DESIGN AND DEVELOPMENT O: AN ELECTRICALLY OPERATED NEEM (*Azadirachta ind*) SEED OIL EXPELLER

BY

YUNUSA AROME LAWAL

MATRIC. No. 2005/21679EA

DEPARTMENT OF AGRICULTURAL AND BIORESOURCES ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.

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BEING A FINAL YEAR PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B. ENG.) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE

JANUARY, 2011.

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 Information derived from personal communications, published and unpublished work were duly referenced in the text.

Yunusa, Arome Lawal

25 - 01 - 2011

Date

CERTIFICATION

This is to certify that the project entitled "Design and Development of an Electrically Operated Neem (*Azadiracha indica*) seed oil expeller" by Yunusa, Arome Lawal 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.

24/01/11

Mrs. B. A. Orhevba
Supervisor

Date

24/01/2011

Engr. Dr. A. A. Balami
Head of Department

Date

13/01/2011

External Examiner

Date

DEDICATION

Blessed Trinity, my life and my hope, kneeling before the throne of grace to say thank you for blessing the work of my hands, specially dedicate this work to you. I also dedicate this work to my dearly beloved parents, Mr. and Mrs. Dandy Yunusa.

ACKNOWLEDGEMENTS

All praises to him that sits upon the throne and maketh the earth His footstool, the one that sets the cloud as the sign of his vow never to destroy the earth with water again. This is the Lord Almighty. Thanks for being my shield in the time of trouble, my defender in the time of war and my provider in the time of lack. Thanks for the completion of this project.

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ABSTRACT

This project is the design and development of an electrically operated neem seed oil expeller. The machine was designed and developed for bringing oil out of neem seeds and the steps include the design stage, material selection, construction and testing . Its efficiency was tested to be 47.7%. The machine is made up of different parts, units and components which include the Hopper, Crushing unit, Expelling chamber, Frame stand, Power transmission components and Heating filament. The seeds used for the testing of the machine were pre treated before use by drying to a moisture content of 10.8% wb. The machine operates at a speed of 60 revolutions per minute with 47.7% efficiency, and has a throughput of 12.19kg/hr an improvement in the design can be achieved by increasing the throughput of the machine and lagging of the heating compartment.

TABLE OF CONTENTS

CHAPTER FOUR

CHAPTER FIVE

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICIES

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the study

Neem (*Azadirachta indica*) is a tree in the mahogany family *Meliacae*. It is one of two species in the genus *Azadirachta* and is native to India, Myanmar, Bangladesh, Sri Lanka, Malaysia and Pakistan, growing rapidly in tropical and semi-tropical climate. Other vernacular names include Neem (Hindu, Urdu and Bengali) and many other names. It is fast growing, can survive drought and poor soil and keeps its leaves all year round. It is a tall tree, up to 30 meters high, with leafy spreading branches. Many white flowers with smell of honey appear for the first time when the tree is 2 to 3 years old, and the tree bears fruit after 3 to 5 years. The ripe fruits are about 2 centimeters (cm) long and oval shaped. Inside the fruit there is a light-colored seed about 1.5 cm long. (Schmutterer, 2002)

The Neem tree is a subtropical tree which is native to the arid region of India, Pakistan, Sri Lanka and part of Southeast Asia and Western Africa. Once or twice a year it bears a yellow bitter fruit. The fruit contains a seed composed of a kernel and a husk. Neem tree is characterized by the trunk which is relatively short, straight and may reach a diameter of 1.2 m (about 4 feet). It is classified as a bush, the leaves are 20-40 cm (8 to 16 in.) long, with 20 to 31 medium to dark green leaflets about 3-8 cm (1 to 3 in.) long. The terminal leaflet is often missing. The petioles are short. Very young leaves are reddish to purplish in colour. The shape of mature leaflets is more or less asymmetric and their margins are dentate with the exception of the base of their basiscopal half, which is normally very strongly reduced and cuneate or wedge-shaped. The (white and gragrant) flowers which are arranged auxiliary, normally in more-or-less drooping panicles which are up to 25 cm (10 in.) long. The inflorescences, which branch up to the third degree, bear from 150 to 250 flowers. An individual flower is 5-6 mm long and 8-11 mm wide and 8-11 mm wide. Protandrous bisexual flowers and male flowers exist on the same individual. Flowers are used to make a curry called *ugadipachadi, Azardirachta indica* fruit is a smooth (glabrous) olive-like drupe which varies in shape from elongate oval to nearly roundish, and when ripe are 1.4-2.8 x 1.0-1.5 cm. The fruit skin (exocarp) is thin and the bitter-sweet pulp (mesocarp) is yellowish-white and very fibrous. The mesocarp is 0.3-05 cm thick. The white, hard inner shell (endocarp) of the fruit encloses one, rarely two or three, elongated seeds (kernels) having a brown seed coat. Neem trees can be grown in areas which have between 400 millimeters (mm) and 1500mm of rain each year. It performs best at an altitude of less than 1,500 meters. (Puri, 1999)

1.2 Oils

Oils from plants are classified as vegetable oil. The largest sources of vegetable oils are annual plants which include soybean, cotton seeds, groundnut, sunflower, rapeseed, melon and sesame seed. Other sources are oil bearing perennial plant such as olive, coconut, cashew, palm fruit, neem oil etc. (Fellow, 2003). Vegetable oil provides twice as much energy as the same quantity of carbohydrate and it is therefore considered to be valuable part of a balanced diet. Oil also contains range of fat soluble vitamins (A, D, E, and K) and essential fatty acids, all of which are necessary for healthy functioning of the body (Wikipedia 2010)

Neem oil is a vegetable oil pressed from fruits and seeds of neem (*Azadirachta indica*). The neem tree is an evergreen tree which is endemic to the Indian subcontinent and has been introduced to many other areas in the tropics. It is perhaps the most important of the commercially available products of neem for organic farming and medicines. It is not used for cooking purposes, but in Indian and Bangladeshi, it is used for preparing cosmetics (soap, hair products, body hygiene creams, hand creams) and traditional medicine; in the treatment of wide range of afflictions. The most frequently reported indications are skin diseases, inflammations and fevers, and more recently rheumatic disorders, insect repellent and insecticide effects (Ekanem, 1971). It is generally light to dark brown, bitter and has rather strong odour which is the combine odours of peanut and garlic. It comprises mainly of triglycerides and large amounts of triterpenoid compounds, which are responsible for the bitter taste. It is hydrophobic in nature and in order to emulsify it in water for application purposes, it must be formulated with appropriate surfactants, (Gerpen, 2008).

Rajeev, (2009) reported that neem oil also contains steroids (campestrol, beta-sitosterol, stigmasterol) and a plethora of triterpenoids of which Azadirachin is the most well-known and studied. The *Azadirachtin* content of neem oil varies from 300ppm to over 2500ppm depending on the extraction technology and quality of the neem seeds.

1.3 Oil Extraction

Oil extraction is the process of recovering oil from oil-bearing agricultural seeds (Eteng, 2008). The traditional method for oil extraction is usually a tedious process and labour intensive. The various stages involved in traditional method of processing differ somewhat from place to place, thus it will not be feasible to record all minor variations. The oil can be obtained through pressing (crushing) of the seed kernel both through cold pressing and through a process of incorporating temperature controls. The flesh is first removed from the seeds of fruits been harvested for neem oil. The cleaned seeds are dried in the shade and stored in a cool, dry place. Dried seed can be stored from 8 to 12 months awaiting oil extraction.

Neem oil also can be obtained by solvent extraction from the seed, fruit, oil, cake or kernel. This solvent-extracted oil is of lower quality as compared to the cold pressed oil and is mostly used for soap manufacturing. Neem cake is a by-product obtained in the solvent and large capacity operations. In the production process the method used is likely to affect the composition of the expelled neem oil. (Gerpen, 2008)

1.4 Objectives of the Study

1. Design and development of an electrically operated neem seed oil expeller.

2. To test and determine the efficiency of the developed machine.

1.5 Statement of the Problem

Apart from its domestic uses, Neem oil also serves as one of the major industrial raw materials used in the manufacture of various consumer products in the tropical region of the World, most especially India and other Asian countries. Based on research, it has been discovered that the neem tree has many benefits and it is being put to many uses, one of which is the production of Medicines, insecticides, pesticides and production of cosmetics etc. In Nigeria today, only the bark and leaf are widely used for producing local herbs. Consequently there is an urgent need to fabricate an expeller that will be introduced into the Nigeria market which will perfectly fit into the purpose of extracting the neem oil from its fruits, and thus provide a much needed source of raw material for the manufacturing industries.

1.6 Justification of the Study

The major objective of this work is to design and develop an effective electrically operated neem seed oil expeller. This would be reliable in the production of quality neem seed oil which is an important raw material in the pharmaceutical, cosmetics and other relevant industries.

1.7 Scope of the Study

This work is an experimental one, therefore the design and construction materials for the fabrication of the expeller is limited to affordable cost, good mechanical properties and efficient materials. Consequently the volume of oil that will be produced per time will be according to its designed capacity.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 The Neem Tree

Neem (*Azadirachta indica*) is known as the "village pharmacy" in its native India where it has been used for nearly 5000 years as a cornerstone of the Ayurvedic tradition. The neem tree is noted for its drought resistance. Normally it thrives in areas with sub-arid to sub-humid conditions, with an annual rainfall between 400 and 1200 mm. It can grow in regions with an annual rainfall below 400 mm, but in such cases it depends largely on ground water levels. Neem can grow in many different types of soil, but it thrives best on well drained deep and sandy soils. It is a typical tropical to subtropical tree and exists at annual mean temperatures between 21-32 °C. It can tolerate high to very high temperatures and does not tolerate temperature below 4 °C. Neem is a life-giving tree, especially for the dry coastal, southern districts. It is one of the very few shade-giving trees that thrive in the drought-prone areas. The trees are not at all delicate about the water quality and thrive on the merest trickle of water, whatever the quality. In Tamil Nadu it is very common to see neem trees used for shade lining the streets or in most people's back yards. In very dry areas, like Sivakasi, the trees are planted in large tracts of land, in whose shade fireworks factories function. Neem is considered an invasive species in many areas where it is non-native. The Pakistani scientist, Salimuzzaman Siddiqui was the first scientist to bring the plant to the attention of phytopharmacologists. In 1942, while working at the Scientific and Industrial Research Laboratory at Delhi University, India, he extracted three bitter compounds from neem oil, which he named *nimbin, nimbinin,* and *nimbidin* respectively. The seeds contain a complex secondary metabolite *azadirachtin* . (Ganguli, 2002)

2.1.1 Neem tree in Nigeria

Neem tree is presently found almost everywhere in Northern Nigeria. The tree which is known to be one of the legacies of the late Sardauna of Sokoto, Sir Ahmadu Bello is popularly referred to as the *Dogonyaro* tree. He is believed to have brought some seedlings as trials from India during one his visits and experts have attributed its success to the similarity in climate between Nigeria and Indian (Idrisa, 2010). The tree is found everywhere in the northern part of the country; on streets, around houses and in the forests. It serves as shelter belts, wind breakers, build-up oxygen levels and absorbs carbon-dioxide as by-products of human respiratory systems like every green-leaved tree. The neem tree or *Dogonyaro* tree as popularly called in Nigeria does not require any special cultivation techniques or efforts because it grows wildly, sprouting up everywhere at the slightest chance. This single quality makes it an easy cultivation capable of multiplying unobstructed. Nigeria and Liberia have both announced the major initiatives to plant neem trees in dry areas where nothing else will grow with the multiple objectives of stopping desertification, creating an environmentally sustainable industry in impoverished areas and providing affordable and effective medicine. (Idrisa, 2010)

2.1.2 Uses of Neem tree

Of all the plants that have proved useful to humanity, a few are distinguished by astonishing versatility. The coconut palm is one, bamboo another. In the more arid areas of India, this distinction is held by a hardy, fast-growing evergreen of up to 20 meters in height – *Azadirachta indica*, commonly known as the neem tree. The neem's many virtues are to a large degree attributable to its chemical constituents. From its roots to its spreading crown, the tree contains a number of potent compounds, notably a chemical found in its seeds named *Azadirachtin*. It is this astringency that makes it useful in so many fields:

2.1.2.1 Medicine

Neem is mentioned in many ancient texts and traditional Indian medical authorities place it at the pinnacle of their pharmacopeia. The bark, leaves, flowers, seeds and fruit pulp are used to treat a wide range of diseases and complaints ranging from leprosy and diabetes to ulcers, skin disorders and constipation (Schmutterer, 2002).

2.1.2.2 Toiletries

Neem twigs are used by millions of Indians as an antiseptic tooth brush. Its oil is used in the preparation of toothpaste and soap. (Schmutterer, 2002)

2.1.2.3 Contraception

Neem oil is known to be a potent spermicide and is considered to be 100% effective when applied intra-vaginally before intercourse. Intriguingly, it is also taken internally by ascetics who wish to abate their sexual desire. (Schmutterer, 2002)

2.1.2.4 Timber

Besides being hard and fast growing, its chemical resistance to termites makes neem a useful construction material.(Schmutterer, 2002)

2.1.2.5 Fuel

Neem oil is used as lamp oil, while the fruit pulp is useful in the manufacture of methane.(Schmutterer, 2002)

2.1.2.6 Agriculture

The *Upavanavinod*, an ancient Sanskrit treatise dealing with forestry and agriculture, cites neem as a cure for ailing soils, plants and livestock. Neem cake, the residue from the seeds after oil extraction, is fed to livestock and poultry, while its leaves increase soil fertility. Most importantly, neem is a potent insecticide, effective against about 200 insects, including locusts, brown plant-hoppers, nematodes, mosquito larvae, Colorado beetles and boll weevils. Neem leaves and neem oil have also been used traditionally to protect stored grains and legumes. Neem leaves are mixed with the grain in storage or the grain is stored in jute bags treated with neem oil or other neem extracts. These methods can protect food and seed stores from pests for several months. The neem leaves is also used as soil amendment, nematicide and mulch in areas where there is abundance. Neem cake is used by farmers as a soil amendment to promote the slow, controlled release of nitrogen and additionally against parasitic nematodes associated with vegetable crops, wheat and folder crops. It is harmless to earthworms. Neem-based formulations do not usually kill insects directly, but they can alter their behavior in significant ways to reduce pest damage to crops, and reduce their reproductive potential. *Azadirachtin* affects insect physiology by mimicking a natural hormone. It has been shown to affect egg production and hatching rates. In larvae, *Azadirachtin* can inhibit molting, preventing them from developing into pupae.(Schmutterer, 2002)

2.2 Oils

Oil is extracted from a number of fruits, nuts and seeds (Table 1) for use in cooking and soap making or as an ingredient in other foods such as baked or fried goods. Oil is a valuable product with universal demand, and the possible income from oil extraction is therefore often enough to justify the relatively high cost of setting up and running a small scale oil milling business. Oils from plants are classified as vegetable oil. The largest sources of vegetable oils are annual plants which include soybean, cotton seeds, groundnut, sunflower, rapeseed, melon and sesame seed. Other sources are oil bearing perennial plant such as olive, coconut, cashew, palm fruit, neem oil etc. (Fellow, 2003).

Neem oil is a vegetable oil pressed from fruits and seeds of neem (*Azadirachta indica*). It has all the typical features of edible oil, vegetable neem tree is an evergreen tree which is endemic to the Indian subcontinent and has been introduced to many other areas in the tropics. It is perhaps the most important of the commercially available products of neem for organic farming and medicines (Schmutterer, 2002). It is not used for cooking purposes; it is generally light to dark brown, bitter and has rather strong odour which is the combine odours of peanut and garlic. It comprises mainly of triglycerides and large amounts of triterpenoid compounds, which are responsible for the bitter taste. It is hydrophobic in nature and in order to emulsify it in water for application purposes, it must be formulated with appropriate surfactants (Meyer, 1992)

Table 2.1 Oil composition in some oil bearing seeds and nuts with some of their uses

Agricultural Products	Oil Content (%)	Uses
Oil seeds		
Castor	35-55	paints, lubrications
Cotton	15-25	soap making, cooking
Linseed	35-45	paints, varnishes
Mustard	25-45	cooking
Neem seed	25-45	soap making, perfume
Rape seed	40-45	cooking
Sesame	35-50	cooking
Sunflower	25-40	cooking, bio-diesel
Saflower	30	soap making
Nuts		
Coconuts	35	body cream
Dried copra	64	cooking, body cream
Fresh nut	35	hair cream, soap
Groundnut	45	cooking, soap making
Palm kernel nut	40-50	cooking, soap making
Shea nut	60	cooking, soap making
Fruits		
Oil palm	56	fuel, cooking
Avocado	11-28	soap making

Source: FAO (1995).

2.3 Oil extraction

The term extraction could be applied broadly to describe all the separation processes. But with due emphasis on this project, extraction could be simply referred to as the process of separating oil from oil bearing agricultural product through manual, mechanical or chemical extraction. The agricultural products are classified into oil-seeds (cotton, cashew, sunflower etc.), nuts (groundnuts, coconut, etc.), mesocarp or fruits (oil palm) and leaves. There are basically, three methods of extracting oil from various oil containing seeds. (Eteng, 2008)

2.3.1 Definition of oil extraction

Oil extraction is the process of recovering oil from oil bearing agricultural products through manual, mechanical or chemical means of extraction (Eteng, 2008). The agricultural products are classified into seeds, nuts, mesocarp and leaves. And these could be done in two broad ways, which are traditional and improved method.

2.4 Principle of Oil Extraction

Oil can be obtained through pressing (crushing) of the seed kernel either through cold pressing, solvent extraction or through a process incorporating temperature controls. Oilseed medium is fed continuously into the screw press, where it is compressed under high pressure (4±35 MPa) which ruptures the cell walls so that the oil globules can escape, and forces oil through the slits provided along the barrel length. The compressed solids are simultaneously discharged through a choke provided at the end of the barrel (Ward, 1976). Oil extraction principle in summary, involves pre-treatment of the seeds, by drying, or heating to a low moisture content, about 8% wet basis (Eteng, 2008), to grinding paste or milling and finally, extracting the oil. In neem extraction, The method of processing is likely to affect the composition of the oil, since the methods used, such as pressing (expelling) or solvent extraction are unlikely to remove exactly the same mix of components in the same proportions. The neem oil yield that can be obtained from neem seed kernels varies widely in literature from 25% to 45% depending on the type of extraction employed.

A large industry in India extracts the oil remaining in the seed cake through solvent extraction using hexane. This solvent-extracted oil is of a lower quality as compared to the cold pressed oil and is mostly used for soap manufacture.

2.4.1 Oil extraction process

These involves the stages that must be followed in the oil extraction process starting from post harvesting of the seed, Decortications, Seed cleaning, Size reduction , Rolling, Conditioning, Oil extraction and Oil clarification methods. The crude oil from the expeller is passed through screens and allowed to settle in tanks before it is filtered through a filter press. The seed residue from the settling tanks is known as 'fools'.

2.4.1.1 Kernel pre-treatment

There are some certain preliminary processes that oil bearing agricultural products must undergo to it to be ready for oil extraction. And in some cases the oil expressing devices are assembled as a complete unit with pre-processing equipment included. These preliminary processing enhances the effectiveness and the efficiency of the oil extraction and these may involve the removal of hulls and shells and pre-treatment conditioning such as size reduction, optimum moisture content adjustment, and heat treatment.

2.4.1.2 Separation techniques

This involves cleaning (removal of foreign matter) and removal of the dried drupe. The cleaning process consists of the removal of sand, stalks, plant debris and any other foreign matter found in the nuts or seeds. The cleaning can be done by rotary or table sieves usually with air separators by fans, and cyclones for dust removal from the air. According to Galloway (1976), mechanical system that consists of sieves and or shakers, both with perforated metal or screen are employed. In these machines, the materials flow over the drum or tray, thus cleaning the seeds or nuts.

2.4.1.3 Decorticating/ shelling

The process of freeing oil seeds and nuts from the shells or pods by cracking the shell using a device known as decorticator is called Decortication. Decorticators are of two major types, power and hand operated decorticator. This two type's work based on the same principle and they consist of following main units; loading, beating and separating units. The seeds and nuts are loaded in the loading unit and passed to the beating unit where they are cut and cracked or broken by rotary action of the beater bars. Decorticating operation is then followed by separation of the cracked seeds by means of sieves air separators.

2.4.1.4 Conditioning

Conditioning or 'cooking' oilseeds involves heating the oilseed in the presence of water. The water may be that which is naturally present in the seed, or it may be added. The changes brought about by conditioning are complex but include the coalescence of the small droplets of oil, present in the seed, into drops large enough to flow easily from the seed. In addition, higher processing temperatures improve oil flow by reducing the viscosity of the oil.

Oilseeds are nearly always conditioned before large-scale expelling. Small-scale expellers minimize the need for pre-treatment by using a relatively fast worm-shaft speed which shears the oilseed as it passes through the expeller and produces frictional heating within the expeller barrel. This assists oil expulsion by raising the temperature of the oilseed. However, even when using a small-scale expeller, oil extraction will be assisted by heating and/or steaming the oilseed before expelling. Heat treatment is essential for some seeds with low fibre content such as groundnuts; they must be heated and moisturized before expelling or the machine will produce an oily paste instead of oil and cake. Some companies which manufacture small-scale processing equipment for oilseed processing refer to their seed conditioners as 'seed scorchers'. This is a misleading name because scorched oilseeds will yield oils having characteristically dark colors and burnt tastes which are not normally desirable. Sivakurorah et al (1985) reported that heating temperature, heating time and moisture content are interactive factors that influence the yield of oil to be extracted.

2.5 Methods of Oil Extraction

There are basically three methods of removing oil from raw materials: solvent extraction wet process or dry processing, tradition method of extraction and mechanized extraction. The solvent extraction is not suitable for small-scale processing because of high capital and operational costs, the risk of fire and explosion from solvents and the complexity of the process. Equipment for wet or dry processing is available at different scales of operation from household to industrial scale. The mechanized extraction has higher output compared with other methods. Various small techniques are available to enable people in the rural areas to process their own oilseeds locally. Careful consideration is needed to select the system that will best suit the local circumstances. These circumstances include the scale of operation required, the availability of a power source, and a number of other factors. The options available for small-scale oilseed at levels of up to 100 kg seed/in include small powered expellers, manual- or animal-powered mechanical presses, and simple procedures using water and chemical to separate oil from oilseeds. (Patel, 1943)

The following tree basic oilseed processing methods are available and range from those suitable for use in domestic households, to those more suited to small-scale factories:

- Traditional method
- Mechanical method
- Solvent extraction method (Patel, 1943)

2.5.1 Traditional Method of Oil Extraction

2.5.1.1 Water Extraction Methods

In wet extraction methods water is used to extract oil from oilseeds. These methods involve the use of a relatively large amount of water so that the oilseed is suspended in the water and the extracted oil floats on the surface.

Water-assisted methods involve the addition of a small quantity of water to the oilseed before the oil is extracted by manual kneading. They are not classified as wet methods because all the water used is absorbed by the oilseed and no separate water layer is apparent.

2.5.1.2 Pounding and Boiling Method

Pounding and boiling method, also known as Hot water flotation method of edible oil extraction is traditionally used in the rural areas of many developing countries. Usually, decorticated oilseed is used. The oilseed kernels are heated and ground by pounding in a pestle and mortar. The ground seed is then suspended in boiling water and boiled for at least 30 min. Liberated oil floats to the surface. Further quantities of water are sometimes added after boiling to replace that lost by evaporation, and to encourage the oil to float to the surface. The oil is carefully scooped from the surface of the water using a shallow dish and is then heated over a fire to remove residual moisture.

The advantage of this method over other small-scale oilseed processing techniques, such as those using expellers is its simplicity. The equipment required (pestle and mortar, boiling pans, etc.) is readily available. However, oil yields tend to be low and the process can be time consuming and arduous. This is especially true if traditional pestle and mortar methods are used to grind the oilseed kernel. If long boiling times are used, fuel consumption will also be high.

The above method may be applied to most oilseeds with varying degrees of success. Sources of oil, such as coconut and oil palm fruits, can be processed by traditional methods which make use of the water already present in the seed. (Patel, 1943)

2.5.1.3 Animal Powered Method (Ghani)

Animal powered method (Ghani) is a motar and pestle device which grinds oil seed into fine particles and extracts the oil from it. The oilseeds and subsequently the expressed oil are held in a scooped circular pit in the exact centre of a circular mortar made of stone or wood. In it works a stout, upright pestle which descends from a top curved or angled piece, in which the pestle rests in a scooped-out hollow that permits the pestle to rotate, eased by some soapy or oily lubricant. Today the single angled piece takes the form of two shorter pieces pinioned or chained together. The bottom of the lower angled piece is attached to a load-beam; one end of the load-beam rides around the outside of the barrel, while the other is yoked to the animal. The load-beam is weighted down with either heavy stones or even the seated operator. As the animal moves in a circular ambit, the pestle rotates, exerting lateral pressure on the upper chest of the pit, first pulverizing the oilseed and then crushing out its oil. A typical bullock-driven ghani can process about 10 kg seed every 2 h. The bullock normally becomes fatigued after working the ghani for about 3-4 h and is replaced by another one. (Achaya, 1993)

Electrically-powered ghanis, known in India as 'power ghanis', are now replacing bullock-driven ghanis because bullocks are becoming increasingly costly to maintain. Either the pestle or the mortar is held stationary in power ghanis which are normally run in pairs so that one is always operating while the other is being discharged. About 100 kg seed/ day is the usual throughput. The advantages of the ghani are that it produces a reasonable oil yield of about 60%, it can be made locally, and it has low running costs. Oil produced in a ghani is usually valued for its quality. In addition, no pre-grinding equipment is needed for smaller oilseeds such as groundnuts, rapeseed, sesame and sunflower seeds, and it is suitable for use by small groups in villages. (Patel, 1943)

2.5.1.4 Manual Methods of Kneading

Common with the water flotation process, only simple domestic utensils are needed to extract oil by kneading. This method is used to process groundnuts traditionally in West African villages. Water is added to groundnut paste and the mixture is stirred and kneaded by hand until the oil separates. The water plays a vital but obscure role in the extraction process. It is believed that the water displaces oil from hydrophilic or 'water loving' surfaces in the ground seed. (Achaya, 1993)

2.5.2 Solvent Extraction

It is a process of extracting oil through the process of diffusion with the help of low boiling point solvents. In this process nearly all the oil leaving about 0.5% in the cake is recovered. The process is employed either to extract the oil from the oil seed or from the cake which is produced in the expeller after mechanical pressing. Oil from rice barn, soybean, neem, cotton, sunflower seeds etc. are generally extracted by solvent, but solvent extraction is a complex and costly operation. Solvent extraction isn't suited for small-scale processing because of high capital and operating costs, risks due to fire and explosions from solvents, and the sheer complexity. (Juss, 1992)

2.5.3 Mechanical Method

This method is one of the oldest methods of processing oil. Seeds are placed in a tub or container and a form of press or screw is used to squeeze the seeds until the oil is pressed out and collected. This method is suitable for both small and large scale capacity operations. Primarily, this involves the use of mechanical pressure to express oil out of the pre-treated and heated seed mass. FAO, Catalogue of Small Scale Processing Equipment, 2005 Specified that the two most common mechanical devices in use today are; the hydraulic press and the screw press. But their mode of construction differs which has given it different name according to their modification. The following are some of the available types of oil expeller in use.

2.5.3.1 Hydraulic Presses

2.5.3.1.1 The Wedge Press

The first method of mechanical oil extraction was an ancient Chinese wedge-press. The wedge press, operated manually or by using either wind or water power, was widely used to press oilseeds during the late 18th and early 19th centuries in the West and in the Far East (Broadright, 1979).

2.5.3.1.2 The Plank Press

The plank press represents the simplest mechanical pressing device used in oilseed processing. It consists of two long pieces of wood hinged at one end. The prepared seed, in a suitable woven container, is placed between the planks and squeezed by the application of pressure at the unhinged ends. Plank press is being used in Nepal for the extraction of rapeseed oil. (Broadright, 1979).

2.5.3.1.3 The Curb Press

This press was designed by the Technology Consultancy Centre (TCC) at Kumasi in Ghana. It is a development of the 'Duchscher' curb press which was manufactured in Luxembourg and which has been widely used in Nigeria for extracting palm oil. The cage on the TCC press is made of two halves hinged on one side and locked together with a pin on the other. This enables the cage to be opened easily for unloading the oil-cake after pressing. This makes the press particularly convenient for processing palm fruits, but the central position of the screw inside the cage makes the press unsuitable for pressing other oilseeds

2.5.3.1.4 The Bridge Press

In the bridge press, the press plate is mounted at the base of a screwed rod (often incorrectly referred to as a spindle) which runs in a nut set in the 'bridge' of the frame that surrounds the cage. The screwed rod is turned by a single cross-head bar providing two levers. The design incorporates a thrust bearing which allows the screwed rod to rotate easily against the pressure plate. The press can be used for a range of oil-seeds.

2.5.3.1.5 The Ram Press

It was designed such that a long pivoted lever moves a piston backwards and forwards inside a cylindrical cage constructed from metal bars, spaced to allow the passage of oil. At one end of the piston's stroke an entry port from the seed hopper is opened so that seed can enter the press cage. When the piston is moved forward, the entry port is closed and the oilseed is compressed in the cage. As a result, oil is expelled from the oilseed and emerges through the gaps in the cage. Compressed seed is pushed out through a circular gap at the end of the cage. The width of this gap, which can be varied using an adjustable pressure cone, controls the operating pressure of the press. The design of the press is such that it can achieve operating pressures greater than those obtained in most manually-operated cage presses, and as high as those in small expellers. The ram press has a low seed throughput but has the advantage of continuous operation.

2.5.3.1.6 The Screw-press

Expellers have a rotating screw inside a horizontal cylinder that is capped at one end. The screw forces the seeds or nuts through the cylinder with gradually increasing pressure.

The seed is heated by friction and electric heaters or a combination of the two. Once the cap is removed, the oil escapes from the cylinder through small holes or slots and the press cake, or meal, emerges from the end of the cylinder. Both the pressure and temperature can be adjusted for different kinds of feedstock.

There are two distinct expeller press designs — a single cylinder press that expels the press cake out in pellet form and a traditional cage-style screw press that expels the meal out in large flakes. In operation as the shaft turns, the work assembly moves the bearing seed from the feeding point to the discharge and expelling the oil through the slots in-between the bars of the cage. This is, due to the pressure which ruptures the oil cell in the products and allows the oil to flow. Generally there are two types of screw-press namely the high pressure press which achieve a relatively high oil recovery; then the pre-expeller expeller used to either obtain the maximum oil yield from suitably prepared seed and this is achieved by single pressing at high pressure or pre-press seeds to obtain a cake of moderate oil content which will be further processed.

2.6 Expellers

Expeller pressing is a mechanical process to extract oil from raw materials under high pressure., The earliest expeller was based on a simple screw design which was designed and patented by Valeriusa Anderson in the year 1900. Expellers can recover up to 75% of the oil. (Anderson 1990). Hard nuts and oil seeds might need greater pressure. Expellers have a rotating screw inside a horizontal cylinder that is capped at one end. The screw forces the seeds or nuts through the cylinder with gradually increasing pressure. The seed is heated by friction and electric heaters or a combination of the two. Once the cap is removed, the oil escapes from the cylinder through small holes or slots and the press cake, or meal, emerges from the end of the cylinder. Both the pressure and temperature can be adjusted for different kinds of feedstock. Raw materials are fed through one end of the expeller and the residue comes out through the other end. The high pressure that is being is being applied in the oil extraction will create heat in the range of 140-120 F and some expellers have cooling mechanisms to retain the quality and property of the oil. (Herz, 1997).

2.6.1 Principle of Operation

Oilseed expellers produce oil and oil-cake from oilseed continuously, unlike bridge presses which operate on a batch system. The expeller is driven either by an electric motor or by a diesel engine. At the heart of the machine is a powered worm shaft which rotates inside a closely fitting cage. The oilseed is fed continuously into the press through a hopper and is crushed as it is transported through the cage by the worm shaft. Pressure is exerted on the system by restricting the gap at the end of the cage through which the oil cake is discharged from the press. The expelled oil drains out of the cage through small gaps.

2.6.2 Types of Oil Expellers

1. Full-Press Expellers
2. Pre- Press Expellers.

While the full press expellers are used by small and medium oil mills, the pre-press expellers are used by large scale capacity oil plants. Maximum oil is extracted from the oil seeds in the full press process, leaving the oil cakes with just about 5% to 8% of oil content. Whereas in the Pre-

Press process, the oil cakes contain about 15% to 20% of oil, which are then fed into the solvent extraction plant so as to extract the remaining oil from the cakes. The oil that is extracted with the use of Oil Expellers is completely organic and contains no chemical (Fellows and Hampton, 2002)

2.6.3 Parts of an Oil Expeller.

An oil expeller developed based on the concept of single feed double stage compression consists of the following parts: hopper, speed reduction unit, frame, cake collecting tray, worm-shaft, barrel, spacers, oil collection tray, clearance adjustment, electric motor, choke mechanism and worm-shaft regulator. Figure 2.1 shows the sectional view of a typical single cylinder Oil expeller.

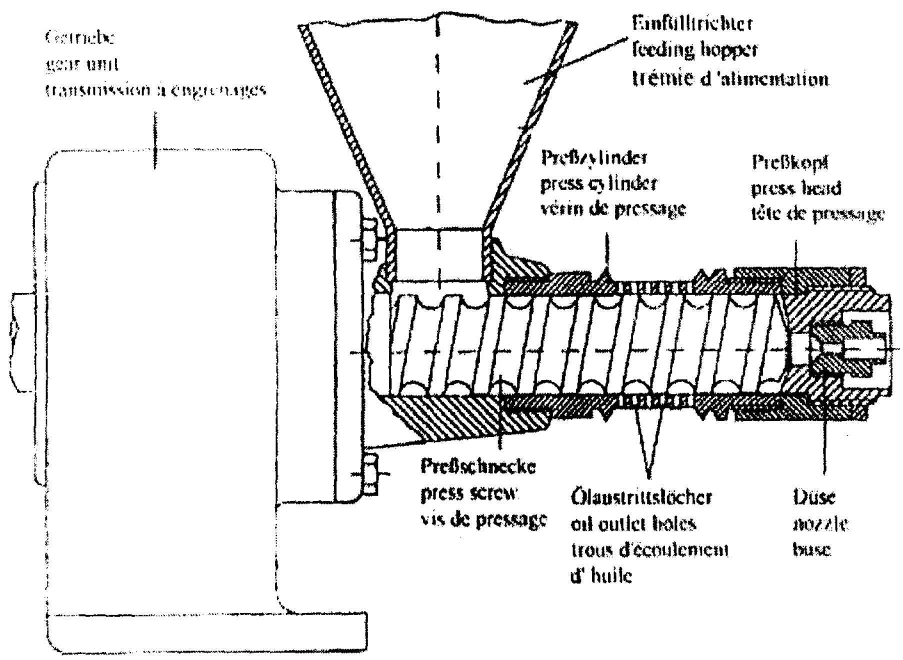

FIG. 2.1: Sectional view of an oil expeller (German, English and French Labeling)

2.7 Refining of extracted oil

The oil produced by expression generally contains a suspension of finely divided seed debris which needs to be cleared. In most cases, clear oil can be obtained by allowing the oil to stand for a few hours or days in a clean container. The fine seed, debris then settle at the bottom of the container leaving an upper layer of clear oil which can be decanted. Alternatively, the oil should be filtered through a filter press, or locally by using a plastic funnel fitted with a cloth can sometimes be used to produce clear "polished" oil (Woodroof, 1966). The purpose of refining oil is to remove any substance which may be injurious to the consumer from the under oil. Refining consists of alkali-Refining, to neutralize the free fatty acid, using sodium hydroxide, bleaching, to improve flavor, stability, odour and taste, using steam distillation under vacuum.

2.8 Factors affecting oil extraction

The amount of oil expressed is very much depended on the following factors;

Heating temperature

Heating time

Particle size

Moisture content of seed

Applied pressure

Pressing time.

Anganwal, (1995) suggested the fact that the inability to extract oil from whole or half of soya beans seed clearly shows that the cell walls must have to be broken by flowing operation to allow the oil to be removed. Hickoy, (1984) ascertain that the effect of temperature and pressure on residual oil content of cotton seed, have been found to be correlated and so to achieve minimal residual oil, the pressing temperature should be increased and moisture content decreased.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Design Considerations

The following design considerations were taken into account in order to achieve the objectives of this study.

i Engineering Properties of Neem Seed

Engineering properties of neem seed are of paramount concern in the design of machine, for expelling the neem seed oil. According to Mohsenin (1970), engineering properties include physical properties such as: shape and size, volume, density, surface area, rheological properties such as compressive and tensile strength, hardness, etc. Therefore, these properties, as well as behavior of neem seeds have been taken into consideration.

Other considerations that should be taken into account in design and fabrication of neem seed expeller are:

ii Shape and Size of Neem Seed

Neem seeds are ovate in shape and because of the complicated nature of the seed diameters, it was assumed to be spherical. The assumption was used to determine the clearance between the worm-shaft and the barrel for the development of oil expelling machine.

iii Strength of the Machine

In machine design, many factors influence the selection of materials and the proportioning of parts. Such factors that must be considered are; strength, rigidity, ability of the machine to withstand the expression pressure, critical speed or speed of operation, the appearance and the stability of the machine.

3.2 Project Methodology

The procedure used in carrying out the design of the neem seed oil expeller is as follows;

1. A preliminary design of the machine structure so as to establish the broad overall features and make it possible to write specifications for major components.
2. Design of all components and preparation of all detailed specification. This includes sizes and choice of material.
3. Force analysis and power requirements

3.3 Physical properties of Neem seed used for the design are:

Mass of one neem seed = 0.28 g

Major diameter of neem seed = 1.578 cm

Intermediate diameter of one neem seed = 0.755 cm

Minor diameter of one neem seed = 0.837 cm

Density of one neem seed = 0.48 g/cm^3

Moisture content = 10.8 %

Volume of one neem seed = 0.6 cm^3

Crushing force of neem seed = 5 N

Area of neem seed = 3.124 cm^2

3.4 Design calculations

3.4.1 Determination of Power Required

Force (F) required expelling maximum oil mechanically from 10 neem seeds of area 0.00312m^2 is 96720 N

But, Area of impact on seed; Area of worm = worm diameter – shaft diameter

$$A = \frac{\pi(D^2 - d^2)}{4}$$

Where,

D = Worm diameter, 0.04 m

d = shaft diameter, 0.025 m

$$A = \frac{\pi(0.04^2 - 0.025^2)}{4}$$

$$A = \frac{\pi(0.000976)}{4}$$

$$A = \frac{0.00306}{4}$$

$A = 0.00077\ m^2$.

Pressure (P) applied therefore $= F/A$

Where;

F = force 23870 N

A = area of impact on seed, 0.00077 m^2

$$P = \frac{23870}{0.00077}\ P = 31\ Mpa$$

But power = τw

Where,

$\tau = torque, (Nm), = rF_e$

$\omega_e = angular\ speed\ {}^{rad}/_{sec} = \frac{2\pi N}{60}$

$N = Speed\ of\ rotation\ of\ worm\ shaft, 60\ rpm$

$r = radius\ of\ \ shaft = \frac{0.025}{2} = 0.0125m$

Therefore, the torque (τ) becomes,

$\tau = 0.0125 \times 23870 = 298.36\ Nm$

And power (p) needed becomes

$$P = \frac{2\pi N\tau}{60}$$

$$P = \frac{2\pi \times 60 \times 298.36}{60}$$

$$P = \frac{11247.07}{60}$$

$P = 1874.65\ w$

$P = 2.51\ Hp.$

Therefore 3 hp motor is required to power the machine.

3.4.2 Determination of Shaft Pulley Diameter

$N_1 D_1 = N_2 D_2$

Where;

N_1=motor speed in rpm

D_1=motor pulley diameter

N_2=shaft speed in rpm

D_2=shaft pulley diameter

Choosing a ratio of 1:3 for motor pulley to shaft pulley,

i.e, $\frac{1}{3} = \frac{60}{D_2}$

$$1 \times D_2 = 3 \times 60$$

$$D_2 = \frac{3 \times 60}{1}$$

$$D_2 = 180mm$$

$$N_1 D_1 = N_2 D_2$$

Substituting with; D_2=180mm, N_1=1440rpm, D_1=60mm and N_2=?

$$1440 \times 60 = N_2 \times 180$$

$$N_2 = \frac{1440 \times 60}{180}$$

$N_2 = 480rpm$

3.4.3 Center Distance between Two Pulleys

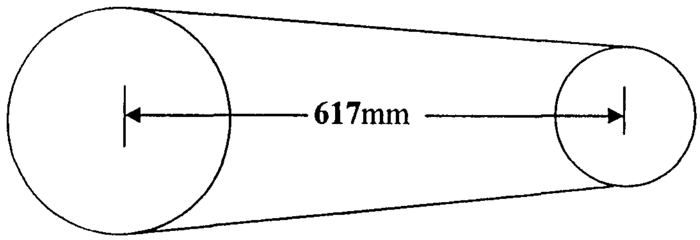

Fig 3.1 Length of open belt

$C = \frac{D_2 - D_1}{2} + D_1$ (Khurmi and gupta, 2005)

Where;

C = distance between the center of two pulleys

D_2 = shaft pulley diameter, 240mm

D_1=motor pulley diameter, 60mm

Substituting;

$$C = \frac{180 - 60}{2} + 60$$

$$= \frac{120}{2} + 60$$

=90+60

C =120mm

Total length of belt, L (mm) is given by;

$$L = 2C + \frac{\pi}{2(D_1 + D_2)} - \frac{D_2 - D_1}{4C}$$ Khumi and Gupta, (2005)

Where;

L= length of belt?

C=center distance, *120mm*

D_1=motor pulley diameter, *60mm*

D_2=shaft pulley diameter, *180mm*

Substituting;

$$L = 2 \times 120 + \frac{\pi}{2} \times (60 + 180) - \frac{180 - 60}{4 \times 120}$$

$$= 240 + \frac{\pi}{2} \times 240 - \frac{120}{600}$$

$$= 240 + 376.99 - 0.2$$

$$= 616.79mm$$

$$\simeq 617mm$$

3.4.4 Determination of Belt Velocity

$$v = \pi N_1 D_1$$

Where; v=belt velocity?

D=motor pulley diameter, 60mm or 0.6m

N_1=motor diameter, 1440rpm or $\frac{1440}{60} = 24rps$

Substituting;

$$v = \pi \times 24 \times 0.6$$

$$= 45.239m/s$$

3.4.5 Angle of Contact or Lap

$sin\alpha = \frac{r_1 - r_2}{C}$ (Khurmi and Gupta, 2005)

r_1= radius of larger pulley, 90mm

r_2= radius of smaller pulley, 30mm

C= distance between two pulleys, 120mm

$$sin\alpha = \frac{90 - 30}{120}$$

$$= \frac{60}{120} = 0.5,$$

$$\alpha = sin^{-1}(0.5)$$

$$\alpha = 30^o$$

Angle of contact θ

$$\theta = (180° - 2\alpha) \times \pi/180rad$$

$$\theta = (180° - 2 \times 30°) \times \pi/180rad$$

$$\theta = (120) \times \frac{\pi}{180}$$

$$\theta = 120 \times 0.0175$$

$$\theta = 2.094\, rad$$

3.4.6 Determination of Belts Tensions

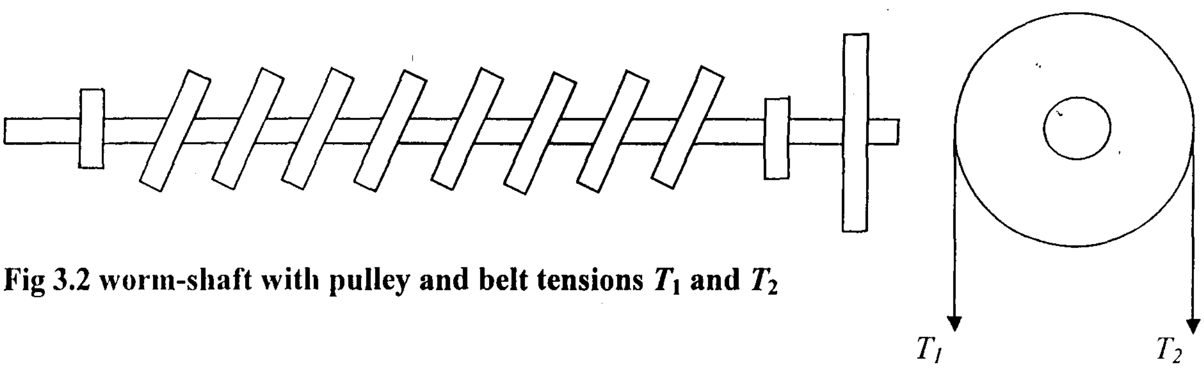

Fig 3.2 worm-shaft with pulley and belt tensions T_1 and T_2

Ratio of driving tension in belt; R

$2.3 \log\left(\frac{T_1}{T_2}\right) = \mu \times \theta cos\beta$ (Khurmi and Gupta, 2005)

Such that;

$$\frac{T_1}{T_2} = log^{-1}\left[\frac{\mu\theta cosec\beta}{2.3}\right] = K$$

Average grove angle of pulley β =17.5

Coefficient of friction between belt and pulley, μ

$$\mu = 0.54 - \frac{42.6}{152.6 + V_b}$$

V_b = belt velocity, 45.24

$$\mu = 0.54 - \frac{42.6}{152.6 + 45.24}$$

$$\mu = 0.54 - \frac{42.6}{197.84}$$

$$\mu = 0.32$$

Where;

θ = angle of contact/lap, 1.86 rad

T_1= tension in tight side (N)

T_2= tension in slack side (N)

Torque transmitted by a driven belt given by; $T_m = (T_1 - T_2)r_2$

Where;

r_2= radius of driven pulley, 90mm, ≃0.09m

r_1= radius of driving pulley, 30mm,≃0.03m

T_m=driving torque, (Nm)

$$T_1 = \left(\frac{T_m}{r_2}\right) + T_2$$

From equation $T_1 = KT_2$

Equating the two above equation,

$$\frac{T_2}{r_2} + T_2 = KT_2$$

$$T_2 = \frac{\frac{T_S}{r_2}}{k-1}$$

μ=0.32, β=17.5, T_S=37.799Nm, r_2=90mm≃0.09m, r_1=30mm≃0.03m

$$K = log^{-1}[\frac{0.32 \times 1.86 \times cosec17.5}{2.3}]$$

$$K = log^{-1}\left[\frac{0.32 \times 1.86 \times 3.326}{2.3}\right]$$

$$K = log^{-1}0.701$$

$$K = 4.944$$

$$T_2 = [\frac{\frac{14.84}{0.12}}{4.944 - 1}]$$

$$T_2 = \frac{123.67}{3.94}$$

$$T_2 = 31.39\ N$$

$$T_1 = KT_2$$

$$T_1 = 4.944 \times 31.39$$

$$T_1 = 155.19\ N$$

3.4.7 Angle of Wrap of the Belt (Ø)

$$\emptyset = 180 \pm 2sin^{-1} \times \frac{r_2 - r_1}{C}\ \textit{machine design, schaums series, } 2003$$

r_2=120mm, r_1=30mm, C=150mm,

Sign (+) is for larger pulley, while (–) is for smaller pulley.

For larger pulley,

$$\emptyset_1 = 180 + 2sin^{-1}\left(\frac{90 - 30}{120}\right)$$

$= 180 + 2sin^{-1}\left(\frac{60}{120}\right)$

$= 180 + 2sin0.5$

$= 180 + 2 \times 30$

$= 180 + 60$

$\emptyset_1 = 240°$

For smaller pulley

$\emptyset_2 = 180 - 2sin^{-1}\left(\frac{90 - 30}{120}\right)$

$= 180 - 2sin^{-1}\left(\frac{60}{120}\right)$

$= 180 - 2sin^{-1}0.5$

$= 180 - 60$

$\emptyset_2 = 120°$

3.4.8 Design of Speed Reduction Unit

$Velocity\ radio = \frac{\omega_G}{\omega_P} = \frac{T_P}{T_G}$

where;

$\omega_G = Angular\ speed\ of\ bigger\ gear = \frac{2\pi N_G}{60}$

$\omega_P = Angular\ speed\ of\ small\ gear = \frac{2\pi N_P}{60}$

N_G = *Big gear speed, 480 rpm*

N_P = *Small gear/pinion gear speed, 60*

$\omega_G = \frac{2\pi \times 480}{60} = 50.264\ ^{rad}/_{sec}$

$\omega_P = \frac{2\pi \times 60}{60} = 6.238\ ^{rad}/_{sec}$ $Velocity\ ratio = \frac{50.264}{6.283} = 8$

$\therefore Velocity\ ratio\ is\ 8 : 1$

3.4.9 Worm Shaft/ Conveyor/Auger Design

The shaft, used in the expelling chamber is a solid shaft with worm; therefore, there would be a combined bending and torsional stresses acting on the solid shaft during operation. The bending forces include reactions on the two bearings that support the shaft and the pulley that is driven. These reactions are calculated below;

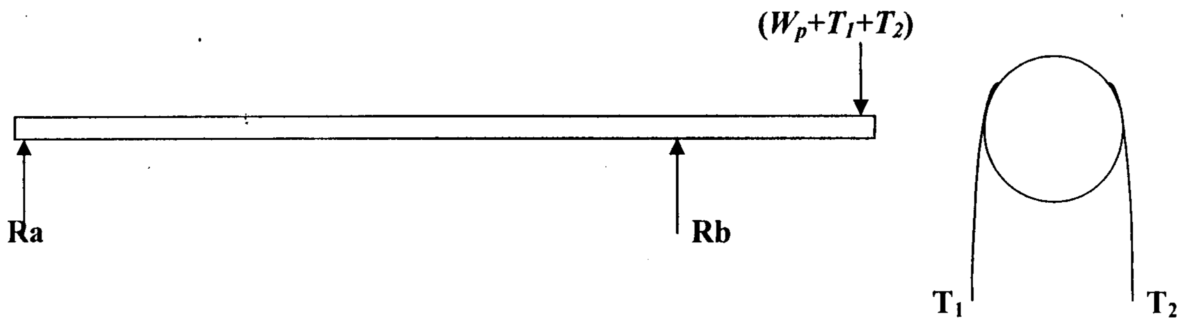

Fig 3.3 Worm-shaft showing the forces and reaction acting on it.

Where; Wp = Weight of the pulley, 2.3 Kg

T_1= tension in tight side, 155.19 N

T_2= tension in slack side, 31.39 N

$W_P + T_1 + T_2 = 209.143$

Ra + Rb =209.143

(∑Ma↑) = Moment about point a

$Rb \times 0.6 = 209.143 \times 0.7$

$0.6Rb = 146.40$

$$Rb = \frac{146.40}{0.6}$$

$Rb = 244.0$

$Ra + Rb = 209.143$

$Ra = 209 - 244$

$Ra = -34.85$

3.4.10 Shear Force and Bending Moment Determination

Shear Force; between AB and BC

$-35 + Vx = 0$

$Vx = 35N$

$-35 - 38 + Vx = 0$

$Vx = 35 + 38$

$Vx = 73N$

$-35 - 38 + 244 + Vx = 0$

$Vx = 35 + 38 - 244$

$Vx = -171N$

Bending Moment;

$(\uparrow \mathrm{EM_A}) = 0,$

at point AB.

$$M_x = \frac{63.8 \times 0.6^2}{2} - 244 \times 0.6$$

$M_{AB} = 11.484 - 146.4$

$M_{AB} = -134.92 \text{ Nm}$

at Point BC.

$$M_{BC} = \frac{63.8 \times 0.6^2}{2} - 244 \times 0.6 + 209 \times 0.7$$

$M_{BC} = 11.484 - 146.4 + 146.3$

$M_{BC} = 11.384 \text{ Nm}$

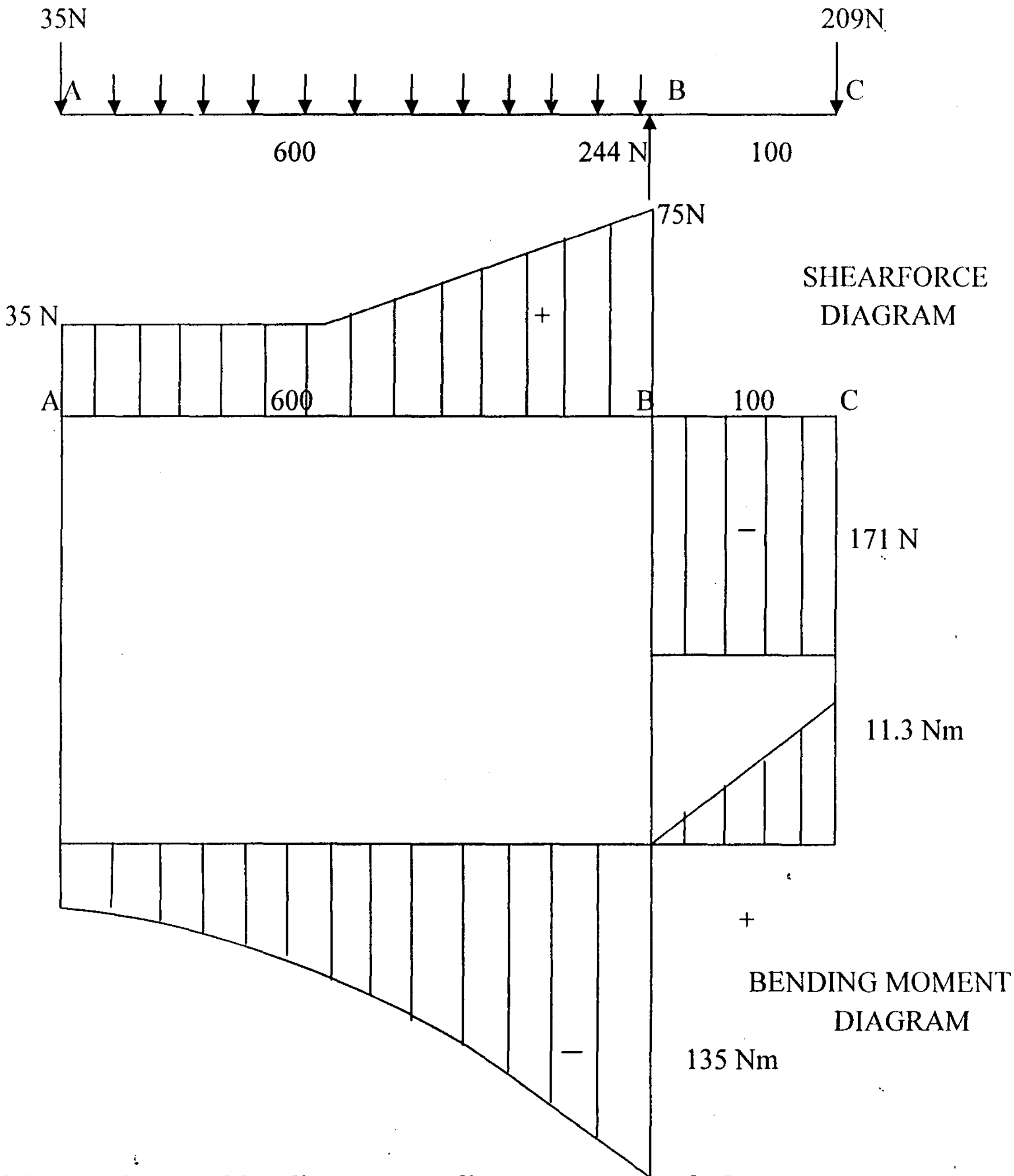

Fig. 3.4 Shearforce and bending moment diagram on worm-shaft.

3.4.11 Shaft Diameter.

$$\tau_{max} = \frac{16}{\pi d^3}\sqrt{(M^2 + T^2)}$$

Where;

τ_{max} = Maximum shear stress (N/m), 42 Mpa

T = Torque (Nm), 298.36 Nm

M = Bending moment of shaft (Nm), 11.384 Nm

d = Shaft diameter of the machine (m).

$$d^3 = \frac{16}{\pi \times 42 \times 10^6}\sqrt{11.384^2 + 298.36^2}$$

$$d^3 = \frac{16}{132 \times 10^6}\sqrt{129.6 + 89018.7}$$

$$d^3 = 1.213 \times 10^{-7} \times 89148.3$$

$$d = \sqrt[3]{0.01081}$$

$$d = 0.022\, m \equiv 22\, mm.$$

The shaft diameter is rounded-up to 25 *mm*

3.4.12 Torsional Deflection

The shaft, used in transmitting power to the expelling chamber must be proportioned to provide the strength required to transmit a given torque and prevent torsional deflection (twisting) through greater angle.

Torsional deflection in degree is given by α;

$$\alpha = \frac{584Tl}{D^4G}$$

G = Torsional modulus of elasticity, 80,000 N/mm^2

D = Shaft diameter, 25mm

T = torsional moment in N-mm

L = Shaft Length (mm), 700mm

α = angular deflection of shaft in degree

Allowable twist in steel shaft transmission of standard 0.26 degree per meter length is given by;

$D = 2.26 \times \sqrt[4]{T}$ (Oberg *et al*, 2004)

Where, $T = (D/2.26)^4$

D= Shaft diameter 25mm

T = Torsional moment in N-mm

N = 60 rpm

$$T = \left(\frac{25}{2.26}\right)^4$$

$$T = 11.06^4$$

T=14973.60N-mm

Substituting,

$$\propto = \frac{584 \times 14973.60 \times 700}{25^4 \times 80000}$$

$$\propto = \frac{6121207680}{3.125 \times 10^{10}}$$

$$\propto = 0.1906°$$

3.4.13 Barrel / Worm Casing Design

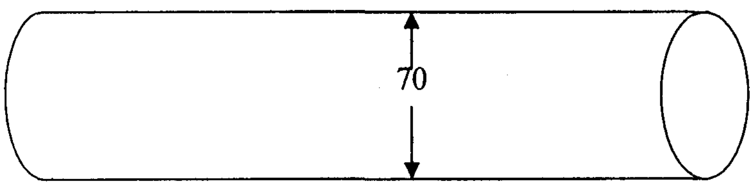

Fig. 3.5 Barrel closed at both ends; where oil is being expelled out.

$$total\ surface\ area, (TSA) = 2\pi r^2 + 2\pi rh$$

$TSA = (2\pi \times 35^2) + (2\pi \times 35 \times 600)$

$TSA = 76796.90 + 131946.89$

$TSA = 139643.79\, mm^2,$

$volume\ of\ barrel, V = \pi r^2 h$

$V = \pi \times 35^2 \times 600$

$V = 2309070.6\, mm^3 = 0.0023091 m^3$

3.4.14 Hopper Capacity Design

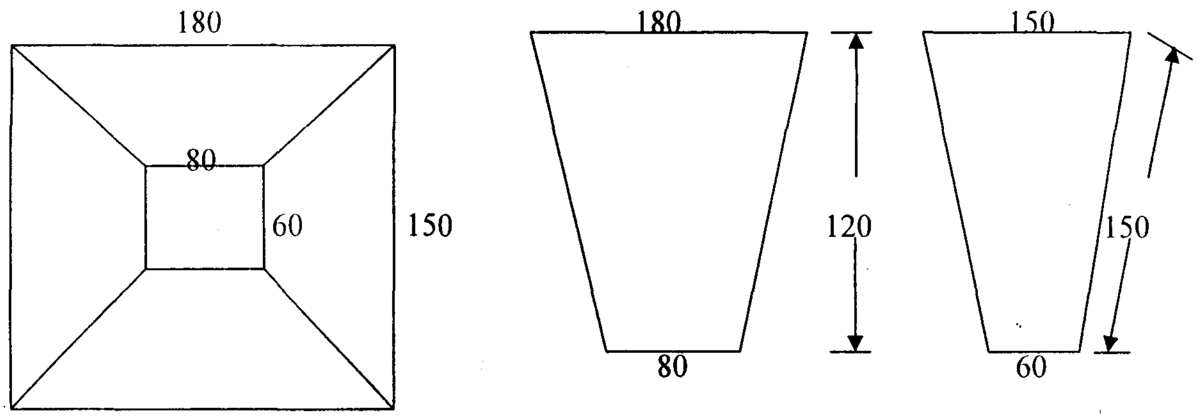

Fig. 3.6 **Top and sides views of hopper**

$V_H = \frac{1}{3}[(area\ of\ frustrum\ base) \times overall\ height\ of\ frustrum]$

$-\frac{1}{3}[(area\ Of\ truncated\ frustum\ base) \times height\ of\ truncated\ frustum]$

$V_H \frac{1}{3}[(0.15 \times 0.18) \times 0.238 - (0.06 \times 0.08).118]$

$V_H = \frac{1}{3}[0.00643 - 0.0005664]$

$$V_H = \frac{1}{3}[0.00586]$$

$$V_H = 0.00195m^3.$$

3.5 Manufacturing Process

There are three fundamental critical notes which determine the economic product of various parts of machines. These are as follows;

i) Functional design of parts assembly, with maximum simplicity and consistency, and with appropriate authentic quality.

ii) Choice of material from a compromise of physical properties, appearance, cost and ease of processing.

iii) Choice of the correct processes to produce accurately and at lowest cost.

3.6 Major Units/ Parts of The fabricated Machine

- Hopper
- Crushing unit
- Expelling chamber
- Frame stand
- Power transmissions components
- Heating filament

3.7 Construction Methods/ Method of Assembly

After completing the design successfully, the following construction methods were employed for each unit which include;

i) Marking out the dimensions for the different components (hopper, barrel, frames, etc) from the galvanized metal sheet; equipments used; scribe, tri-square, divider, meter rule, etc.

ii) Cutting of the marked out galvanized metal sheet; metal sheet cutter was used

iii) Folding and forming of the cut part to the desired shape for the auger housing (barrel), crushing chamber and hopper.

iv) Forming of worm-shaft; the worm-shaft is made by welding a coiled rod along 25mm shaft with varying pitch distance.

v) Two short shafts with fixed gears at one end each was incorporated into crushing chamber to form the crushing unit.

vi) Worm-shaft was fixed inside the barrel and covered at both ends with bearing bolted at its two ends after the barrel cover on the frame stand

vii) The frame is made of 50 x 50 mm angle bar iron. It comprises four stands, which are held in position by welding. Based on design considerations, the stand has dimensions of 750 x 430 mm at top and height of 700 mm from the ground. The frame was cut to the required dimensions using hacksaw and welded together.

viii) The hopper, crushing unit, barrel are fixed by welding on frame stand.

ix) Pulley and sprocket was forced unto the worm-shaft near the bearings close to the hopper.

x) Another sprocket was forced to one of the crushers and chain was forced on both sprockets.

xi) Final assembly of all components into a unit using the necessary bolts and nuts, and welding using electric arc welding machine where necessary.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Testing of the Machine

After fabrication, the performance test was carried out.

4.2 Test Procedures

The machine was first run under no-load condition using an electric motor of 3 hp with speed rating of 1440 rpm, at a speed of 60 rpm. Essentially, the no-load test was carried out to ascertain the smoothness of operation for the machine's rotating parts. The actual test was conducted by introducing heated dried neem seeds into it. Testing of the machine was targeted at evaluating its expelling efficiency and the volume of oil produced per time. 5000g of neem seeds dried to a moisture content of 10.8% was used for this testing.

4.3 Machine Description

The Neem oil expeller is driven by an electric motor. At the heart of the machine is a powered worm-shaft (screw conveyor) which rotates inside a closely fitting cage. The oilseed is fed continuously into the press after it is crushed in the crushing unit through a hopper and transported through the cage by the worm-shaft. Pressure is exerted on the system by restricting the gap at the end of the cage through which the oil cake is discharged from the press and the expelled oil drains out of the cage through small gaps under the barrel.

4.4 Cost Analysis

The cost of construction of the oil expelling machine is classified into three namely;

i. Material cost: This is the cost of materials used in the construction of neem seed oil expelling machine. The table below shows the unit and quantity prices of materials used for the construction.

ii. Labour cost: This is the cost of services rendered by human being during the construction of the machine.

iii. Over-head cost: This is the cost of feeding, transportation and other miscellaneous expenses involved during the construction of the machine.

The costs of materials are shown on Table 4.1.

Table 4.1: Cost of Materials

S/No	Material Description	Material Specification	Quantity	Unit (₦)	Total (₦)
1	Angle bar	35 x 35 x 540 mm	2	1500	3000
2	Bearing	25mm inner diameter	2	250	500
3	Chain		1m	250	250
4	Cylindrical pipe	20mm inner diameter	¼	1500	380
5	Electrode	10 gauge	1 packet	1200	1200
6	Galvanized sheet	800 x 200 x 2 mm	½	6000	3000
7	Gear box	8:1 gears	1	2500	2500
8	Heating filament	240v, 1800w	1	1000	1000
9	Mild steel plate	400 x 260 x 2mm	1	1500	1500
10	Paint	Auto base	1 litre	1200	1200
11	Pulleys	mild steel	3	300	300
12	Solid shafts	25 x 700 mm	1	1000	1000
13	Sprocket	18 teeth	2	250	500
14	Square rod	14 x 14 x 540mm	1	1200	1200
15	v-belt	rubber & fibre	2	200	400
	Total				**#17,930**

Total cost of Materials is therefore #17,930

4.4.1 Labour cost (L_C)

This is 60% of the material cost that is:

$$\text{Labour cost } (L_C) = \frac{60}{100} \times \text{Material cost} = \frac{60}{100} \times ₦\,17{,}930 = ₦\,10{,}758.00$$

4.4.2 Over head cost (O_C)

The overhead cost is 50% of the material cost, which is:

$$\text{Overhead cost } (O_C) = \frac{25}{100} \times \text{labour cost} = \frac{25}{100} \times ₦\,10{,}758 = ₦\,2{,}689.50$$

Total cost of fabrication (TC) = Material cost + labour cost + over head cost.

Tc = ₦ 17,930 + N10,758 + ₦ 2,689.50 = ₦ 31,377.50

Therefore, the total cost of construction of the machine was ₦ 31,377:50.

4.5 Efficiency of the Machine

The efficiency of the machine was calculated using the given expression;

$$Efficiency = \frac{practical\ oil\ yield}{theoretical\ oil\ yield}$$

The theoretical oil yield for neem seed mechanically is 37%.

When heat was not applied;

$$Efficiency\ test\ 1a = \frac{16.4}{37} \times \frac{100}{1} = 44.3\%$$

$$Efficiency\ test\ 2a = \frac{16.6}{37} \times \frac{100}{1} = 44.8\%$$

$$Efficiency\ test\ 3a = \frac{17.2}{37} \times \frac{100}{1} = 46.4\%$$

$$Average\ efficiency = \frac{efficiency\ tests\ 1+2+3}{3} = \frac{44.3 + 44.8 + 46.4}{3} = 45.1\%$$

When heat is applied;

$$Efficiency\ test\ 1b = \frac{17.4}{37} \times \frac{100}{1} = 47.0\%$$

$$Efficiency\ test\ 2b = \frac{17.8}{37} \times \frac{100}{1} = 48.1\%$$

$$Efficiency\ test\ 3b = \frac{17.8}{37} \times \frac{100}{1} = 48.1\%$$

$$Average\ efficiency = \frac{efficiency\ tests\ 1+2+3}{3} = \frac{47.0 + 48.1 + 48.1}{3} = 47.7\%$$

4.6 Throughput of the Machine.

Throughput is the ratio of the mass of material to the time spent in extraction of oil and it expressed in gram per seconds.

$$\text{Throughput (TP)} = \frac{\text{mass of material worked on (g)}}{\text{time of operation(sec)}}$$

$$\text{Average time(sec)} = \frac{300 + 288 + 298}{3} = 295.3\text{ secs} \equiv 0.082\text{hr}$$

Average weigth of material $= 1000g. \equiv 1kg,$

therefore thoroughput $TP = \frac{1}{0.082} = 12.19 kg/hr$

4.7 Discussion

Oil is a valuable product with universal demand and the possible income from oil extraction is therefore often enough to justify the relatively high cost of setting up and running a small scale oil milling business.

The results obtained during testing suggest that the performance of the machine is highly depended on the quantity of material fed into the machine. Preliminary tests carried out on the machine revealed that, without heating of the neem seed, the oil yield obtained was 45.1%, with heating, however, the oil yield obtained was 47.7%, this increase in oil yield as a result of heating could be because of the breaking of oil bearing cells during heating. Finally, this constructed oil expeller is simple in design and easy to operate and by anybody, even without any previous technical training.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

An electrically operated neem seed oil expeller was designed and developed. The oil yield before heating was found to be 45.1%; the value after heating was found to be 47.7%. The throughput was found to be 12.19kg/hr. This machine can be used for extracting the oil needed for the production of varieties of different neem oil products. In addition to this, local farmers who are involved in local production of neem oil can find this machine useful, because it is easy to operate and produces more oil per time.

5.2 Recommendations

1. For hygienic and better quality of neem seed oil, a stainless steel material is recommended.

2. The size of the machine may be increased to give higher production of oil.

3. The outer cover of the heating element should be lagged from the outside to prevent loss of heat and to prevent the risk of burning the operator.

4. One of the factors that affect the yield of any oil bearing material is the amount of moisture in it. Thus, in order to obtain maximum yield from neem seeds, it is recommended that seeds should be dried to reasonable moisture content.

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APPENDICES

Appendix 1

Test under NO HEAT

Sample No	weight of seed(g)	weight of oil(g)	weight of cake(g)
1	1000	164	756
2	1000	166	767
3	1000	172	769

Test under HEAT

Sample No	weight of seed(g)	weight of oil(g)	weight of cake(g)
1	1000	174	770
2	1000	178	774
3	1000	178	773

Appendix 2

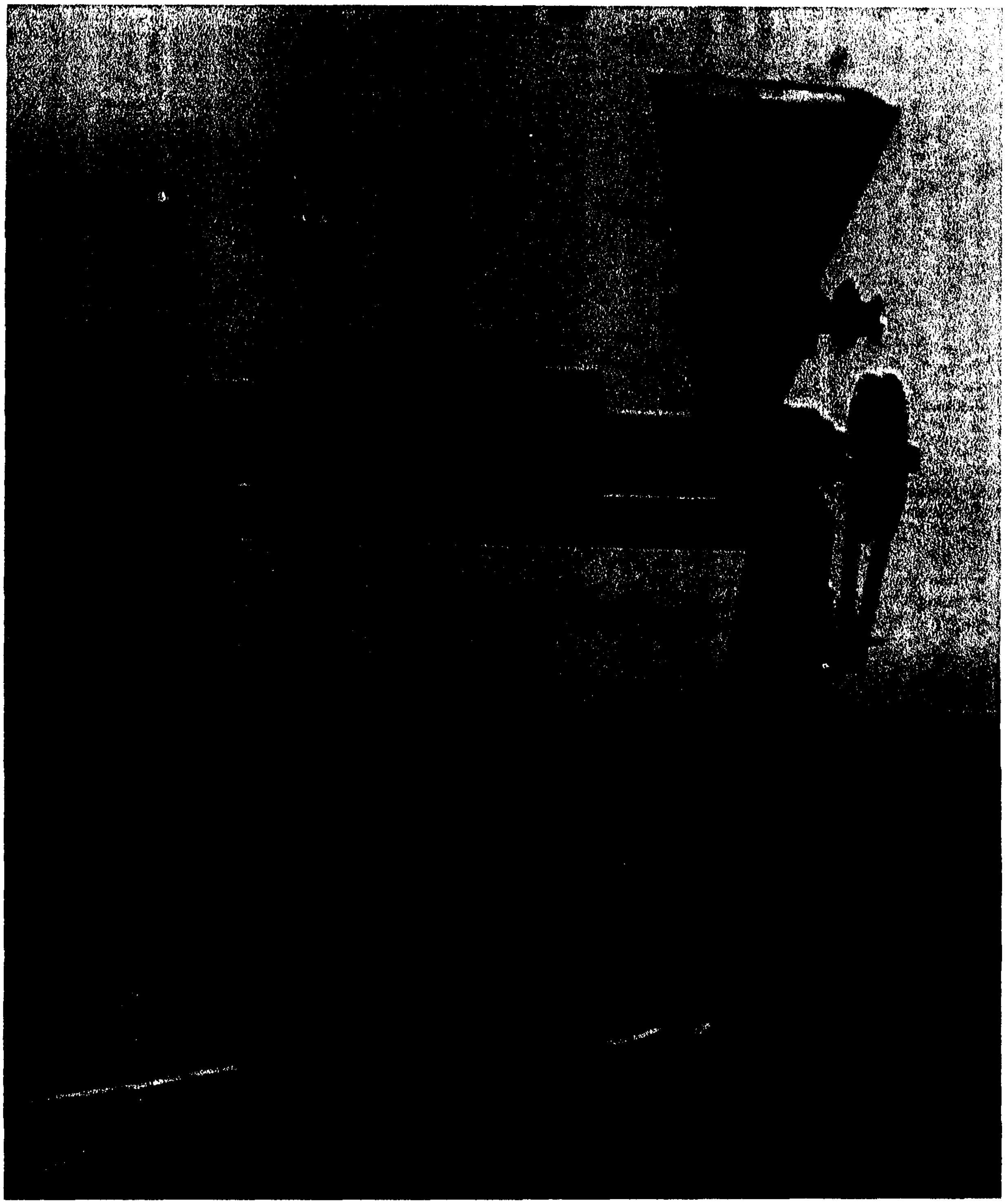
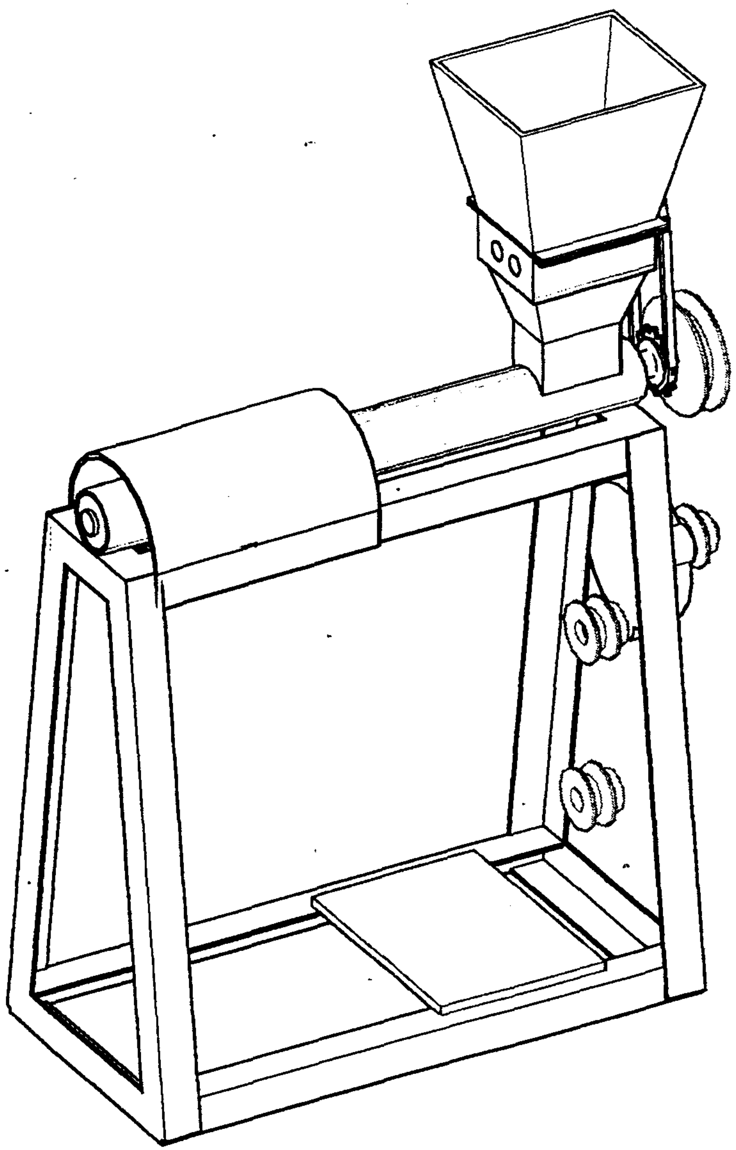


Plate 1: NEEM SEED OIL EXPELLER



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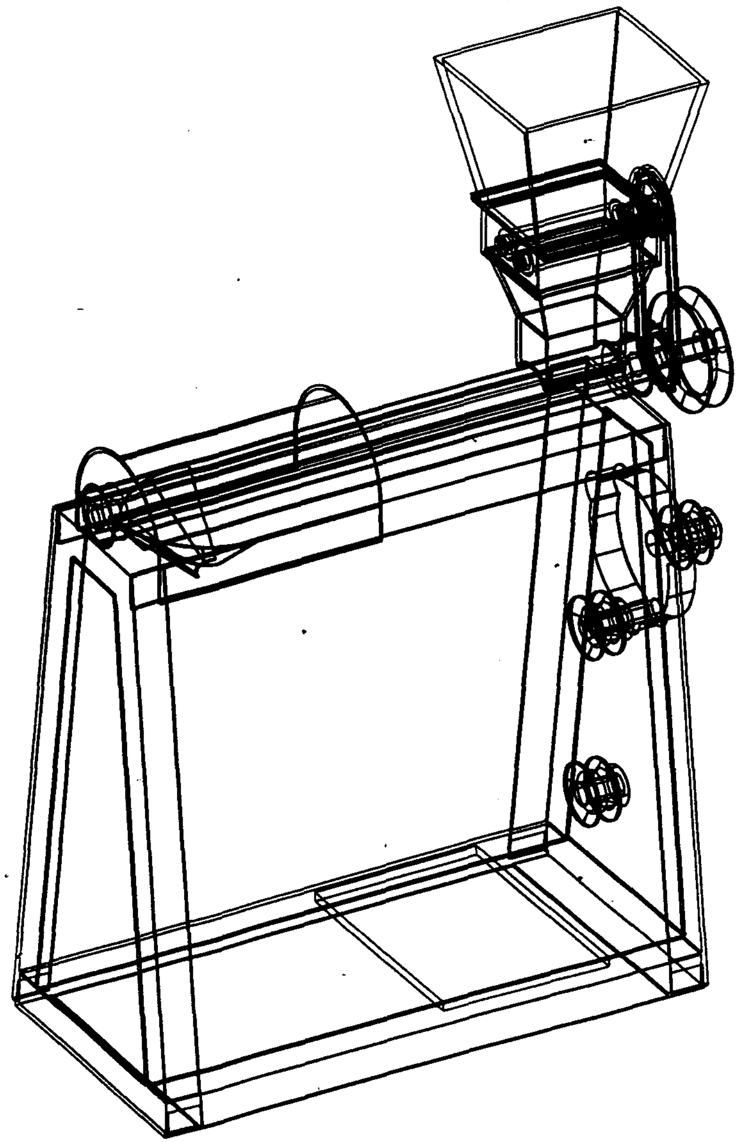

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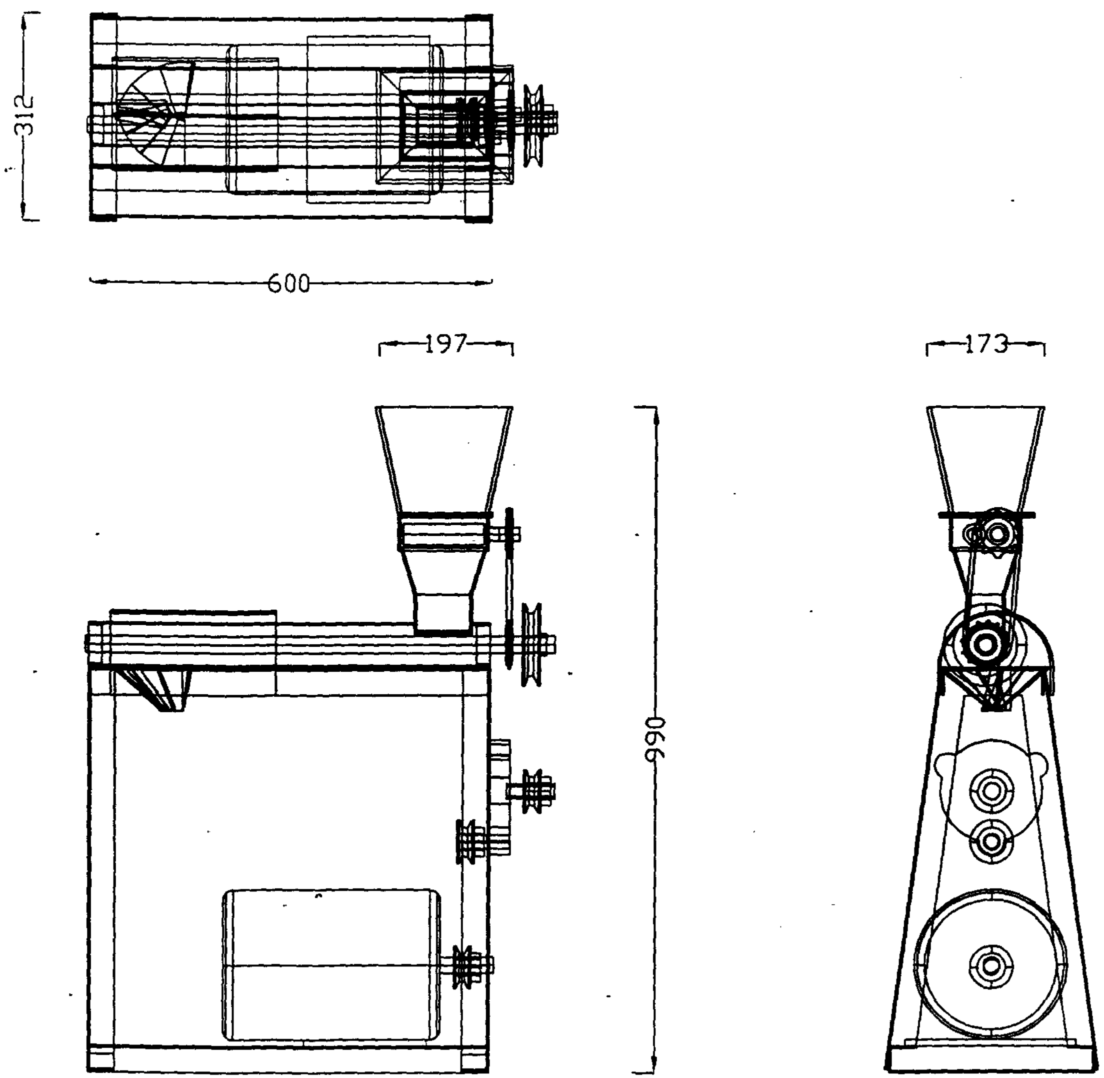

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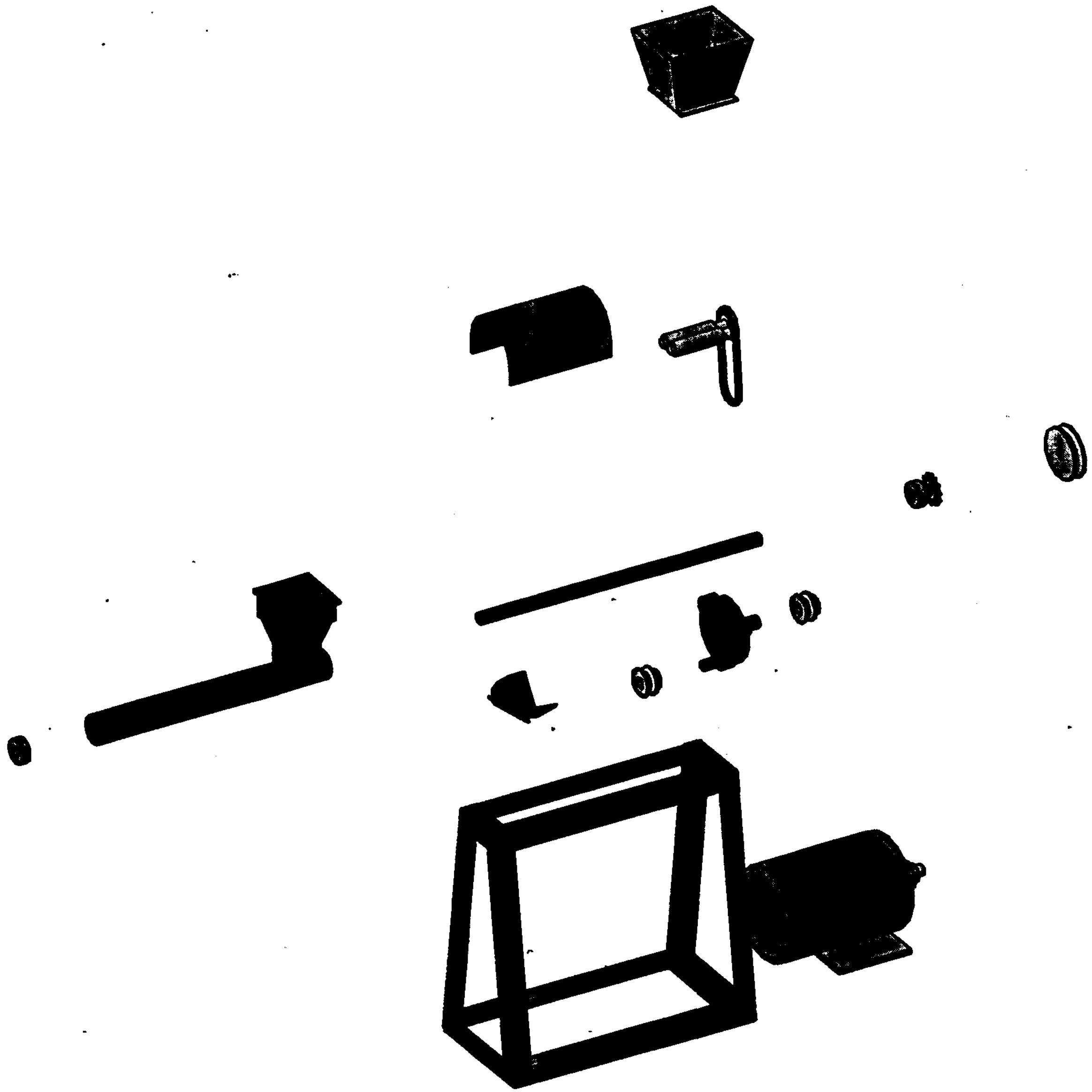

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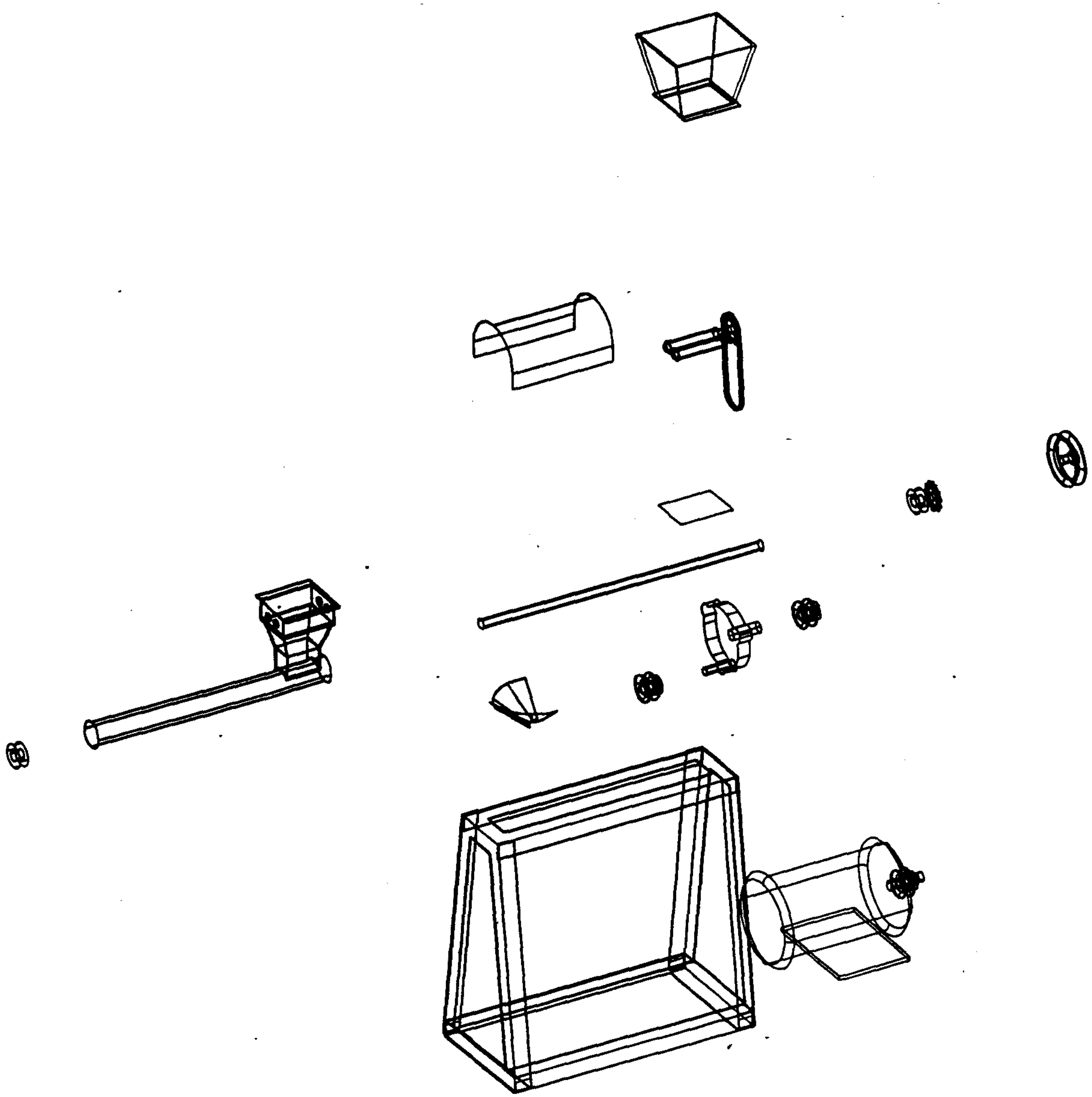

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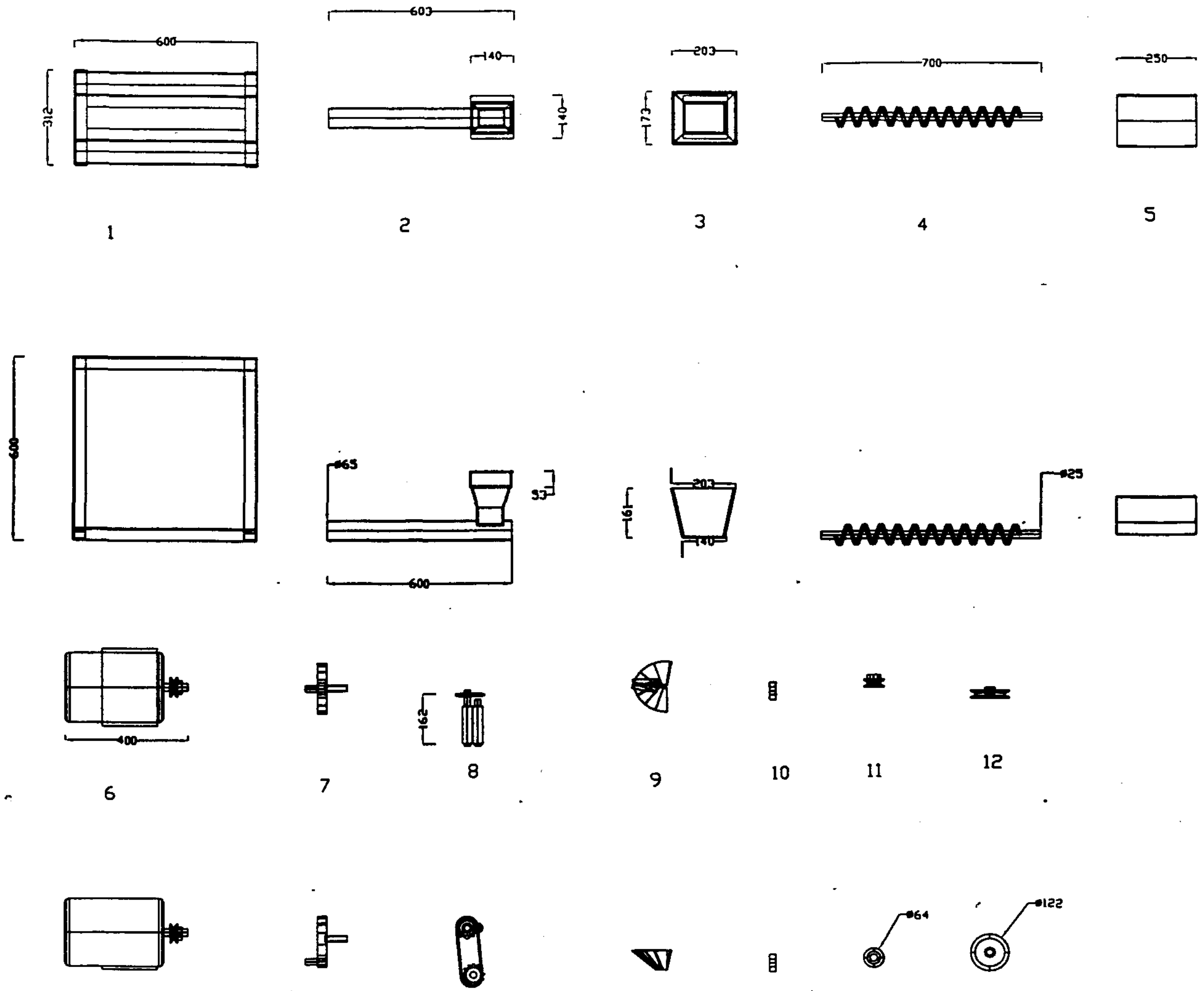

S/no	PART	MATERIAL
12	LARGE PULLEY	MILD STEEL
11	SMALL PULLEY	MILD STEEL
10	BEARING	STEEL
9	OUTLET CHANNEL	MILD STEEL
8	CRUSHER ROLLER	MILD STEEL
7	REDUCTION GEAR BOX	CAST IRON
6	ELECTRIC MOTOR	STEEL
5	HEATER UNIT	MILD STEEL
4	AUGER	MILD STEEL
3	HOPPER	GALVANISED STEEL
2	EXTRACTION CYLINDER	MILD STEEL
1	FRAME	MILD STEEL

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