International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 6 June 2021, pp: 548-562 www.ijaem.net ISSN: 2395-5252

Performance Evaluation of a Mobile Multi – Nutrient Block Moulding Machine

*V.M Dagala; A. M. Zaka and **A.Y. Arku
*Department of Mechanical Engineering
**Department of Agriculture and Environmental Resource Engineering
University of Maiduguri, Borno State, Nigeria

Submitted: 25-05-2021 Revised: 01-06-2021 Accepted: 05-06-2021

ABSTRACT:
The machine was designed and fabricated for the purpose of producing twenty (20) multi-nutrient blocks in one operation to serves as a feed supplement for ruminant animals, constructed using locally sourced materials. In the accomplishment of the project, only the detailed design and fabrication of the various components of the machine were taken into consideration these includes; a mould of 120mm×35mm× 90mm, a paddle of 170mm, a board of 620mm×550mm and a wooden tray of 630mm×560mm, with other components such as the roller ball bearing, the angle iron, the iron, spring, and bolts and nuts were assembled to form the machine. Also considered in detail were the working principle and maintenance of the machine. After construction, the machine was tested and produced a multi-nutrient block (MNB) for feeding ruminant animals. The result shows that for an average weight of 8kg of feed supplement, 4.60kg of 20 blocks could be produced. The efficiency of the machine was found to be 76.7% and the production cost of the machine was N92, 170.

I. INTRDUCTION

Multi – nutrient blocks (MNB) are commonly used feed supplement for ruminant (goats, sheep, cattle, Buffaloes, etc. They provide fermentable energy (usually from molasses), non-protein nitrogen (usually from urea), essential materials and vitamins. To increase productivity of ruminant animals, alternative nutritional practices need to be developed which include feed supplementation by the use of multi-nutrient blocks containing fermentable nitrogen and other microbial growth factors. A major constraint to ruminant livestock is the severe scarcity of feeds and fodders both in quality and quantity. Due to high pressure on land for crop production for human consumption, farmers cannot share land for fodder production. Cattles and buffaloes mainly subsist on straw based diet with limited supplement of green fodder and little or no concentrate. So, the productivity of ruminants is severely constraint by inadequate nutrition which interact growth and reproduction rates **(Kellou, 2005)** and **Judith et, al, 2013).** The introduction of feed supplements is highly essential for farmers in developing countries, like Nigeria, that do not have easy access to extension services and limited resources for feeding their ruminant live stocks. Ruminant diets are based on fibrous supplements mainly of mature pastures. Particularly, at the end of the wet season, these supplements are deficient in energy, proteins, minerals and vitamins **(Ramchuru, 2000).** Table 1.0 shows the responses to supplement of milk cows with urea-molasses multi-nutrient block, while Table 1.2 shows the impact of feeding urea – molasses multi-nutrient blocks to livestock from different countries (**Balehegn et., al 2020),**

Table 1.0: Response to Supplement of Milk Cows with Urea-Molasses Multi-Nutrient Blocks.

Country	Increase in Intake (%)	Increase in milk produced (%)	Decrease in time to 1st Oestrus (d)	Decrease in inter calve interval (d)
Bangladesh	30	22	30	40
Pakistan	21	9	83	40 – 60
Philippines	21	26	83	17
Sri – Lanka	20 – 30	21	30	30
Thailand	20 – 25	2	11	40
Vietnam	20 – 30	11	25	30

Table 1.2: Impact of Feeding Urea – Molasses Muti-Nutrient Blocks to Livestock.

	Benefit/Cost	Increase In Income(/Cow/D)	% Increase In Income (/Cow/D)
Bangladesh	2.4	11Taka	22
Pakistan	4.0	-	10
Philippines	1.9	40peso	26
Sri – Lanka	5.5 – 7.6	28Rupee	22 – 35
Thailand	1.2	31 Baht	23
Vietnam	2.8	3.610Dong	180
China	2.0 – 2.3	2.3 – 2.6 Yuan	15 – 30

1.2 Manufacturing Process of the Blocks

The manufacturing process differs substantially from one country to another, depending on the scale of operation used to mix the ingredients. Various approaches have been used, ranging from the use of shovel or even bare hands to mechanical mixing, using a dough mixer or concrete mixer. Similarly, moulds can either be made from metal, wood, cardboard or plastic, which can be square, circular or rectangular in shape. Cars and trucks tyres and buckets are been used as well in some countries to shape these blocks depending on the composition of the blocks. Particularly, the concentration of the binder in the blocks is hardened with or without the use of pressure. This pressure is generally applied either by foot by standing on the moulds or through mechanical devices such as a car jack, screw-driven press or lever, electrical, steam or diesel motors in countries such as Vietnam and Malaysia to compress the blocks. Various formulation and process of production of multi-nutrient blocks have been developed in various countries around the world such as Syria, Australia, Jordan, and China. **(Mubi et. al., 2013).** Three categories of production process of multi-nutrient block have been suggested below according to some authors viz; the hot process, warm process and cold process.

1.3 Hot Process

This process consists of cooking molasses along with the other ingredients at a temperature of 100-120^{0}C for ten minutes. The content is later brought to a temperature of 70^{0}C and the mixture is allowed to cool slowly to solidify. This is done in a double jack rational boiler with circulating water and steam **(Leng1990).**

1.4 Warm Process

This involves the heating of molasses to bring it to the temperature of about 40 to 45^{0}C, then followed gradually with other ingredients and mix thoroughly then allows cooling in order to solidify **(Leng 1990).**

1.5 Cold Process

This involves horizontal paddling of mixtures with double axis, the ingredients used are mixed in the following order: Molasses, followed by the other ingredients. The whole mixtures after thorough mixing are then placed into moulds (plastic pails or frames) measuring 2.5 x 2.0m which is then compressed by a compression machine. After 15hours, the blocks are solidified and are ready for usage **Mubi et., al (2013)** reported then that equipment used in the formulation of multi-nutrient block has been simplified as far as possible with existing materials. To avoid losses due to rats, birds, insects and fungal growth in high humidity areas, polyethylene packing has been the most used when it is necessary to store blocks for a long period of time. In most countries, when the farmer has to buy the blocks, a smooth surface and good quality packing are proffered.

1.6 Block Formulation

In Africa, Grazing, usually on communal land is the dominant feeding system and nutritive value, the principles underlying the efficient use of fibrous crop residues and matured tropical grasses (standing Hay) by large ruminants are now well understood. Ruminants need a minimum of fibrous supplements for survival, but its nutritional value is not high enough for the maintenance of these animals and some times, not even for their survival. Crude protein is the main deficiency in their nutritional needs, this is provided to ruminants in the form of non-protein nitrogen, usually in urea, as molasses is an excellent carrier for urea. The association of the urea with molasses distributed in limited quantity provides an excellent complement to fibrous supplements. Molasses is highly palatable to animals and provides easily fermentable energy and minerals with urea which provides the nitrogen needed for adequate development of the ruminants. Other agro-industrial by-product such as oil cake can easily be added to improve the quality of the mixture. Such a mixture is act a catalytic supplement enabling ruminants to make better use of the fibrous supplement under improvised conditions. The primary objectives in the formulation of the mixtures are to manufacture an emergency or even a survival supplement and not to provide the animals with a balance ratio in line with standard supplying to intensive care. In animal husbandry under such circumstances, Urea is essential because it's the economical form of nitrogen for ruminants. However, its use in supplements must follow specified rules because it may be toxic and can also load to sickness or death of the animals if not properly administered **(Mubi et. al., 2013).**

1.7 Block Composition

Molasses provide energy and minerals, Urea provides nitrogen, salt provide sodium chloride (Wall) and bran (Wheat) supplies some fibre energy, nitrogen and phosphorous. It also serves to absorb the molasses and give some structure to the block. Quick time serves only to solidify the mixture.

1.8 Binder

In the first trials made in Australia, India and Philippines **(Leng, 1990),** solidification involves preheating molasses up to 100 – 200c for about ten minutes in a double jacketed boiler with circulation water and steam (hot process). A gelling agent (magnesium oxide) was added about 6% and day. However, cement provide less effective than QuickTime. Under these circumstances, cement cannot be considered a practicable alternative to quick lime because result of the first trials with cement were all not as good as those with quick time as the blocks were not so hard, and above all, hardening time was much longer.

1.9 Hardness

Multi – nutrient block hardness is an important aspect in transportation and consumption by live stocks. After compression, the block is removed from the mould without risk of disintegration. After two days, they can be transported by any transportation means, either by car, truck, motorcycle, and bicycle; and so on the block can withstand stocks occurring during transportation. Hardening however, continues for several days and perhaps for several weeks depending on the binder. **(Judith et, al 2013).**

1.10 Factors Influencing MNB Hardness

1.10.1. Molasses Quantity: Molasses must not be diluted, although this is sometimes done to facilitate hurdling. It should have a brick degree (related to dry matter) equal to or more than 85% binder, QuickTime, cement or a mixture of both.

1.01.2. Proportions of Ingredients: -The more the molasses, the less the hardness. For a given rate of molasses, hardness varies with the proportion of the binder and of the wheat bran. The proportions of urea and salt, also affect the solidification because the two ingredients are highly hygroscopic.

1.10.3 Moulding and Drying Process

Moulds can be made of wood, plastic, iron or carton boxes, which may be of any shape and size. A plastic sheet placed in the mould or an oil film prevents the block from sticking to the wall and allows easy removal from the mould. Once the mixture is placed in the mould, it should be lift in a well-ventilated room the mixture takes about forty-eight (48hours) hours to set, after which the blocks are ready to be utilized. For cattle's, 10kg block seems to be convenient enough for consumption (**Mubi et. al., 2013).**

1.10.4 Method of Feeding Multi – Nutrient Block to live stocks

Multi – nutrient blocks must only be fed to post – weaning growing or adult ruminant, but never to monogastric species or to pre – ruminant calves, kid goats, lambs and deer fawns because of urea toxicity problem, since blocks are supplements, they should always be used with a minimum quality of roughage. Block is introduced gradually in the diet of ruminants during a transition period of about two weeks (210kg) to enable the animal to adapt to the new supplement. Afterwards, the blocks are offered to animals without any interruption. Blocks being palatable are licked by animals according to their requirements, thereby, regulating the intake of urea, so as to ensure its efficient utilization without any risk of toxicity. The targeted daily intake by adult livestock should be 700g/head for cattle, 150g/head for deer and 100g/head for goats and sheep **(Stear et. al 2006).**

1.10.5 Effect of Multi-Nutrient Block on Feed Intake

Multi-nutrient block lick supplementation of a straw based diet increase digestibility, feed intake, live weight
again and that macro and micro elements can be easily incorporated in the blocks thereby correcting

multi-nutritional deficiencies of ruminants. It can be concluded that urea molasses multi-nutrient block supplementation of straw based diets increases live weight of cows and calves, condition score, increases milk production and effective reproductive performance of animals. (**Judith et, al 2013).**

1.10.6 Effects of Unbalanced Nutrient in Animals

The effects of unbalanced nutrient supply in animals, particularly, of protein and fermentable nitrogen are:-

1.10.6.1 Low calving percentage
1.10.6.2 Low calf birth weight
1.10.6.3 Low weaning weight
1.10.6.4 High calf mortality rate
1.10.6.5 Stunted body size
1.10.6.6 Late sexual maturity
1.10.6.7 Reduced milk production (in cattle's and Buffaloes) **(Judith et., al 2013).**

1.10.7 Storage Pattern

Multi-nutrient is best stored in polypropylene sack, because they are inexpensive, easy to get and are easy mobile in case of transportation. The polypropylene sacks will help the blocks in dry and hard form if property kept in a good store house. Blocks wrapped in plastic sheet or left in carton boxes can also be kept in a dry place for several months.

II. MATERIALS AND METHOD

2.0.1 Material Selection

The selection of materials are based on the basic requirement of the intended use with regards to the physical, mechanical and other related properties associated with the performance of the material in service and their formation into the desired shape. Hence, a compromise has been made between the requirements and the properties and other regards to the economic considerations. The following materials are used in the construction of the machine based on their properties and criteria of selection.

2.0.1.2 Frame

The frame serves as the base and structural support of the machine. It supports various loads acting on the machine. Low carbon steel was used because it is cheap and possess good formability and weld ability.

2.0.1.2 The Mould

All the operation of compressing the urea-molasses block is carried out on the mould. Low carbon steel was used because it can withstand pressure when applied.

2.0.1.3 Wooden Tray

This is a flat tray, carved out of wood, layed under the mould, on which the urea-molasses block will be formed. It is also used to carry the urea-molasses block from one location to another, in order to prevent it from collapsing.

2.0.1.4 The Board

The board is a flat sheet metal made of mild steel which compresses the mould and serves as a rigid support for the mould cavity.

2.0.1.5 Elbow Joints

The elbow joints transfers the force from the paddle to the mould cavity. It lift up the mould cavity after compression of the multi-nutrient block (MNB) supplement in the mould, so that with the help of the wooden tray, the entire block can be removed in one operation.

2.0.1.6. The Handle

The handle is made of mild steel, which is welded to the body of the board. It is used to support and hold the board to a position.

2.0.1.7. The Paddle

The paddle is a small flat sheet metal made of mild steel which works in connection with the elbow joints to transfer force to the mould cavity.

2.0.1.8 Method

This project is basically about feed supplement moulded in block shapes. In order to meet the specified objectives, the following was carried out: sourcing for

2.0.1.8.1. The design specification
2.0.1.8.2. Locally available materials
2.0.1.8.3. The processes involved in the construction of the multi-nutrient block (MNB) moulding machine.

2.2. The approaches adopted were

2.2.1. Determination of the accurate amount of different supplements and minerals used in producing the blocks.
2.2.2. Determination of the labour requirement needed in operating the machine.

III. DESIGN ANALYSIS AND CALCULATIONS

The design parameter is to produce a machine that would compact/compress on urea-molasses mixture of 120mm x 135mm x 90mm. The construction of the machine involved among other considerations; property of the machine member to safely withstand the maximum stress which was induced within the machine member when subjected separately the combination of bending, torsional, axial and transverse loads. According to **Hall et., al (2002).** Ductile materials such as soft steel; are weaker in shear and are designed on the basis of the maximum shear stress.

3.2. Selection of Manufacturing Method

When selecting the method to be used in constructing the machine parts, many factors were considered. These includes; the basic size and shape of the machine, its required strength, dimensional tolerance and the materials from which it is to be made, as well as the economics of quality and cost as well as the manufacturing operations involved (welding, machining, followed by the finishing) Figure 1.0 (a) and the multinutrient (MN) blocks produced Figure 1.0 (b)

Figure 1.0(a): MNB Molding Machine

Figure 1.0 (b): MN blocks

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 6 June 2021, pp: 548-562 www.ijaem.net ISSN: 2395-5252

3.2.1. Mould Design

Area of Mould= length X breadth. Where,
Length of mould = 0.12
Breadth of mould = 0.135
Therefore, A = L X B---------------------- (1)
= 0.12 x 0.135
= 0.0162m^2

3.2.2. Board Design

Mass of board = 8.5kg (measured)
Therefore, force exerted by board F = mg …... (2).
Where; F = Applied Force, N
M= Mass, kgg = Acceleration due to gravity, m/s
Thus, F = 8.5 x 9.81 = 83.39N

3.2.3. Bolt Diameter

Exerted body weight on the paddle = 60.5kg (specified)
Thus, force applied by body weight (P) = 60.5 x 9.81 = 593.505N
Since, load is being carried by the four (4) steel nuts supporting the upper press,
Therefore, Load carried by each bolt. P_1 = P/4…(3)
Where P is the exerted body weight on the paddle.
P_1 = 593.505N/4
= 148.38N
From, (**Gupta, 2008)** table 31.5, p. 1110
Load Stress Factor δ_k δ_k for steel = 0.415N/mm^2

Cross-sectional area of the body (A) = $\frac{\pi d^2}{4}$ $\frac{\pi d^2}{4}$ = $0.7854d^2$ $0.7854d^2$ But, $\delta_k = \frac{P_1}{A}$ $\delta_k = \frac{P_1}{A}$,

We know that load carried by each bolt $(P)_1 = \delta_k.A$ $(P)_1 = \delta_k.A$

$$148.38N = 0.415 \ x \ 0.7854d^2 \quad 148.38N = 0.415 \ x \ 0.7854d^2 \qquad = 0.3259d^2$$
$$= 0.3259d^2$$

$$d^2 = \frac{148.38}{0.3259} \quad d^2 = \frac{148.38}{0.3259}$$
$$d^2 = 455.2 \quad d^2 = 455.2$$

D = 21.34mm say 21mm bolts used

3.2.4. Stress on the Washers

They are tightened and calculated as follows:-
Outer diameter of bolt and Nut (D) = 22mm
Inner diameter of bolt and Nut (d) = 10mm
Diameter of washer,

$$A = \frac{\pi}{4} \ x \ (22^2 - 10^2) \qquad = 301.63mm^2$$

Since the load is equally distributed, therefore, load on each washer before the nuts are tightened.

$$P_1 = \frac{593.505}{4} = 148.38N \qquad \text{-------------(4)}$$

$$\delta_t = \frac{148.38}{301.63} = \frac{0.49N}{mm^2}$$

The stress on the washer before the nuts are tightened is; $\delta_t = \frac{0.49}{mm^2}$ $\delta_t = \frac{0.49}{mm^2}$.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 6 June 2021, pp: 548-562 www.ijaem.net ISSN: 2395-5252

3.2.5. Spring Design

Mean diameter of the spring coil (D) = 20mm
Diameter of the spring wire (d) = 15mm

$C = \frac{D}{d}$ $C = \frac{D}{d}$, called the spring index.

$C = \frac{20}{15} = 1.33 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$

The shear stress is given by

$$\tau = \frac{8KFD}{\pi d^3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$\tau = \frac{8KFD}{\pi d^3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

(Hall et al, 2002)

Where,

$$K = \frac{4C-1}{4C-4} \ x \ \frac{0.615}{C} \ (Wahl's\ stress\ factor) \ldots\ldots\ldots (7)$$

$$K = \frac{4C-1}{4C-4} \ x \ \frac{0.615}{C} \ (Wahl's\ stress\ factor) \ldots\ldots\ldots (7)$$

$$K = \frac{4(1.33)-1}{4(1.33)-4} \ x \ \frac{0.615}{1.33}$$ $$K = \frac{4(1.33)-1}{4(1.33)-4} \ x \ \frac{0.615}{1.33} = 1.505 \approx 1.51$$

$$= 1.505 \approx 1.51$$

From value of allowable shear stress, Table 23.1 (Gupta, 2008) Allowable shear stress (τ) (τ) of spring wire =

$420 \ x \ \frac{10^6 N}{m^2}$ $420 \ x \ \frac{10^6 N}{m^2}$ From equation (6)

$$F = \frac{\tau \ x \ \pi d^3}{8KD}$$

$$= \frac{420 \ x \ 10^6 \ x \ 3.142 \ x \ (0.015)^3}{1.51 \ x \ 8 \ x \ 0.02}$$

$$= \frac{4453.79}{0.2416}$$

$$= 18434.56 \approx 18434.6N$$

The deflection in the spring due to axial load (F=18434.6N) is

$$\gamma = \frac{8FD^3 n}{G.d^4} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

$$\gamma = \frac{8FD^3 n}{G.d^4} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

(Hall et al, 2002)

Where: n n = number of active coils

$\gamma =$ $\gamma =$ Axial deflection, m m

$G =$ $G =$ Modulus of rigidity = 80 x 10^9 for steel.

Therefore,

$$\gamma = \frac{8 \ x \ 18434.6 \ x \ (0.02)^3 \ x \ 25}{(0.015)^4 \ x \ (80 \ x \ 10^9)}$$ A

$$= 7.28 \ x \ 10^{-3} m$$

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 6 June 2021, pp: 548-562 www.ijaem.net ISSN: 2395-5252

Spring rate

$$K = \frac{F}{\gamma} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (9)\ K = \frac{F}{\gamma} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (9)$$

(Hall et al, 2002)

$$= \frac{18434.6N}{7.28\ x\ 10^{-3}mm}$$

$$= 2532225.3 = 25.3\ x\ \frac{10^{-3}N}{m}$$

3.2.6. Stand/Frame Design

The machine is supported by two supporting members with dimensions of 540mm x 610mm made of low carbon steel which has the ability to withstand the loads when applied during idle or non-operating, and when the machine is operating.

The summation of forces action on the machine was calculated.

M_1 = Mass of body acting on the paddle = 60.5kg

Therefore, force of Body acting on the paddle (F_1) = Mg

= 60.5 x 9.81

= 593.505N

3.2.7. For the Mould

M_2 = mass of 20 moulds = 1.8kg (each of 20 mould

1.8 x 20 = 36kg

Therefore, Force exerted by the mould (F_2) = mg

F_2 = 36 x 9.81

= 353.2N

For the Board and Handle

M_3 = Mass of Board and Handle= 12.5kg

F_3 = Force exerted by the Board and Handle = 12.5 x 9.81= 122.63N

Therefore, Summation of forces acting on the frame

$F_1 + F_2 + F_3$ = (593.505 + 353.2 + 122.63) N = 1069.29N

Assuming the force exerted is equally distributed between the two supporting members, hence, on each member, the force acting is given by:-

$$\frac{W}{2} = \frac{1069.29}{2}$$

$$= 534.645N = 534.645N$$ (When no compression is taking place)

Maximum deflection

$$\gamma = \frac{WL^3}{48EI} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (10)$$

$$\gamma = \frac{WL^3}{48EI} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (10)$$

Where; I = Second moment of area (m^4)

E = Young Modulus (Nm^{-2})

L = Length of the member (m)

W = Weight (MgN)

From steel designer manual for structural steel, 1972 Figure 1 Bending Moment and shear force diagram, E = $207GN/m^2$

I = $1.4 \times 10^{-8} m^4$

W = 1069.29N

L = 540mm = 0.54m

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 6 June 2021, pp: 548-562 www.ijaem.net ISSN: 2395-5252

Reaction at the support $\frac{W}{2} = 534.645N$ $\frac{W}{2} = 534.645N$
Using equation (10) above,

Maximum deflection γ γ

$$\gamma = \frac{1069.29\ x\ (0.54)^3}{48\ x\ 207\ x\ 10^9\ x\ 1.4\ x\ 10^{-8}}\ \gamma = \frac{1069.29\ x\ (0.54)^3}{48\ x\ 207\ x\ 10^9\ x\ 1.4\ x\ 10^{-8}}$$

$$= 1.21\ x\ 10^{-3} m\ = 1.21\ x\ 10^{-3} m$$

Checking for the buckling factor (K_B) using Euler's theory Buckling load (P) = $\frac{K\pi^2\ x\ EI}{L^2} \ldots\ldots\ldots\ldots\ldots . (11)$ $\frac{K\pi^2\ x\ EI}{L^2} \ldots\ldots\ldots\ldots\ldots . (11)$ as used by Mohammed and Daneshmehr (2014)

Where; K = 0.25, factor dependent
E = Young modulus, 200GN/m^2
L = Total length, 540mm = 0.54m
I = 1.4 x 10^{-8}m^4

$$P = \frac{0.25\ x\ [(3.142]^2)x\ (200\ x\ 10^9)x\ (1.4\ x\ 10^{-8})}{[(0.54]^2)}$$

Therefore,

$$P = \frac{0.25\ x\ [(3.142]^2)x\ (200\ x\ 10^9)x\ (1.4\ x\ 10^{-8})}{[(0.54]^2)}$$

$$= 23698.6N\ = 23698.6N$$

3.0 Bolts and Nuts Design

3.3.1. Bolt designation for M22 Bolt

Using design dimensions of screw threads, bolts and nut according to international standard: 4218 (part III) 1976 (reaffirmed 1996). Table 11.1 p. 387, (**Gupta, 2008**)
Diameter of Pitch (dp) = 2.5mm
Diameter of Core (dc) of bolt = 18.933mm
Diameter of Core (dc) of Nut – 19.294mm
Stress Area mm^2 = 303mm^2
Nominal diameter of bolts, mm (d) = 22.000

3.3.2. Initial Stress Due to Screwing of Bolts

The initial tension in a bolt, based on experiments, may be found by the relation
P_i = 2840d N ……………………… (Gupta, 2008)
Where, P_1 =Initial tension in a bolt
D= nominal diameter of bolt, in mm
Therefore, P_1 = 2840 x 22.000
= 62480N.

Stress set up in the bolt ($\delta_1 t$) ($\delta_1 t$) . ; $\delta_t = \frac{P_1}{A}$ $\delta_t = \frac{P_1}{A}$ $= \frac{62480}{303} = 206.2mpa$ $= \frac{62480}{303} = 206.2mpa$

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 6 June 2021, pp: 548-562 www.ijaem.net ISSN: 2395-5252

$= \frac{62480}{303} = 206.2mpa$ $= \frac{62480}{303} = 206.2mpa$

3.3.3. Compressing or Crushing Stress on Threads

The compression or crushing stress between the threads (dc) may be obtained by using the relation;

$$\delta_c = \frac{P}{\pi\left[d^2 - (dc)^2\right]n} \quad \ldots\ldots\ldots\ldots.. (12)$$

Where; d = major diameter = 22.000mm
dc = Minor diameter = 18.933mm
n = number of threads in engagement = 20

$$\delta_c = \frac{62480}{\pi\left[(22.000)^2 - (18.933)^2\right] x\ 20}$$

$$\delta_c = 7.92Mpa$$

3.3.4. Eccentric Load Acting Perpendicular to the Axis of Bolts

Each bolt is subjected to a direct shear load of

$$W_S = \frac{W}{n}$$

Where, $n = is\ the\ number\ of\ bolts$ $n = is\ the\ number\ of\ bolts$

$W = Load\ applied\ on\ bolts$ $W = Load\ applied\ on\ bolts$

$$W_S = \frac{593.505}{4} = 148.38N$$

Therefore, the maximum tensile load on bolt

$$W_{t_2} = W_t = \frac{W.\ L.\ L_2}{2[(L_1^2) + (L_2^2)]} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)$$

$$W_{t_2} = W_t = \frac{W.\ L.\ L_2}{2[(L_1^2) + (L_2^2)]} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)$$ (Gupta 2008).

Where, L = 250mm (measured) [Acting vertically at a distance from the face of the column]
L_1 = 30mm (measured) [Distance of bolt 1 and 2 from the tilting edge]
L_2 = 600mm (measured) [Distance of bolt 3 and 4 from the tilting edge].
W = 593.595N (when compressing)
When compressing

$W_{t.}$ = $\frac{593.505\ x\ 250\ x\ 600}{2\left[(30)^2 + (600)^2\right]}$ $\frac{593.505\ x\ 250\ x\ 600}{2\left[(30)^2 + (600)^2\right]}$ $= 123.34N$ $123.34N$

3.4. COST ANALYSIS

The price of materials fluctuates with change in demand and supply. These are the current prices obtained from the market as at the time of construction, including joining, machining and other related inspection work.

Table 3.0: Bill of Engineering Measurement and Evaluation (BEME)

S/N	Component	Material used	Quantity	Unit cost ₦	Total Cost ₦
1	Frame	Low carbon steel	1	25000	25000
2	Mould	Low carbon steel	20	900	18000
3	Wooden Tray	Wood	1	5000	5000
4	Scraps	Low carbon steel	1	5100	5100
5	Consumables	Electrode	½ pack	2200	2200

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 6 June 2021, pp: 548-562 www.ijaem.net ISSN: 2395-5252

6	Bolt, Nut, and washers	Alloy steel	4	2000	800
7	Board	Low carbon steel	¼ sheet	4,800	4,800
8	Stainless steel pipe	Stainless steel pipe	2 pipe	4000	8000
9.	Paint and Brush		2 Liter	1000	2000

Grand total: 70,900

3.4.1. Cost Estimate:

Labour cost 30% of the material cost =21, 270.Therefore, Total production cost= 21,270+70,900 = **92,170**

$$(TPC) = Mc + DLC + OHC$$

IV. CONSTRUCTION

The construction is made up of a number of processes, each being characterized by definite machining and assembly methods. It consists of operations which in turn are made up of several component parts. Qualities and accuracy in construction operations demand that dimension control be maintained to turn out parts which are inter-changeable and give the best operating services. A product made of inter changeable parts is easily assembled, low in cost and easily serviced.

4.1 Construction of Components

In the production of the multi-nutrient block moulding machine, below are the list of the components fabricated.

Table 4.0: Main features of the MNB production machine

S./No	Component	Dimension	Method of Fabrication	Material Used	Quantity
1	Mould	120 × 135mm × 90mm	Welding	Low carbon steel	20
2	Frame	900mm × 600mm	Welding	Low Carbon Steel	1
3	Bolts and Nuts	22mm	Standard Components	Cast alloy Steel	4
4	Spring	20mm	Standard Component	Cast alloy steel	2
5	Board	620mm × 550mm	Welding	Mild Steel sheet	1
6	Roller Ball Bearings	40mm	Standard component	Cast alloy steel	2
7	Angle iron	40mm × 40mm	Welding	Low carbon steel	1
8	Rod Iron	12mm	Standard component	Cast alloy steel	2
9	Paddle	170mm	Welding	Low Carbon Steel	1
10	Wooden Tray	630mm × 560mm	Wood Working	Wood	1

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 6 June 2021, pp: 548-562 www.ijaem.net ISSN: 2395-5252

Table 4.1: Summary of the parameters of the MNB production machine

Buckling Load (max) (N)	23698.6
Dynamic Load Rating for Bearing (N)	432674.8
Maximum Deflection (M)	1.21×10^{-3}
Rate of production (blocks/hr)	60
Spring rate (N/m)	25.3×10^{-3}
Spring deflection (max) (m)	7.28×10^{-3}
Size of supplements that can be produced (mm)	$120 \times 135 \times 90$
Thickness of supplements produced (mm)	100

4.2 Machine Assembly

This is the process of putting together into a whole unit, components produced and sub-components of given products to make one main unit system or machine. The methods used for this project includes; Cutting, Welding, Machine and Bolting. Among instrument used are ; Measuring tape, bending machine, bench Vice, Hammer, Arc Welding Machine, scriber flat file, Hack Saw, Drilling Machine , Anvil, threading Machine and so on. The measuring tape used to mark out the specified dimensions on the angle iron before cutting into various sizes. The angle iron was then fitted together to form the frame of the machine by welding. The frame which serves as the base was made strong enough to withstand the weight of the mould, the board and that of the wooden tray. Rod iron of length 120mm as a shaft was directed inside the ball-bearing which was connected to the mould to lift the mould after compression, for easy removal of the blocks after formation. Elbow joints which was connected to the mould, were also connected directly to the paddle, so as to allow directional flow of force when force is applied on the paddle to the mould. The wooden tray, carved out of wood was placed under the mould for moulding purposes as indicated in the assembly drawing. Finally, the machine was run unloaded, the revolving components were observed to run or work smoothly without noise.

4.3. General Finishing

The constructed parts were assembled together as shown in the assembled drawing; the edges of the machine were smoothened with a file. Also, a hand grinding was used to grind the portion or joints where too much flux of the electrode was deposited. Cleaning of the whole system of the machine, the board, mould, handle, wooden tray, frame, paddle etc., was done by using brush to remove all forms of dirty.

4.4. Painting

Paints are applied on machine body to protect the metal from corrosion and other contaminants. It was also applied to beautify the machine.

4.5. Safety Precaution

The safety precautions mentioned below should be adhered to, to prevent any damage to the machine and the user.

4.5.1. It should be ensured that hand should not be put on top of the mould, when pressing down the board.

4.5.2. It should be ensured that the big lock nut holding the shaft is tight enough before compression.

4.5.3. It should be ensured that the bolt holding the elbow joints be checked before applying force on the paddle.

4.5.4 It should be ensured that the lock nuts beside the mould are tight before pressing down the paddle.

4.8. Evaluation

The test was carried out in order to determine the ratio of the various supplement mixtures weights before and after compression in order to determine the hardness and compactness of the supplements.

4.7. Process of Block

The MNB to be compressed was measured before compression and the weight noted. The mould was then smoothened with vegetable oil to enable easy removal of the MNB followed by the introduction of the supplement into the mould by using shovel. When the MNB is been compressed, the mixture is immediately under pressure.

After about 20-30 seconds depending on the thickness of the MNB, the MNB is removed and weighted again, the final weight noted. The

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 6 June 2021, pp: 548-562 www.ijaem.net ISSN: 2395-5252

moisture content of the MNB produced was calculated with the relation;

Moisture content =
$(Wet\ matter - dry\ matter)/(Wet\ matter\ )$

$(Wet\ matter - dry\ matter)/(Wet\ matter\ )$ kg $\times$ 100…. **(Leng 1990)**

The efficiency of the machine was also calculated from the relation; Efficiency =
$$\frac{number\ of\ undamaged\ blocks}{expected\ number\ of\ blocks} \times 100 \quad \frac{number\ of\ undamaged\ blocks}{expected\ number\ of\ blocks} \times 100$$
………**(Leng1990)**

Table 4.2: Formulations of the MNB

Ingredients %	Form 1	Form 2	Form3
Molasses	5	10	25
Poultry litter	20	20	20
Nutrients Salt	5	5	5
Wheat bran	65	65	50
Cement	5	0	0
Water (liter)	1.5	1.3	1.3

Table 4.3: Moisture Content (For 10 Drying Days)

FORMULATIONS	1	2	3
Wet matter	2.02	1.57	1.91
Dry Matter	1.80	1.50	1.90
Moisture content %	0.100	0.0445	0.010

4.7 Test

It was discovered that the hardness of the supplement is improved compared to the supplement manually produced by hand. This supplement has low moisture absorption, and the surface smoothness was improved. The hardness was determined by a universal testing machine and the compactness was very good. A 120mm $\times$ 135mm $\times$ 90mm MNB was formed. From the test of the mobile operated multi-nutrient block moulding machine, Tables 4.4 and 4.5 shows the result obtained.

Table 4.4: shows the quantity of MNB produced per time

S/n	Weight of feed (kg)	No of mould	Time taken to load all molds (mm)	Weight of each block produced (kg)	Remark
1	8	20	18	3.2	High moisture content, the block sticked
2	8	20	20	3.1	Soft, the block sticked, high moisture content
3	8	20	19	4.8	Moderate molasses
4	8	20	22	4.6	A strong MNB block was formed.
5	8	20	21	4.7	A strong MNB block was formed

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 6 June 2021, pp: 548-562 www.ijaem.net ISSN: 2395-5252

Table 4.5: Evaluated Efficiency for the MNB Production Machine

Formulations	No Unchanged	Expected No	Efficiency %
1	15	20	75
2	16	20	80
3	12	16	75

V. RESULTS

From the results obtained as shown in the tables above, the MNB production machine has been simplified. It can be clearly observed that the MNB production machine has a high production capacity. The capacity of the MNB production machine is 23,698.6N of buckling load which means that the machine can resist higher loads. The average production time were 15-20 minutes/ 20 blocks, having a thickness of 100mm and drying time of 10-12 days. The simplicity of the MNB production machine also bring to ease its fabrication and low maintenance cost. It was observed after sun drying that when water was poured on the surface of the blocks, the blocks kept shape. Blocks maintained their shape intact when submerged in water within a period of one (1) hour but dispersed after 2-3 hours. The shape of the blocks did not change under finger pressure. The block produced by the machine had good level of compactness, low moisture absorption and hard enough to control intake, the blocks produced by the machine were squares in shape with a thickness of 100mm and an average weight of 4.60kg, they did not moisten before 24hour under Maiduguri weather condition if 30-39^{0}c. The machine has an average efficiency of 76.7% since 15 of 20 blocks were undamaged. The MNB production machine is efficient and highly economical, since it has the capacity to produce twenty (20) MNB blocks in just 20 minutes and forty (40) MNB block in about 40 minutes. The machine had a total production cost of ₦92, 170 which makes it easily affordable by local farmers, especially local farmers in the rural settlement for block production

VI. MAINTENANCE OF THE MACHINE

Maintenance is the care which is carried out on a machine or component to ensure or yield effectively performance at minimum cost.

The following periodic maintenance is recommended for this machine:

6.0.1 Wash the machine and clean the entire body of the machine after daily working hours.

6.0.2 Tight loose bolts and nuts when noticed immediately

6.0.1 Apply grease to the moving parts to reduce friction.

6.0.3 Re-painting of the body of the machine when paint has faded out so as to prevent corrosion, rusting etc.

VII. CONCLUSION

On testing the effectiveness of the compacting machine, samples of the supplement with dimension of 120mm × 135mm × 90mm and thickness range of 100mm were produced in an average time of 20 minutes/20 blocks. A simple and effective way of compressing these supplements has been achieved. It has been demonstrated that MNB can be used to improve the productive performance of animals with access to low quality roughage. Test result reveals that for an average weight of 8kg of supplement feed, 4.60kg of block was produced in 22minutes.the efficiency of the machine was found to be 76.7%. The cost of producing the machine was cheap which amounted to ₦92, 900. With help of the simplified MNB production machine, job opportunity can be created which is the motor of engineering profession: “Engineering for self-reliance”.

REFERENCE

[1]. Balehegn M, Duncan A. Tolera A and Ayatunde A.A (2020). Improving Adoption of Technologies and Intervention for Increasing Supply of Quality Livestock Feed in Low- and Middle –Income Countries. Global food security, volume 26, September, 2020 100372.

[2]. Hall, A.S., Holowenko, A. R. and Laughlin, H.G. (2002). Theory and Problems of Machine Design S.I. (Metric) Edition. Tata McGraw-Hill Publishing Company Limited. New Delhi. Pp. 192.

[3]. Judith L. Capper and Dale E. B (2013). The Role of Productivity in Improving the Environmental Sustainability of Ruminant System. Annual Review of Animal Bioscience, April 2012.Pp. 9.1 -9.22.

[4]. K.Gupta, R.S. khurmi (2008): A text book on machine design. 9th edition, Eurasia Publishing House (PVT). New Delhi. Pp. 1340

[5]. Kellou, K.M, (2005). Development of Multi-nutrient blocks for dry season supplementary feeding of sheep in a semi-arid environment. M.Sc. thesis, University of Maiduguri-Nigeria, Pp. 23-28.
[6]. Leng, R.A., (1990). Drought feeding strategies and practice. Lilley, R.K. (Ed.), Penambul Books, Armidale, New Southwest Wales. Australia, Pp. 149-151.
[7]. Mohammed M.A and Daneishmehr (2014). An Investigation of Modified Couple Stress Theory in Buckling Analysis of Micro Composite Laminated Euler-Bernoulli and Timoshmehr. International Journal of Engineering Science 75, 40-53, 2014
[8]. Mubi A.A, Kibon A, Mohammed .D (2013). Formulation and Production of Multi-nutrient Blocks for Ruminants in the Guinea Savannah Region of Nigeria. Agriculture and Biology Journal of North America, 4 (3), 205-215, 2013.
[9]. Ramchuru,R. and Raggo J, (2000). The development of multi-nutrient blocks for domestic rabbit Mauritius. Livestock Research for Rural Development, 12: 1-6.
[10]. Stear M.J, Doligalska M and Donskow - Schmelter K (2006). Alternative to anthelmintic for the control of nematodes in livestock, November, 2006. Pp.138-151