieve would sharply separate a feed mixture in such a way that the smallest particle in the overflow would be just larger than the particle in the under flow. Such an ideal separation defines a cut diameter "Dpc" which marks the point of separation between the fractions. Usually DPC is chosen to be equal to the mesh opening of the sieve.

Actual sieves do not give a perfect separation about the cut diameter (Dpc), instead the cumulative sieve analysis of the underflow and overflow. Commercial sieves, which is an example of actual sieve, usually give poorer separation than testing sieve eg Ro-Tap machine, and sonic classifier. See figure below.

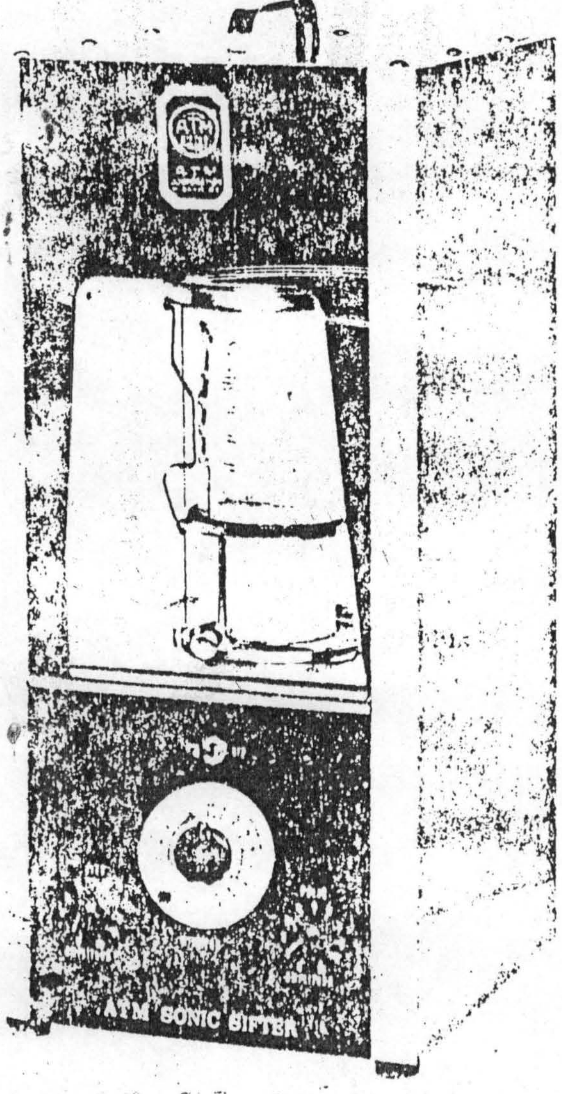


Figure 4: A sonic classifier for granular material.

The testing sieve of the same mesh opening operating on the same mixture gives a more effective sieving compared to the commercial sieve.

2.6 Sieve analysis:

In making an anlysis a set of standard sieves are arranged serially in a stack with the smallest mesh at the bottom and the largest at the top. The sample is place on the tope sieve and the stack shaken mechanically for a definite time perhaps 20 minutes. The particles retained on each sieve are removed and weighed, and the masses of the individual sieve increment are converted to mass fraction or mass percentages of the total sample. Any particle that pass the finest sieve is caught in a pan at the bottom of the stack.

The results of a sieve analysis are tabulated to show the mass fraction of each sieve increment as a function of the mesh size range of the increment. Since the particles on any one sieve are passed by the sieve immediately ahead of it, two numbers are needed to specify the size range of an increment, one for the sieve through which the fraction passes and the other on which it is retained. Example is the notation 14/20 meaning “through 14 mesh and on 20 mesh”.

The cumulative plots are made from the results, it may also be made on logarithmic probability paper on which the abscissa scale is divided in accordance with a Gaussian probability distribution. Size analysis of the product from a crusher or grinder often gives linear plot on such paper, at least over much of the particle size range. Plots of this kind were formerly used for extrapolation of small particle sizes below the range of testing sieves, but this is no longer necessary because of available methods.

2.7 Capacity and effectiveness of sieves.

The effectiveness of a sieve (often called screen efficiency) is a measure of the success of a sieve in closely separating material. A and B. If the sieve functioned perfectly all the materials A would be in the overflow and all of material B would be in the underflow.

In addition to effectiveness, capacity is an important factor in industrial sieving. The capacity of a sieve is measured by the mass of material that can be fed per unit time area of the sieve.

Capacity and efficiency are opposing factors. To obtain maximum efficiency the capacity must be small and large capacity is obtainable only at the expense of a reduction in effectiveness (Arthur, 1976). The capacity of a sieve can simply be controlled by varying the rate of feed to the unit. The efficiency obtained for a given capacity depends on the nature of sieving operation.

CHAPTER THREE

3.0 DESIGN AND CONSTRUCTION DETAILS

3.1.0 Design Considerations:

The primary goal of designing the mechanically operated sieve is to meet all requirements for the separation of solid mixture into two or more fractions. The sieve, which is basically designed for domestics and industrial uses is expected to separate food stuff of granular and flour form effectively with minimum effort. To achieve this, the followings were considered in the design.

1. The materials used for the construction should be compatible with the particles without contaminating the foodstuffs.
2. The selection of sieves with suitable mesh and screen interval.
3. The stacking of the sieves in ascending order of aperture size.
4. Inclining of the sieves at an angle between 0^o - 35^o with the horizontal.
5. The mechanical shaking and gyrating to ensure proper sifting and the flowing of the particles on the slope of the sieves to the discharge.
6. The ease of construction with readily available local material.
7. Minimizing the cost of construction of the machine, so as to make it cheap and affordable.
8. Provision for adjustment and interchangeable sieves to make the machine versatile for sieving.
9. The ease of operation such that one man can operates the machine successfully.

10. The design in such a way that each part of the sieving component can be easily accessible or dismantled. This makes repairs and maintenance easy.

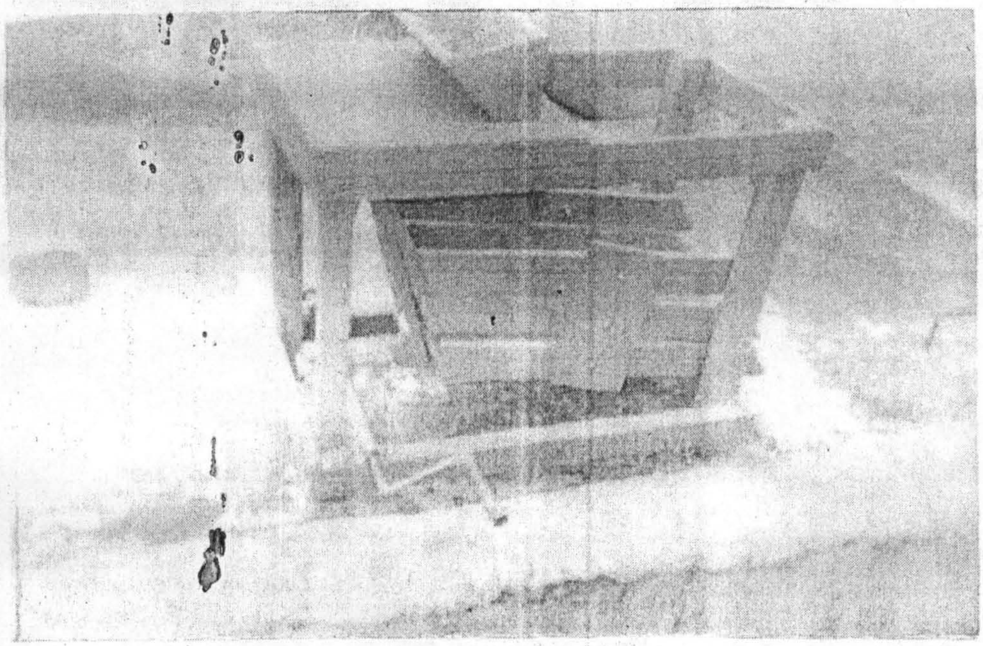
3.2.0 Description of the mechanical sieve

Plate 1 on page 19 shows the mechanical sieves. It consist of three units, namely, the main frame, the powering unit and the sieving unit.

a) The main frame: This is the supporting structure which carrys the remaining parts of the machine. The frame has four legs which is built in a table-like manner with a hopper at the top. The hopper saves as an opening through which the materials are feed into the sieve. The four legs are connected by another wood which saves as a brace to keep the frame stable. Appendix I: and II shows the assembly diagram of the main frame and the hopper.

b) Powering unit: The powering unit which produces the shaking and gyrating of the stacked sieves consists of the handle, the crankshaft, the connecting rod and four plain bearings at the points of connections. The shaft and the connecting road are made up of 10mm diameter iron road. The handle is directly welded to the shaft which is connected to the stacked sieves by the connecting rod. At the point of connection of the shaft to the frame, the shaft to the connecting rod and the connecting rod to the sieve mounting, plain bearings were use to enable free rotation. Appendix III shows the diagram of the powering unit.

c) The sieving unit: This unit comprises of two sieves and a collecting tray at the bottom. The sieves are arranged such that the coarser in mesh size is at the top and the whole stack can slightly be inclined to the horizontal or be operated horizontally. It is in this unit that the main sifting is



Carried out. The diagram and method of arrangement of the sieving unit is shown in appendix IV.

3.3 Operational Considerations

Ideally, the objective of sieving is to separate a mixture into a desired fraction sizes. A number of factor must be considered in other to achieve this objective.

1. The rate of feeding – if the rate of feeding is too high the screening efficiency will reduce.
2. Particles size – The particle will only pass the sieve if its alignment, relative to the openings is favourable.
3. Flow of particles – The particles should flow by gravity down the slope of the sieve. This can be influence by the physical properties of the particle.
4. A gyratory movement is necessary to spread the particles over the area entire area of the sieve and facilitates flowing of the particles.
5. The effort required in operating the machine is minimum.
6. The collection of different particle fraction at separate tray.
7. The portability of the machine so that it can be easily carried to the work.
8. The angle of tilt of the sieves can be adjusted between 0^o to 35^o.
9. The sieves are interchangeable.
10. The major maintenance required is to avoid clogging of sieve opening. If clogging occurs, the sieve can be remove and cleaned with a wire brush.

3.4 Design Analysis

3.4.1 The Main Frame:

The material use for the frame is treated wood. The frame consist of the following parts which are designed as shown in table 2 below.

Table 2: Specification of parts of the main frame

Part		Quantity Require	Specifications (C.M)
1.	Leg	4	4:4 wood of 50cm length
2(a)	Reinforcement bars (along the length)	4	2:4 wood of 60cm length
(b)	Reinforcement bars (at the width)	4	2:4 wood of 32cm
3.	Top cover	1	3¼ ply wood 30:32
4.	Hopper	1	Ply wood -

The total area of the frame will be the length multiple by the breadth.

i.e A = Lx b------------------- (1)

A = are (cm^2)

L = length (cm)

b = breath (cm)

A = 60 x 32 = 1920cm^2

Giving a clearance of 10cm from the ground level, the height of the frame being 50cm, then the internal height will be 50 – 10 = 40cm.

Therefore

Total space provided by the frame for housing the powering unit and the sieve unit will be, area multiply by height.

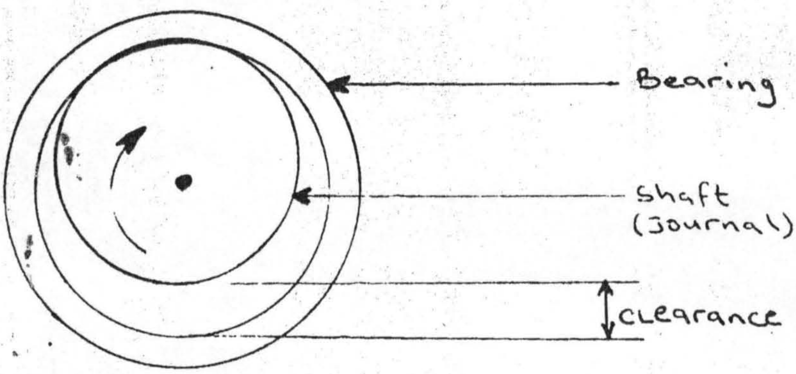


Figure 5: A Plain bearing.

Total space = A x h ------------ (2)

h = height (cm)

Total space = 1920 x 40

= $76900cm^3$

= $0.0768m^3$

3.4.2 Powering unit:

At the powering unit, requirements for the selection of bearing were considered as well as design for the velocity of gyration of the system.

(a) Plain bearing: Four plain bearings are employed for power transmission, two connecting the crank shaft with the main frame, one connecting the crank with the connecting rod and another connecting the rod with the sieve mounting.

The function of the plain bearing is to allow the transmission of the rotary motion from the operating handle to the powering system. Generally, plain bearings are design to carry a radial load or to carry an axial or thrust load. The bearing develop hydrodynamic pressure to carry the loads and separate the bearing element ion order to minimize friction. The load-carrying capacity arises because the lubricant resists being pushed around in the radial clearance zone. Figure 5 shows the arrangement of the plain bearing, the shaft with the clearance.

Bearing

Shaft
(journal)

Clearance

Figure 5: A plain bearing.

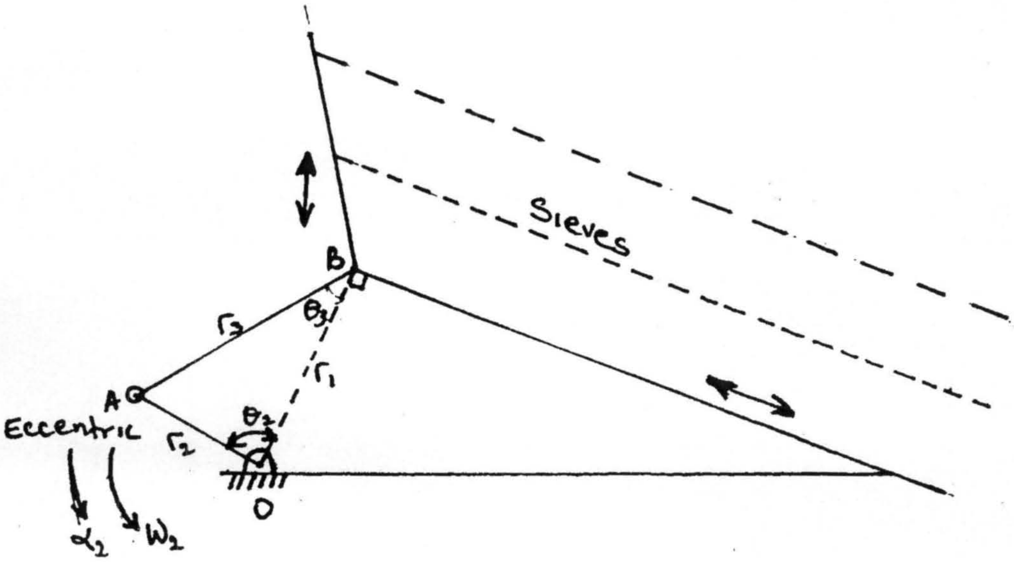


Figure 6. Crank machanism of the sieve.

The plain bearings requires only thin film or boundary lubrications. Other factors considered in choosing plain bearings are:

i) Little or no service requirements

ii) Lower cost

iii) Greater tolerance between the journal and the bearing.

iv) No elaborate enclosure requirement

(b) Velocity of the crank:

The speed of gyration and the amplitude of throw plays an important role in sifting particles through the sieve opening. The rotation of the handle which is transmitted to the crank through the plain bearings is converted to a reciprocating motion by the connecting rod and this reciprocating motion is used for gyrating the stack sieve. The mechanism of the crank is similar to the sliding crank mechanism. Figure 5 shows the analytical nomenclature of the mechanism.

Figure 6: Crank mechanism of the sieve.

At 30^o angle of sieve tilt.

r_2 = radius of crank = 5cm = 50mm

r_3 = length of connecting rod = 10cm = 100cm

Angle O A B = 90^o

Therefore $r^2{}_1 = r_2{}^2 + r_3{}^2$----------------------(3)

$r_1 = 125 = 11.2cm = 112mm$

Assuming the crank rotates 100 rev/min.

$W_2 = 10.47$ rad/sec.

Linear velocity of the connecting rod can be calculated as

$V_B = r_2 W_2 \text{ Sin } 0_2 - r_3 W_3 \text{ Sin } 0_3$ ---------------(4)

$V_B = -(50 \times 10.47 \text{ Sin } 0_2) - (100 \times W_2 \text{ Sin } 0_3)$

Since angle O A B = 90^o

$\text{Sin } 0 = {}^{10}/11.2$

$0_2 = 63.2^o$

$0_3 = 180 - (90 + 63.2) = 26.8^o$

$$W_3 = - W_2 \left\{ \frac{r_2 \cos 0_2}{r_3 \cos 0_1} \right\} \text{-----------------(5)}$$

$$W_3 = - 10.47 \left\{ \frac{50 \cos 63.2^o}{100 \cos 0_3} \right\}$$

$W_3 = 2.6$ rad/sec.

$V_B = - 341$mm/S.

Linear velocity of the sieve = 0.341/sec.

Acceleration can thus be calculated as

$$3 = r_3 \frac{(W^2{}_2 S - 2 \text{ Cos } 0)}{r_3 \text{ Cos } 0} + \frac{W^2{}_3 \text{ Sn } 0}{\text{Cos } 0} \text{ ----------------(6)}$$

3.4.2 The Sieves.

Design analysis on the sieve include determination of sieve sizes to be used, the angle of sieves tilt with the horizontal and the surface area of the sieves.

(a) Determination of sieve sizes.

Most commercial sieve sizes ranges between 4 – mesh and 48 mesh, are normally referred to as fine sieving. By sampling, must domestic sieve are between 8 – mesh to 28 mesh. Hence the two sieves provided with the machine are of 10 – mesh (with cut diameter (DP) as 1.651mm and 20 – mesh, with cut diameter as 0.0833mm. But provision is made for interchanging the sieve replacing with the desired sieve.

(b) Angle of sieves tilt with the horizontal.

The angle of sieve tilt reflects the angle of friction of the particles which governs the flow of the particle. Must granulated particles has Coefficient of friction of 0.7, (Mohseuin 1986). The tangent of this Coefficient gives the angle of internal friction.

U = tan 0 -------------------- (7)

Where u= Coefficient of friction

= angle of internal friction

0.7 = tan

= 35°

To allowed for tolerance the machined is design so that the angle of tilt can be varied between 40° - 0°.

(c) Surface are of the sieve:

The surface are of the sieve was designed to comply with the minimum requirement of width: length ration i.e at least 1:2 or 2.5.

To achieved clearance fit with the main frame the maximum width of each sieve should not exceed 220mm. Therefore the length will be at least 440mm.

In this particular case the width of 220mm was used and the length of 550mm, giving the total are of 121000mm^2 i.e 0.12/m^2.

3.5 Construction of the mechanically operated sieve.

The first step of the construction was fabricating and assembling of the main frame and hopper according to the design. Nails were used in joining the various part. See appendix II. Next is the fabrication of the two sieves compartment, the bottom tray and the sieve mountings, see appendix IV. The powering unit was also fabricated as shown in appendix III.

The general assembling was done with screws, bolt and nuts where every application for adjustment and access to maintenance.

3.6.0 Cost/Material Estimates

It is not sufficient alone to design a machine to meet all the special and operation requirements/without taking into account the cost of production. A good designer should always put the cost of producing the machine into consideration with the aim of presenting an acceptable machine at the lowest possible cost.

As part of the objectives of this project i.e to produce a sieving machine at an affordable cost, it is therefore essential that accurate cost of production be made available.

Table 3: Material cost estimate

Description of item		Quantity	Unit cost N	Total cost N
1.	2" : 2":12' plant	2	200	400
2.	2':4', ply wood 19.05cm thickness	1½ yard	180	270
3.	1.6mm mesh sieve	½ yard	75	75
4.	0.8mm mesh sieve	½ yard	200	200
5.	30mm length bolt and nut (3.cm)	9	10	90
6.	Small wood screw	10	5	50
7.	10mm Iron rod	800mm	100	100
8.	Plane bearings (15mm internal diameter)	4	25	100
9.	Nails	-	50	50

Total cost = N1,335.00

Labour and overhead cost:

Assuming the labour cost and the overhead cost to be 25% of material cost i.e

Labour/overhead cost = 25/100 x 1335.

= N333.75k

Total cost of production can be calculated as sum of material cost and labour/overhead cost.

Which is

Total cost = 1335 + 333.75

= N1668.75k

CHAPTER FOUR

4.0 TESTING AND RESULTS

Testing of the mechanically operated sieve is essential, so as to evaluate the performance of the machine. Generally, there are some factors that influences the performance of industrial sieves. These factors include, the particle size distribution, feed rate, physical properties of the particle, angle of sieve tiits and the speed of operation among other factors.

4.1 Materials and Methods:

Three types of materials of different texture were used for the testing. They are:

Sample "A"

Gari:- This constitutes granulated particles of cassava. The cassava tubes are grated and then fried to reduce moisture content, the product is further dried and the granulated particles is commonly referred to as Gari.

Sample "B"

Corn flour:- The corn flour is obtained by grinding dry maize into smaller particles. This can be achieve by the use of Hammar mill, burr mill or stone milling depending on the degree of fineness required. The sample use for this testing was grinded by our mill.

Sample "C"

Yam flour (Albo): This is the product obtained from grinding dried yam. Normally it is in powdery form and it is the fineness of the three samples.

Method:

The machine is set with the sieves arrange in ascending order, that is the coarser sieve at the top and the finer one below, before placing the bottom container. The stack sieves are tilted at angle 35^o to the horizontal as to ensure complete discharge of the fed materials from the sieve. The materials are fed into the sieves through the hopper and the machine is operated sequentially. The rate of feeding is such that the particles do not piled up in one place. The speed of operation was between 75 to 100rpm this is to avoid excessive losses during operation.

Table 4 gives the result obtained from sieving gari, corn flour and yam flour.

4.2 Analysis and presentation of results.

For each test, one kilogram of the sample is used.

The terminologies used in the analysis of results are define below.

i) Sieve opening (mm) – The space between the individual wires of a wire mesh sieve normally measured in millimeters or inches.

ii) Mesh number – This is the standard number of a individual sieves according to the Tyler standard.

iii) Mass fraction retained (g) – The mass of materials failing to pass a given sieve.

iv) Percentage Mass fraction retained (%) – The percentage of the oversize in the mixture.

v) Percentage finer than – Percentage of the under size in the mixture.

vi) Average particle size (DPC) = This marks the point of separation between the fractions. It is defined as a cut diameter of an ideal separation.

vii) Fineness modulus – define as the sum of weight fraction retain above each sieve divided by 100:

Results of sieve analysis, to determine the particle size relationship

Table 4:

Sample	Mesh No.	Sieve opening (mm)	Mass fraction retained(%)	Percentage retained(%)	Percentage finer than %
Gari	10	1.6	276.95	27.7	71.4
	20	0.8	407.9	40.8	30.6
	Pan	0	305.8	30.6	-
Corn	10	1.6	73.1	7.3	91.2
Flour	20	0.8	425.2	42.5	48.7
	Pan	0	487.1	48.7	-
Yam	10	1.6	0	0	100
Flour	20	0.8	163.3	16.3	82.6
	Pan	0	836.4	82.6	-

Note: During testing, 0.9% losses was observed for Gari, 1.5% losses for corn flour and 1.1% for yam flour.

The graph in figure 7 shows the plot of percentage finer than against sieve size for the samples.

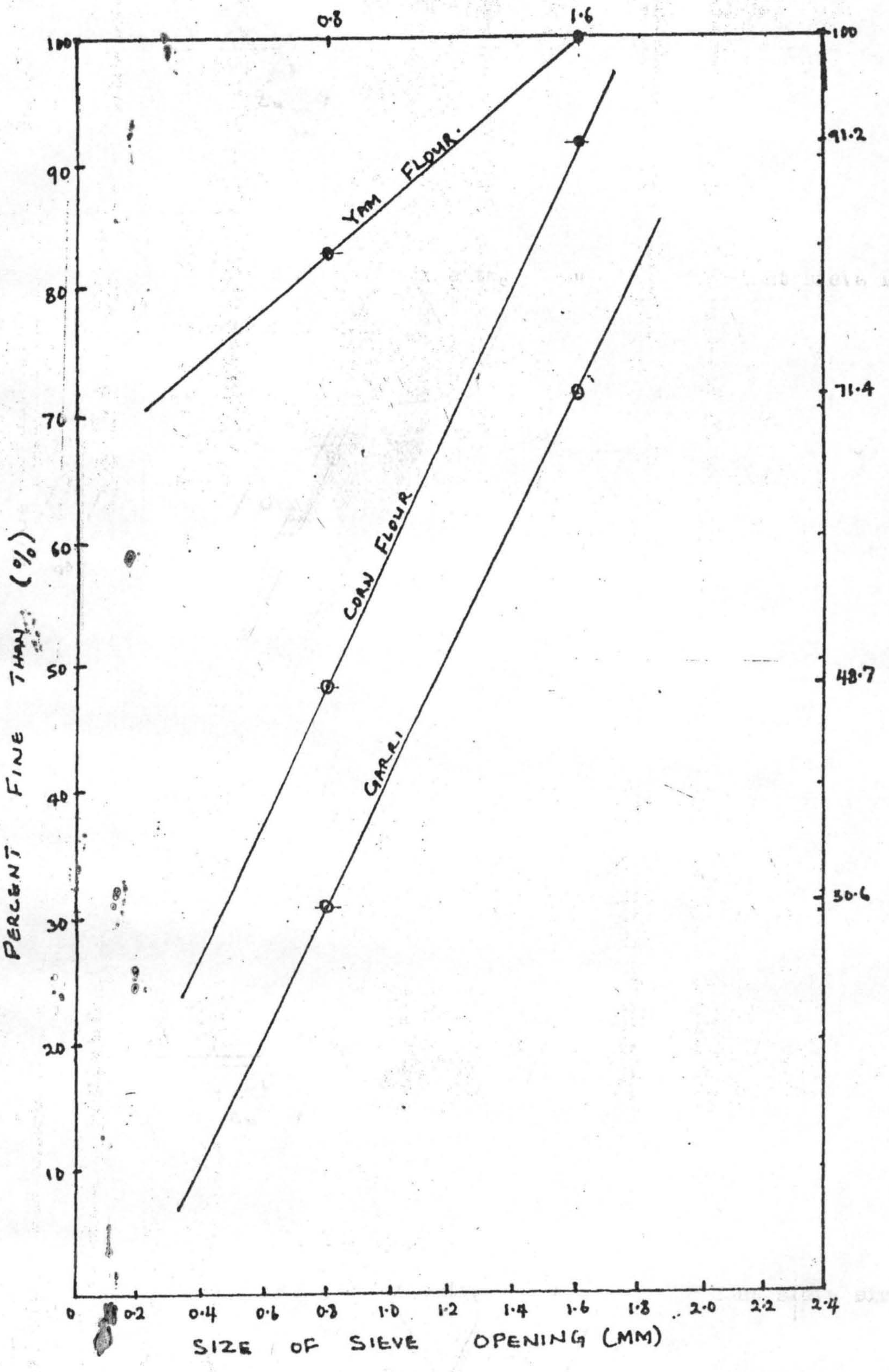


Figure 7: Graph of"percentage finer than" against sieve sizes

For s tandard s ieve t est, the g raph i s a c urve u sually s igmoid i n s hape a nd i s a configuration that is not easily represented by a mathematical equation. From the graph the results and the size distribution represented by the straight line is represented by the equation.

$$Y = \{\underline{x}\} \text{ ---------------(8)}$$

where

Y = weight percent finer than size X.

X = particle size based on smallest sieve opening it will pass through

K = Product size modules (representative sieve size which 100% of the materials will pass through.

= distribution modules.

Another factor used for sieve analysis is the fineness modules, used for determining the performance of feed grinders. The fineness modulus indicates the uniformity of grind in the resultant product. Below are tables of results obtained to determine the fineness modulus of each sample.

Table 5: Result of sieve test on gari to determine the fineness modulus.

Mesh No.	Sieve size (mm)	Mass fraction retained(g)	Percentage (%)	Multiplied by
10	1.6	276.95	27.7	x2 = 55.4
20	0.8	4.07.9	40.8	x1 = 40.8
Pan	0	305.8	30.6	x0 = 0
	Total	990.65	99.1	96.2

The result above indicates 0.9% losses.

$$\text{Fineness modulus} = \frac{96.2}{100} = 0.96$$

Table 6: Results of sieve test on corn flour to determine the fineness modulus.

Mesh No.	Sieve size (mm)	Mass fraction retained(g)	Percentage (%)	Multiplied by
10	1.6	73.1	7.3	x2 = 14.6
20	0.8	4.25.2	42.5	x1 = 42.5
Pan	0	487.1	48.7	x0 = 0
	Total	985.4	98.5	57.1

The results show 1.5% losses for corn flour.

$$\text{Fineness modulus} = \frac{57.1}{100} = 0.57$$

Table 7: Results of sieve test on yam flour to determine the fineness modulus.

Mesh No.	Sieve size (mm)	Mass fraction retained(g)	Percentage (%)	Multiplied by
10	1.6	0	0	x2 = 0
20	0.8	163.3	16.3	x1 = 16.3
Pan	0	836.4	83.6	x0 = 0
	Total	999.7	99.9	16.3

The result above indicates 0.1% losses.

$$\text{Fineness modulus} = \frac{16.3}{100} = 0.16$$

It should be noted that when using this mechanical sieve to determine the fineness modulus of a material, the value will range between 1 and 2. The graph in figure 8 represents the plot of sieve sizes against the fineness modulus.

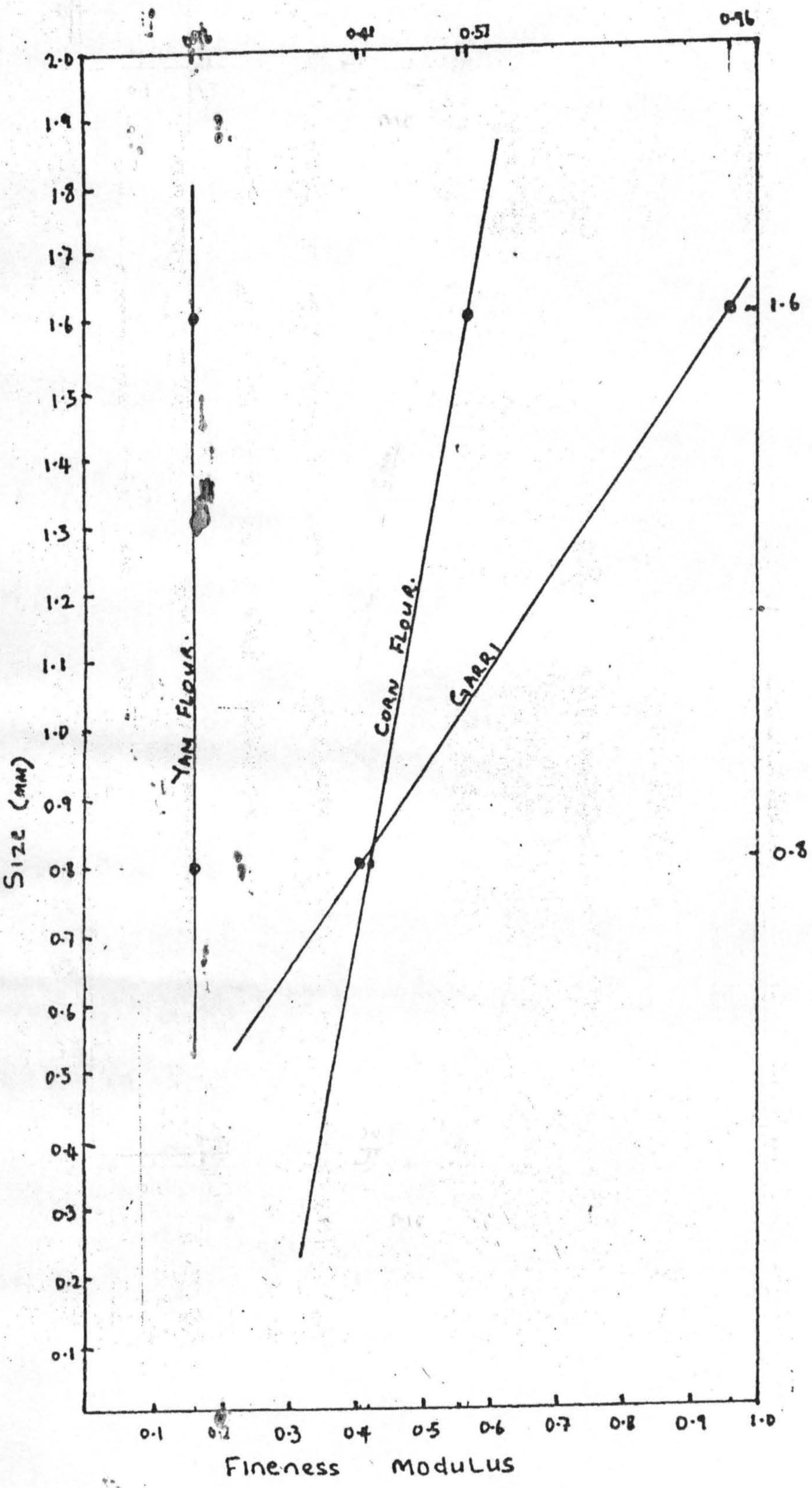


Figure 8: Graph showing relationship between the fineness

4.2 Capacity and effectiveness of the mechanical sieve:

Capacity and effectiveness are opposing factors. To obtain maximum effectiveness the capacity must be small and large capacity is obtainable only at the expense of a reduction in effectiveness.

At an average clapacity of 5 kg/min., and acceptable effectiveness of sieving is obtainable as compared to a Ro-tap test sieve.

Using the Ro-tap machine, the mass fraction finer than the 0.8mm sieve was 576.4g for corn flour.

Thus sieving effectiveness can be calculated as

$$E = \frac{XB}{XF} \times 100\% \quad \text{------------- (9)}$$

Where E = overall effectiveness

XF = actual mass fraction of material finer than

XB = Mass fraction of material finer than as obtained from the mechanical sieve.

Therefore, effectiveness

$$E = \frac{487.1}{576.4} \times 100 = 84.5\%$$

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion:

The course of work of this project involves choosing suitable materials to be used as components, putting all necessary factor into consideration, carrying out the design calculations wherever it is essential, construction of parts and assembling all the component part to give a sieving machine that operates on the principles of continuous process rather than the familiar batch process sieving equipment.

The machine was tested and the results obtained shows its ability to sift granulated particles successfully and to some extent flours. With flours, such as yam flour, wreath flour etc, the inability of the particles to flow easily along the sieves to the point of discharged was observed. This provides another scope for modification.

In terms of cost, the machine is cheap compared to imported sieving machines, the materials used for construction are locally available, and technically it requires no special skill for operating it or carrying out maintenance.

5.2 Recommendation:

Due to the limitation of time in carrying out the project work, some areas of the design and the machine as a whole may need some modification, before suggesting for it mass production. The followings are therefore recommended.

1. In further design, the number of sieves should be increase from two to five, so as to widen the range of particle fractions obtainable.

2. An improvement on the rate of gyration is necessary, this is to enhance even distribution of the particles over the sieve are and flowing of the particles to the discharge point.

3. A device to regulate the feeding rate into the machine should be incorporated with the hopper, this will give an accurate rate of feed.

4. Transparent material such as transparent plastic can be used to incase the sieve, this will improve the appearance of the machine.

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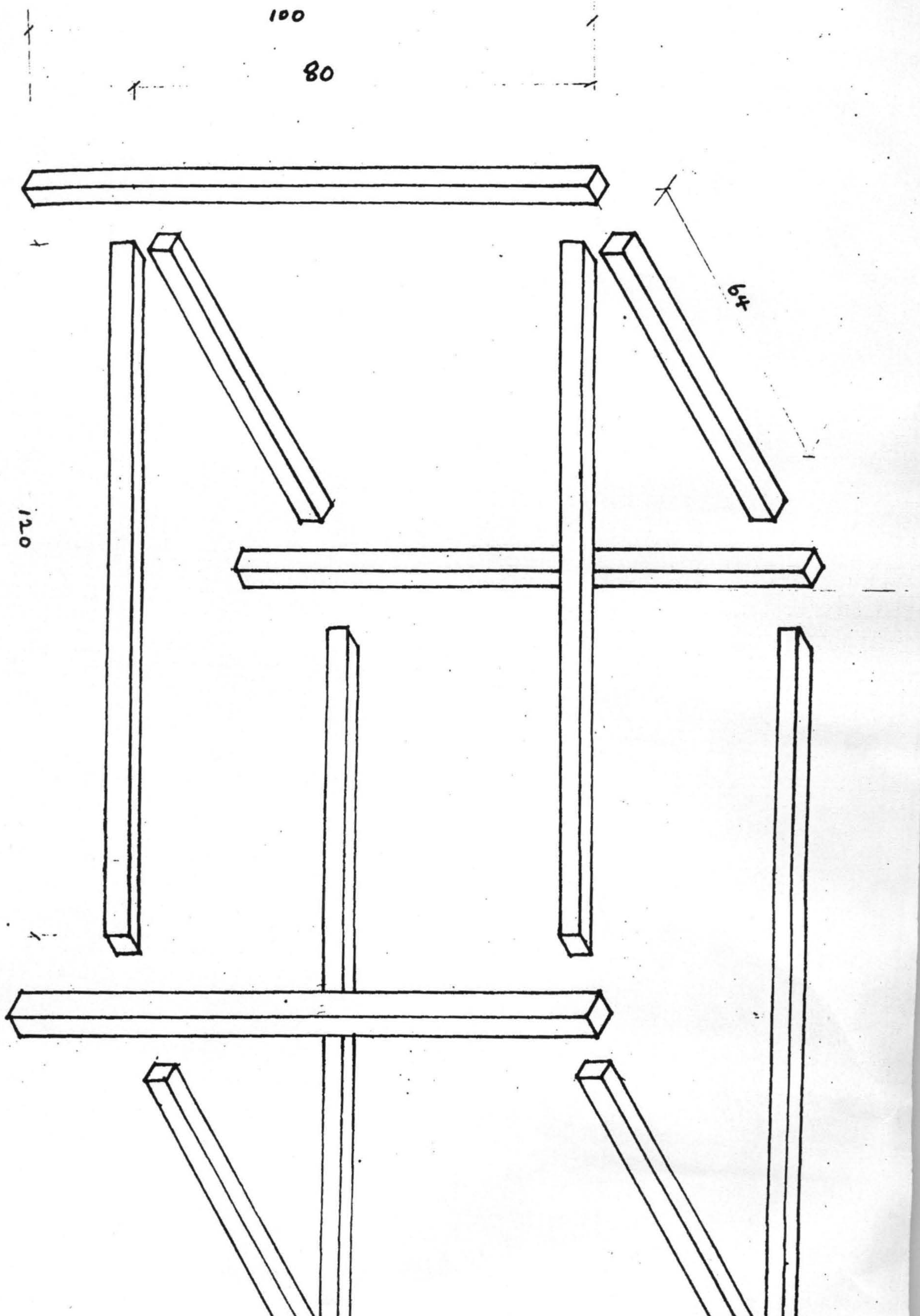
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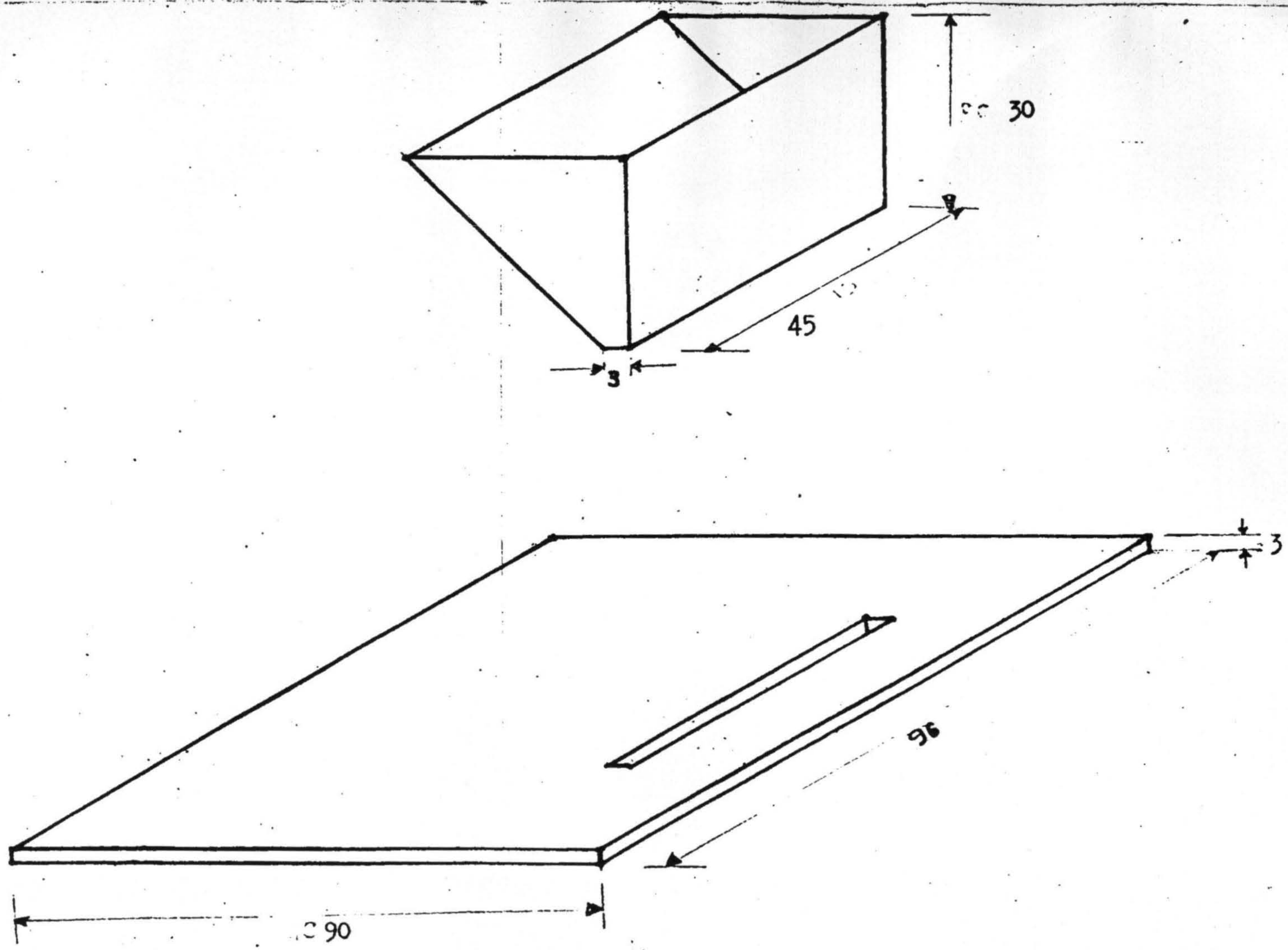

30
45
3
3
96
90