DESIGN AND FABRICATION OF A SOLID FERTILIZER APPLICATOR MACHINE

BY

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2004/18409EA

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A Project Report Submitted in Partial Fulfilment of the Requirement for the

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Nigeria.

February, 2010.

DECLARATION

I hereby affirm that this project titled "design and fabricated of a solid fertilizer applicator" is an original work and has never been submitted anywhere else before, neither has it been wholly or partially presented for any other degree. All sources of information have been duly acknowledged by means of reference.

....

Name of student Date

CERTIFICATION

This project entitled "Design and Fabrication of a Solid Fertilizer Applicator Machine" by Onatola Iyiola Tope, meets the regulations governing the award of the degree of Bachelor of Engineering (B.ENG.) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

Engr. Dr. Agidi Gbako
Supervisor

17/02/2010
Date

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Date

External Examiner

10/2/2010
Date

DEDICATION

I hereby dedicate this project work to almighty God for his unspeakable, undeniable and unqualifiedly blessings, mercies and favours granted unto me. To my wonderful and lovely parent Mr. and Mrs. Onatola for their support and also to the family of late Mr Oyawoye and my aunt Mrs Lola Oyawoye for her tireless support to me in the course of my programme.

ACKNOWLEDGEMENT

In a write up like this, it is impossible to acknowledge all those who contributed to the success of this project; however I wish to acknowledge the special contribution of some:

My greatest thanks goes to Almighty God through his son our lord Jesus Christ who has been keeping my life in all endeavours to this present moment and through my program successfully. My special gratitude goes to my project supervisor Dr Agidi for his invaluable contribution in terms of advice, patience and corrections rendered through my write up and also to see that this work is a success.

I wish to also thank the HOD Dr Balami and other departmental Staff for their contribution towards the completion of this project and too many of my colleagues in this prestigious department, who space will not allow me to mention all their names. I say thank you all for your support and encouragement

However, I wish to also extend my gratitude which I owned to my wonderful parents Mr and Mrs Onatola for their moral ,financial, spiritual care and support they rendered to me during my days in school. Also to my siblings; aunty ibunkun, aunty bunmi, yetty, femi, seun and my cousins for their encouragement, I similarly wish to thank my one and only Treasure Oladosu for her lovely advice and support. I say thank you to my lovely aunty Mrs Lola Oyawoye and her family for the care they bestowed on me during my program, may God bless you ma.

My appreciation equally goes to Primate T.O Oladosu for her prayer support and also to my blossom friends Temitope Lawal and Adu Emmanuel for their encouragement and lastly, may God Bless you all.

ABSTRACT

machine was designed and fabricated with locally available materials. The machine eliminates time and aterial wasting encountered during the conservation method of manual hand application of granular ertilizer. The applicator has some adequate considerations of some design parameters such as strength, urability and rigidity. The designs of various components of the applicator were made for proper unctioning of the equipment as a whole.The machine requires an average of 0.669KW (0.897hp) to perate, although the value depends on the maximum speed of operation. The machine which is light in weight also makes it transportation easier without being trailed by an animal. The machine was tested for rate of application, field capacity and efficiency of the machine with values of 1.599m^3/ha, 0.2998ha/hr and 76.7% respectively. The results obtained are encouraging and due to prevailing dry season, field test were still carried out appropriately on the field. Hence, it is therefore, recommended that the performance of the fertilizer applicator should be improved.

TABLE OF CONTENT

CHAPTER TWO

CHAPTER THREE

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Notation

A =area

C= Basic dynamic load for bearings

Cd= Design capacity of tank

D = Diameter

E = Modulus of electricity

F = force

f = soil friction co – efficient

f_{au} = Allowable stress

f_{max} = maximum stress

f = ultimate stress

g = gravitational stress

H = Depth

I = moment of inertia

K = combine shock and fatigue factor

L = length

L= rating life in revolutions

L H = life bearing in working hours

LT = total length

Mo = maximum bending moment

N = factor of safety

N = speed in revolutions per minute

P = power

Pcr = critical load

Pab = Drawbar pull

Pe = Euler crippling load

Pk = rolling resistance

Pt = friction resistance in bearing

Pu = implement total draft

Qq = Discharge rate

R = reaction force

Ra = application rate

S = maximum forward speed

Sk = application blade spacing

Sw = wheel spacing

ρS = Density of steel

V = velocity

W = equivalent dynamic load rating

Wc = weight of chasis or frame

Wbd = weight of draw bar

Wf = weight of fertilizer

Wr = radial Load

Wt = Total weight

Z = sectional modulus

B = mass per unit length

LIST OF APPENDICES

CHAPTER ONE

1.0 INTRODUCTION

One of the many functions of soil is it primary function of serving as medium of plant growth. The ability of soil to support any plant is determined by its fertility. A fertile soil is therefore defined as any soil that can supply the entire nutrient for the healthy growth of the plant. However, continued cropping on the same piece of land leads to the depletion of the essential plant nutrients. For the land to continue to be productive, the lost nutrients must be replenished. The age long method of replenishing plant nutrients include the addition of crop residue, farmyard manure, compost, green manure and other forms of organic materials.(Jones U.S, 2001).

Fertilizer is a material added to the soil or applied directly to the crop foliage, to supply elements, needed for plant nutrition. The materials may be in the form of solids semi-solid, slurry suspensions, pure liquids, aqueous solutions or gases. Fertilizer may be organic or inorganic. Organic fertilizers are usually manure and waste materials which in addition to providing small amount of growth elements also serves as conditioners for the soil. Commercial fertilizers are most often inorganic.

According to Hignett, 1972, many fertilizers used since ancient times contain one or more of the three elements important to the soil. For example, manure and guano contain nitrogen. Bones contain small quantities of nitrogen and larger quantities of phosphorus. Wood ash contains appreciable quantities of potassium (depending considerably on the type of wood). Clover, alfalfa, and other legumes are grown as rotating crops and then ploughed under, enriching the soil with nitrogen. The term complete fertilizer often refers to any mixture containing all three important elements;

such fertilizers are described by a set of three numbers. For example, 15-15-15 designates a fertilizer (usually in powder or granular form) containing 15 percent nitrogen, 15 percent phosphorus (calculated as phosphorus pent oxide), and 15 percent potassium (calculated as potassium oxide).

The chemical elements are Nitrogen, phosphorous and potassium is the macronutrients or primary fertilizer elements which are required in greatest quantity. Sulphur, calcium, and magnesium called secondary elements are also necessary to health and growth of vegetation, but they required in less amounts compared to the macro-nutrients. Some other elements which are important provided for plant's ingestion in small amount (or trace) amounts include Boron ,Cobalt, Iron , manganese , molybdenum and Zinc. These minor elements are called micronutrients. (Hignett, 1972)

Fertilizers are essential to modern agriculture; their overuse can have harmful effects on plants and crops and on soil quality. In addition, the leaching of nutrients into bodies of water can lead to water pollution problems such as eutrophication, by causing excessive growth of vegetation. The use of industrial waste materials in commercial fertilizers has been encouraged in the United States as a means of recycling waste products. The safety of this practice has recently been called into question. Its opponents argue that industrial wastes often contain elements that poison the soil and can introduce toxic chemicals into the food chain. (Jones US, 2001)

1.1 The History of Fertilizer

Even from the ancient, at that time the man started planting, receiving more benefit from the soil and having better produce became his main concern. Then he made his best to make the soil more fertile.

Chinese and British were the first people who tried to enrich the soil by adding bone meals and marls, which contain Carbonate Calcium and clays.

In 19th century, by developing the chemistry science, the chemist found that in plant growth the composition in mineral elements of the soil would be important so that even all elements to be abundant, lack or deficiency of mineral elements will effect on poor or richness of the plant. (FAO, 2005)

During the ages, men found that different kinds of fertilizer will help them to make the soil more fertile and then they added Potassium, Calcium, Magnesium, Nitrate, Phosphate and Sulphates. For the last years of the 19th century, the markets were faced with different types of fertilizers which was adopted for agriculture. They are in three main categories namely: 1 - Nitrogen 2 - Potash 3 - Phosphate. (Cooke, 1982)

Nowadays, the fertilizer industry in the major fertilizer consuming markets is confronted with the challenges and opportunities associated with satisfying agricultural demands. Under pressure from the market, regulators and the public, the agriculture products are changing. This provides an opportunity for the fertilizer industry to add value to its operations, through the products it provides.

1.2 Fertilizer in Agriculture Development

The use of fertilizers has been a key factor in raising crops yields and income in advanced countries, because not only the fertilizers only, but with combination with other improved practices which increases yields, they also decrease unit cost of farm input and increase profit. About 60% of yield increases was achieved during 145 years (FAO, 2005), is due to the rational use of the fertilizers. Much has been done in developing countries with the assistance of multilateral and bilateral aids to introduction inorganic fertilizers into agriculture in a large scale. Considering the needs however, only modest beginning has been made, which calls for renewal of efforts to develop fertilizer use.

The use of fertilizer in an extensive scale requires the development of distribution network, including transportation, storage and credit facilities; which can also be used for distribution of other farm inputs. The fertilizer produce quicken results on the field and its effects a re directly measurable. It therefore provides an excellent basis for extension work which can include other production factors in which the farmer can accept it. For these reason, fertilizer use development has already proved to be the spearhead which opens up a short cut to integrated agricultural development. (Butterworth B. 2004)

Although, there are consideration differences from country to country , the main obstacles against a rapid development in fertilizer use are :insufficient knowledge about the use of fertilizer and also in relation to other inputs, inadequate facilities for the transfer of the knowledge to the individual farmers and adequate facilities for fertilizer marketing and credit.

1.3 Objectives of the Project

For the fertilizer application machine under design, the following objectives are expected to be achieved:

-To design a fertilizer application machine with maximum efficiency, durability, simplicity, and quite affordable to a peasant farmer.

-To fabricate the machine using locally available materials.

-To test the performance of the machine.

1.4 Justification of the Project

It is an acceptable fact that some fertilizer application machine has been developed. Therefore the development of a simple fertilizer applicator like the one in this project became imperative because -It will be affordable by the average farmers and to encourage the use of fertilizer application machine.-It will reduce the labour involved in manual application of fertilizer which is very laborious.

1.5 Scope of the Project

The scope of this project encompasses developing a fertilizer applicator for applying fertilizer to crops .It consisting of metering device employing constant head gravity flow through an orifice. The implement is to be drawn by man and is operated with pull effort and could be used in both pre and post immergence operations. The activity of the project entails the design and fabrication of an affordable fertilizer applicator which will reduce the labour involved in manual application of fertilizer.

1.6 Limitations

The efficient performance of this implement is limited to post secondary Tillage soil and soft conditions free sub –surface obstructions. It is post immergence Application is limited to field crops in rows as well as growing trees in rows. The Performance is also limited to the solid or semi- solid fertilizer basically from inorganic Fertilizer and it is free from solid and semi – solid materials etc.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Fertilizer

Fertilizer are material added to the soil and is applied directly to the crops foliage, to supply elements, needed for plant nutrition. These materials may in the form of solids, semi- solid and slurry suspensions, pure liquid, aqueous solutions or gases. Fertilizer may be organic or inorganic and is added to the soil to supply nutrient for healthy growth of the plant. Fertilizers have been the main source of plant nutrient and are usually majorly applied to plants. With the advancement in technology, machine or equipments were developed for the application of fertilizer.

2.2 Classification of fertilizers are:

(A) Organic Fertilizer and

(B) Inorganic Fertilizer

2.2.1 Organic Fertilizers

Organic Fertilizers these are added to the soil to supply elements essential to the growth of plants. These elements include the major nutrients such as nitrogen, phosphorus, potassium, and sulphur, as well as the trace elements such as iron, zinc, and magnesium. Organic fertilizers are made from materials derived from living things. Animal manures, compost, bone meal and blood meal are organic fertilizers. Chemical fertilizers are manufactured from non-living materials. Rock phosphate for example, is a common source of phosphorus in chemical fertilizers.

(Jones U.S. 2001)

Organic fertilizers are not immediately available to plants. Before the plants can use them, they must be broken down by soil micro-organisms into simpler, inorganic molecules and ions. In contrast, the nutrients in chemical fertilizers are already in inorganic form and so can be immediately used by the plants. It is important to understand that there is no fundamental difference in nutritional quality between organic and inorganic fertilizers. It makes no difference to the beet root if the atoms of potassium it absorbs are from an organic fertilizer such as wood ash or an inorganic one such as nitrate of potash. (Butterworth B. 2004)

2.2.2 Inorganic fertilizers

Although they are immediately available to plants, inorganic fertilizers have three main disadvantages. They are subject to leaching, which occurs when the fertilizers are washed by rain or irrigation water down below the level of the plant roots. Nitrogen is particularly susceptible to leaching. As well, a heavy application of chemical fertilizers can "burn" seedlings and young plants. This is actually a process of drying out, or desiccation, due to the presence of chemical salts within the commercial fertilizers. A third problem associated with the use of commercial fertilizers is that overly heavy applications can build up toxic concentrations of salts in the soil and create chemical imbalances.

Organic Fertilizers - Unlike chemical fertilizers, organic material does more than provide organic nutrients. It also improves the soil structure, or tilts, and increases its ability to hold both water and nutrients.

As microorganisms in the soil break down the organic material into an inorganic soluble form, a slow release of nutrients is provided over a longer period of time. This is probably a healthier situation for plant growth in that an over-supply of a nutrient such as nitrogen can lead to lush, succulent tissue growth which is more vulnerable to fungal and bacterial entry, more appealing to some insects, and more prone to stress injury from heat, cold, or drought.

On the other side of the coin, there are some disadvantages to the use of organic fertilizers. As noted above, they are not immediately available to the plants. The manure which is applied to a vegetable garden in the spring may not be broken down into organic form by soil bacteria (and therefore available to plants) until mid-summer. If organic nutrients have been added to soils continually on an on-going basis, this may not be a problem. However, if you are just beginning to rely solely on organic material as a nutrient source, your garden may experience an initial nutrient deficiency until the system is in place.

The amount of nutrients and the exact type of elements available from a given amount of manure, compost or other inorganic fertilizer can only be determined. It is dependent on such factors as: the age of the manure or compost; its origin (chicken, cow, horse, sawdust, garden residue, grass clippings); and weather conditions such as temperature and rainfall. It is therefore a less exact way of providing for a plant's nutritional needs. With inorganic fertilizers, the type and amount of any given element in the fertilizer formulation are known. (Jones U.S. 2001)

2.3 Types of fertilizer

There are two main types of fertilizer; they are simple and complex fertilizers.

2.3.1 Simple fertilizers

They contain or supply only one essential nutrient e.g.

1. ammonium nitrate
2. ammonium sulphate
3. triple super phosphate
4. single super phosphate

2.3.2 Complex fertilizer

They are also known as compound or multiple fertilizers they contain or supply two or more nutrients e.g.

N.P.K 10. 10. 10.

N.P.K 15. 15. 15

N.P.K5. 5. 5

N.P.K 20. 5. 10

N.P.K.Mg 10. 15. 10. 2

Waste fertilizer appears in ratio forms and the proportion of nitrogen, phosphorus and potassium is N: P_2O_5:K_2O

Macro minerals these are the mineral salt required in large amount and their deficiency can easily manifest on the plant. They include potassium calcium magnesium and sulphur

Micro mineral these are the mineral salts required in small quantity and their deficiency does not easily manifest on the plants they include carbon iron magnesium zinc copper and cobalt

2.4 Primary fertilizer elements (NPK)

The primary fertilizer elements are also refers to as macronutrients or fertilizer elements needed for plants nutrition. These include elemental nitrogen N, phosphorous P, and potassium K which are required in greatest quantity.

2.4.1 Nitrogen (N)

Nitrogen has been recognized as an essential nutrient for crops because of its key role in protein formation. It is responsible for lash vegetative growth and a dark green coloration .Its deficiency is usually recognized first by pale green or with yellowish-green colour of the leaves with the exception of legumes, all crops required the addition of nitrogenous fertilizers if high yield are expected. (Hignett, T.P. 1972)

2.4.2 Phosphorus (P)

Phosphorus is a constituent of lecithin and other lipoids in plants. The average phosphorus, P_2O_5, content of the whole plant is about one – third of the nitrogen content. Highest concentrations are found in the germ and bran of green crops. Phosphorus is the eleventh most abundant element in the earth's crust. The elemental form of phosphorus does not exist in nature. Its minerals are widely distributed in the earth's crust in moderate concentrations and it includes phosphate rock, super phosphate etc Lack of in plants manifest itself in one or more of the following observable symptoms: stunted growth, premature leaf fall, purple or red anthocyanin pigmentation. Phosphorus is highly mobile in the plant and symptoms before the young leaves. (Hignett, T.P. 1972)

2.4.3 Potassium (K)

Potassium has several important functions in the plant metabolism. It appears to play an essential role in the water economy of plants through the action of its soluble compounds on osmotic pressure. Potassium is involved in oxidative reactions as a carrier for required by important an enzyme that converts sugar to starch and amino acid to protein.

However, potassium is one of the major nutrient elements required in relatively large quantities by plants. Adequate supply of potassium to crops increases their resistance to pest and disease attack, thereby ensuring good quantity produce. Visible symptoms of potassium include a mottled chlorosis followed by the development of necrotic area at tips and margins of leaves. (Hignett, T.P. 1972)

2.4.4 CALCIUM (Ca)

It helps in high flocculation. It is also good in aeration and water infiltration and retention, calcium improves the PH of the soil so that nitrogen fixation can be carried out, it strengthens plants cell walls and it is necessary for the normal growth of root tips together with most abundant element in plant leaves.

Deficiencies of calcium are; it causes stunting of the root system, it causes acidity and week slender plants. It causes pale yellow colour of the leaves.

2.4.5 MAGNESIUM (Mg)

Magnesium is an essential constituent of chlorophyll which is necessary for photosynthesis. It helps in the transportation of phosphate ion, hence its importance in oil crops and it also functions as calcium. Magnesium is occasionally used for liming particularly magnesium compound. Deficiencies are; it causes chlorosis or yellowing of leaves along the leaf veins, it causes stunted growth along side with photosynthesis can not take place. And lastly it affects the viability of seeds.

2.4.6 SULPHUR

It is a member of many plant proteins e.g. cystine and methionine. It is essential for chlorophyll formation. Sulphur id also require required for carbohydrate metabolism and nitrogen fixation by legumes. And lastly it influences some plant physiological processes has the following deficiencies, yellowing of leaves or chlorosis stunted growth, disturbed photosynthesis stems are small in diameter and the leaves get smaller.

2.4.7 IRON (FE)

It is necessary for chlorophyll formation and it is important in enzymes systems for oxidation – reduction reactions. Irons are an essential for the synthesis of proteins contained in the chloroplasts. Deficiencies are: it causes chlorotic condition in leaves, which becomes pale green. Iron causes other parts and margins of leaves keep their green colour. And lastly, the veins too are green while the affected leaves curl in upward.

2.4.8 COBALT

Essential for the symbiotic filtration of nitrogen in legumes. Deficiency is lack of nitrogen filtration in legumes.

2.4.9 MANGANESE

It is a member of certain enzymes essential for protein synthesis. Manganese is essential for certain nitrogen transformation in plants and micro-organisms. Deficiency of manganese is that it causes a pale greenish yellow discoloration between veins of young leaves.

2.4.10 COPPER

It is a constituent of certain enzymes. It is also necessary for photosynthesis; it is involved in respiration and in the utilization of 2iron. Also it is an activator of other element with in the plants, it promotes the formation of vitamin A. it has a regulation function when nitrogen content of soil is high or depleted. Deficiencies are: pale green colour of leaves, the tips die back and in citrus, its deficiency is marked with reddish brown coloration of this fruits.

2.4.11 ZINC

It is necessary for the action of certain enzymes, essential for the formation of some growth hormones; also it is important for the reproduction process of certain plants. And lastly, it formation in the formation of chlorophyll in conjunction with iron and magnesium. Deficiencies are: production also moulted leaves, small leaves are also produced, fruit bud formation is reduced and the twig begins to die back after the first year.

2.5 Method of application of fertilizer into the soil:

There are two major method of applying fertilizer to the soil. (a) Manual method and (b) machine method.

2.5.1 Manual method:

Manual method is the earliest form of applying fertilizer to the soil. In this method the fertilizer is applied using the hand either by scattering or placement close to the plants. Although this method is very effective, it is very laborious and can only be used where the land area is small. This method is still in practice by the small holder farmer with small plots of land.

2.5.2 Machine Application Method:

Advancement in technology has brought about the development of different machines for the application of both organic and chemical fertilizer. The development of this machine has brought about the cultivation of larger land areas as the drudgery is reduced to barest minimum.

CHAPTER THREE

3.0 METHODOLOGY

3.1 MODE OF OPERATION OF THE DESIGN FERTILIZER APPLICATION

The implement can be driven by man or animal drawn type. The application blade (knife) spacing and metering valve discharge are set to precision. However, in the field the implement application knifes (furrow openers) discharges the fertilizer into the soil to a precise depth and little effort is applied to set the machine in motion.

When the machines moved, the metering valve through constant head gravity plough meters out the fertilizer at desired application rate with the discharge is inversely proportional to the forward speed

The metered fertilizer goes under gravity in the hoses (lines) and down to the exist at the lower rear edges of the applicator knifes, deep inside the soil.

3.2 THE FERTILIZER APPLICATOR COMPONENTS

The basic components of the fertilizer applicator from the design point of view are handle assembly, frame or chassis, wheels, shaft, bearings, hopped, metering valve, hoses, drawbar (variable), application knifes and furrow closer.

3.3 THE COMPONENT FUNCTIONS ARE:

Handle: functions to be the point at which the effort is exerted on the machine. It is made of hollow steel pipe and fixed on the chasses.

Frame: frame or chasses provides the necessary function of forming a rigid structure for linking other components of the applicator.

Wheels: movement of the implement is only possible with help wheel; wheels also served and selected on the basis of size and ply rating.

Shaft: the shaft is made of steel material. The major function of the shaft is to transfer the implement to the wheel.

Furrow Opener: the knives inject the fertilizer deep into the soil horizon, they are fabricated from hardened steel; they posses narrow sharp edges and hole to accommodate hoses.

Furrow closer: the furrow closer functions to close the furrows in order to prevent immediate vaporization of the fertilizer content.

3.4 DESIGN CONSIDERATION AND CRITERIA

From the previous works on fertilizer applicator, it has been discovered that the main principle of operation employed in the application of fertilizer is not that effective.

The concept of the design carried out in this project work is to improve the effectiveness, and to reduce labour involved in manual application of fertilizer which is laborious.

In designing an efficient and effective fertilizer applicator, the basic factors to be considered includes the choice of materials besides their availability and cost. In selecting materials to achieve main objective of this project design, such as cost of material, availability of materials amount of labour, and properties of materials such as strength, corrosion, resistance, weight durability and workability are to be taken in to consideration.

The design calculation of all the components will be based on steel material.

The design calculation of all the components will be based on steel material.

3.5 FORCE ANALYSIS AND COMPONENTS DESIGN

For analysis and components design of the fertilizer applicator was based on the following:

- Suggested fertilizer application rate,
- Density of the fertilizer
- Soil resistance
- Maximum working depth for applicator knives,
- Forward speed
- Engineering properties of materials specified.

3.5.1 Design Assumptions And Parameters

- Application rate Ra = 500 to 800L/ha
- Density of solid fertilizer = $700Kg/m^2$
- Soil resistance, α = $30KN/m^2$
- Maximum working depth, a = 15cm = 1.5m
- Maximum forward speed, s = 2m/s = 7.2Km/hr.
- Density of steel used, δs = $7703Kg/m^2$
- Ultimate stress of steel, fu = $4.136854x10^8N/m^2$
- Gravitational force, g = 9.81N/Kg.
- Modulus of elasticity of steel material, E = $200N/m^2$
- Wheel spacing, Sw = 44cm = 0.4m.

3.6 DESIGN OF THE COMPONENTS OF THE MACHINE

3.6.1 The Hopper

The hopper is to be constructed using a 2mm thick metal sheet. It is to be made into a rectangular and trapezoid shape with the following dimensions.

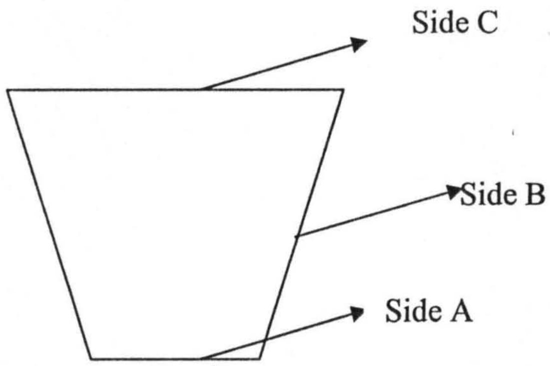


Fig 3(a) side view of the hopper

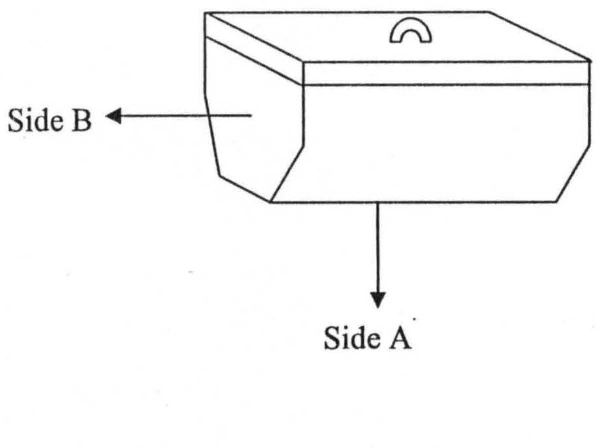


Fig 3 (b) a covered hopper

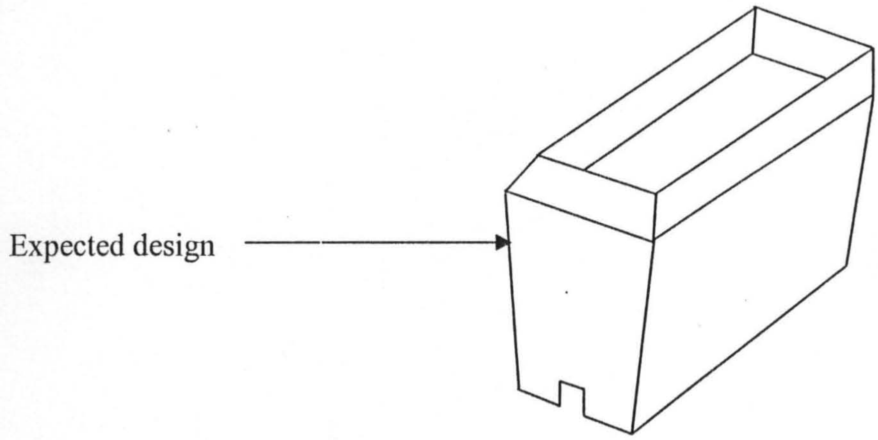


Fig 3.0 uncovered hopper

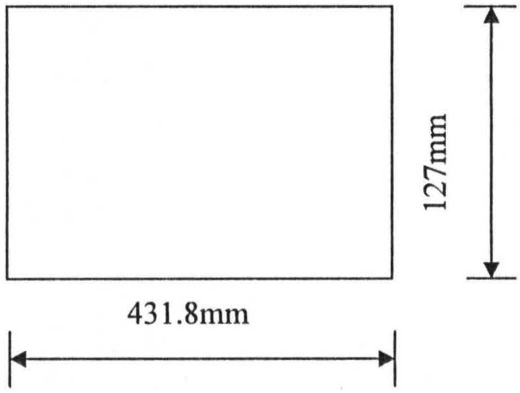


Fig. 3.1 fertilizer hopper

Thickness of metal sheet = 2mm

Density of steel used δs 7703Kg/m^3

Area of side A, A_r = L x B

A_r = 345 x 350 = 120750mm^2 and 0.12075m^2

Vol. of material of side A, (V_A) = area x thickness

= 0.12075 x 0.002 = 0.0002415m^3

Mass of materials of side A, M_A = vol. x density

= 0.0002415 x7703

= 1.86028Kg.

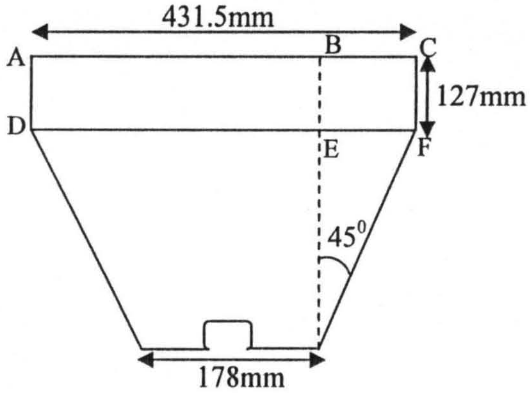


Fig. 3.2 side B of the hopper

Area of rectangle section ABCD, A_B = L x B

A_B = 431.5 x 127 = 58650mm &0.05865m^2

Volume of rectangle section ABCD, V_B = area x thickness

= 0.05865 x 0.002

= 0.0001173m^3

Mass of material of rectangle ABCD, M_B = vol. x density

= 0.0001173 x 7703

= 0.9036Kg.

Now considering trapezoid ADEF, A_{BII} = ½(a + b) x h

= ½ (345 +170) x 350

= ½ (515) x 350

= 90125mm or 0.090125m^2

Vol. of ADEF, V_{BII} = area x thickness

= 0.090125 x 0.002 = 0.00018025m^3

Mass of material of trapezoid ADEF, M_B = density x vol.

= 7703 x 0.00019025m^3

= 1.38846575Kg.

Total mass of side B = area rectangle ABCD + area of trapezoid ADEF

= M_{tB} = 0.9036 + 1.3885 = 2.2921Kg

Total mass of hopper material

Mass of side A, M_A x 2 = 1.86028 x 2

= 3.72056 x 2

Mass of side B, M_B x 2 = 2.8921 x 2

= 4.5842 x 2

Total mass of hopper material (Mt) = 3.72056 + 4.5842

= 8.30476Kg.

Mass of fertilizer in the hopper

Vol. of rect. Portion of hopper V_r = L x b x h

$V_r = 345 \times 245 \times 170 = 20234250 => 2.0 \times 10^7 mm^3$

$V_r = 0.20m^3$

Vol. of trapezoid portion of the hopper (V_E)

$V_E = ½ (a + b) \times h$

$= ½ (345 + 170) \times 350$

$= 0.090125m^2$

Total vol. of hopper (V_T) = 0.20 + 0.090125

= $0.290125m^3$

Bulk density of fertilizer = $700Kg/m^3$ (Boser et al 1988)

Mass of fertilizer (Mm) = density x vol. of the hopper

Mm = 700 x 0.290125Kg = 203.1Kg

Weight of hopper & material $M_{TM} = (M_T + M_M)$

= 8.3048 + 203.1 = 211.40N

Side B of the hopper is slanted at 40^0 being the angle of repose of fertilizer which varies between 50^0 & 30^0 (Bosei et al 1988)

3.7 ANALYSIS OF BUCKLING FOR HOPPER BARS

The fertilizer hopper is supported by four 350x45x5mm mild steel bars. These members may fail due to the weight of the hopper and the fertilizer in it. To ensure safety, the critical load using Euler formula is determined and then compared with the actual load acting on them.

Euler's formula for calculating buckling is given as

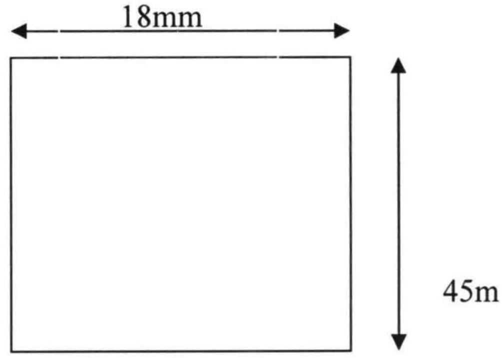
$P_{er} = 4 \pi^2 EI/L^2$ (Spot 1990)

Where Per = critical load (N)

E = elastic modulus of the material (GN/m^2)

I = moment of inertia of the material (M^4)

L = axial length of the member (m)



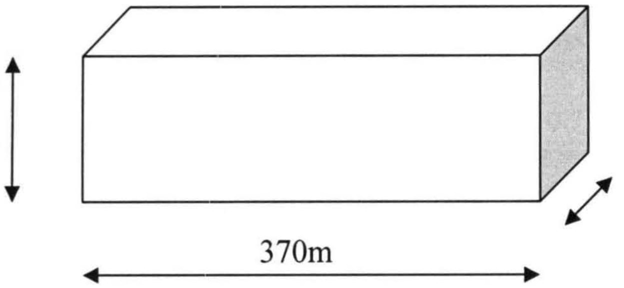


Fig. 3.3 hopper support bar

Using the formula $I = b^2h/12$

$$= 0.018^2 \text{ x } 0.043/12 = 2$$

L = 370mm

$\pi = 3.141592$, Per = 4 x π^2 x 207 x 10 2.187 x $10^{-8}/12$

$$Per = 1458.96KN$$

Since the critical load of 1458.9KN is greater than the load of 2.89KN acting on the number design is safe.

3.8 FRAME DESIGN ANALYSIS

The chassis or frame is the carrier of all the other components of the machine. Therefore stability, rigidity and strength are the important criteria to be considered in the design of fertilizer applicator.

The design involves the determination of all the forces acting on the frame and choosing the correct size of material that will not fail due to bending or deflection. The geometry of the frame is chosen to ensure a higher mechanical advantage and man-machine compatibility (ergonomics).

Fig. 3.4 below shows the diagrammatical representation of the chassis or frame.

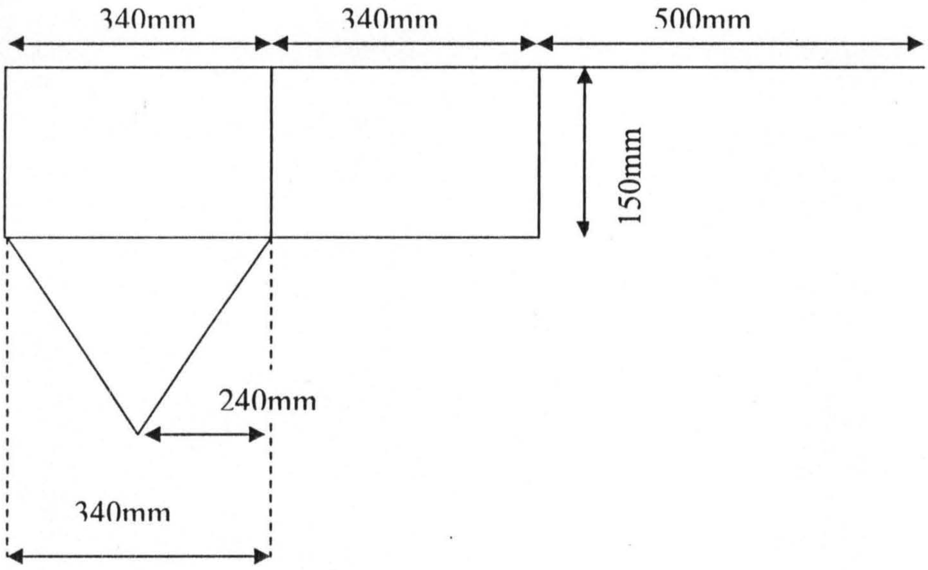
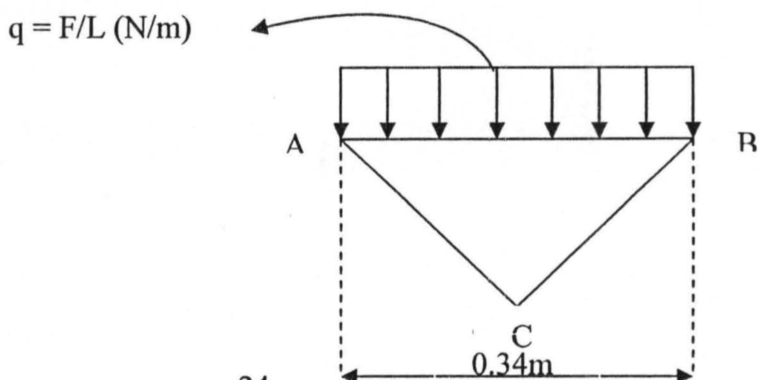


Fig.3.4 applicator frame

The load of the fertilizer is mainly carried on the equally spaced four legged truss system of the chassis.

3.9 DESIGNS FOR THE TRUSS MEMBERS

One of the active member of the truss system supporting the fertilizer is as shown in figure 3.5 (a) below. $Wf = M_{TM} = 211.40N$



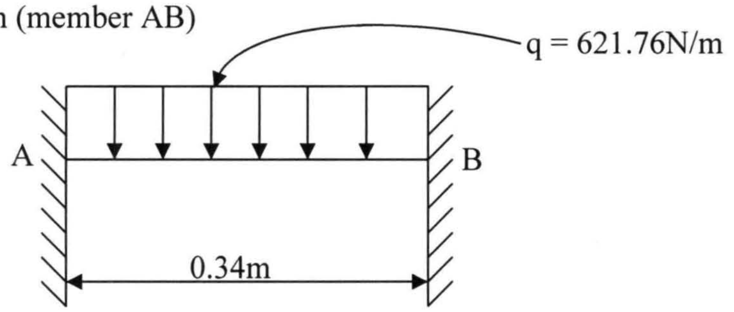


Fig 3.5 (a) frame members

Designing for beam (member AB)

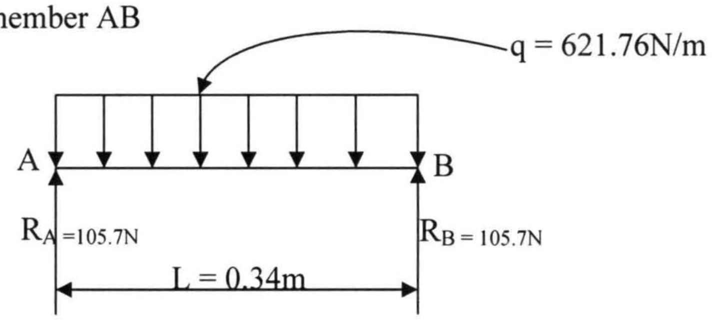


Fig. 3.5 (b) force diagram for member AB

Fig. 3.5 (c) free body diagram of member AB

$R_A = qL/2$

$R_A = 621.76 \text{ x } 0.34/2$

$R_A = 105.7\text{N}$

$R_B = R_A$ (for a simply supported beam)

$R_B = 105.7\text{N}$

Bending moment

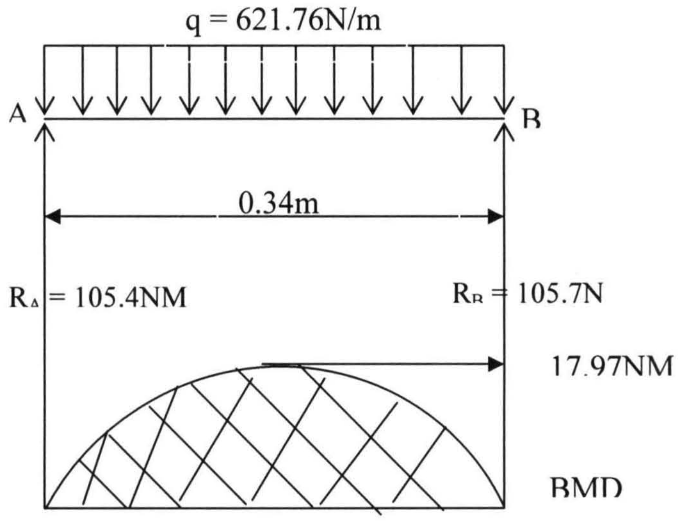


Fig. 3.6(d) bending moment diagram

Maximum bending moment (Mmax)

Mb = qL½ and is maximum at 1 = L/2

$Mmax = qL^2 /4$

$= 621.76 \times 0.34^2 / 4$

$= 621.76 \times 0.1156 / 4$

= 17.47Nm.

Maximum bending moment is 17.97 Nm.

The structural steel for the beam would fail under maximum shear stress or strain energy. Maximum shear stress theory is used which states that; allowable stress = ultimate stress (i.e. $F_{all} = F_u/2$).

In designing for stability and strength, maximum shear stress is ensured, so that the applied load lies within a safe limit and the part has sufficient strength to resist any distortion or failure. This is known as allowable stress and is kept well within the elastic limit or yield point.

$F_{all} = Fu / 2$

$= 4.1368542 \times 10^{-2} / 2$

$F_{all} = 2.068427 \times 10^{2}$ N/m^2

To get the maximum shear stress (F_{max}) factor of safety of 2.5

$F_{max} = Fu/2n = F_{all} /n$

$= 2.068429 \times 10^{8} / 2.5 = 82737080$N/m^2

To find the sectional modulus

$F_{max} = M_{max} /2 \Rightarrow Z = M_{max}/F_{max} = 17.97/82737080$

$Z = 2.17 \times 10^{-7}$ m^5

$Z = 0.217$cm^3 or 0.217mm^3

The nearest modulus of section on the design table to the calculated value is 0.5 x 10^{3}mm is chosen using table 3.1 shown below.

Designation	Size A x B mm	Thickness t, mm	Sectional area, a, mm^2	Mass/length B, kg/m	c.g Cxx =Cyy cm	Modulus Section Z Zxx = Zyy
L25, 25, 3	2.5x25	3.2	148	1.14	0.59	0.3

Moment of inertia, T (10^6, mm^4) = 0.008

Source (Higdon, 1978).

Frame column design

Any member of a structure or component which is in comparison may be called STRUCT. Strut for long slander is liable to fail by building, while the short column fails by compressive stress.

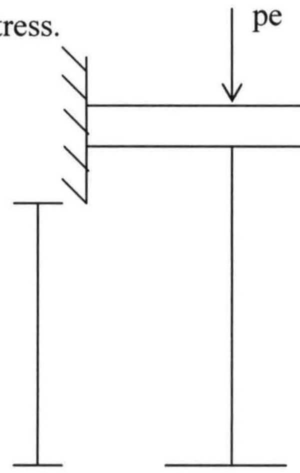


Fig. 3.7(a) direction fixed at both ends hence Pc = $C\Pi^2 \in I/L^2$ (Halls, 1982).

Here C = 4, Pe = $4EI/L^2$, where Pc = Euler cropping load

I = least moment of inertia

L = length of the struct

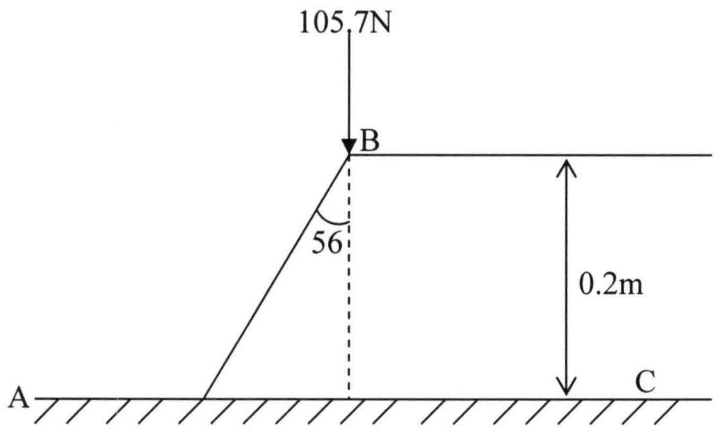


Fig. 3.7(b) chassis column

Pc = Pa cos56

Pc = 105.7 x cos56

$Pc = 59.11N$

Critical load put on strut BC

$Pcr = Pc \times n,$

Where n = factor of safety, let n = 2.5

$Pcr = 59.11 \times 2.5$

$Pcr = 147.77N$

$Pcr = C\Pi^2EI/L^2 \Rightarrow I = PcrL^2/C\Pi^2E$ or $I = PcrL^2/4\Pi^2E$

Where L = 0.2m = 200mm

E = 200,000N/mm^2 – young modulus of elasticity

$I = 147.77 \times (200)^2/4x\Pi^2x200,00$

$I = 56910800/4x3.142^2x200,000$

$I = 5910300/7897731$

$I = 7.48x10^{-1}mm^4$

$I = 0.75mm^4$

The calculated moment of inertia of the sections is very small compared to the least obtained able in the table of standard. Therefore, the least section of the L = 25, 25, 3 is also used for the column.

Computing the total length of the structural metal equal legs angle used for frame total length L_T

$L_T = (0.2 + 0.2 + 0.3) \times 4 + 0.24 \times 2 + 0.34 \times 6 + 0.15 \times 4 + 0.4 \times 2$

$L_T = 6.72m$

The total length of angle iron used is 6.7cm

Computing the weight Wc of frame.

Total weight of chassis = weight of total length of angle iron used + weight of the Drawbar

i.e. Wc = Wl + Wd

$Wl = L_T \times B \times g$

Where, L_T = total length

B = mass per unit length of the metal used

g = gravitational force

L_T = 6.72m, B = 1.19Kg/m, Wd = 15.325N and g = 9.81N/Kg

Wc = (6.72 x 1.19 x 9.81) + (15.325)

Wc = 93.78N

Wc ≈ 94N.

3.10 METERING VALVE AND DELIVERY HOSES

The material value is designed o the basis of its size and minimum metering head capable of giving maximum desired fertilizer application rate

Design parameters

Maximum forward speed of application (S) = 2m/s = 7.2Km/hr.

Maximum application rate (Ra) = 800L/ha = $0.8m^2$/ha

Metering head (h) = 500mm = 0.5cm

Tool spacing metering valve size (d_o)

From application rate (m^3/ha) = discharge (m^3/s) x 10,000/speed (m/s) x working width (m)

I.e. Ra = 10,000Q (m^3/ha)/s x b................................3.1

Where Q = discharge or flow rate across metering valve orifice of diameter do

Q = Ra x s x /10,000...3.2

$Q=0.8x2x0.55/10,000 = 0.000088m^3/s$

But $Q = A_0 x \mu_0$

Where A_o= cross section area of orifice

μ_o= Velocity of across the orifice

$$\mu_o = \sqrt{2gh} \quad 3.3$$

Where h = metering head = 0.5m

G = acceleration due to gravity

$\mu o = \sqrt{2x9.81x0.5}$

= 3.1321m/s

$Q= \pi d^2_o x \mu_o/4$

$d_o = \sqrt{(4Q/ \pi \mu_o)}$

$d_o = \sqrt{\underline{(4x8.8x19^{-5})/(\pi x3.1321)}}$

$3.5773x10^{-5}$

= 5.981x10-3m = 5.981mm

do≈6.0mm

Therefore, a valve of 6mm minimum orifice is required but to avoid blockage and clogging of the valve and hoses a metering valve of higher size (25mm)is chosen.

3.11 DELIVERY TUBE

Primary hoses are made of pre-pipe of size 25mm (diameter) determine by metering pipe size computed above.

A flexible hose of 25mm size is chosen for secondary delivery tube to ensure free flow of fertilizer and to blockages and leakages.

3.12 APPLICATION KNIVES (BLADE)

The application knives are designed to base on the physical features, which will reduce tillage during operation of the applicator (i.e to walk through the soil with minimal soil resistance and to eliminate damage to the most system? The feature include

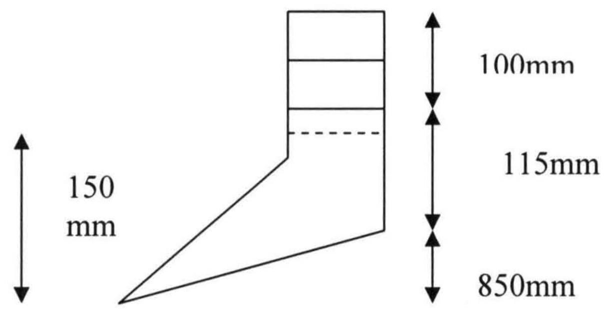


Fig 3.7

Application Blade (knife)

Force acting on the application blade due to soil resistance p_{db}. P_{db}=kxaxb

3.5

Where k =soil resistance = 10kn/m2 adopted adopted

A = maximum working depth = 15cm = 0.15m

B = maximum tool width = 4cm = 0.04m

Therefore P_{db} = 10x103x0.15x0.04 = 60N

Weight of the application knives wk from weight = volume x density x gravitational force

I.e W = v x p x g

Wk = 2(1/2 (0.1x0.04x0.004)+ (0.1 x 0.04 x 0.004)] x 7703 x 9.81

= 2 x [3/2(0.1 x 0.04 x 0.004)]x 7703 x 9.81

= 3.6272N

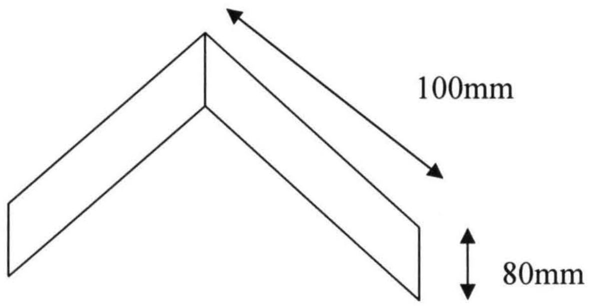
Weight of the tool holds water

Wt = 2[(0.14 x 0.04 x 0.004) x 7703 x 9.81]

Wt = 3.3854N

3.13 FURROW CLOSERS

The furrow closer are designed in form of V shape and for minimum wear soil resistance to motion and efficiency of covering



3.14 DESIGN ANALYSIS OF DRAWBAR

The drawbar is the applicator component on which applicator knives are fixed. It is subjected to the horizontal bending load resulting from soil resistance on the two knives, resistance or drag force from furrow closer is neglected

Therefore, the drawbar is aligned so that the bending load acts on its wider face, and designed for strength on the basis of those bending loads

DESIGN ASSUMPTIONS

Forward speed s = 2.0m/s = 7.2km/hr adopted soil resistance k = 10 km/m2 from literature knives (tool) spacing Sk = 55cm

Working depth, a = 15cm = 0.15m

Maximum knives width, b = 4cm = 0.04m

Knives thickness t = 0.4c (4mm) = 0.004m

Drawbar pulls (draft) p_{bd}

F_{db} = k x a x b x c--3.7

Where I = number of tools or knives (other variables are as defined above

i = 2

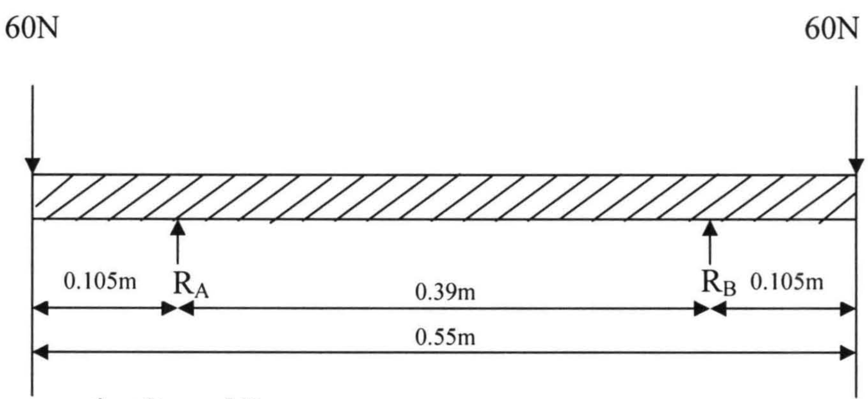
p_{bd} = 10 x 0.15 x 0.04 x 2

= 0.060 x 2

p_{bd} = 0.12 x N = 120N

Drawbar cross section

The force diagram of the loaded drawbar is as shown with the effective length of drawbar as 0.55m



Determining reaction R_A and R_B

$\sum fy = 0$, $R_A + R_B = 120$ ---3.8

$R_A = R_B$, since the system is loaded symmetrically

$2 R_A = 120 \Rightarrow R_A = 120/2 = R_A = 60N$

$R_A = R_B$ (simple loaded beam)

$R_B = 60N$

Determining bending moment M_b

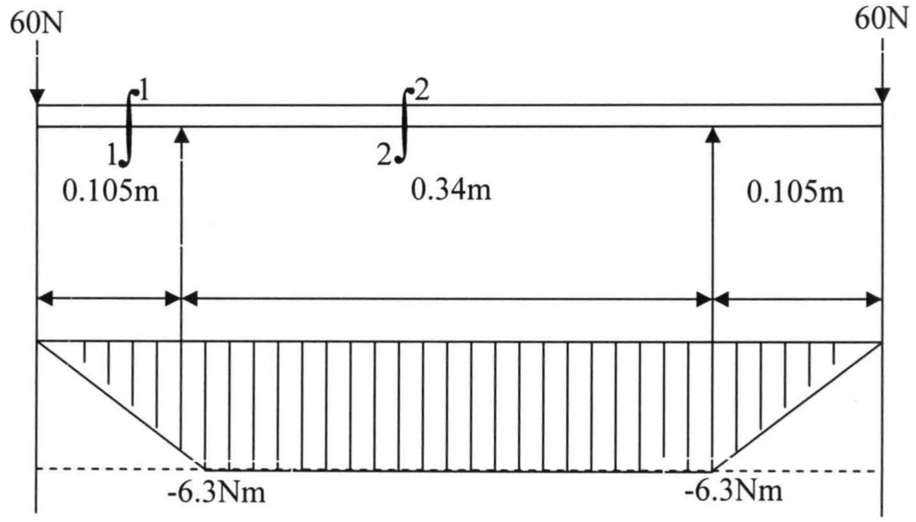
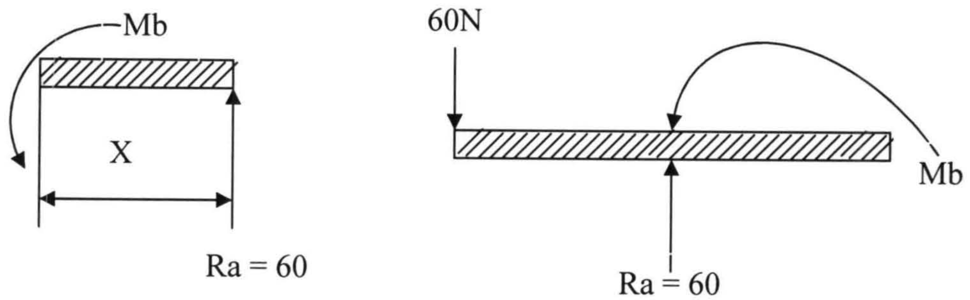


Fig. 3.9 bending moment diagram for the draw bar



At section 1 – 1

$0 = x < 0.105$

$R_A X + M_b = 0$

at section 2 - 2

$0.105 \leq x \leq 0.348$

$60\,(0.105+X) - R_A X + M_b$

$\Rightarrow M_b = -60.X$ $\quad\quad$ $\Rightarrow 60 \times 0.105 + 60X - 60X + M_b = 0$

When $X = 0 \Rightarrow M_b = 0$. $\quad\quad$ $\Rightarrow M_b = -60 \times 0.0105$

When = 0.105 $\quad\quad$ $M_b = -6.30Nm$

$M_b = -60 \times 0.105$ $\quad\quad$ i.e. when $X = 0.105$, $M_b = -6.3Nm$

$M_b = -6.30Nm$ $\quad\quad$ when $X = 0.445$, $M_b = -6.3Nm$

Maximum bending moment M_b

$M_b = \sqrt{(-6.30)2}$

$M_b = 6.30Nm.$

Bending stress analysis

It was assumed that the draw bars will fail under maximum shear theory or strain energy theory maximum shear stress theory is used which state that, failure will occur when the valve of the maximum shear stress is simple tension at the elastic limit.

In designing for stability and strength minimum shear stress is ensured so the applied load lies within a set limit and the part has sufficient strength to resist any distortion as failure. This is known as allowable stress to safeguard against any permanent set or plastic deformation, the allowable stress is kept well within the elastic limit or yield point.

I.e. fail = Fu/2

fall = 4.1368542x103/3

$= 2.068427 \times 10^8 N/m^2$

To get maximum shear stress (F_{max}) factor of safety n of 2.5 is used.

F_{max} = ultimate stress/2n

$F_{max} = fail/2n = 2.068427 \times 10^3/2.5$

$= 82737084N/m^2$

$= 82.737MN/m^2$

Sectional modulus, Z.

$Z = M_b/F_{max}$

$Z = 6.30/82.7373x10^3$

$= 7.145x10^{-8}m^3$

$= 7.6145x10^{-2}cm^3$ or $76.145mm^3$

Draw bar cross section (b x d).

Assume section 5 x 40mm (0.5 x 40cm)

$Z = bd^2/6$ – section modulus for a rectangular section

Where b = 5mm, d = 40mm

$Z = 5 \times (40)^2/6$

$= 1333.333mm^3$

$\approx 1.333x10^{-6}m^3$

Maximum shear stress, F_{max}

$F_{max} = M_b/Z$

$= 6.30/1.333x10^{-6}$

$= 4726181.545N/m^2$

$F_{max} = 0.04726181x10^8N/m^2$

$F_{max} = 0.04726181x10^8N/m <$ fail

The design is safe since the maximum stress is less than the allowable stress. Therefore, the standard steel bar of section 5x40mm is chosen.

Weight of the drawbar W

Weight of drawbar = length x cross sectional area x density x gravitational force.

i.e. $W = L \times b \times d \times \rho_s \times g$

Where $L = 0.55m$, $b = 5 \times 10^{-3}m$, $d = 40 \times 10^{-3}m$, $\rho_s = 7709Kg/m^3$, $g = 9.81N/Kg$

$W = 0.55\ (5 \times 10^{-3} \times 40 \times 10^{-3}) \times 7703 \times 9.81$

$W = 8.3123N$

$W = 8.31N$.

Weight of drawbar assembly including applicator knives and tools holders $W_{ab} = W + W_K + W_t$

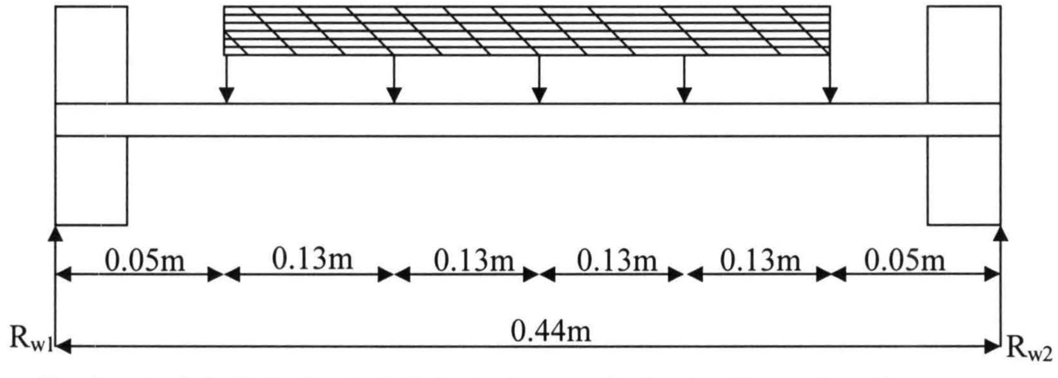
Where W_K and W_t are weight of knives and tool holders respectively

$W_{db} = 8.312343.6272 + 3.3854$

$= 15.3249N$

3.15 DESIGN ANALYSIS OF SHAFT

The shaft is subjected to only bending load exerted by the weight of the implement, the maximum bending occurs when the



Application tank is fully loaded. It is design on the basis of pure bending.

Fig. 3.10 the shaft under pure bending

W_T = total weight of the loaded applicator

$W_T = W_f + W_c$

Where W_f = weight of fertilizer content = 211.40N

Wc = total weight of frame = 94.0N

$W_T = 211.40 + 94.0$

$= 305.4N$

Determining the reaction R_{W1} and R_{W2} by wheels, since wheels are symmetrically loaded

$R_{W1} = R_{W2}$

$\sum fy = 0$

i.e. $R_{W1} + R_{W2} - W_T = 0$

$2R_{W1} = W_T$

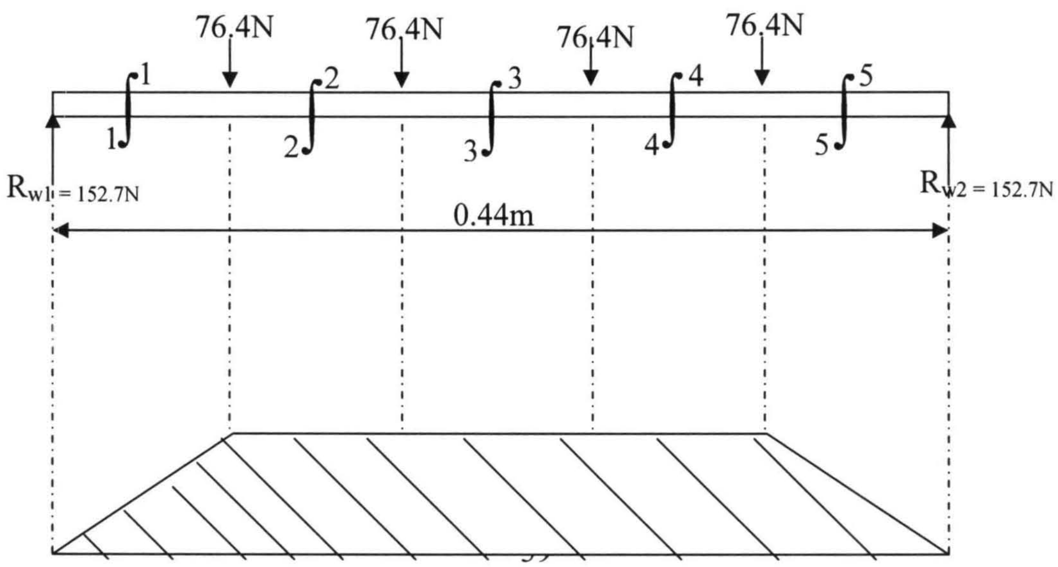
$R_{W1} = W_T/2$

$R_{W1} = 305.4/2$

$R_{W1} = 152.7N$

$R_{W1} = R_{W2} = 152.7N$ (for simple loaded beam)

Determining the maximum bending moment (M_b) of the shaft



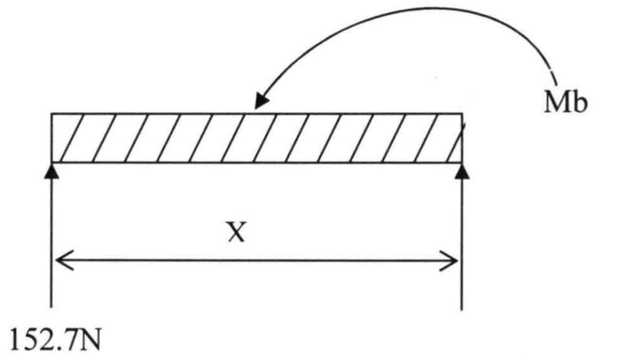
B, C, D and E are being positions of bearings

Fig. 3.11 bending moment diagram for the shaft

Assuming the shaft housed or supported by bearing reactions R_{W1} and R_{W2} on the wheels

Taking section 1 – 1

$0 \leq X \leq 0.05$



$M_b - 152.7 \times X = 0$

$M_b = 152.7X$

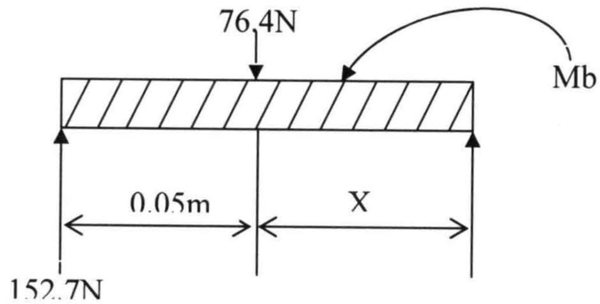
When $X = 0$, $M_b = 0$

When $X = 0.05$

$M_b = 152.7 \times 0.05$

$M_b = 7.635$Nm.

Taking section 2 – 2; $0.04 \leq X \leq 0.163$



$M_b - 152.7X + 76.4\,(X - 0.05) = 0$

$M_b = 152.7X - 76.4X + 76.4 \times 0.05$

$M_b = 152.7X - 76.4X + 3.82$

When $X = 0.05$

$M_b = 152.7 \times 0.05 - 76.4 \times 0.05 + 3.82$

$M_b = 7.635 - 3.82 + 3.82$

$M_b = 7.635$Nm.

When X = 0.163

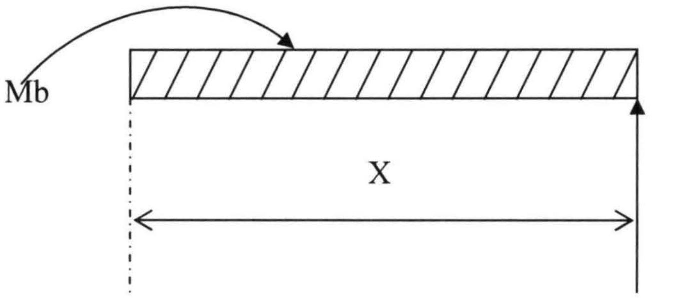
$M_b = 152.7 \times 0.163 - 76.4 \times 0.163 + 3.82$

$M_b = 24.89 - 12.45 + 3.82$

$M_b = 16.26$Nm.

Taking section 3 – 3

$0 \leq X \leq 0.05$



$M_b - 152.7X = 0$

$M_b = 152.7X$

When X = 0, $M_b = 0$.

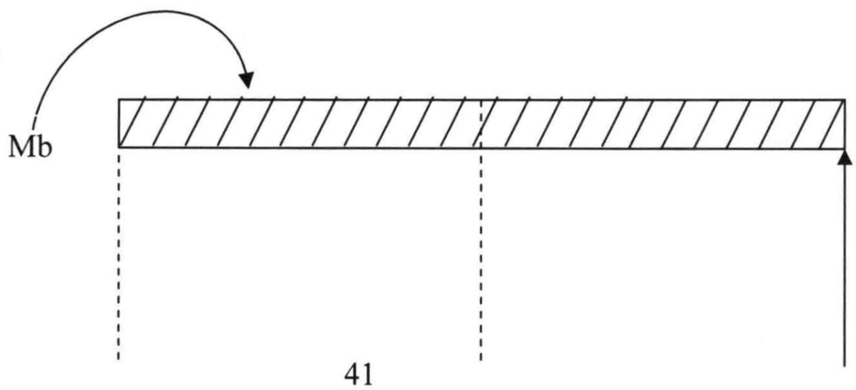
When X = 0.05

$M_b = 152.7 \times 0.05$

$M_b = 7.633$Nm.

Taking section 4 – 4

$0.05 \leq X \leq 0.163$



$\longleftarrow$ X $\longrightarrow\longleftarrow$ 0.05m $\longrightarrow$

$M_b + 76.4\,(X - 0.05) - 152.7X = 0$

$M_b = 152.7X - 76.4\,(X - 0.05)$

$M_b = 152.7X - 76.4X + 3.82$

When $X = 0.05$

$M_b = 152.7 \times 0.05 - 76.4 \times 0.05 + 3.82$

$M_b = 7.635 - 3.82 + 3.82$

$M_b = 7.635$Nm.

When $X = 0.163$

$M_b = 152.7 \times 0.163 - 76.4 \times 0.163 + 3.82$

$M_b = 24.89 - 12.45 + 3.82$

$M_b = 16.26$Nm.

Maximum bending moment

$M_b = \sqrt{16.26}$

$M_b = 4.032$Nm.

Determining the shaft diameter, d

For the solid shaft subjected to pure bending with little or core axial loading.

$d^3 = 16\,(K_b \times M_b)/\pi \times Ss$ (Halls, 1982)

Where d = shaft diameter

Ss allowable shear stress

= $40N/m^2$ for shaft with key ways

K_b = combine shock and fatigue factor applied to bending

Let $K_b = 1.5$

$d^3 = 16\ (1.5 \times 4.032)/(\pi \times 40 \times 10^6)$

$d^3 = 16(6.048)/3.142x40x10^6$

$d^3 = 96.77/125680000$

$d^3 = 7.6997x10^{-7}$

$d = \sqrt[3]{7.6997x10^{-7}}$

$d = 1.97465x10^{-3}m$

d = 19.7mm.

Therefore, the calculated shaft diameter is 19.7mm for the purpose of this design we use 25mm diameter shaft.

Determining the weight of the shaft, Ws

Ws = volume of the shaft x density of steel x gravity

I.e. $Ws = \pi d^2 L \times \rho_s \times g/4$

$Ws = \pi(25x10^{-3})^2 \times 7703 \times 9.81/4$

Ws = 37.09358N

$Ws \approx 37.10N$

3.16 SELECTIONS OF WHEELS

The selection of wheels was based on their sizes types and load bearing capacity (ply rating) as well as their inflation pressure which are capable of supporting the weight of the loaded applicator.

3.16.1 Determining the weight of the solid fertilizer applicator when fully loaded

$W = W_f + Wc + Ws$

Where W_f = weight of fertilizer (full load) = 211.40N

Wc = weight of the frame = 94.0N

Ws = weight of the shaft = 37.10N

W = 342.5N

In order to facilitate the road and on farm transportation of the applicator and to avoid separate conveyance of applicator and fertilizer to the fields, a rubber tyre wheel with designation: "30x20", and load bearing capacity 250Kg was chosen.

Determining the External Diameter of the Wheel

dw = (3.0+20)x25

dw = 23.0x25

dw = 575mm (this gives the diameter of the wheel)

3.17 BEARING SELECTION

According to Resheton (1978), ball and Rotter bearing comprise a group of machine components which have been most extensively standardized on an international scale and are manufactured in a central mass production plant.

Therefore, in the design of nay machine, calculations are made to enable the designer select the bearings which are appropriate for his design. Anti-friction bearings are often subjected to combine action of radial and axial loads which may be constant or occasional by stocks and impacts, either the inner or outer wing may rotate; the temperature may be normal, below the normal or elevated. All these factors affects the performance of bearing and should be taken into account in the selection of bearing.

The basic dynamic load rating C for rolling contact bearing is given by the fundamental equation:

$C = W [L/10^6]^{1/K}$ (Khurmi and Gupta, 2004)

Where C = basic dynamic load rating (N)

L= rating life in revolutions

W = equivalents dynamic load (N)

K = 3 for all bearings (10/3 for roller bearings)

The relationship between the in revolutions (L) and the life in working hours (L_H) is given by the equation:

$L = 60.N.L_H$ revolutions

Where N = speed in r.p.m

Therefore, the rating life in working hours for bearing used in agriculture machine are between 4000 to 8000 hrs (Khurmi and Gupta, 2004)

We chose 8000hrs, the revolution of bearing in r.p.m. is given by the revolution of shaft which is turn given by the revolution of wheel N (r.p.m.)

$N = 60 \times S/d$.

Where S = tangential velocity or forward speed (m/s)

d = diameter of the wheel (m)

N = speed in (rpm).

Where, = 2m/s, d = 0.575m

$N = 60 \times 2/0.575$

$N = 208.70$ rpm

Also, $L = 60NL_H$

$L_H = 8000$hrs – chosen

$L = 60 \times 208.70 \times 8000$

$L = 100.176 \times 10^6$ revolutions

Selecting identical bearings C, D, E and F

Shaft diameter = 25mm

Required bearing bore = 25mm

3.18 Dynamic Radial Load, W_R

$W_R = 234.45N$

Design dynamic radial load, W

$W = W_R \alpha_S$

Where α_S = service factors (1.5 for light shock loads)

$W = 234.45 \times 1.5$

$W = 351.3675N$

$W \approx 351.68N$

3.19 Basic dynamic load rating C

$C = [W/10^6]^{1/K}$

$C = 351.68\ [100.176x10^6/10^6]^{1/3}$

$C = 351.68\ [100.176]^{1/3}$

$C = 1633.30N$

C = 1.633KNFrom the table single row angular contact ball bearing number 205, having

C = 11.6KN is selected.

s3.20 CHAIN SELECTION.

When designing chain drives the follow parameters have to be considered: (1) the horse power to be transported.

(2) The speed of the drive members

(3) The diameter 0f the drive shaft

(4) The diameter of the sprockets

(5) The loading characteristics

(6) Lubrication (to be intermediate, periodic or continuous)

The horse power to be transported multiply by the service factor equals to designed horse powers

3.21 DETERMINATION OF APPLICATOR TOTAL DRAFT FORCE

The force acting on the applicator area function of the weight distribution, geometry of the frame, capacity of the hopper, type of wheel and the means of securing traction. The main force acting is illustrated on the figure 3.12 below.

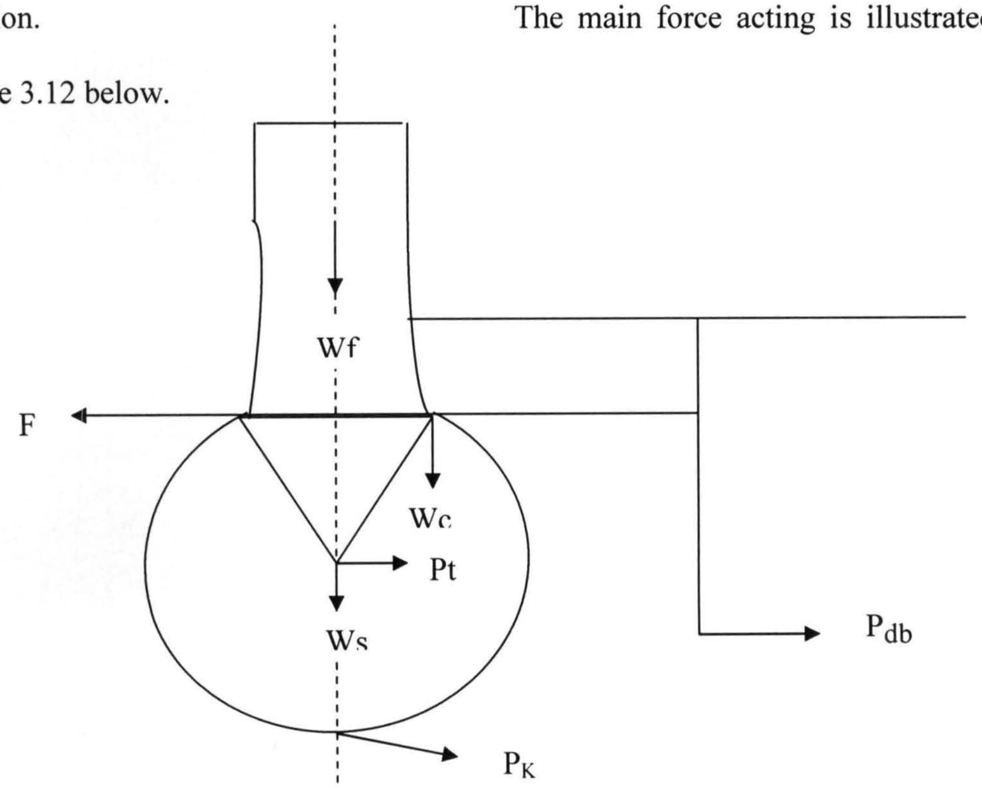


Fig. 3.12 forces acting on the fertilizer applicator.

Ws = weight of the shaft = 37.10N

F = Tractive effort

W_f = weight of fertilizer at full load = 211.40N

Wc = weight of frame = 94.0N

$_{ab}$ = drawbar pull or draft = 120N

= total draft

= friction resistance in bearing = 0

= rolling resistance

lement's total draft, P_u (total resistance in operation) is given by $P_u = P_k + P_t + P_{ab}$

$[W_f + W_s + W_c] \times f$

oil friction coefficient

2 – 0.22 for rolling friction

se f = 0.22

[211.40+37.10+94.0] x 0.22

[342.5] x 0.22

75.35N

for rolling (friction less) bearings

75.35 + 120

195.35N

refore, the implement total draft = 195.35N

3.22 DETERMINATION OF POWER REQUIRED TO OPERATE THE MACHINE

Force required for the applicator to work effectively, the tractive force (force applied) must be greater than or equal to the implement total draft.

I.e. $F \geq P_u$

$P_u = 195.35N$

$F = 195.4N$

Power required, P

Fromm $P = F \times S$

Where F = force (N), S = speed (m/s) = 2.0m/s

$P = 195.35 \times 2$

$= 390.7W$ or .03907KW

$\approx 0.5237hp$

3.23 TYRE SIZE

In addition to the selection of tyres according to the type of thread or ribs, tyres are selected according to size. Tyre sizes designated by cross sectional diameter and the diameter of the rims (smith and Wilkes, 1980).

A tyre size designated as 13.6 – 38 means that the tyre cross sectional diameter is 36.6cm and rim diameter of 38cm. in an afford to aid manufacturers and users of machine, standards have been established by the ASAE for the purpose of providing selection tables of tyres for applications to machines. The major factor considered in the choice of tyres is the weight to be carried by the machine or implement.

3.24 COST ANALYSIS AND MATERIAL SPECIFICATION

the cost elements of the production of this machine are: (a) Material cost (b) Labour cost.

S/NO	MATERIAL	QUALITY	UNIT COST (#)	TOTAL COST (#)
1	ANGLE IRON	1	1000	1000
2	SQUARE PIPE	2	125	500
3	WHEEL ASSEMBLY	2	250	500
4	ROUND PIPE	1	200	200
5	BEARINGS (NO.6205)	4	200	800
6	CONTROL VAVLE	1	150	150
7	12.5mm HOSES	1	100	100
8	25mm SHAFT	4	250	1000
9	STEEL PLATE(5mm thick)	1	3500	3500
10	WEIDING ELECTRODE	100	10	1000
11	CHAIN AND SPROCKET	4	250	1000
12	RIM,TYRE AND TUBE	4	250	1000

13	FLAT BAR	1	250	250
	TOTAL			10,750

3.22.1 The material cost. Is the cost of purchasing the material for the construction of the machine and these materials were source locally?

3.25 LABOUR COST

This is the cost of the labour put in the production of the machine

(B) LABOUR COST

S/NO	WORK	COSTS (#)
1	CUTTING OF METAL PLATE	1500
2	WELDING	2000
3	MACHINE WORK	1000
4	ASSEMBLY WORK	1000
5	PLUMBING WORK	500
	TOTAL	6000

The total of fabricating the machine is the sum of the material cost +Labour cost = #10,750 +# 6000 = # 16,750

CHAPTER FOUR

4.0 PERFORMANCE EVALUATION

4.1 TESTING THE MACHINE

The solid fertilizer applicator was tested after all the components were perfectly put together. Two tests were conducted on the machine, namely mechanical performance, field performance.

4.1.1 MECHANICAL PERFORMANCE TEST

This test was conducted to determine the working of the components. The machine was put to work on the field by the help of the operator. The observation made was that the furrow closer were not closing the soil approximately this was corrected by adjusting the stem of the furrow closer and after the correction, all the parts of the machine were moving freely. It was therefore found to be mechanically alright for field testing.

4.1.2 FIELD PERFORMANCE TEST

ASAE standard 341.2 which is the procedure for measuring uniformity and calibration of granular or solid fertilizer applicator was adopted for the field test of this machine. The purpose of this standard is to establish a uniform method of determining and reporting performance data on fertilizer applicator designed to apply granular material to the soil. Test performance according to this standard makes it possible to predict field performance of the fertilizer applicator and to compare the fertilizer applicator distribution pattern.

4.2 CALIBRATION PROCEDURE

4.2.1 THE MATERIAL

The material t be used for the test is a solid or granular fertilizer with a bulk density of

and moisture content of about 40%.

4.2.2 THE FIELD

A field representing a field condition for normal use was selected for the test. A distance of about 100meters was marked and demarcated as the test distance to be covered (ASAES 341.2)

4.2.3 THE TEST

The test consists of these parts; determine the rate of application, to determine the field capacity, efficiency of the fertilizer applicator.

4.2.4 CALIBRATION PROCEDURES

i. the hopper was loaded with about 35kg of solid fertilizer.

ii. A container was set under each fertilizer outlet

iii. A controller metering valve is opened

iv. While the fertilizer applicator is running along the 100meters marked, one container is empted and put back for a period of 30seconds.

V. the valve is closed and the volume of fertilizer were collected over 30 seconds was measured.

vi. The procedure was repeated for various metering valve settings at different time intervals.

vii. Application rate, Ra on each metering valve setting was determined.

4.2.6 RESULT OF CALIBRATION

The result of calibration is shown in table 4.1 solid fertilizer test application rate at various metering valve settings considering forward speed of 2m/s and working width of 0.55m.

Meeting Valve Position	Time Taken (seconds)	Volume V1 collected	Distance (m)	Quality (kg)	Discharge Q= cv/t (m^3/sec)	Application Rate, Ra M^3/ha	Average
1	15 30 60	3.707x10^{-3} 2.727x10^{-3} 8.639x10^{-3-}	100 100 100	35 35 35	2.47x10^{-4} 9.09x10^{-4} 1.440x10^{-4}	2.246 8.264 1.309	0.15
2	15 30 60	2.62xx10^{-3} 2.943x10^{-3} 6.032x10^{-3}	100 100 100	35 35 53	1.508x10^{-4} 9.81x10^{-4} 1.005x10^{-4}	1.371 8.918 9.136x10^{-1}	0.664
3	15 30 60	3.422x10^{-3} 4.530x10^{-3} 5.117x10^{-3}	100 100 100	35 35 35	2.28x10^{-4} 1.510x10^{-4} 8.528x10^{-4}	2.074 1.373 7.753	0.177

(a) Rate of application or application rate (Ra) can be calculated from the formula.

$$\text{Application rate (Ra)} = \frac{10{,}000 \text{ x discharge } (m^2/ha)}{\text{Speed (m/s) x working width (m)}}$$

$$\text{I.e. Ra} = \frac{10{,}000\, Q(m^3 ha)}{s \text{ x } b}$$

Where, Q is known as discharge (m^3/ha)

S = known as speed (m/s) and b to be working width (m)

S = 2m/s and b = 0.55m/s

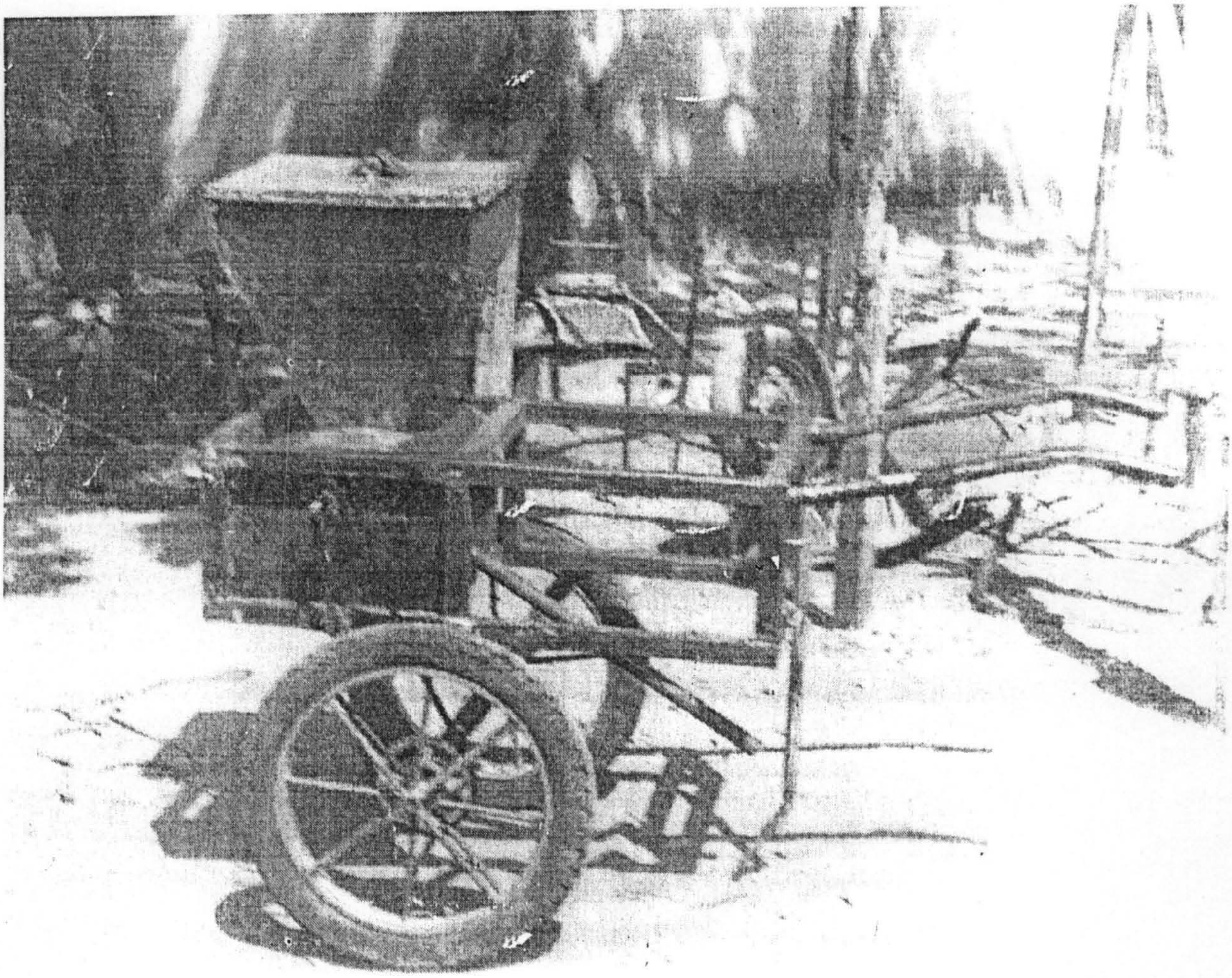


PLATE 1.0 SIDE VIEW OF A SOLID FERTILIZER APPLICATOR MACHINE

The plate 1.0 above was taken during the assembling of various components of the fertilizer applicator. The components that were assembled are: the hopper, the metering device, the delivery tube, the frame or chassis, the furrow opener and furrow closer, the two wheel tyres, and lastly, the handle. However, all these components depend on each other for an effective application of fertilizer during farm operations.

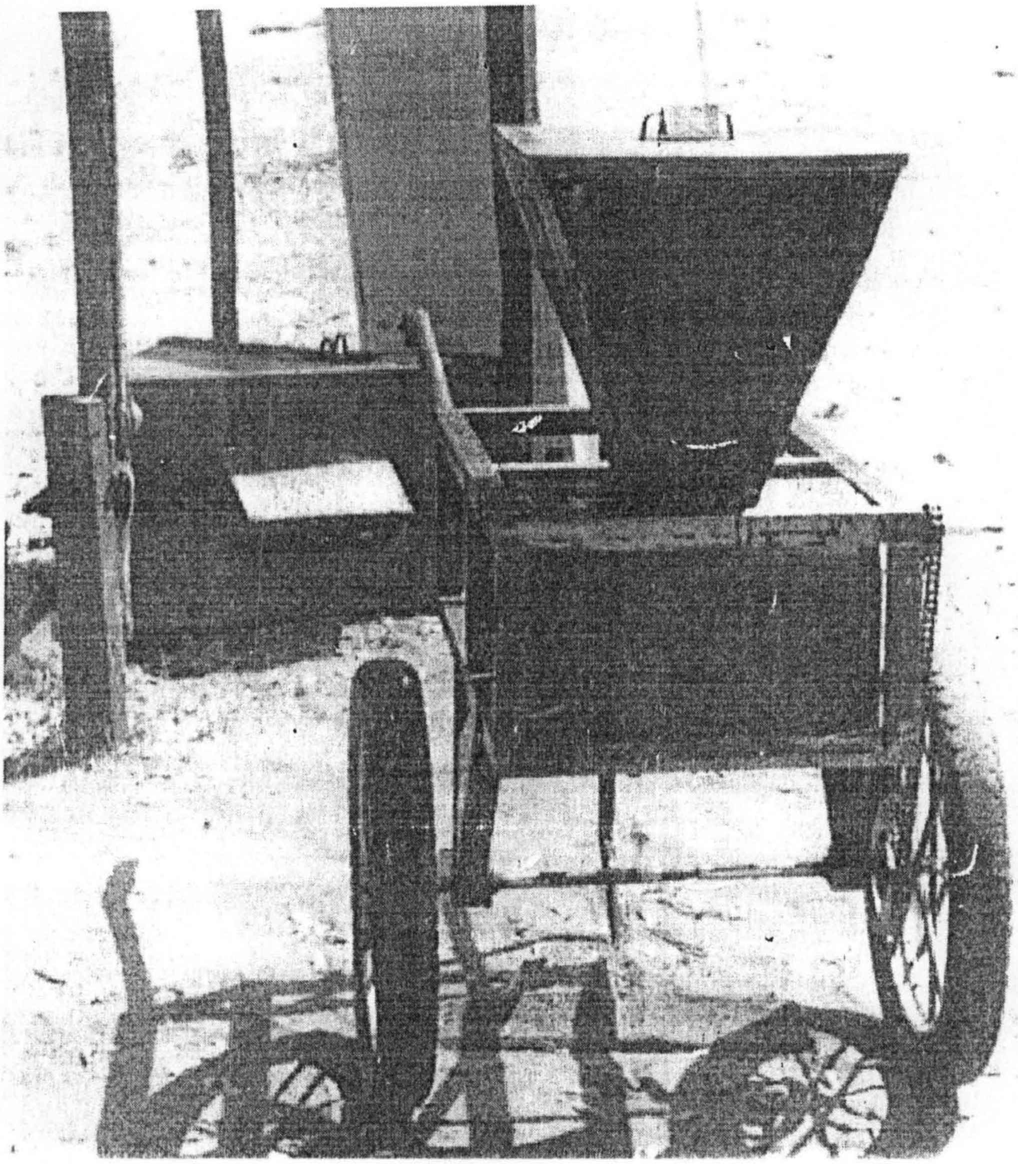


PLATE 2.0 FRONT VIEW OF A SOLID FERTILIZER APPLICATOR MACHINE

The plate 2.0 above was also taken during the assembling of various components of the fertilizer applicator. The components that were assembled are: the hopper, the metering device, the delivery tube, the frame or chassis, the furrow opener and furrow closer, the two wheel tyres, and the handle. In summary, all these components depend directly on each other for an efficient application of fertilizer during farm operations.

4.3 TEST APPLICATION

Test application was carried out based on the calibration of the fertilizer applicator. The metering valve was set to precision at position 2 which gives close to maximum design application rate. The applicator was run on the field over a distance of about 100m to observe the discharge pattern and evenly discharge from the fertilizer outlet (furrow openers).

4.3.1 TEST APPLICATION RESULT

Time taken to fill the tank = 66sec.

Test time = 68sec.

Effective working width = 0.55m

Intended application speed = 2m/s

Test delivering of the outlet = $1.759 \times 10^{-4} m^3/s$

Field delivery per hour = $1.759 \times 10^{-4} \times 60 \times 60$

$= 0.63324 m^3/hr$

Rate of application Ra $= \dfrac{10{,}000 \times 1.759 \times 10^{-4}}{2 \times 0.55}$

$= 1.599\ m^3/hr.$

4.4 DETERMINATION OF CONSISTENCY OF APPLICATION

The determination of consistency of the applicator carrier out on the basis of how consistent is the applicator rate at a fixed metering valve position over a period of time. The table 4.2 below shows the result or outcome of the consistency test on the fertilizer applicator.

Metering Valve position	Time (second)	Volume(v) Collected(m^3)	Discharge Q ($V/T1(M^3/S)$)	Consistency Index, I_C
1	15	$4.898x10^{-3}$	$2.932x10^{-4}$	
	15	$4.273x10^{-3}$	$2.849x10^{-4}$	
	30	$4.995x10^{-3}$	$1.665x10^{-4}$	0.54
	30	$4.712x10^{-3}$	$1.571x10^{-4}$	
2	15	$8.168x10^{-3}$	$5.445x10^{-5}$	
	15	$9.111x10^{-3}$	$6.074x10^{-5}$	
	60	$1.885x10^{-3}$	$6.283x10^{-5}$	0.87
	60	$1.854x10^{-3}$	$6.180x10^{-5}$	
3	30	$1.885x10^{-3}$	$6.283x10^{-5}$	
	30	$1.916x10^{-3}$	$6.387x10^{-5}$	
	60	$3.456x10^{-3}$	$5.760x10^{-5}$	0.89
	60	$3.864x10^{-3}$	$6.440x10^{-5}$	

The mean consistency of application $= \frac{0.89 + 0.87 + 0.54}{3}$

$$= \frac{2.30}{3} = 0.7667$$

$$\approx 0.767 \text{ or } 76.7\%$$

4.5 FIELD CAPACITY OF THE MACHINE

The field capacity of a machine is the rate at which it can cover a field while performing its intended function or useful work. Usually expressed in ha/hr. it is calculated using the formula.

C = S x W .... (Hunt, 2005)

Where c = field capacity (ha/hr), s = speed of machine (km/hr) and w = width of work (m), distance covered = 100m, time taken = 66.00 seconds

$$\text{Speed} = \frac{\text{distance}}{\text{Time}} = \frac{100}{66.0} = 5.455\text{km/hr}$$

$$\text{W1 of work} = 0.55\text{m} = \frac{100}{66.06} = 1.513\text{m/s}$$

$= 5.450 km/hr.$

$C = s \times w$

$= 5.450 \times 0.55 = 2.9975 \text{ (km/hr x m/1)}$

$= \frac{2.9975m^2}{hr} \times \frac{1}{10} = 0.2998 ha/hr.$

$C = 0.2998 ha/hr$

4.6 CONSISTENCY OF APPLICATION

One of the most important features of the applicator is its consistency of application which determines how well the equipment keep to a fixed application rate or discharge over a particular metering valve setting.

Consistency index is the ratio comparing the minimum discharge or application to the maximum discharge or application rate observed on a fixed metering position over considerable time interval

$$\text{I.e. } Ic = \frac{Qmin}{Qmax}$$

The consistency of application was determined by taking the mean of consistency indices across all the metering valve positions. The mean consistency of application of the fertilizer applicator was found to be 76.7%

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The objective and attempt to design and fabricated a solid fertilizer applicator locally has been achieved in this project. The applicator indeed yielded an appreciable result, which leads to the construction of relatively cheaper, effective and durable sub soil solid fertilizer applicator.

Therefore, the applicator requires a power of about 0.669kW (0.897hp) which is less than a horse power. Hence the consistency test that 100g carried out on the machine indicates a consistency of application of about 76.7%, the result of field capacity of 0.2998ha/hr and rate of application of 1.599m^3/ha. The prevailing season did not affect the field test; however, further work is required to improve upon the results obtained above.

5.2 RECOMMENDATION

It has been stated earlier that further work is required to improve the performance of the machine. From the result obtained, the following observations were made and recommendations suggested.

1. Manual agitator or a belt drive operation should be employed; it will help in improving the flow of material.
2. Since the fertilizer applicator will be used in a large area of land, I recommend that multiple delivery outlets should be attached to the fertilizer applicator in order to ensure time saving factor.

However, in view of the above mentioned problems it could be highly recommended that more effort be put in place to modify the fertilizer applicator and to incorporate adequate metering and control arrangements.

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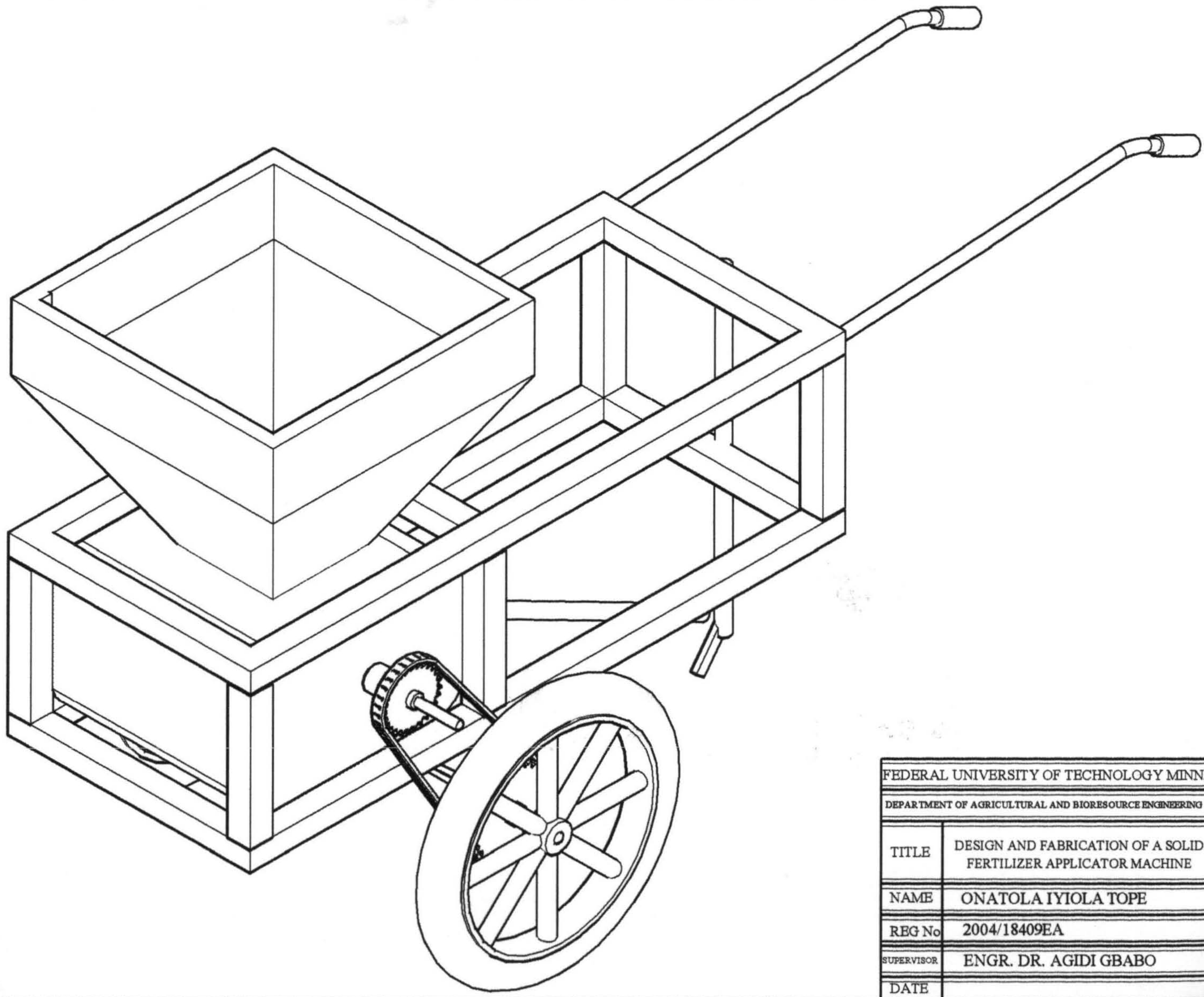

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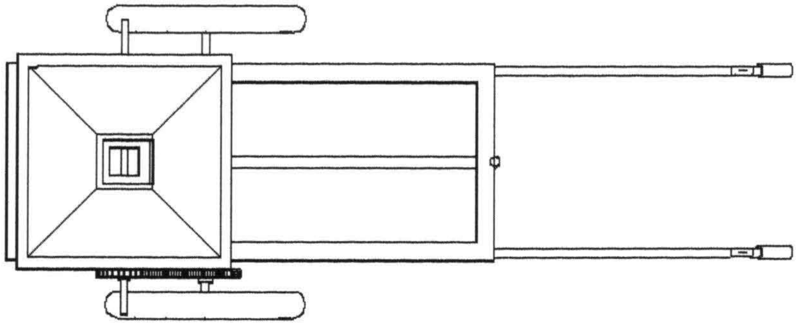
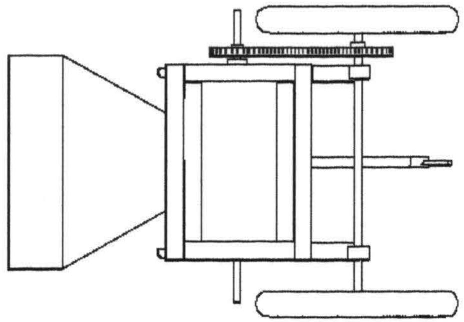
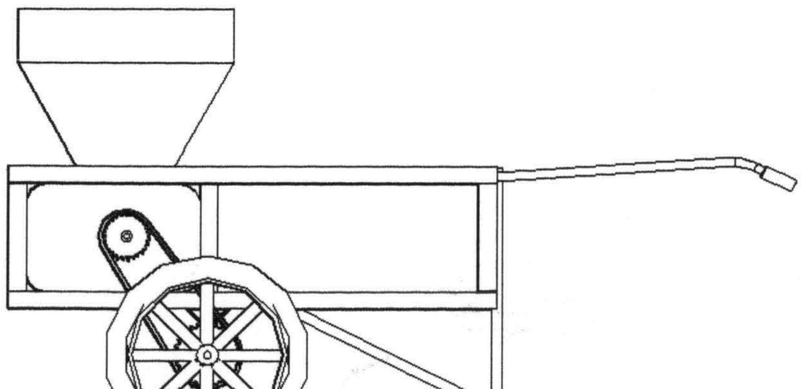
TITLE	DESIGN AND FABRICATION OF A SOLID FERTILIZER APPLICATOR MACHINE
NAME	ONATOLA IYIOLA TOPE
REG No	2004/18409EA
SUPERVISOR	ENGR. DR. AGIDI GBABO
DATE	







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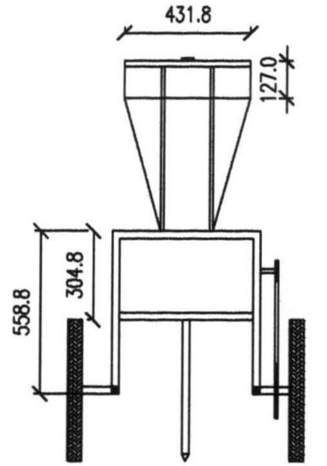
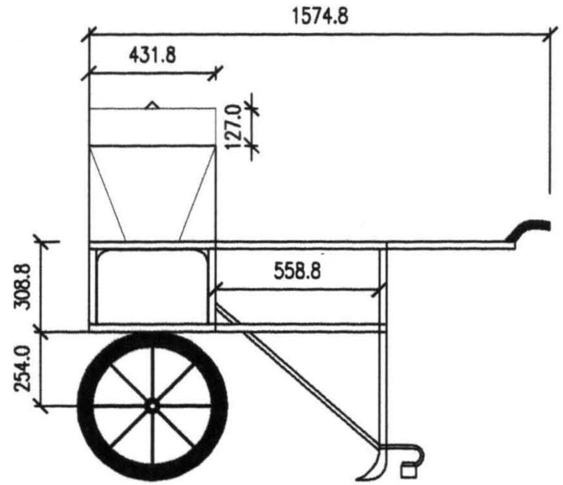
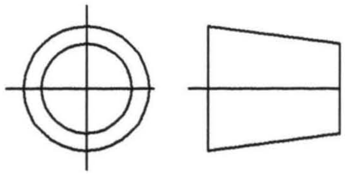
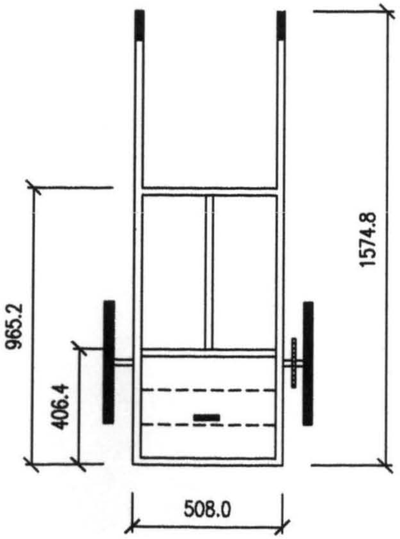


FRONT VIEW



SIDE VIEW





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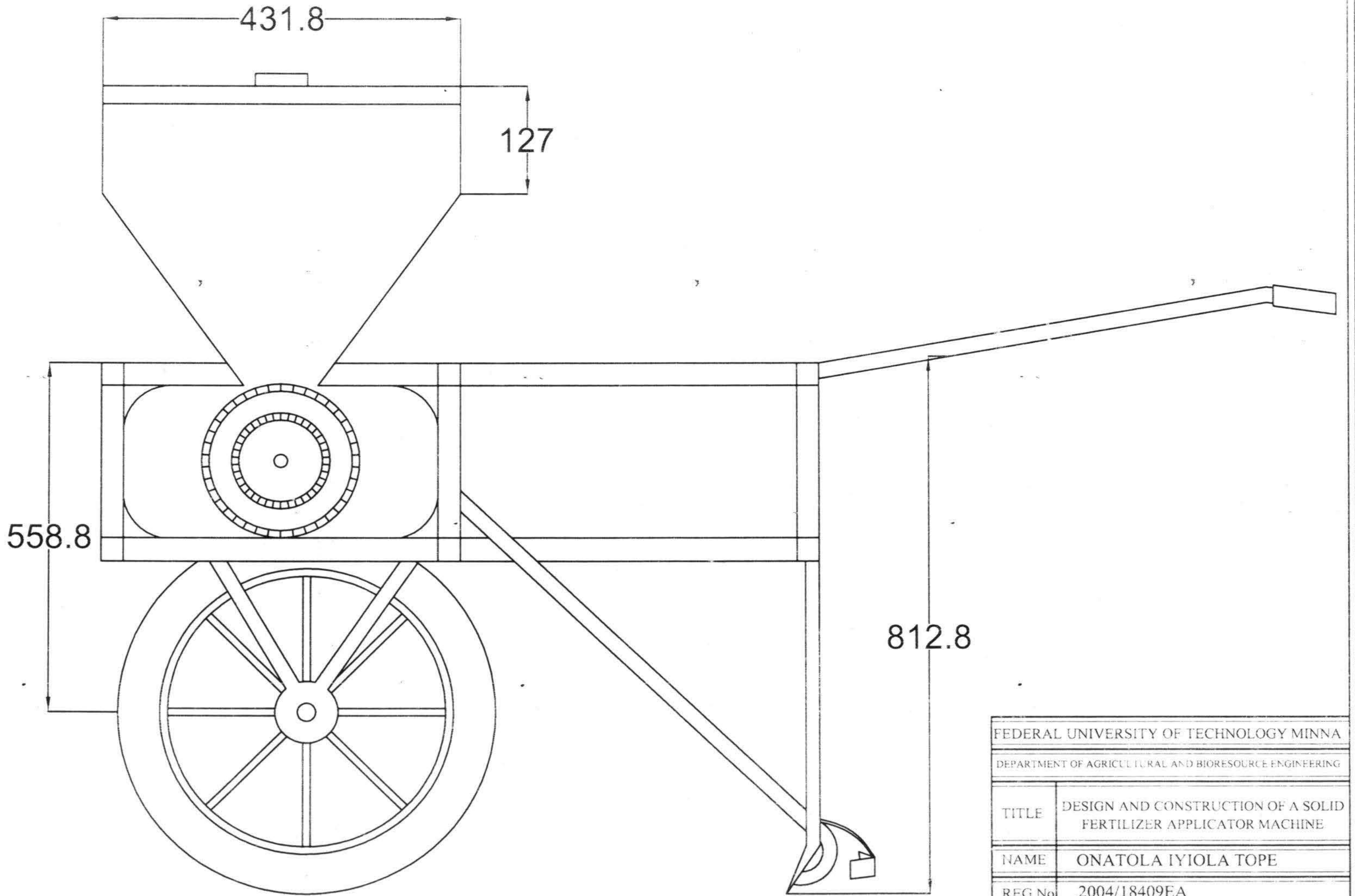
ORTHOGRAPHIC DRAWING OF SOLID FERTILIZER APPLICATOR

	NAME	SIGN	DATE
DRAWN BY	ONATOLA .I. TOPE		
CHECKED BY	DR. .G. AGIDI		
APPROVED BY	DR. .G. AGIDI		



SIDE ORTHOGRAPHIC VIEW OF THE FERTILIZER APPLICATOR

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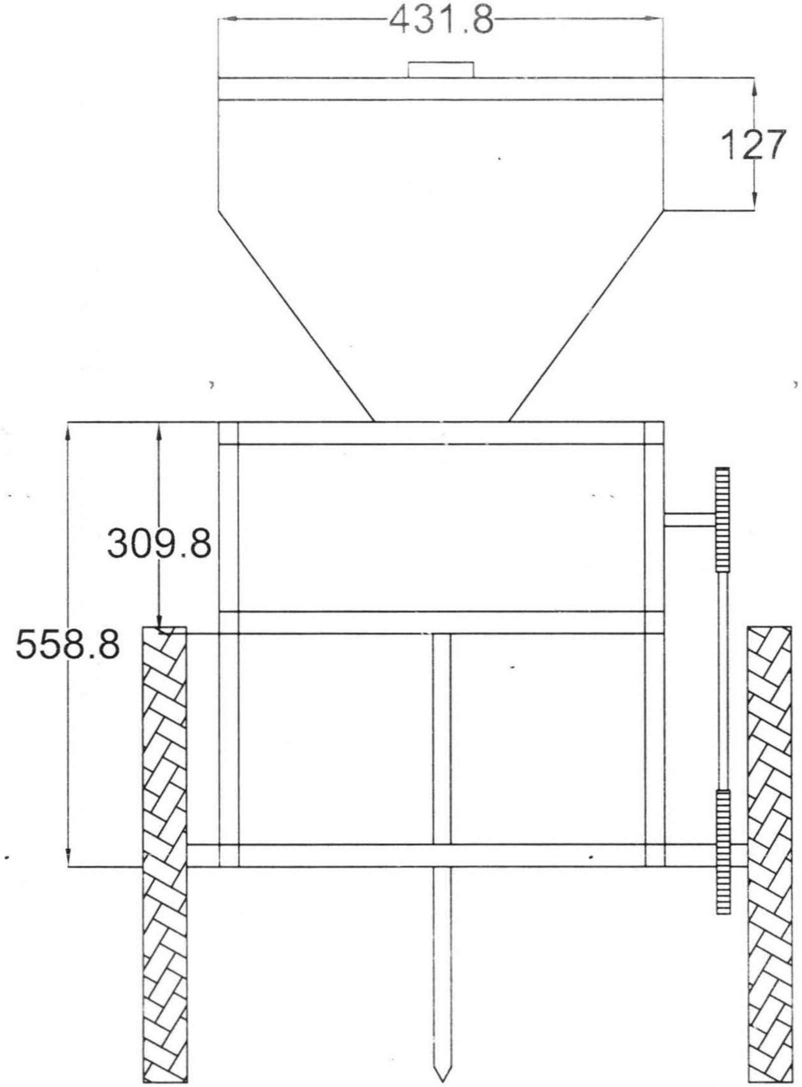

FRONT ORTHOGRAPHIC VIEW OF THE FERTILIZER APPLICATOR

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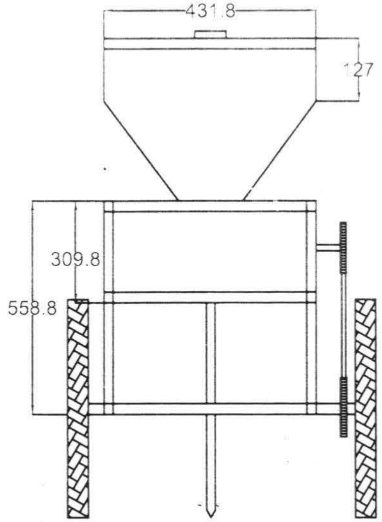

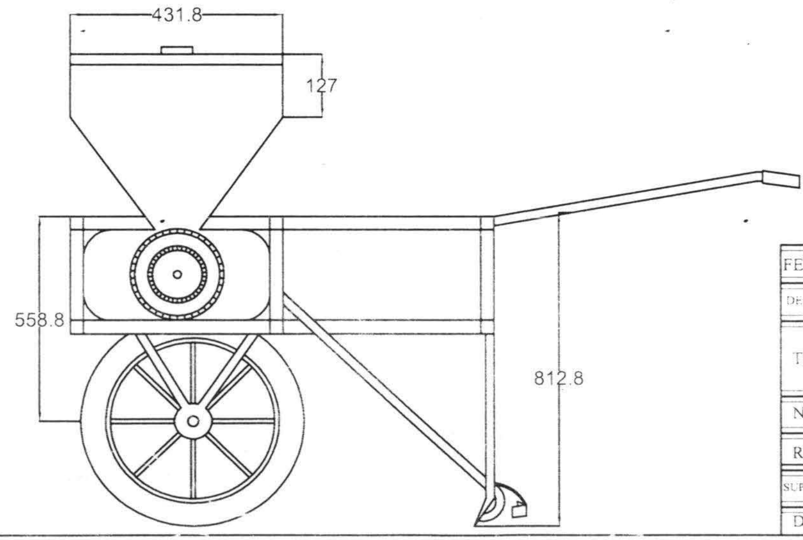

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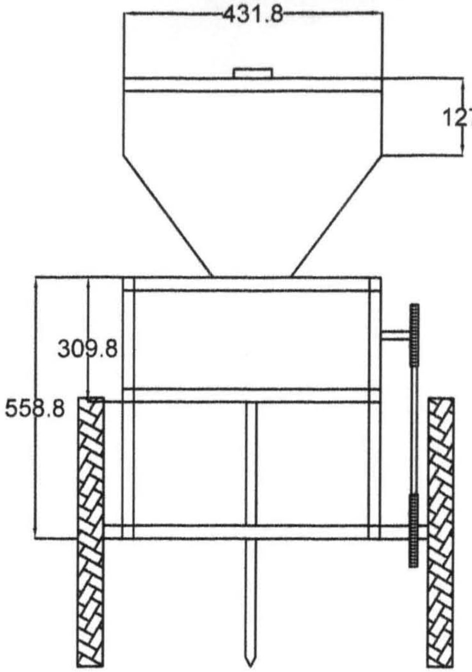

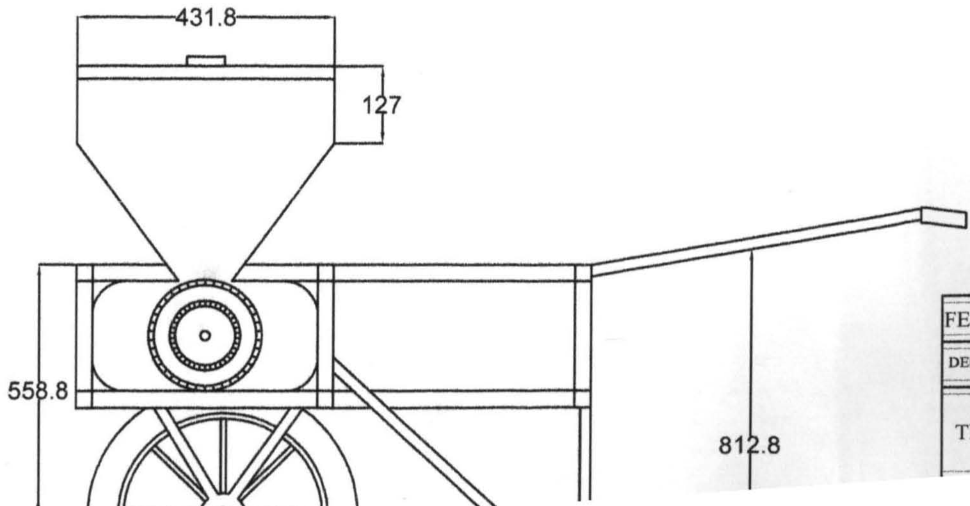

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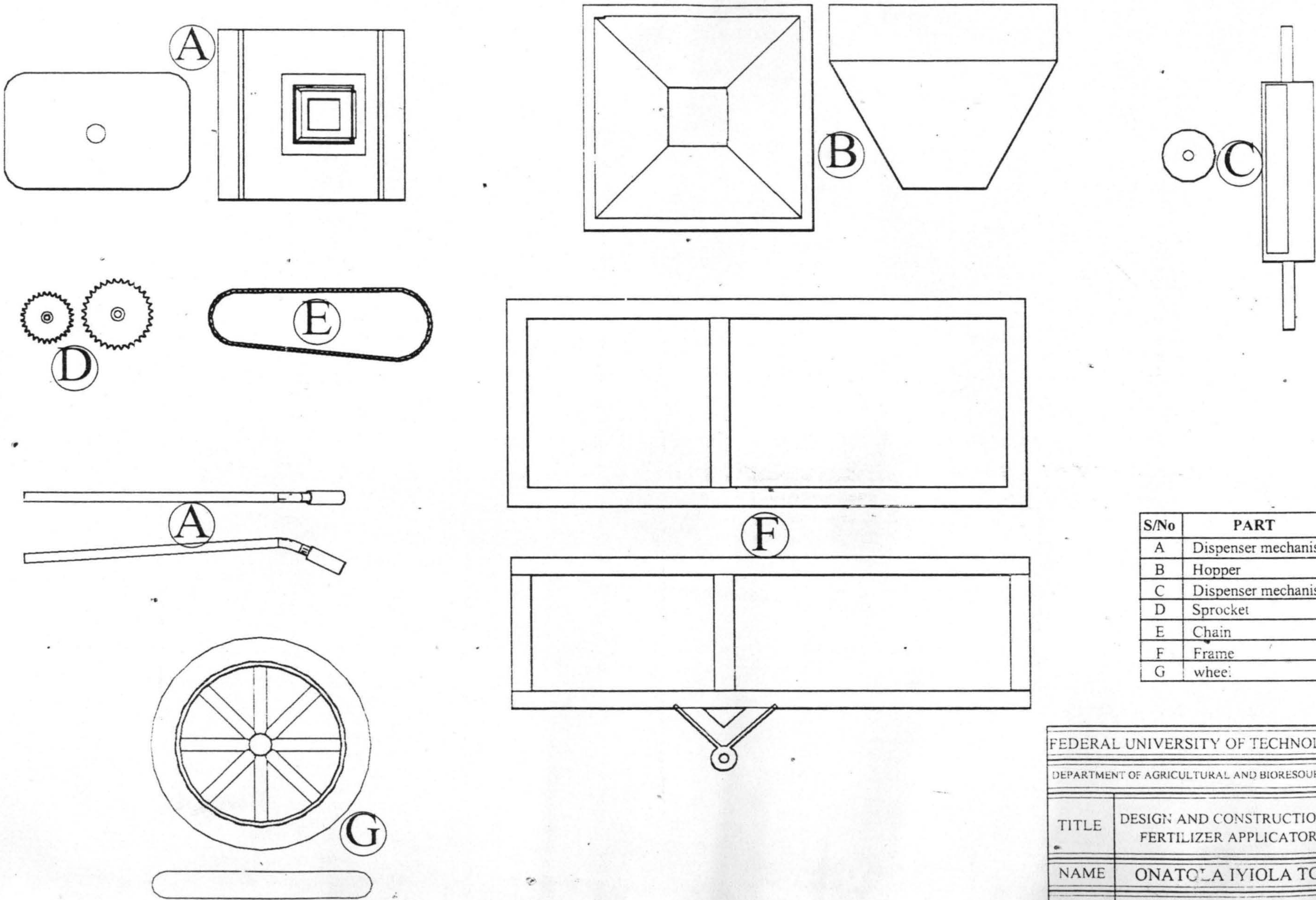

S/No	PART	QTY
A	Dispenser mechanism case	1
B	Hopper	1
C	Dispenser mechanism	1
D	Sprocket	1
E	Chain	1
F	Frame	1
G	wheel	2

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TITLE	DESIGN AND CONSTRUCTION OF A SOLID FERTILIZER APPLICATOR MACHINE
NAME	ONATOLA IYIOLA TOPE
REG No	2004/18409EA