DESIGN AND FABRICATION OF FISH FEED PELLETIZING MACHINE

BY

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SEPTEMBER, 2010

DECLARATION

I hereby declare that this project work is a record of a research work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any university or institution. Information derived from personal communications. Published and unpublished works were duly referenced in the text.

Agada, David Achile

27/10/2010

Date

(2004/18368EA)

CERTIFICATION

This project entitled "Design and Fabrication of Fish Feed Pelletizing Machine" by Agada, David Achile, 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.

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DEDICATION

This project research is dedicated to God, my Late Father, Mr. Agada, Moses Onoja and also to Mr Don S. Agada

ACKNOWLEDGEMENTS

My profound gratitude goes to God Almighty for seeing me through the entire period of this project.

I also appreciate my supervisor Engr. Dr. O Chukwu for all his support in this project and making me understand the effect of this project to my life and career at large and for his time and effort in making sure that the purpose of this project was achieved. My appreciation also goes to my H.O.D. Engr. Dr. A.A. Balami, Mrs Bosede Orhevba, all the lecturers in the department of Agricultural and Bioresources Engineering and the staff in the central workshop for their assistance during the fabrication.

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ABSTRACT

In this work, the design and fabrication of fish feed pelletizing machine was carried out with the view to encourage local technology, as most of the machines available are imported. This project discusses the local design and fabrication of an electrical powered fish feed Pelletizer. The pelletizer uses a screw auger (shaft) propelling the feed mix through the die. The screw auger is enclosed in the auger casing and is propelled by an electric motor with the aid of belt and pulleys. This auger is fed by a hopper, which is able to hold a large quantity of the feed mix at a time. A cutting blade is mounted on the shaft which cut the pellet as it comes out from the die. The pelletizer was tested to have the following results; pelleting efficiency and capacity as 88.9% and31.4 kg/h respectively and similarly the efficiency and capacity for pelleting and cutting as 41.3% and 8.6 kg/h.

TABLE OF CONTENTS

List of Tables

List of Figures

CHAPTER ONE

1.0 INTRODUCTION

Aquaculture has been considered as the solution to the global decline in captured fisheries production. This is the practice of fish husbandry whereby fishes are kept and fed in confinement and managed to achieve quick growth and accelerate production. This is certainly one of the main arguments that lured international organizations and National government into intensifying aquaculture. The intensification of the culture of fish species is bound to make them more dependent on artificial or compounded feed. Therefore, aquaculture using artificial diets is in a sense competing with people and terrestrial livestock farming for basic feed ingredients. Feed cost is considered to be the highest recurrent cost in aquaculture, often ranging from 30% to 70%, (Foltz, 1982).

Due to the intensification of aquaculture, it is faced with the following setbacks such as; the survival of fish in a high population density, the pollution of water by high feed loading and the economy of fish farming due to high cost of feed. It is only an advancement in technology of fish feed production such as pellet feed; which has improvements in the uniformity of feeds, feed utilization, water stability, better physical characteristics to enhance better handling and storage, that could address such feedbacks. The envisaged developments are likely to occur in these areas: Diet will be formulated with an emphasis on minimizing water pollution, enhancing the quality of the produce and enhancing fish survival and growth. Pelletizing machines are built to produce soft flakes in form of pellets, which can be consumed by fish easily, (Stivers, 1970).

1.1 Background to the Study

Pellets were first used in the production of iron ore for blast furnace in pig iron production, production of chemical pellets and pellet as source of fuel from wood dust. Not until the mid 1920 was it introduced in the animal feed industry in United States in order to improve feed utilization, increase the density of feed and improve handling characteristics. Later in about 1930, different types of pelletizing machine were used, (Stivers 1970).

The early pellet process involves the grinding and mixing of the feed ingredient and producing them with on further treatment. The reason for this approach was to prevent alteration to vitamins and proteins due to the action of heat to the feed mixed. In late 1930s some animal feed processors began to subject pellet forming mixtures through a conditional heat treatment prior to the introduction of the pellet extruders. The addition of steam improves rate, reduce die(s) wear and improve pellet quality. Steam conditioning was quickly adopted by the industries and has remained an integral part of the pellet process to the present time according to Ndukwe *et al.,* 2006.

1.2 Statement of the Problem

Despite the progress in the previous ways that the feed were made, they were faced with many challenges. These challenges includes

- The poor physical characteristic of the feed which come in non-form shape as in powder, meal, dough, ball and cakes, as well as low density which segregate to individual feed ingredient when in water within shortest time.
- The disintegration of the non- pellet feed in water and loss of nutrient to leaching.
- The high cost of pellet feed in the market as most of the ones available are imported and the pelletizing machine used in the production may also be imported.
- The difficulty in storage of feed fish which come in powder or meals form tend to lose their nutrient with time.
- The pollution of aquatic environment (water) by un-ingested feed, fish tend to ingest the individual ingredient they prefer most and leave the other.

1.3 Objective of the Study

The main objective of this study is the fabrication of a pelletizing machine from locally available materials which will be used in the production of pellets feed. The other objectives are:

- To improve water stability of fish feed through pellets.
- To produce feed that will withstand the rigour of handling, transportation as well as improved storage characteristics
- To produce feed that is acceptable and easily consumed by fish.
- To reduce contamination of feed

1.4 Justification of the Study

The significance of fish pelletizing machine cannot be over-emphasized. It is a known fact that the development of every society lies on its technological advancement. This pellet machine will ensure the return of investment with time to farmers, feed processors and investors. This in turn boosts the economy and also the living standards of the people. The machine will be moderately affordable, and pellet for fish could be produced in larger quantity in little or no time with reduced drudgery.

Due to government's effort in enhancing agriculture, there is a need to encourage local production and this can be achieved by empowering the local manufacturer. The need to go into production of machine for locally available material of international standard is of great importance as this could boost our industrial sector. The fabrication of pelletizing machine is a drive towards the local production of machines which will in turn enhance the technical knowledge and also create a platform towards industrialization that will create jobs for the unemployed in the society thereby improving the standard of living of the populace and leading to a national development of the country as productivity will be enhanced.

1.5 Scope of the Study

This work, design and fabrication of a fish feed pelletizing machine is limited to the following

- Design of the component part of the machine using engineering principles.
- The use of electric motor as the source of power.
- The use of pulleys and belt as the means of transferring power.
- Fabrication of the hopper using 4mm metal sheet.
- Construction of the frame with use of angle bar.
- Fabrication of screw auger (shaft).
- Drilling of round metal sheet to form the die (Screen).
- Assembling of the fabricated parts into complete machine.
- Painting of the machine.
- Testing the performance of the machine.

CHAPTER TWO

2.0 LITERATURE REVIEW

Pelleting of fish feed involves the integration of the feed mixtures into smaller units called pellets. Pelletizing machine is essential equipment in which the preparation of pellet feed is being processed into the particular size required. The pellet production was stimulated by the need to improve the uniformity in shape and size of fish feed required by the users of animal feed producer (Gabriel, 2007).

The power operated pelletizing machine involves passing the dough through the hopper and a rotating screw auger compressing it into a die to form a hard pellet which is resistant to crushing or disintegration when in water. Previously, pellet machines capable of producing pellets of this type were not available locally, (Oresegun *et al.,* 2005). But, pelletizing machine are now being fabricated locally and adopted to produce feed pellets of variable hardness. Before the advent of the mechanized pelletizer, the manually/hand pelletizing was being used to pelletize fish feed compounded which usually result in drudgery and waste. The domestic hand pelleting involves the use of a perforated cylindrical can and the feed dough is pressed against the uniform perforation on the bottom plate.

2.1 Definition of Pellets

The pellet is a small round mass of substance compressed together. It is also said to be a small hard ball or tablets of any substance often of a soft material that has become hard, gotten from a very powdered particle sticking together by a short range of physical force, (Ocheme *et al,*. 2002). They are usually formed by compacting and forcing the mixed feed through a die opening by a mechanical process. Pellet feeds are usually for animals like cattle, poultry, rabbits and even fish which are dominantly fed with pellet feeds.

2.2 Aquaculture and Aquaculture Review

Aquaculture is the practice of fish husbandry whereby fishes are kept and fed in confinement and managed to achieve quick growth and accelerate production. It is an economic venture where by the farmer is expected to make good return on his investment. Although the history of aquaculture is relatively recent in sub-Sahara Africa compared to Asia and some other parts of the world, most known aquaculture system have been introduced over the last 50 years (FAO, 1992).

Aquaculture is spread unevenly in the world. The epicenter of aquaculture is in Asia, which contributes 85% of the world total production, followed by Europe of about 7-10%. The three continents Africa, South America and Oceanic each contribute less than 1% to the total production (FAO, 1992).

The number of species for which aquaculture is developed is about 195 which include 92 species of fin fish (22 Species groups belonging to 12 order), 23 species of crustaceans, 36 species of *mollusks* and 44 species of aquatic plants (FAO, 1992). Although many species are cultured, relatively few are important commercially, Fin fish species are currently cultured, based on volume produced, the most important one belong to the order *cypriniformes, salmoniformes, siluriformes* and *anguilliformes.*

Apart from human consumption, aquaculture may be cultured for variety of other reasons, among which are

- Conservation, such as production of nature fish species to augment decline in wild stocks e.g. the Australian species trout and Murray cod.
- The maintenance of wild capture fisheries, such as the Japanese abalone fishery and Salmonid fisheries of the Pacific and the Atlantic.

- The production of ornamental fish for the aquarium industry e.g. gold fish.
- The production of industrial products such as pharmaceuticals.
- The production of specialized food sold as health products e.g. the algae specie *spirulina* and
- Environment manipulation such as removing of aquatic vegetation.

The aquaculture industry is divided into four major species groups:

Fin fish, crustaceans, mollusks and aquatic plants.

2.3 Diet Formation

Most aquaculture practices are semi-intensive and intensive, they differ from extensive practice in the sense that external feed input is required for the well-being of the fishes. The science of fish nutrition has advanced over the last 3-4 decades, primarily in response to development commercial aquaculture. Proper nutrition is one of the most essential factor influencing the ability of cultured organisms to attain the genetic potential for growth, reproduction and longevity. The nutrient requirements vary between species and within species between different stages of the life-cycle.

The main objective or aim of diet formulation and preparation is to utilize the knowledge of nutrient requirements, locally available feed ingredient and digestive capacity of the organism for the development of nutritionally balanced mixture of feedstuff which will be eaten in adequate amount to provide optimum production of the cultured organism at an acceptable cost. However, apart from nutritional value, cost and availability of ingredients, other considerations are pelletability of the resulting diet, anti-nutritional factor in the ingredients and diet acceptability (palatability). Diets which are expected to provide the

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- Nutrition requirement: it is of vital importance that a formulated feed meet the nutritional requirement of the cultured organism. Depending on the intensity of the culture, the feed may be expected to provide all nutrition required or only some of it. Moreover, taking into consideration of the species, strain, and state of the development and health, as well as temperature and environment conditions of the culture system.
- Composition of ingredients: the knowledge of the nutrient composition and available energy of the dietary ingredients is essential for their selection for the use in diet formulation. The composition of feed stuff are known to vary regionally, seasonally and also with soil fertility and of processing and storage. Feedstuff need to be screened for enzyme inhibition and indigenous toxin.
- Digestibility and nutrient availability: for compounded feed to perform correctly, the knowledge of digestibility of the individual nutrients of all the ingredients is essential. Apart from digestibility considerations, the bio-availability of certain nutrients in different feedstuffs needs to be taken into consideration.
- Other dietary components (additives): these are added to diet for physiological or economical reasons. They are usually added in small quantities and often may have no direct nutritional value and may not act as energy sources. When formulating appropriate diet, allowances need to be made for their inclusion, they include;

a) Synthetic amino acids such as L-lysine And DL-methonine. They are used as chemoathactants as well as to supplement deficiencies in a compounded feed

b) Vitamins: individual vitamins or premixes of vitamins prepared for special purpose are available. Vitamins are used to supplement for deficiencies in the ingredients of compounded feeds and also provide protection against lipid oxidation, enhancing its storage life, (Gatline *et al.* 1992).

c) Binders: Binders are substances used in diets to improve their pelletability, enhance their durability, and preserve their physical form during handling and storage and to preserve the water stability. Commonly used binders in compounded feed are *carboxymethylcallulose* (CMC), hemicelluloses, bentonites, agar, carageenin and collagen. Heat treatment during pellet process results. In carbohydrates gelatinizing, also provide good binding qualities to the resultant feed when high-carbohydrate ingredients are used.

d) Antioxidants are usually included in vitamins premixes or add to lipids to prevent or delay the onset rancity. Rancity make feeds unpalatable and generates toxic chemical. Antioxidant such as vitamin E (natural), BHT (butylated hydroxyl toluene), BHA (bytylatedhyroxyaqnislole) and ethoxyguin are commonly available.

e) Preservatives: these substances added to feeds to control the rate of deterioration, particularly from fungal attack. Most are sodium or potassium salts of propionic, benzoic or sorbic acid.

f) Chemo-attractants are synthetic chemical or natural ingredients containing elements, such as free amino acids, which elicit feed responses. Attractants are a mix of chemical comprising nitrogenous compound including free amino-acids, low molecular weight peptides nucleotide and related compound and organic bases.

g) Hormones are used in the culture of certain species with the view to enhance growth such as thyroid hormones and also the use of anabolic steroid in the diets during the fry stages with a view to obtaining population of a single sex, generally all male population of certain species.

h) Antibiotics are added to feed to treat disease. The use of antibiotics done supposedly as a prophylactic measure in some culture practices. Routine use of antibiotics in feed is not recommended as it leads to resistant strains of bacteria.

i) Carotene supplements are most important classes of pigment for fish and crustaceans. Canthaxatlin and astaxanthin add color to the flesh and eggs. High value culture such as salmon and red sea bream do not have the ability to convert xanthophylls to carotenoid, and therefore must receive these pigments in their diets. Carotenoid supplementation is provided to this specie by adding natural material containing the specific pigments such as *papnka*, krill Products and processing waste of shrimp and crab.

2.4 Forms of Feeds

They basically fall into one of two general forms i.e. dry and non dry (moist) feeds.

Dry feeds: are generally made from dry ingredients or mixture of dry and moist ingredients. The dry feeds are not entirely devoid of moisture; contain 6-10% water, depending on the environmental condition. Dry feed may be sub-divided into mashes or meals and those that are compacted into a defined shape, generally by mechanical means called pellet.

In conventional steam pelleting, mixture of dry ingredients is forced together to form large stable particles by the application of heat, moisture and mechanical pressure.

Non dry feeds: can be either wet or moist. Wet feed are those made from wet ingredients such as trash fish, slaughter house waste, undried forages and contain 45-70% moisture. Moist feed are made from mixtures of dry and wet material or from dry ingredients in which water is added and contain 18-40% moisture. However, the difference between these forms is not great.

2.5 Pellet Processing

The processes involved in pelleting of feed include grinding, mixing, pelletizing cutting and drying.

Grinding: reduces particle size and increases surface area of the ingredients, thereby facilitating mixing, pelleting and digestibility. The type of grinder mills used may vary. The most commonly used mill for grinding are plate mill and harmer mill.

Mixing: ground ingredients are mixed in the desired proportions to form a homogenous blend provided the sizes are uniform, segregation of ingredients is minimized and the blend should produce pellets of similar formulation. Generally, dry ingredients are mixed first, followed by liquid ingredients as mixing continues. Mixing can be done in batches or continuous. Continuous mixers are such that the materials moves through the mixer as it is been mixed. The type of mixers used varies and include horizontal, vertical and turbine mixers.

Pelleting: converts the homogenous blend of the ingredients into durable forms having physical characteristics that make them suitable for feeding. Maximum compaction is needed for good pellet quality. But compassion and capacity are antagonistic and hence economic balance has to be reached in the machine. In pelleting, a die and screw auger is involved, which then compresses the material into the die-holes. The process is continued until the pressure increases and moves the material through the die hole. The pellet that comes out of the die is cut or broken into a defined length.

There are two basic types of pellet that are made in aquaculture industry, these are compressed pellets and extruded pellets.

Compressed pelleting involves exposing the mixture to steam for 5-20 seconds, attaining 85^0 C and 16% moisture, followed by forcing the mix through a metal die. The combination of heat moisture and pressure, compresses the mixture into a compressed pellet which starch is gelatinized called steam pelleting. The pellet quality is influenced by fat level, moisture and humidity. Though fat level make the pellet unduly hard while high fat level make pelleting difficult. Excessive moisture results in soft pellet and insufficient moisture results in crumbly pellets.

Extruded pellets: involves the use of different physical conditions and results in a very different product. Here, the temperature is increased to about 125-150^0C in a pressurized conditioning chamber (20 seconds) and moisture is increased to about 20-24%, enhancing gelatinization of starch. This result in a mixture been made into dough-like consistency, which is then forced through a die at a high pressure.

As the pellet leaves the die, the fall in pressure causes the trapped water to evaporate and gelatinized material to expand forming air pocket. When cooled, the density is greatly reduced so that the pellet formed floats or sinks slowly.

Cutting: normally takes place immediately after pelletizing and it makes the pellet to have reasonable equal length. This can be achieved either by cutting manually with a knife/hand or with a knife edge placed on the shaft which cut the pellet as it comes out from the die by rotation.

Drying: This is done to reduce the moisture content present in the pellet feed. There are two methods of drying; namely sun drying and mechanical method.

The sun drying involves putting the pellet in the sun to allow it to dry. The mechanical method involves the use of fan (blower) and heating element to remove the moisture from the pellet. The mechanical method is more reliable as it is not dependent on the climatic condition of the environment and uses a shorter period of time to dry.

2.6 Types of Pellet Machine

The pellet machine is classified based on the relative importance of the various mechanism involved and the type of motion and speed. These include

- Pellet machine with screw(auger), extruder (extrusion system)
- Pellet machine with a flat diet and Muller type press roll (press system)
- Pellet machine with an internal press roller (roller system)

Roller system: the roller system consist of a hopper in which material fed into the machine, two rollers on each side which press material against the die for pellet to be formed by the use of rotary motion. The roller adjuster is to adjust the space between the roller and the die for effective performance of the machine.

Press system: this operates on a reciprocating motion of a press system to force the feed ingredient through the die to form pellet. The main mechanism of this machine is the die of required diameter and a press system.

Extrusion system: this operates on a rotary motion of the shaft (screw) which conveys and compresses the feed particle through the die opening to form pellet. The major components of this type of machine are the hopper, the auger (shaft) and die.

CHAPTER THREE

3.0. MATERIALS AND METHODS

3.1. Design Consideration

The following factors were considered while constructing the power operated pelletizing machine. (Hall *et al.*, 2002)

1. Availability of material
2. Type of material to be used
3. Durability of the materials
4. Cost of the materials.

3.2 Machine Description and Operation Procedure

The fish feed pelletizer is a machine operated by an electric motor. The power from the electric motor is transmitted through the V – grooved belt to the shaft with the aid of the pulleys. The shaft is attached to the pulley by means of a key (bolt), which holds both in place and they rotate as one body. The shaft is held in place by two bearings for proper rotation.

The rotary force is transmitted to the screw auger which developes friction force a as result of compression between the food formulated and the die. This force pushes the feed through the holes in the die causing pellet formation.

3.3 Descriptions of Component Parts of the Machine

1. Hopper
2. Screw auger (shaft)
3. The screw auger casing
4. Die

5. The Frame

3.4 Hopper Design

The hopper is chosen to be a rectangular based pyramid frustum, which is made of mild steel, is considered.

The selected dimensions are

Upper face of the hopper: 340mm by 340mm

Lower face of the hopper: 120mm by 120mm

Height of the hopper: 190mm

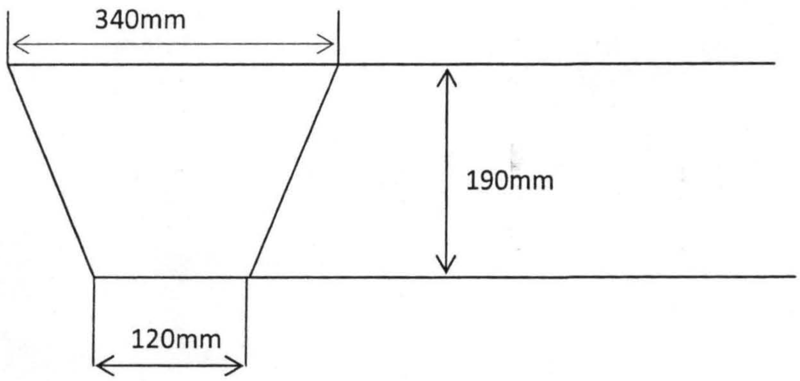

Fig.3.1: Sectional View of the Hopper (Frustum of Pyramid)

To calculate the volume of rectangular section by reproducing the complete triangle

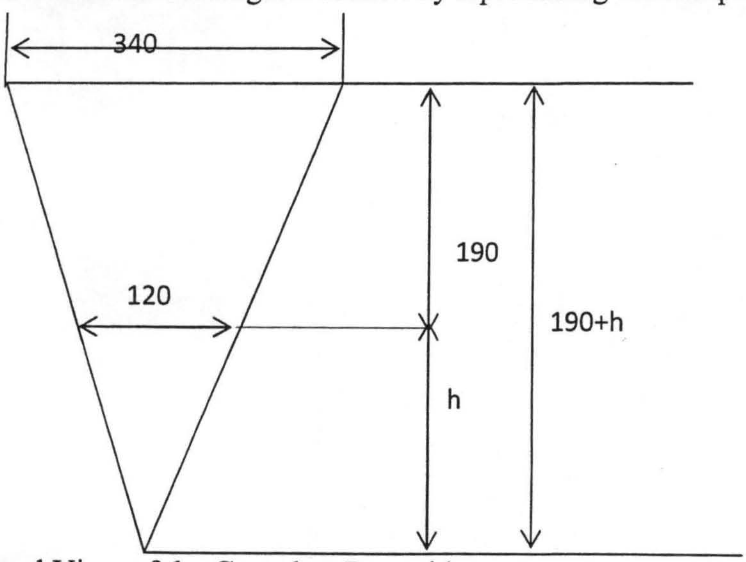

Fig. 3.1: Sectional View of the Complete Pyramid

Calculating for height h, the principle of similar triangle is used, Tuttuh *et al.*, (1998)

$$\frac{h}{120} = \frac{h+190}{340}$$

$$340h = 120(h+190)$$
$$340h = 120h + 22800$$
$$340 - 120h = 22800$$
$$220h = 22800$$
$$h = \frac{22800}{220}$$
$$h = 103.64mm$$

Height of the complete pyramid = 190 + 103.64

= 293.64mm

Volume of frustum = Volume of big pyramid – volume of small pyramid

Volume of pyramid = $\frac{1}{3} \times L \times B \times H$ Tuttuh *et al.,* (1998)

Where, L = 340 and l = 120

B = 340 b = 120

H = 293.64 h = 103.64

Volume of frustum = $\frac{1}{3}$(LBH – lbh)

= $\frac{1}{3}$ (340 x 340 x 293.64 – 120 x 120 x 103.64)

= 10817456 mm^3

= 0.0108m^3

Volume of hopper is 0.0108m^3

3.5 Die Design

The die is made from a circular plate of mild-stead of thickness of 100mm with a diameter of 67.5mm. A pellet size of 4.5mm was chosen for the screen holes in the die.

Die design calculation

Area $=\frac{\pi d^2}{4}$

$where\ \ d = diameter = 67.5mm$

$\pi = 3.142$

$$Area = \frac{\pi 67.5^2}{4}$$

$= 3578.93mm^2$

Area covered by die hole = Area of 1 hole x number of holes

Number of holes is 63

Area covered by die holes= $\frac{\pi \times 4.5^2 \times 63}{4}$

$=1002.01mm^2$

The area of the shaft that passes through the die as the shaft is reduced to a diameter of 8mm at the die.

Area of shaft = $\frac{\pi \times 8^2}{4}$

$= 50.27mm^2$

Area of the machined part of die = $1002{,}10 + 50.27$

$= 1052.37mm^2$

3.6 Shaft Design

Power of the electric motor 3.75Kw

Speed of the electric motor 1450rpm

Diameter of the driving pulley 70mm

The forces acting on the shaft is as follows;

- Axial load (Fa) due to the weight of the feed formula, tensions in the belt and weight of the driven pulley
- Torsional force as a result of rotation of the shaft
- The combined effect of these forces will cause;

i. Bending moment

ii. Torsional moment

iii. Compression

3.6.1 Determination of Torsional moment on the shaft

To calculate the torsional moment m_t, the speed of the driven pulley is determined by the relationship: $N_1 D_1 = N_2 D_2$ (3.1) (Hannah & Stephen, 1979)

$\frac{N_1}{N_2} = \frac{D_2}{D_1}$

Where

N1 = speed of the driving pulley, 1450 rpm

N2 = speed of the driven pulley, rpm

D1 = Diameter of the driving pulley, 70mm

D2 = Diameter of the driven pulley, 200mm

Inputting data

$$\frac{1450}{N_2} = \frac{200}{70}$$

$$N_2 = 507.5rpm$$

The torque (T) on the shaft can be calculated from the formula

$T = power \times \frac{60}{2\pi N_2}$

$= \frac{3.75\times10^3\times60}{2\pi\times507.5}$

$$= 70.552Nm$$

$= 70552Nm$

Therefore, Torsional Moment (M_t), $= \frac{16T}{\pi D^3}$ (3.2) (Khumi&Gulpta, 2006)

$M_t = \frac{16\times70552}{\pi D^3}$

$= \frac{359271.8}{D^3}$

$$WhereD = diameteroftheshaft$$

3.6.2. Determination of the Tension in the Belt

The belt is a V-grooved which is inclined at 30^O to the horizontal. The following formula can be used to determine the tight and slack side tension. The belt is inclined at an angle of 30^O to the horizontal

$T = (t_1 - t_2)R$ (3.3) (Shigley&Mischke, 2001)

$\frac{t_1}{t_2} = e^{\mu cosec\beta}$ (3.4)

Where

T = Torque

R = Radius of the driven pulley

t_1 = Tight side tension of the belt

t_2 = Slack side tension of the belt

μ = co-efficient of friction (0.3)

θ = Angle of wrap or contact

2β = Groove angle of the pulley (36^O)

$$\theta = \frac{(180-2\alpha)\pi}{180} \qquad (3.5)$$

$$sin\alpha = \frac{r_1-r_2}{180} \qquad (3.6.)$$

Where r_l	=	Radius of the driven pulley, 100mm
r_2	=	Radius of the driving pulley, 35mm
x	=	Distance between pulleys, 500mm

Inputting Data

$$sin\alpha = \frac{100-35}{180}$$

$$\alpha = 7.47^o$$

Substituting 7.47 for α in (3.5)

$$\theta = \frac{(180-2\times 7.47)\pi}{180}$$

$$= 2.88rad$$

$$\frac{t_1}{t_2} = e^{0.3(1 \div sin18)}$$

$$t_{1=16.38t_2}$$

Substitute $16.38t_2$ for t_1 in (3.3)

$$70552 = (16.38t_2 - t_2)100$$

$$t_2 = \frac{70552}{15.38}$$

$$t_2 = 45.87N$$

$$t_1 = 16.38 \times 45.87$$

$$= 715.35N$$

3.6.3 Determination of Bending Moment

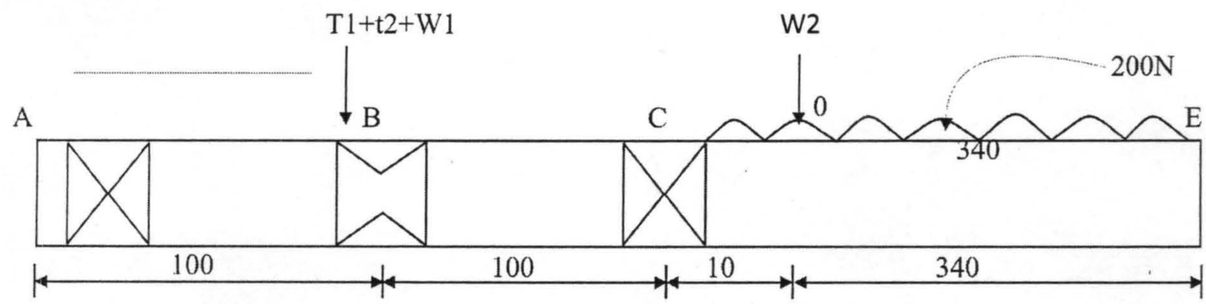

Fig. 3.3: Shaft Design (all dimension in mm)

Total load at B = $t_1+t_2+W_1$

Where W_1=weight of pulley = 100N

But the belt is inclined at 30^O to the horizontal

Effective tension for t_1

Horizontal component = $t_1 sin30$ = 375.67N

Vertical component = $t_1 Cos\theta$ = 650.69N

Similarly effective tension for t_2

Horizontal component = $t_2 sin30$ = 22.94N

Vertical component = $t_2 Cos\theta$ = 39.72N

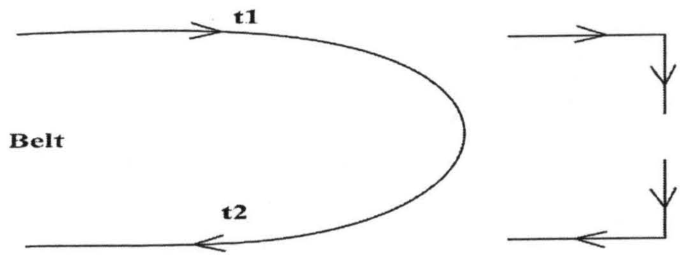

Fig.3.4: Diagram Showing the Direction of Forces on the Pulley

Resolution of Forces

Vertical Component = 39.72 + 650.69N (Khurmi 2007)

= 690.41N

Horizontal Component = 375.68 – 22.94

= 352.74N

Effective force of the shaft = 690.41N

Therefore at B = 690.41 + 100 = 790.41N

Force at D = W_2, weight of feed formula

$$W_2 = 850 \times 0.0108 \times 9.81$$
$$= 90.06N$$

The uniform load between CF will have its centre of gravity at the midpoint between CF. i.e. 175mm.

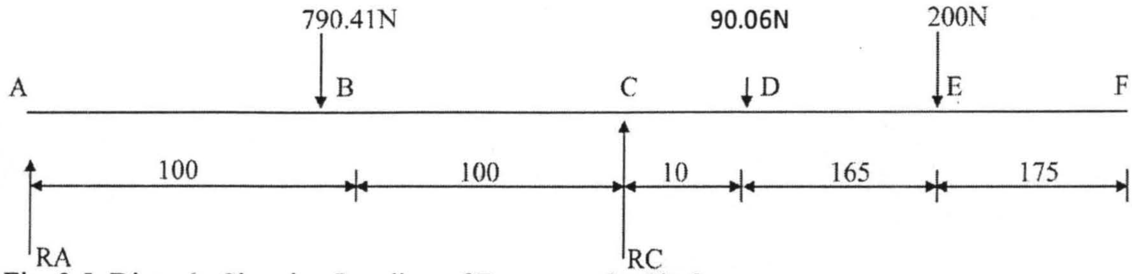

Fig. 3.5: Diagram Showing Loading of Forces on the Shaft

Resolution of Forces

$$RA + RC = 1080.47$$

$$RC = 1080.47 - RA \qquad (3.7)$$

Taking Moment at C

$$\sum MC + \hat{C} = 0$$

$$RA \times 200 - 790.41 \times 100 + 90.06 \times 10 + 200 \times 175 = 0$$

$$RA = \frac{43140.4}{200}$$

$$= 215.70N$$

$$RC = 1080.47 - 215.70$$

$$= 864.77N$$

Bending Moment at A and F = 0

BM at B = 790.41 x 100 = 79041Nmm

BM at C = -864.77×10 = -8647.7Nmm

BM at D = 90.06×10 = 900.6Nmm

BM at E = 200×175 = 35000Nmm

Therefore, maximum bending moment is 79041Nmm.

Shear force (sf);

At A, $sf_a = 215.7$

B, $sf_b = 215.7 - 790.41 = -574.71N$

C, $sf_c = -574.71 + 864.77 = 290.06N$

D, $sf_d = 290.06 - 90.06 = 200N$

s E, $sf_e = 200 - \left(200 \times \frac{1}{2}\right) =$ F, $sf_f = 100N$

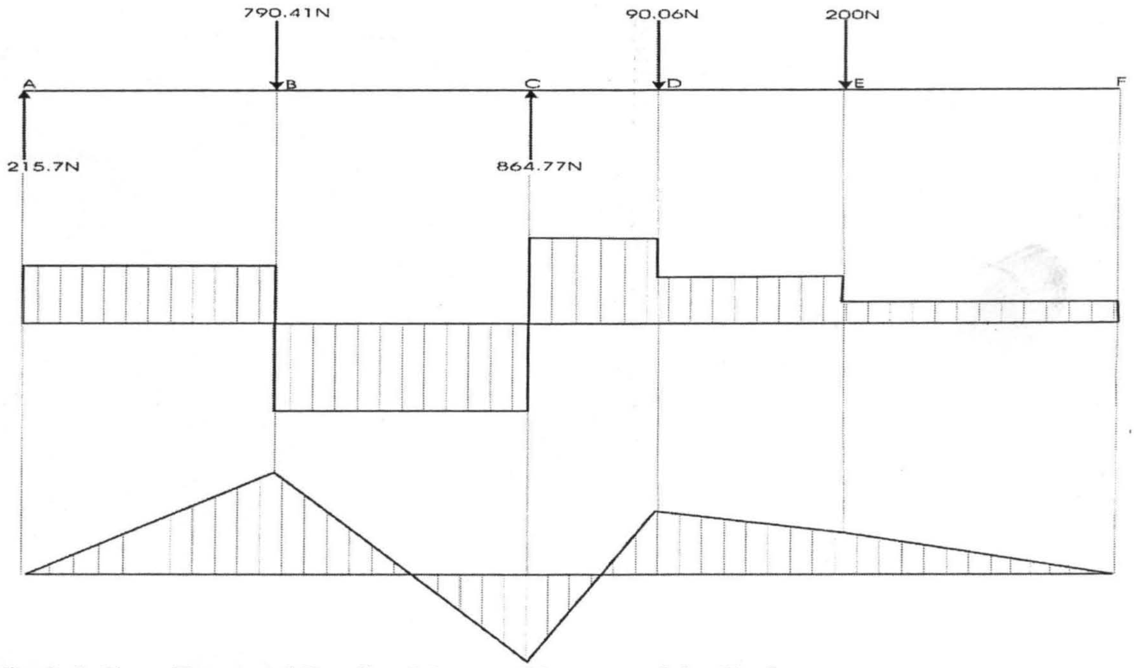

Fig. 3.6: Shear Force and Bending Moment Diagrams of the Shaft

3.6.4 Determination of Axial Load (Fa)

Total Force on the shaft = 790.41 + 90.06 + 200 = 1080.47 (Shigley&Mischke, 2001)

$$Fa = \frac{1080.47 \times 4}{\pi D^2}$$

$$= \frac{1375.52}{D^2} N / mm^2$$

3.6.5 Determination of Shaft Diameter

The ASME Code for Solid Shaft with combine's torsions, bending moment and axial load, apply the maximum sheer stress equation modified by introducing the shock and fatigue factors as follows;

$$Sa = \frac{16}{\pi D^3} \sqrt{((K_b M_b + \frac{F_a}{8})^2 + (M_t K_t)^2)} \qquad (3.8) \quad \text{(Adeyemi, 2008)}$$

Where Mt = torsional moment $\frac{359271.8}{D^3} N / mm^2$

Mb = bending moment 79041N/mm

Fa = axial load, $\frac{1375.52}{D^2} N / mm^2$

Sa = allowable stress for steel as 550 but reduced to 420Mpa for allowance for keyway

$K_t = 1.0$ and $K_b = 1.5$

Substituting Data

$$420 = \frac{16}{\pi D^3} \sqrt{\left(1.5 \times 791041 + \frac{1375.52D}{8D^2}\right)^2 + (\frac{35971.80}{D^3})^2}$$

$$82.48D^3 = \sqrt{(118651.5 + \frac{171.94}{D})^2 + (\frac{359271.80}{D^3})^2}$$

Table 3.1: Showing Various Diameter of the Shaft

d (mm)	$82.48D^3$	$\sqrt{(118651.5+\frac{171.94}{D})^2+(\frac{359271.80}{D^3})^2}$
0	0	0
5	10310	1186599
10	82480	1186579
15	278370	1186573
20	659840	1186570
25	1288750	1186568

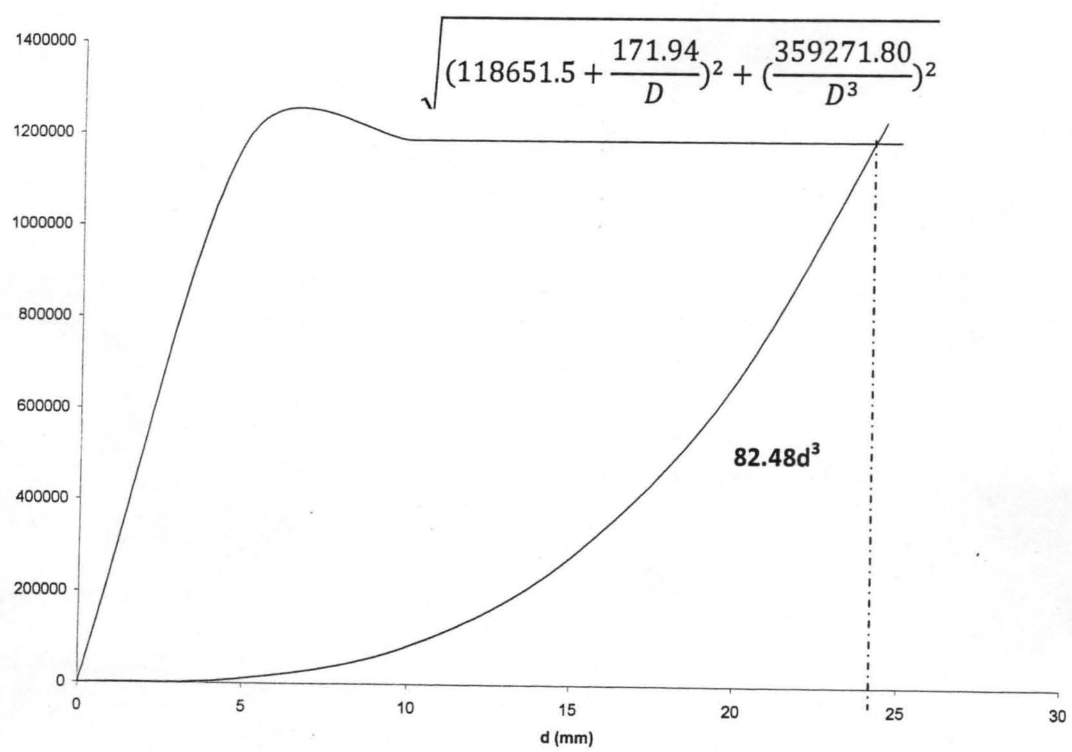

Fig. 3.7: Graph Showing the Diameter of the Shaft

From the graph $d = 24mm$

Therefore $d = 25mm$

3.7 Design of the Screw Auger Casing

The screw auger casing was made from a hollow pipe of external and internal diameter of 75mm and 67.5mm respectively. The length of the pipe is 350mm. Using the failure of a cylindrical shell due to internal pressure, for the vessel to be considered a thin or thick shel,l the relationship (Shigley&Mischke, 2001):

$t/d_1 > 0.05$ for a thick shell and $t/d_1 < 0.05$ for a thin shell

Where, t= $(d-d_i)/2$

And d = external diameter, 75mm

d_i = internal diameter, 67.5mm

$$\therefore t = \frac{75 - 67.5}{2}$$
$$t = 3.75mm$$
$$and\ t/d = \frac{3.75}{67.5}$$
$$= 0.056$$

Therefore the cylinder is a thick shell

Circumferential Stress $\sigma_c = \dfrac{P.r^2}{R^2 - r^2}$ (3.9) (Shigley&Mischke, 2001)

Where P = intensity of internal Pressure

R = external Radius (37.5mm)

r = internal radius (33.75mm)

But, pressure = Force/Area

$$and\ Area = \frac{\pi(67.5)^2}{4}$$
$$= 3.578.93smm^2$$
$$force = \frac{torque}{radius}$$
$$T = 70552$$

Radius= (R_m-R_n)

R_m=major radius of screw: 33mm

R_n=minor radius of screw: 12.5mm

$$force = \frac{70552}{33 - 12.5}$$
$$f = 34415.56$$
$$p = \frac{341.56}{3421.64}$$
$$P = .1.00Mpa$$

Therefore $\sigma_C = \frac{1 \times 33.752}{37.5^2 - 33.75^2}$

$$= 4.263N/mm^2$$
$$= 4.263Mpa$$

Comparing this result (4.263Mpas) with the maximum stress of mid-steal (430Mpa), the casing will not fail due to internal pressure.

3.8 Determination of the Belt length

The belt length is given by

$$L = \pi(r_1 + r_2) + 2x + \frac{(r1 + r2)^2}{x} \qquad (3.10)\ \text{(Hannah\& Stephen, 1979)}$$

Where r_1 = radius of driving pulley; 35mm

r_2 = radius of driven pulley; 100mm

x = distance between pulleys; 500mm

Therefore;

$$L = \pi(35+100) + 2\times 500 + \frac{(35+100)^2}{500}$$
$$= 1460.62mm(57.50inches)$$

3.9 Determination of Extrusion Pressure

The extraction force computed from

$$Fe = \rho e \times A \qquad (3.11)$$

Where $\rho e = 4.263 Mpa$

$A = Area,$

$$and\ A = \frac{\pi d^2}{4} = \frac{\pi(67.5)^2}{4}$$
$$= 3578.93mm^2$$
$$= 0.003579m^2 \quad Fe = 4263000 \times 0.003579 = 15261.54N$$

But the extruding pressure of the die is given as

$$\rho e = \frac{Fe}{An}$$

Where n = 63(number of the die holes)

A = area of die

$$A = \frac{\pi(4.5)^2}{4}$$
$$A = 15.91mm^2$$

Therefore;

$$pe = \frac{15261.54}{15.91 \times 10^{-6} \times 63}$$

$= 15226063.27N/m^2$

$= 15.23Mpa$

3.10 Determination of Power required in operating the Machine

Power needed to operate the machine is given by

$P = \frac{T \times 2\pi N}{60}$ = (Khurmi & Gupta, 2005)

Where P = Power

T = Torque; 70.552Nm

N = Speed; 507.5rpm

$$= \frac{70.552 \times 2\pi \times 507.5}{60}$$

$= 3749.99W$

$= 3.75kW$

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Testing

The fish pelletizing machine was assembled together after all the component parts were designed and fabricated. The performance evaluation of the pelletizer was carried out with a 3hp electric motor, a speed of 1450 rpm was used to run the fish feed pelletizer.

The testing was done using 2.5kg of fish feed made from groundnut cake, maize, toasted soya bean, bone meal, palm oil, common salt, vitamin, premix, lysine, methonine, and cassava. Cassava served as the binding agent. Table 4.1 shows the composition of the feed mix.

The feed was gradually increased until the machine was fully loaded; 500g of water was added to the feed mix to allow free flow of the material in the machine. The pellet was collected at the point of the die and allowed to dry. The process was timed from the introduction of the feed formula to the time it took to pass through the machine. The output was observed by visual inspection, the pellet feeds, broken pellets and those remaining in the machine were sorted and weigh.

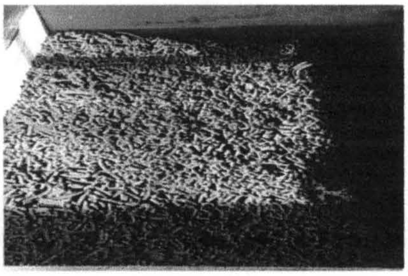

Plate 4.1: Pelletized feed

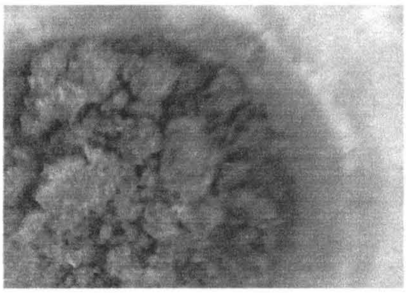

Plate 4.2: Feed mixed before pelletizing

Table 4.1: Material Composition

Ingredient	Weight (g)	Percentage Composition (%)
Soya bean	400	16
Groundnut cake	600	24
Fish meal (72)	500	20
Maize	400	16
Palm oil	200	8
Cassava	300	12
Bone meal	10	0.4
Common salt	10	0.4
Vitamin premix	20	0.8
Lysine	50	2
Methonine	10	0.4
Total	2500	100

4.2 Results

The following results were obtained after the tests were carried out using 3000g of the feed mixed for each test

Table 4.2: Shows the Amount of Feed Pelletized with Time and the Amount of Feed Pelletized and Cut with Time.

S/N	Pelletized Feed (g)	Time (s)	Pelletized and Cutting (g)	Time (s)
1	2550	300	600	300
2	2650	305	1620	620
3	2800	315	1800	650
Mean(X)	2667±125.83	307±7.64	1340±647.15	523±194

4.3 Discussion

The performance parameter used in evaluating and computing the efficiency of the machine using throughput method, include

- Pelletizing efficiency η_p (%): this is defined as the ratio of the quantity of the feed pelletized to the ratio of total quantity of the feed meal formula introduced into the machine.
- Cutting efficiency η_c (%): defined as the ratio of the quantity of pellet cut with equal length to the total quantity of pellet produced.

Pelleting Efficiency $(\eta_p) = \frac{Xp}{Qi} \times 100\%$. (4.2)

Where,

η_p=pelletizing efficiency (%)

X_p= Average quantity pelletized 2667g

Q_i= quantity introduced to machine 3000g

$_p\eta = \frac{2667}{3000} \times 100$

$_p\eta = 88.9\%$

And

$\eta_{pc} = \frac{Xpc}{Qi} \times 100\%$. (4.2)

Where

η_c=cutting efficiency (%)

X_{pc}=quantity of cut pellet 1240g

$\eta_c = \frac{1240}{3000} \times 100$

$\eta_c = 41.3\%$

Therefore, $\eta = \frac{\eta c + \eta p}{2}$ (4.3)

Where, η =average efficiency

$\eta = \frac{88.9+41.3}{2}$

η =65.1%

The pelletizing capacity (Rate) is the quantity pelletized in kilogram per hour

$P = \frac{X_p}{T}$ (4.4)

P=pelletizing capacity (kg/h)

T = Average time taken, 307s (0.085h)

X_p= Average Quantity pelletized 2667kg

Therefore, pellet rate;

$P = \frac{2667 \times 10^{-3}}{0.085}$

P_c= 31.4kg/h

Similarly, pelletizing + cutting capacity (p_{pc}) (kg/h)

X_{pc}= Average Quantity pelletized and cut 1.24kg

T_{pc}= Average time taken for (pelletizing + cutting), 523s (0.145h)

$P_{pc} = \frac{1240\, x 10^{-3}}{0.145}$

= 8.6kg/h

4.4 Material, Specification and Cost of the machine

The cost and material specification of each part of the machine are given in table 4.3

Table 4.3: Material Specification and Cost

Material	Specification (mm)	Quantity	Amount(₦)
Die	ϕ75 x10	1	300
Shaft	ϕ25 x 600	1	500
Iron sheet	350 x 1200 × 4	2	3000
Angular Iron	5500 x 40 x 40 x 25	1.5	1800
Bearing	ϕ25	2	500
Pulley	ϕ200	1	800
	ϕ70	1	500
Bolt & Nut	17	6	200
Electrode	Gauge 12	50	1000
Iron Pipe	ϕ75 x 400 x 3.75	1	500
Belt	A40	1	200
I beam Iron	250 x (100 x 55) x 50	1	500
Paint		1	250
Electric Motor	3hp	1	17000
		Total:	₦27050

Cost of material (M_{ac}) is ₦27050, from table 4.4.1

Labour cost (L_c): is the amount paid for labour of the machine, this include welding turning, cutting and bending. It is 20% of material cost, which is ₦5410

Miscellaneous cost (M_c): is the amount spending on transportation and call in order to purchase the material needed for the fabrication of the machine. It is 5% of material, ₦1353

Total cost = $M_{ac} + M_c + L_c$

= 27050 + 5410 + 1353

= ₦33813

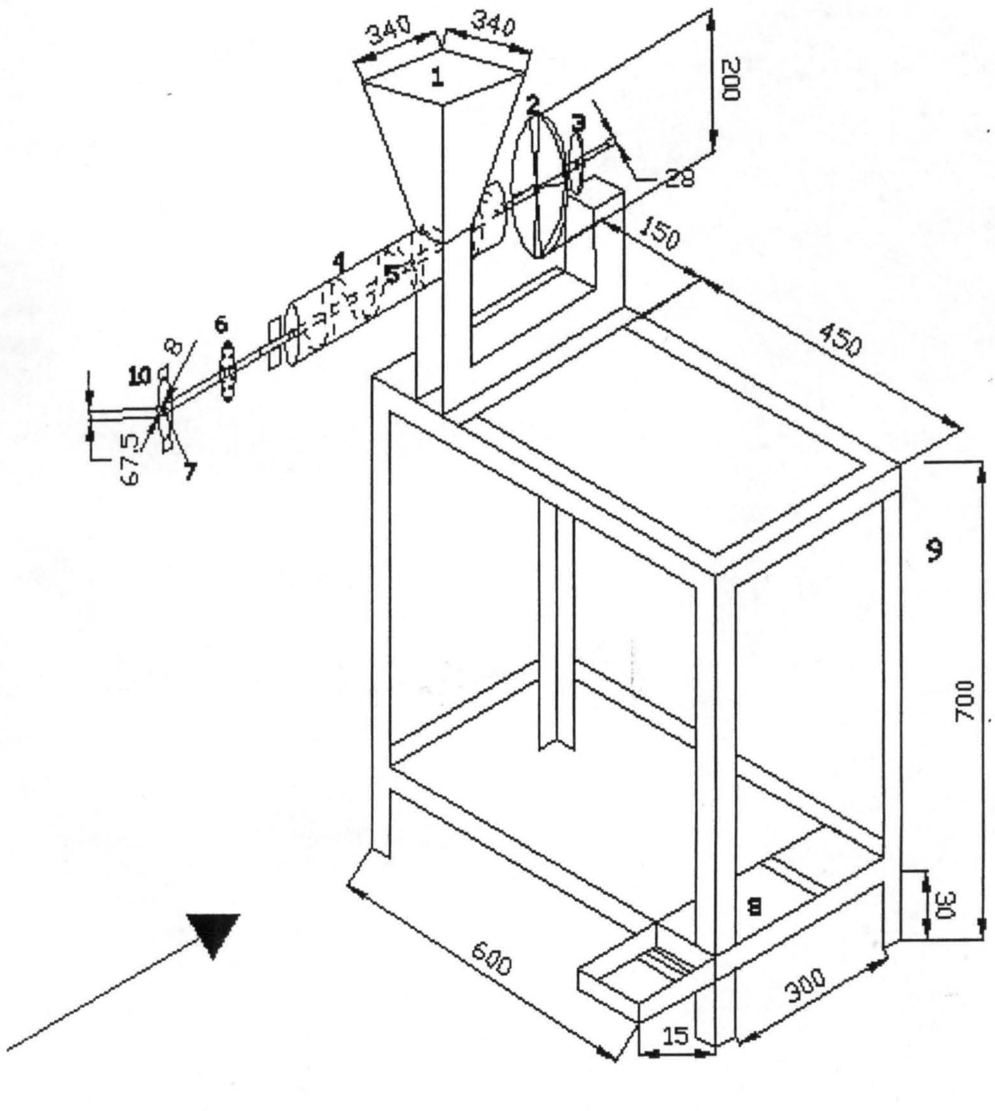

Fig. 4.1: Diagram of the Pelletizer with Frame (Isometric View)

Legend

1. Hopper 2. Pulley 3. Bearing 4.Screw case

5. Screw auger (Shaft) 6.Die 7.Cutting blade

8.Position for motor 9.Frame 10.Die positioner

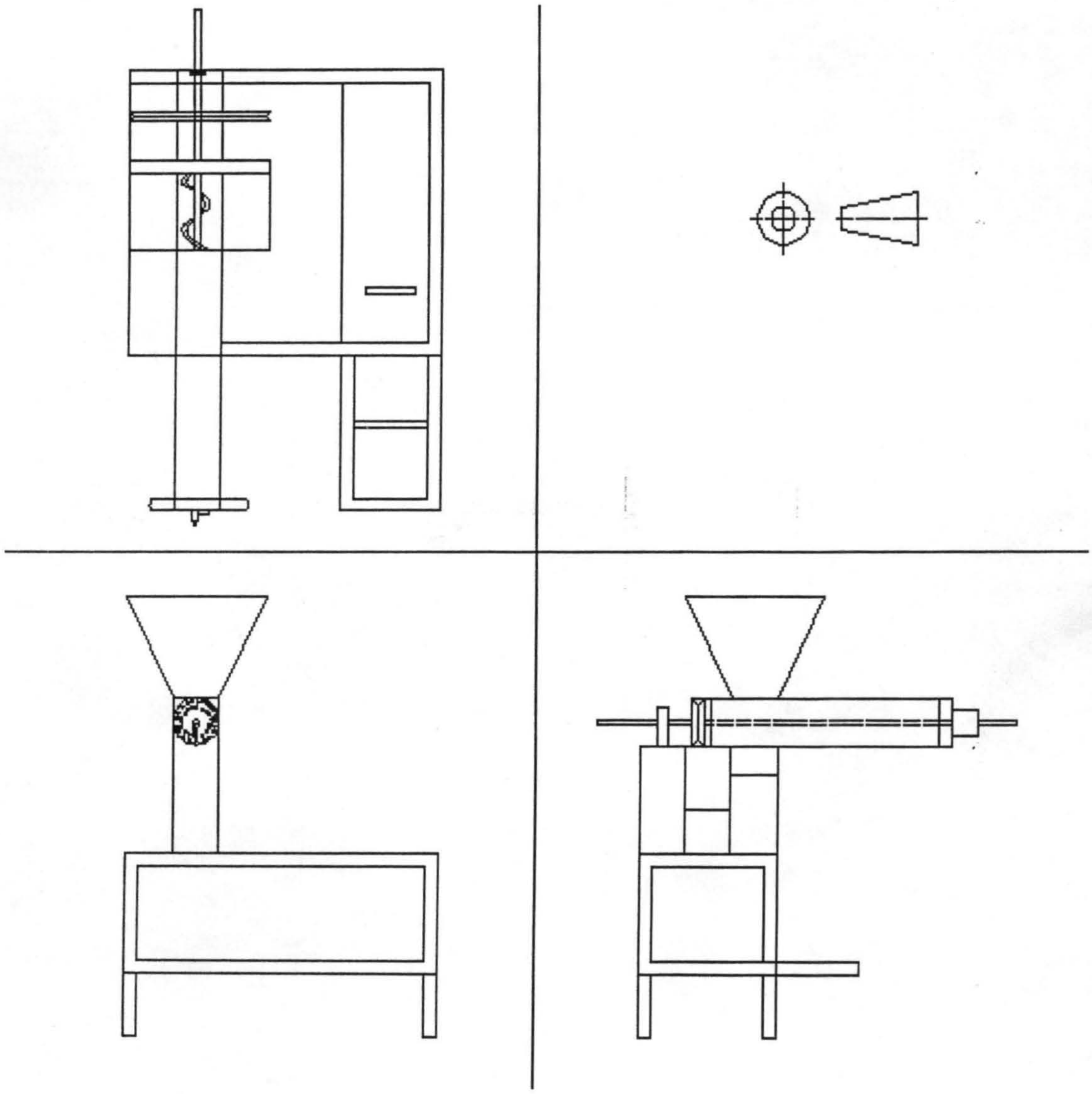

Fig. 4.2: Orthographic View of the Pelletizer

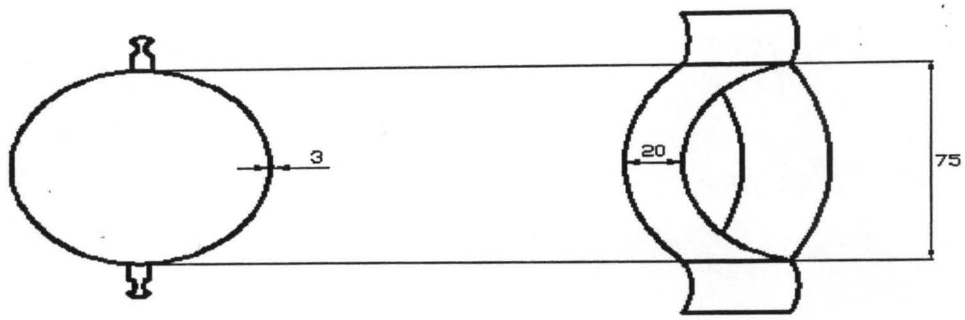

Fig. 4.3: Die Holder

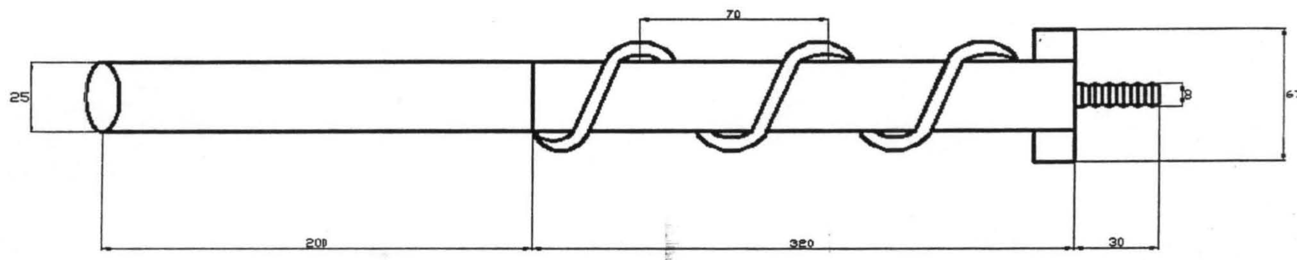

Fig. 4.4: Shaft with Screw Thread

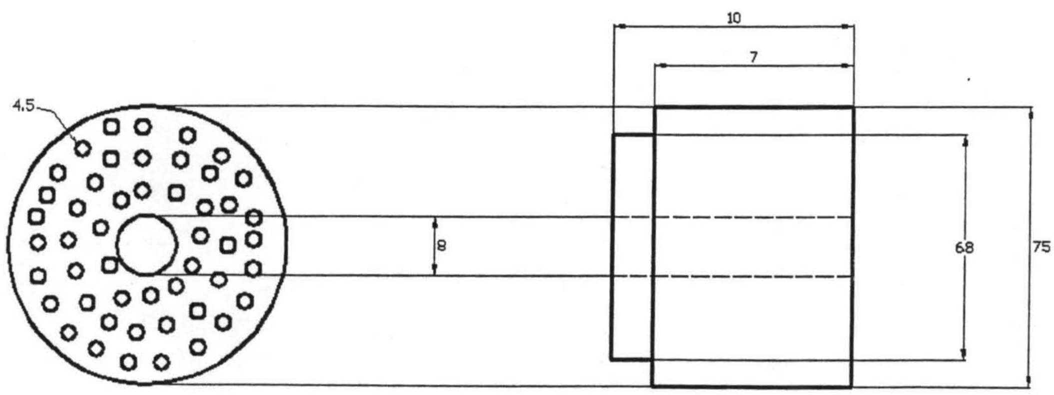

Fig. 4.5: Die

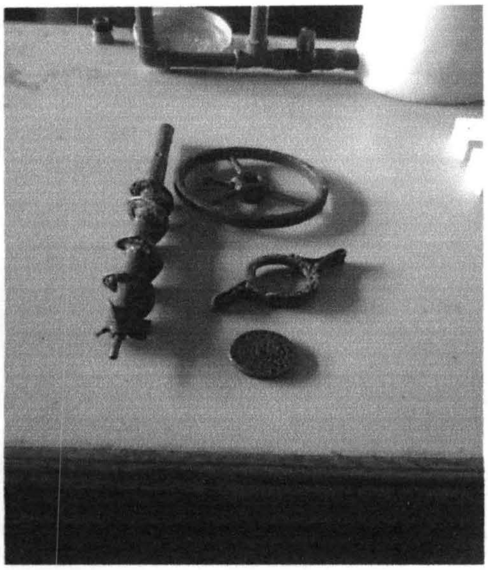

Plate 4.3: Parts of the pelletizer

(screw shaft, pulley, die and die holder)

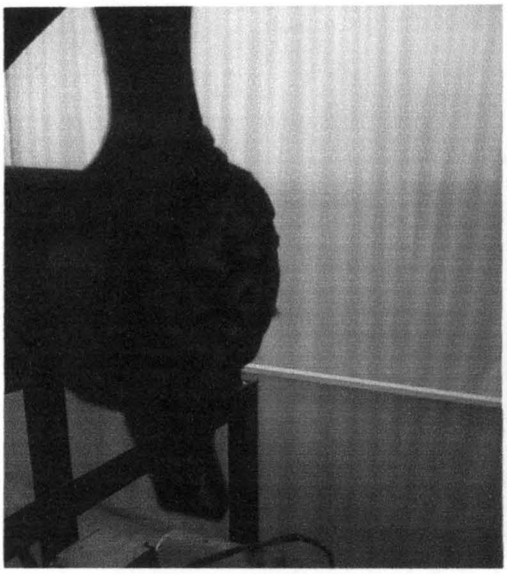

Plate 4.4: Pelleted and cut feeds coming out of

the pelletizer

Plate 4.5: Pellets without cutting coming out the pelletizer

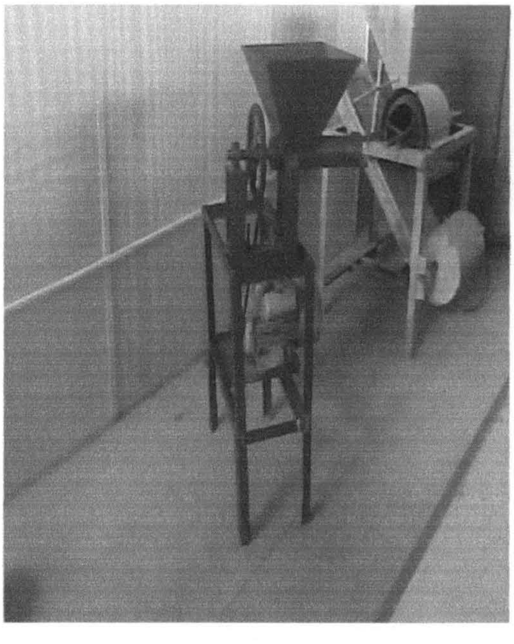

Plate 4.6: The complete assembly of the fish pelletizer

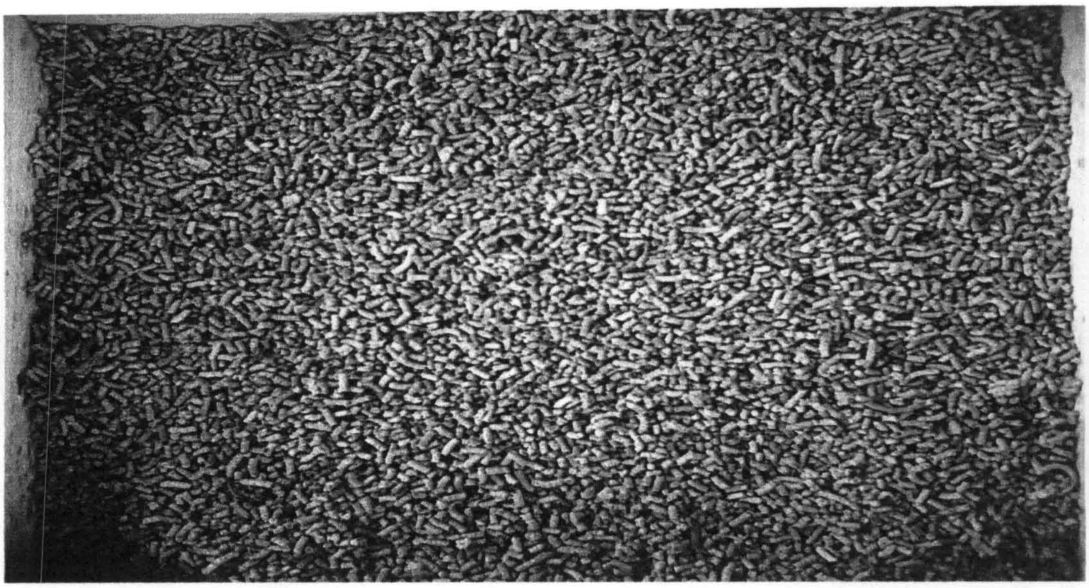

Plate 4.7:Pelletized and cut Feeds

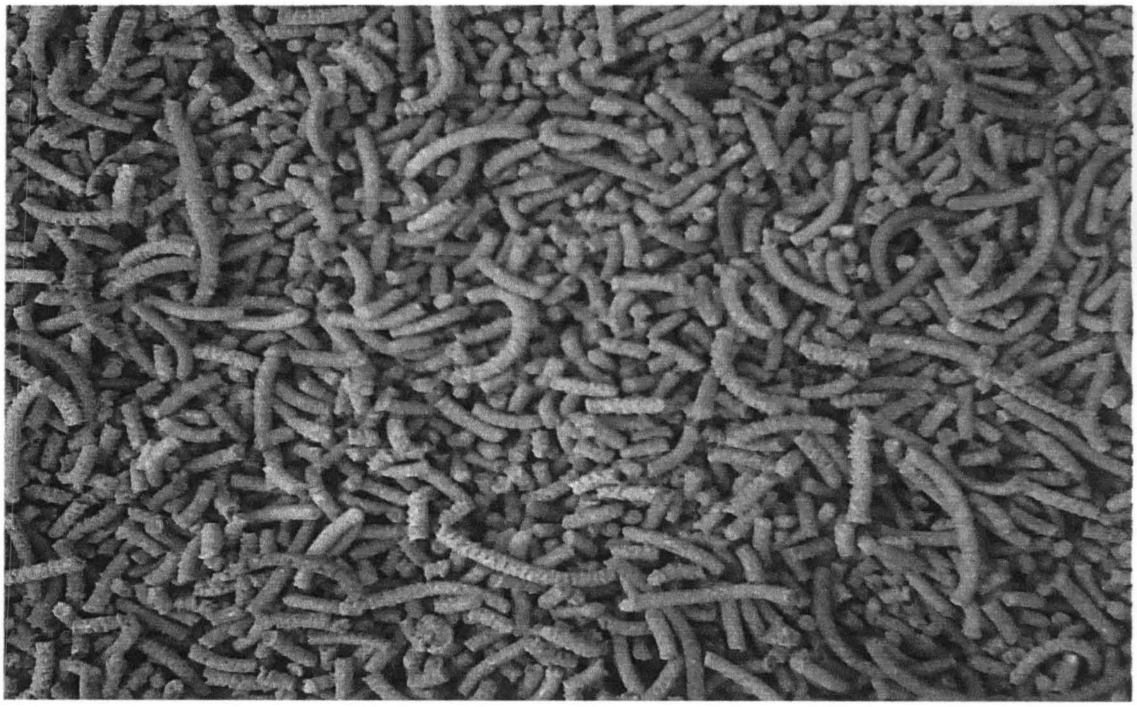

Plate 4.8: Pelletized Feeds

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From the results, it can be seen that the fish feed pelletizing machine is highly effective and has a low cost which is affordable and easy to operate. The pellets produced were homogenous and uniform in terms of shape and size.

5.2 Recommendations

Although, the pelletizer is highly effective, more work is needed to bring it to perfection. The following recommendations should be adopted to produce a pelletizer that will produce floating pellets;

The shaft should be machined on a lathe machine to form the screw auger.

The screw case and shaft should be made from stainless steel to minimize the decomposition of iron compound into the feed.

Heating element should be incorporated on the screw case to ensure high pressure and temperature.

A blower system should be incorporated to the pelletizer to ensure fast drying and formation of air pocket.

The cutting blade should be very sharp and thin for better cutting ability.

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