DESIGN AND DEVELOPMENT OF LOW DENSITY POLYETHYLENE RECYCLING MACHINE

BY

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MATRIC. NO: 2005/21597EA

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DECEMBER, 2010.

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

DECEMBER, 2010.

DECLARATION

I, Elisha-Nissi David Oluwamakinde of the Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, hereby declare that this project work was carried out by me under the supervision of Engr. Dr. O. Chukwu. All sources of information have been duly acknowledged in the text.

……………………………… ……………………………
Elisha-Nissi, David Oluwamakinde Date

CERTIFICATION

This is to certify that the entitled "Design and Development of Low Density Polyethene Recycling Machine" by Elisha, Nissi David Oluwamakinde 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.

13/12/2010

Engr. Dr. Chuku O.
Supervisor

Date

13/12/2010

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

Date

10/12/2010

External Examiner

Date

DEDICATION

I dedicate this project work to God Almighty the Beginning and the End, the Author and Finisher of our faith for seeing me through this phase of my life.

ACKNOWLEDGEMENTS

I give all the praises to God for He alone deserves it. For his protection, guidiance, inspirations, provisions, supplies and sound health throughout my first degree program I return all the glory to Him.

My profound and sincere gratitude go to my supervisor Engr. Dr. Chukwu for his immense contributions to the success of this project. I also want to appreciate the Dean of the School of Engineering and Engineering Technology, FUT, Minna, Engr. Prof. M. S. Abolarin, the Head of Department of Agricultural and Bioresources Engineering, FUT, Minna, Engr. Dr. A. A. Balami, my Lecturers who have at one stage or the other imparted knowledge to me and the entire members of staff of the Department of Agricultural and Bioresources Engineering, FUT, Minna.

I wish to express also my heart of gratitude to my parents Pastor and Deaconess Philip Nissi for their love, care, support (financially, morally, and spiritually), advice encouragements and prayers during the course of my study and to all my siblings (Toluwashe, Issac, Joy, and Debby). I love you all.

I also appreciate everyone that God has used in one way or the other including, Philip Damisa, Ponmile Joseh, Grace Odiri, Sis. Toyin Balogun, Pastor and Dcns. Kayode Olutoki, Pastor and Dcns. John Adelakan, Pastor Eddie Adeoye, Engr. Patrick Elisha, Segun David, Kemi, Ester, Ester Miracle, Patience Gana, Tunde Pillar, all members of the World Changers Forum FUT Minna and every other person that space will constrain me to mention, I apprecite you all.

ABSTRACT

The design, development and performance evaluation of a low density polyethylene (LDPE) recycling machine were carried out in this study following simple standard engineering principles. The recycling process of polyethylene is aimed at reducing the menace of waste polythene to agriculture as well as the environmental pollution and hazard caused by improper disposal of used polythelene. The developed LDPE recycling machine can recycle used packaged water sachets in three stages. The first stage is the melting stage where the polythelene is melted at a temperature of 115°C, the melted polythene is then cooled by convention using water as a coolant. The final stage is the size reduction or recovery of the cooled material. The machine has a power requirement of 2 kW, a cutting speed of 1450 rpm, an input capacity of 5 kg and an output of 3.6 kg, a melting efficiency of 81%, cooling efficiency of 52% and cutting efficiency of 72%. The developed machine can effectively recycle used water sachets. For better performance, it is recommended that the coolant be recycled.

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CHAPTER ONE

1.0 INTRODUCTION

Plastics are organic polymeric materials consisting of giant organic molecules. (Source: Microsoft Encarta 1998).

Plastic materials can be formed into shapes by one of a variety of processes, such as extrusion, molding, casting or spinning. Modern plastics (or polymers) possess a number of extremely desirable characteristics; high strength to weight ratio, excellent thermal properties, electrical insulation, resistance to acids, alkalis and solvents, to name but a few. These polymers are made of a series of repeating units known as monomers. The structure and degree of polymerization of a given polymer determine its characteristics. Linear polymers (a single linear chain of monomers) and branched polymers (linear with side chains) are thermoplastics, which soften when heated. Cross-linked polymers (two or more chains joined by side chains) are thermosetting, that is, they harden when heated (Source: Vogler, Jon, Small-scale recycling of plastics. Intermediate Technology Publications 1984)

1.1 Background to the Study

Various forms of plastics are ubiquitous in today. Most plastics can be successfully recycled. Low density polyethylene (LDPE) is a type of plastic which research has shown has its largest single use is packaging. It is used to package consumables, glossaries, portable sachet water, toilet rolls, kitchen towel, magazines, bread, and fruits. It can also be used to wrap sandwiches, and snacks. It therefore holds that among other solid wastes that man generates, polyethylene has a high percentage. (Source: recycling Texas society of professional engineers 1997)

Unfortunately, discarded polyethylene is also a major environmental problem considering that it is non-biodegradable. It chokes waterways, pollutes streets and takes up precious space in landfills. Research has it that only about 3.5% of all plastics generated are recycled compared to 34% of paper, 22% of glass, and 30% of metals. Plastics recycling only minimally reduce the amount of virgin resources used to make plastics. Recycling papers, glass and metal materials that are easily recycled more than once, saves far more energy and resources than are saved with plastics recycling (volger 1981).

1.2 Statement of the Problem

In western countries, plastic consumption has grown at a tremendous rate over the past two or three decades. In the consumer societies of Europe and America, scarce petroleum resources are used for producing an enormous variety of plastics for an even wider variety of products. Many of the applications are for products with a life-cycle of less than one year and then the vast majority of these plastics are discarded. Plastic wastes are major environmental problems with non-biodegradable plastics choking waterways, polluting streets and taking up precious space in landfills (dumping ground). Plastic litter poses serious health and ecological issues like:

- Offers breeding places for the mosquitoes that are the carrying dengue and malaria.
- Is being eaten by cattle and wild animals and endangers their lives,
- Where it lays, it stops vegetation from growing, thereby affects plant growth
- Washed down by rain, it obstructs drains and pippins causing flooding.

- Washed down along rivers, it ends in the sea where birds and fishes eat it, or it is torn Apart in thousands of small pieces and slowly releases toxic chemicals in the water (source: Vogler, 1981)

More serious problem with plastic waste concerns the additives contained in plastics. These additives include colorants, stabilizers, and plasticizers that may include toxic components such as lead and cadmium. These additives are washed into the soil thereby making it unsafe and toxic for agricultural practices, and washed into streams and rivers by rain, which are the major sources of water for agriculture especially in developing countries. Studies indicate that plastics contribute 28 percent of all cadmium in municipal solid waste and about 2 percent of all lead. Researchers do not know whether these and other plastic additives contribute significantly to products leached from municipal landfills.

1.3 Objectives of the Study

The objectives of this project work are:

1. To design a low density polyethylene machine
2. To develop the designed low density polyethylene machine
3. To carry out a performance evaluation of the developed low density polyethylene machine

1.4 Justification of the Study

Polyethylene (plastic) is not biodegradable i.e. it does not decompose easily hence when it is disposed into landfills it poses a great problem to agricultural activities in various ways. This gives the need for a study on how to recycle this waste.

1.5 Scope of the Study

The scope of this study covers the design, development (fabrication) and performance testing or evaluation of a low density polyethylene recycling machine.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Concept of Machine Design

Machine design is the creation of new and better machines or improving on existing ones. A new and better machine is one which is more economical in the overall cost of production and operation. (Krumi and Gubta, 2005)

The process of design begins with the conception of an idea, it is taken through further study keeping in mind the commercial success and given shape and form in the form of drawings. In the preparation of these drawings, the available resources (human, finance, and material) must be taken into consideration, this is to facilitate the successful completion of the project. It is important also to have a good knowledge of subjects like Mathematics, Theory of Machines, Workshop Processes, and Engineering Drawing.

2.2 Types of Machine Design

Machine design can be classified into:

2.2.1 Adaptive Design: This entails the adaptation of existing designs. This type of design needs no special knowledge or skill and can be attempted by designers of ordinary technical training. The designer only makes minor alterations or modification in the existing design of the product.

2.2.2 Development Design: this requires a considerable scientific training and design ability in order to modify the existing designs into a new idea by adopting a new material or different methods of manufacture. In this case, though the designer starts from existing design but final product may differ quite markedly from the original product.

2.2.3 New Design: a new design needs a lot of research, technical ability, and creative thinking. Only those designers who have qualities of a sufficiently high order can take up the work of a new design.

In designs generally, the type of load and the stresses caused by the load, motion parts or kinematics of the machine, selection of materials, form and size of parts, frictional resistance and lubrication, convenient and economical features, use of standard parts, safety of operation, workshop facilities cost of production, assembling and number of machines to be manufactured, must be put into consideration.

2.3 General Procedure for Machine Design

Although there is no rigid rule in design of machines, design problems may be attempted in several ways the general procedure to solve a design problem is as follows:

Recognition of Need: First step in design is making a complete statement of problem.

Mechanisms: Select the possible mechanism or group of mechanisms to be used.

Analysis of Force: Find the forces acting on each member of the machine and the energy transmitted by each member.

Material Selection: Select materials suitable for the each member of the machine.

Design of the Elements: Find the size of each member of the machine by considering the forces acting on the member and the permissible stresses for the materials to be used.

Modification: Modify the size of the member to agree with the past experience and judgment to facilitate manufacture.

Detailed Drawing: Have a detailed drawing of each component and the assembly of the machine with complete specifications for the manufacturing processes.

Production: The component as per the drawing is manufactured in the workshop.

2.4 Definition of Polyethylene

Polyethylene is a thermoplastic polymer consisting of long chains of the monomer, ethylene, with the IUPAC name ethane. The recommended scientific name polyethene is systematically derived from the scientific name of the monomer. The name is abbreviated to PE in a manner similar to that by which other polymers like polypropylene and polystyrene are shortened to PP and PS respectively. The ethane molecule (known almost universally by its common name ethylene) C_2H_4 is $CH_2=CH_2$, has two CH_2 groups connected by a double bond, as shown in Figure 2.1 (Lotfi, 2009).

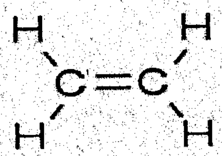


Fig. 2.1: Chemical Structure of Polyethylene

2.5 Types of Polyethylene

Polyethylene is classified into different categories. These categories are based mostly on their density and branching. They include:

2.5.1 Ultra High Molecular Weight Polyethylene (UHMWPE)

This is a polyethylene with a molecular weight numbering in the millions, usually between 3.1 and 5.67 million. The high molecular weight makes it a very tough material, but results in less efficient packing of the chains into the crystal structure as evidenced by densities of less than high-density polyethylene. UHMWPE can be used in can and bottle handling machine parts, moving parts on weaving machines, bearings, gears, artificial joints, edge protection on ice rinks and butchers' chopping boards. It competes with Aramid in bulletproof vests, under the trade names Spectra and Dyneema, and is commonly used for the construction of a particular portions of implants used for hip and knee replacements.

2.5.2 High Density Polyethylene (HDPE)

This has a low degree of branching, stronger intermolecular forces, tensile strength, a density of greater or equal to 0.941 g/cm^3 and can be produced by chromium/silica catalysts, Ziegler-Natta catalysts or metallocene catalysts. HDPE is used in products and packaging such as milk jugs, detergent bottles, margarine tubes, garbage containers and water pipes. One third of all toys are manufactured from HDPE.

2.5.3 Cross-Linked Polyethylene (PEX or XLPE)

This is a medium- to high-density polyethylene containing cross-link bonds introduced into the polymer structure, changing the thermoplast into an elastomeric. The high-temperature properties of the polymer are improved, its flow is reduced and its chemical resistance is enhanced. PEX is used in some potable-water plumbing systems because tubes made of the material can be expanded to fit over a metal nipple and it will slowly return to its original shape, forming a permanent, water-tight, connection.

2.5.4 Medium Density Polyethylene (MDPE)

This is defined by a density range of 0.926–0.940 g/cm^3. It has good shock and drop resistance properties. It also is less notch sensitive than HDPE and stress cracking resistance better than HDPE. MDPE is typically used in gas pipes and fittings, sacks, shrink film, packaging film, carrier bags and screw closures.

2.5.5 Linear Low Density Polyethylene (LLDPE)

This is defined by a density range of 0.915–0.925 g/cm^3. LLDPE is used in packaging, particularly film for bags and sheets. Lower thickness may be used compared to LDPE for cable covering, toys, lids, buckets, containers and pipe while other applications are available. LLDPE is used predominantly in film applications due to its toughness, flexibility and relative transparency. Product examples range from agricultural films, saran wrap, and bubble wrap, to multi-layer and composite films. In 2009 the world LLDPE market reached a volume of almost 24 billion US-dollars (17 billion Euros).

2.5.6 Low Density Polyethylene (LDPE)

This is defined by a density range of 0.910–0.940 g/cm^3. LDPE has a high degree of short and long chain branching, which means that the chains do not pack into the crystal structure as well. LDPE is used for both rigid containers and plastic film applications such as plastic bags and film wrap.

2.5.7 Very Low Density Polyethylene (VLDPE)

This is defined by a density range of 0.880–0.915 g/cm^3. Most commonly produced using metallocene catalysts due to the greater co-monomer incorporation exhibited by these catalysts. VLDPEs are used for hose and tubing, ice and frozen food bags, food packaging and stretch wrap as well as impact modifiers when blended with other polymers.

Source: H. A. Favre and W. H. Powell (2005)

2.6 Physical Properties of Low Density Polyethylene

The melting point for average, low-density polyethylene is typically 105 to 115°C and when incinerated, polyethylene burns slowly with a blue flame having a yellow tip and gives off an odour of paraffin. The material continues burning on removal of the flame source and produces a drip of molten polyethylene. Polyethylenes are generally strong, tough and clear except for Polystyrene which can be easily formed.

2.7 Concept of Recycling Low Density Polyethylene

Polyethylene recycling is the process of recovering scrap or waste plastics or polyethylene and reprocessing the material into useful products, sometimes completely different in form from their original state. For instance, this could mean melting down soft drink bottles or sachet water waste and then molding them into plastic bottles, packaging bags, or as raw materials for other products. Typically a plastic is not recycled into the same type of plastic and products made from recycled plastics are often not recyclable. For a recycling process to be successful, the supply of used plastic has to be of a large quantity, which is collected at certain areas. Once the plastic is collected, the sorting and separating process begins. The sorting and separating process depends upon the type of polymers that makes up the plastic. Plastic products are given codes to help the sorting and separating process these codes helps most in the sorting and separating process. The six categories of plastics are classified into polyethylene and polymer plastics. The polyethylene plastics are labelled HDPE, for high-density polyethylene; or LDPE, for low-density polyethylene. The four polymer plastics that are recycled include polyvinyl chloride, labelled V; polystyrene, labelled PS; polypropylene, labelled PP; and polyethylene terephthalate, labelled PETE. These names and labels can seem confusing, but they are a necessity in the recycling process. The plastic recycling codes came from The Society of Plastics Industry, Inc. (SPI) that introduced its resin identification coding system in 1988 after lobbying by recyclers. This code helps in identifying plastics and helps in sorting for recycling. The recycling codes are explained in the table below:

Codes	Name of Plastics
1 PETE	Polyethylene Terephthalate, PETE
2 HDPE	High Density Polyethylene, HDPE
3 PVC	Polyvinyl Chloride, PVC
4 LDPE	Low Density Polyethylene, LDPE
5 PP	Polypropylene, PP
6 PS	Polystyrene, PS
7 OTHER	Other

Table 2.1 plastic recycling codes (Source: practical action, 2009)

Sorting is followed by reprocessing. The reprocessing of polymers includes the melting process; which can be accomplished if the polymers have not been widely cross-linked with any synthetics. If the cross-linking of polymers contains too many synthetics, the polymers will be difficult to stretch and less pliable after melting the molten plastic is cooled and then grinded into pellets which can be further used as raw materials in fertilizer companies or plastic production industries.

There are four types of recycling processes that usually occur in plastic recycling this includes primary, secondary, tertiary, and quaternary recycling process. The primary recycling process is the recycling of materials and products that contain similar features of the original product. This process is only feasible with semi-clean industrial scrap plastics. Therefore, this process is not widely used. Secondary recycling allows for a higher mixture of combination levels in plastics. When the secondary process of recycling is used, it creates products such as fence posts and any products that can be used in the substitution of wood, concrete, and metal. The low mechanical properties of these types of plastics are the reason why the above products are created. Tertiary recycling is occurring more and more today because of the need to adapt to the high levels of waste contamination. The actual process involves producing basic chemicals and fuels from plastic. The last form of recycling is the quaternary process. This quaternary process uses the energy from plastic by burning. This process is the most common and widely used in recycling. The reason this process is widely used is because of the high heat content of most plastics. Most incinerators used in the process can reach temperatures as high as 900 to 1000 degrees Celsius. For the sake of the environment, the new techniques being used with the incinerators have decreased the amount of air pollutants being released.

2.8 Types of Plastic Recycling

2.8.1 Mechanical Recycling

Mechanical recycling of plastics involves the melting, shredding or granulation of waste plastics. Plastics must be sorted prior to mechanical recycling. Now in the United Kingdom (UK), trained staffs who manually sort the plastics into polymer type and/or colour do most sorting for mechanical recycling. (Janssen and Van Santen 1999)

Technology is being introduced to sort plastics automatically, using various techniques such as X-ray fluorescence, infrared and near infrared spectroscopy, electrostatics, and flotation. Following sorting, the plastic is either melted down directly and moulded into a new shape, or melted down after being shredded into flakes and then processed into granules called regranulate.

2.8.2 Chemical Recycling

Chemical recycling describes a range of plastic recovery techniques, which break down polymers into their constituent monomers, and in turn can be used again in refineries, or petrochemical and chemical production. A range of chemical recycling technologies is currently being explored. These include pyrolysis, hydrogenation, gasification, and thermal cracking. Chemical recycling has a greater flexibility over composition, is more tolerant to impurities than mechanical recycling, although it is capital intensive, and requires very large quantities of used plastic for reprocessing to be economically viable.

2.9 Classification of Plastic Wastes

Plastic wastes can be classified based on their sources as follows

2.9.1 Industrial Waste (or primary waste) is often obtained from the large plastics processing, manufacturing and packaging industries. Rejected or waste material usually has good characteristics for recycling and will be clean. Although the quantity of material available is sometimes small, the quantities tend to be growing as consumption, and therefore production, increases.

2.9.2 Commercial Wastes are wastes obtained from workshops, artisans, shops, supermarkets and wholesalers. A lot of the plastics available from these sources will be PE, but often contaminated.

2.9.3 Agricultural Wastes are wastes obtained from farms and nursery gardens outside the urban areas. This is usually in the form of packaging (plastic containers or sheets) or construction materials (irrigation or hosepipes).

2.9.4 Municipal Wastes are wastes collected from residential areas (domestic or household waste), streets, parks, collection depots and waste dumps. In Asian cities this type of waste is common and can be collected from the streets or from households by arrangement with the householders.

(Lardinois, 1995):

2.10 Review of Related Works

Since a high percentage of domestic waste is made up of plastics, which are generally known to be non bio-degradable (they cannot be easily broken down by bacteria) thereby occupying landfills and causing environmental pollution. In Europe and Japan, there are less land that can be used as landfills this has gingered a great deal of interest in recycling. Dr P. J. Barham, of University of Bristol gave an option to produce polymers that are truly biodegradable, and which may be used in the same applications as existing polymers. He further stated that such materials might be processed through the melt state, that they are impervious to water, and that they retain their integrity during normal use but readily degrade in a biologically rich environment. Polyhydroxyalkonates are a family of naturally occurring polyesters, produced in the form of carbon storage granules by many bacteria. Zeneca Bio products are currently producing these polymers on a pilot plant scale under the trade name BIOPOL. The Bristol Polymer group has been actively involved in the development of these polymers, especially in determining optimum processing conditions.

At Polymer Technology Center (PTC), Department of Chemical Engineering, Northwestern University, a patented, breakthrough technology for plastics recycling has been developed that eliminates sorting by type or by colour in recycling process. This technology, called Solid State Shear Pulverization (S^3P), is a continuous one-step process for recycling unsorted pre- or post-consumer plastic waste. Unlike conventional recycling, S^3P produces uniform powders that can be used to make a variety of high-quality products. S^3P subjects polymers to high shear and high pressure while rapidly removing frictional heat from the process to prevent melting. S^3P can convert multi-colored, unsorted (commingled) waste, industrial plastic scrap, and virgin resins to a uniform, light-colored, partially reactive powder of controlled particle size and particle size distribution. These powders are suitable for direct melt conversion by all existing plastic processing techniques.

In 2009, eighth-grader Nick Gidzak of Polar Bay, Manitoba, Canada, carried out a project on plastic recycling. He recycled plastic and mixed it with cement to produce bricks. He cut up plastic milk cartons and plastic two-liter pop containers and mixed this with cement to make bricks. He then made three bricks with different amounts of plastic mixed with cement. The first brick was made with the most plastic. The second had half as much. The last brick had no plastic. He left them outside for four months and exposed them to snow, rain, and sun. After four months, He pumped water over the bricks for two weeks. The water wore away the bricks and show how much erosion effect it did. The results were that the brick with the most plastic mixed in showed the least amount of erosion.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Theoretical Background

The design and development of low density polyethylene recycling machine has mainly the melting, cooling, and the recovery unit. Heat is applied to completely melt the waste polythene after which the molten polythene is cooled in a mould made of steel by convention using water as coolant to form lumps the final process involves the size reduction where the lumps are broken down into small sizes and the broken pieces which is in form of pellets are allowed to pass through a wire mesh.

The low density polyethylene recycling machine consists of the following major components.

3.1.1 The Heating Chamber:

Hopper: The hopper is essentially the component that aids the introduction of the polyethylene to be heated up, so that it can be melted. The construction of the hopper is made from mild steel sheet and weld to the cooling unit. It is a square at the top and bottom of dimensions 49cm by 49cm and 20cm by 20cm respectively with a height of 50cm.

Heating Element: This device is used as a source of heat energy for melting the polyethylene.

Sieve: This materials is used for the separations of solid and liquid polyethylene, it is designed to allow only molten polyethylene flow through it.

Insulators: An insulator is a material or device that prevents or reduces the passage of heat. They are used to prevent heat loss through the walls of the machine.

Stopper Tray: the stopper tray is used to hold back the melted polyethylene before it flows into the cooling unit.

3.1.2 The Cooling Chamber:

Mould: The mould was constructed in form of a frustum with a small diameter at the top and larger diameter at the bottom

Water Box: The box has an inlet where water enters through and outlet verve for discharge of water with a dimension of 49cm by 49cm and a height of 10cm.

Stopper Tray: the stopper tray is used to hold back the melted polyethylene before it flows into the recovery chamber.

3.1.3 The Recovery Chamber:

Shaft: A shaft is a rotating machine element that is used to transmit power from one place to another. The shaft used in this development has 18 metal blades mounted on it.

The Blade: the flat sharp-edged cutting part of a tool.

Electric Motor: This used to supply power to the shaft.

V-belt: A strip of material worn around pulley.

The Concave: Curved inward like the inner surface of a bowl or sphere it is used in this design to house the rotating shaft.

The Frame: The frame is the component of the machine on which all other components are mounted. Therefore, the frame provides support for the machine.

3.2 Material Selection

In every design, the basic consideration is the cost and availability of materials to be employed for the development of that design. Other parameter to be considered includes performance, workability, and weld ability, so that specific purpose can be achieved using the selected materials. In the design of this low density polyethylene recycling machine, the cost and availability of required materials were first considered after which strength and its ability to resist heat were considered.

All these considerations and materials specifications led to the selection of mild steel, which is the most available and easy to work. Paint was used to reduce rust with time, as well as to beautify the work.

3.2.1 Parameters for Selection of Materials

During the material selections, materials that meet design specifications, which were obtained from the design calculations were selected, this was done to avoid failure of the machine components. Also relatively cheap materials when compared to other engineering materials that meet the design constraints were considered during selection. Additional factors considered were:

Health: Materials known to be dangerous to health were avoided.

Material Properties: The materials selected must possess values of maximum stress equal to or greater than those derived analysis and calculations.

Deteriorative Properties: Such as resistance to oxidation, corrosion or weathering was considered and taken care of by painting of the finished work.

Manufacturing Characteristics: This includes the materials ability to be welded and machined, as most joints are to be made by welding.

Cost: The cost of Materials and labour for the manufacturing cost were considered.

Availability and Aesthetics: The availability of materials and parts in the local market was considered.

3.3 Mode of Operation

The basic component of the machine is a single shaft with uniform loading which rotates at 1450 rpm. The shaft is powered by a 2 Hp electric motor through a v-belt which transfers the rotation of the electric motor to the shaft. The polyethylene is fed through the hopper, the heating elements which are incorporated into the hopper supplies heat to melt the material. To ensure the complete melting of the material, and enhanced efficiency, the heating unit has a stopper at the base it stops the polyethylene from flowing until it has completely melted. After the polyethylene has completely melted, the stopper is removed and the molten material is allowed to flow into the moulds in the cooling chamber. Water is passed directly around the mould and the molten polyethylene is cooled through the process of convention till is solidifies. The cooling chamber also has a stopper tray under it that is used to control the solidified polyethylene when this stopper tray is removed, the solidified polyethylene falls into the recovery chamber. The process of cutting of the lumps of the Low Density Polyethylene into smaller pellets with the help of the cutting blade attached to the shaft driven by the electric motor is carried out. This machine is simple to operate while maintenance and adjustment requires little specialist attention.

3.4 Machine Hopper Design

In designing a hopper for a machine, an important consideration is to achieve mass out-flow of material out of the hopper thereby minimizing arching (i.e. where no flow occurs) and funnelling (i.e. where flow may be reduced). In addition, the hopper's strength and capacity are taken into consideration. In designing a hopper, it is recommended that the angle of inclination of the sides of the hopper to the horizontal must be greater than the angle of friction between the hopper wall and the material. The designed hopper and it dimensions are shown in figure 3.1a to c.

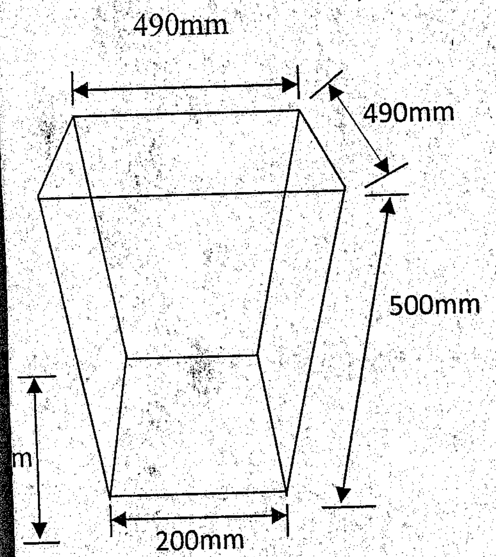


Fig. 3.1a dimenssions of the hopper

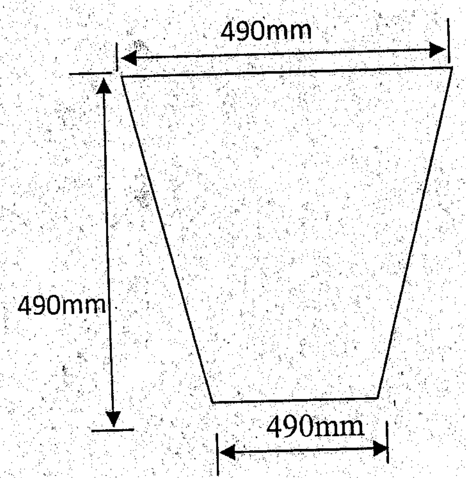


Fig 3.1b Dimensions of the hopper

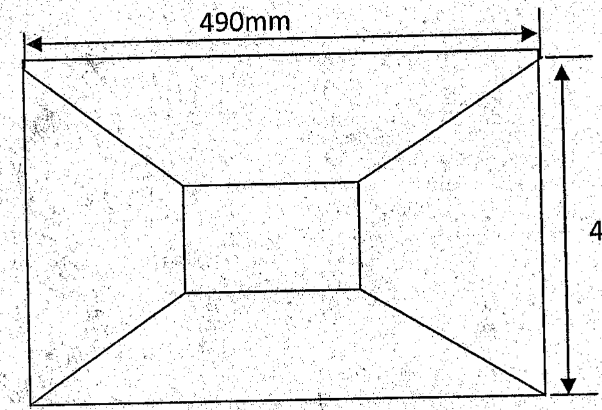


Fig. 3.1c Plan view of the hopper

Assuming that the volume of the hopper is fully loaded with polyethylene (used sachet water), the weight of polyethylene to be feed into the hopper is calculated as follows

The mass of one piece of used sachet water = 2.32 g

$= 2.32 \times 10^{-3}$kg

Using w = mg (3.1)

Where w = weight of material

m = mass of material

g = gravitational force

Therefore, $w = 2.32 \times 10^{-3} \times 9.81 = 0.0227529$ N

$Fg = 2.32 \times 10^{-3} \times 9.81 = 0.0227592$N

Then the weight of 50 pack = 1.13796N which can be fed into the hopper.

3.5 Quantity of Heat Required to Melt the Material

Mass of material to be recycled (m) = 0.116kg

Expressing the value of (m) in volume

From density $\rho = m/v$ (3.2)

Making v the subject of the formula,

$V = m/\rho$

Where ρ = density of the material (i.e. LDPE)

$v = \frac{920\ kg}{m^3}$

(Source: Martienssen Eds warlimat. 2005)

Using the mass, the volume of the material to be recycled

$V = \frac{5\ kg}{920 kg/m^3}$

$= 5.435 \times 10^{-3} m^3$

Taking 20% to be factor of safety

$V = \frac{20}{100} \times 5.435 \times 10^{-3} m^3$

$= 1.0869 \times 10^{-3} m^3$

Total volume (V) $= 5.435 \times 10^{-3} m^3 + 1.0869 \times 10^{-3} = 1086.095435 m^3$

$\approx 1086.91 m^3$

Melting point of Low Density Polythene is 115°C

(Source: Martienssen W. (eds); H wartime. 2005)

Therefore, the quantity of heat required to melt 0.116kg of the material is calculated thus;

Using $Q = MC\Delta T$ (3.3)

Where

Q = quantity of heat required

M = mass of material

$C = 2.303KJ/Kg$,

ΔT = change in temperature = $(T_1 - T_2)$

(T_1 = room temperature, T_2 = melting temperature)

m = 5 Kg

$C = 2.303KJ/Kg$,

$T_1 = 25\ °C$ or 388 K

$T_2 = 115°C$ or 388K

$Q = 5kg \times 2.302 \times (115\text{-}25)$

$Q = 1035.9kJ$

Wattage $(W) = Q/T$ (3.4)

Where

Q = quantity of heat required

T = time taken in seconds.

$$W = \frac{1035.9KJ}{5 \times 60}$$

$W = 3.453$

3.6 Cooling Chamber

The cooling chamber is a tank made of steel with dimension 49 cm by 49 cm by 10 cm.

Volume of a tank = Length × Breadth × Height (L×B×H) (3.5)

$= 49cm \times 49cm \times 10cm$

$= 24010cm^3$

$= 0.02401m^3$

3.7 Mould Design

Taking the following dimension for the mould

Diameter of the top = 3.6cm = 0.036m

Diameter of the bottom = 4cm = 0.04m

Height of the frustum = 10cm = 0.1m

The total number of mould in the cooling chamber is nine (9).

The volume of a the moulds are calculated as follows

Using $V = \pi/3\ h\ (R^2 + r^2 + R \times r)$ (3.6)

Where

V = volume of the mould

R = radius of the top = 0.018 mm

r = radius of the bottom = 0.04 mm

h = height of mould = 0.0

Therefore,

$$V = \frac{\pi}{3} 0.1\ (0.043^2 + 0.02^2 + 0.018 \times 0.02)$$

$$= \frac{\pi}{3} 0.1\ (0.0004+0.00032+0.00036)$$

$$= (0.000113516)$$

$$V = 1.135 \times 10^{-4} m^3$$

Total Volume = (volume of a frustum × Total number of frustum) (3.7)

$$V = 0.042m^2 \times 9$$

$$= 0.381m^3$$

Therefore; to determine the amount of water in the cooling chamber

Total volume of water = volume of a cuboids – total volume of the frustum

Total volume of water = (240.1 - 0.381) m^3

= 239.719m^3

3.8 Rate of Cooling

$Q = MC\Delta T$ (3.8)

Where

$\Delta T = T_1 - T_2$

$T_1 = 0°C \text{ or } 273K$

$T_2 = 115°C$ or 388K

$\Delta T = 273 - 388$

$\Delta T = -1550$ °C

5 kg × 2.302 × -155

Heat loss = 1784.05KJ

3.9 Heat Loss

$$\text{Rate of cooling} = \frac{\text{heat loss}}{\text{Time}} \quad (3.9)$$

$$= \frac{1784.05Kg}{0.01sec}$$

= 178405Kg/sec

3.10 Design Theory

If the cutting shaft is subjected to twisting moment only,

$\tau/r = \tau/j$ (3.10)

$$J = \frac{\pi D^4 - d^4}{64} \tag{3.11}$$

$$T = \frac{\tau r}{J} = \frac{\tau D}{2J} \tag{3.12}$$

$$T = \frac{16DT}{\pi\left(D^4 - d^4\right)} \tag{3.13}$$

$$\frac{M}{J} = \frac{\sigma}{y} \tag{3.14}$$

Where,

M = bending moment

σ = bending

J = moment of inertia

y = distance from neutral axis to shaft diameter = $\frac{D}{2}$

$$M = \frac{\pi\sigma\,(D^4 - d^4)}{32D} \tag{3.15}$$

$$\therefore \sigma = \frac{32M}{\pi\,(D^4 - d^4)} \tag{3.16}$$

Maximum shear stress = $S_{max} = \frac{1}{2}\sqrt{(\sigma^2 + 4\sigma^2)}$(3.15)

$$S_{max} = \frac{1}{2}\sqrt{\left\{\left[\frac{32MD}{\pi(D^4 - d^4)}\right]\right\} + 4\left[\frac{16DT}{\pi(D^4 - d^4)}\right]^2}$$

$$= \frac{16D\sqrt{M^2 + 4T^2}}{\pi(D^4 - d^4)}$$

For cutting blade,

S = M

(3.17)

Z

Where,

M = bending moment

Z = section modulus

Maximum stress

$$\sigma Max = \frac{1}{2}\sqrt{S^2 + 4\sigma^2} \qquad (3.18)$$

$$= \frac{1}{2}\sqrt{\left(\frac{M}{Z}\right)^2 + \left(\frac{F}{A}\right)^2} \qquad \text{(Oluboji, 2004)} \qquad (3.19)$$

3.11 Cutting Blades on the Rotating Shaft

Ahuja and Shama, 1989 establish spike spacing for his manually operated shredding machine at 30 to 50mm. most existing shredders have one legged spike. In this design, one legged spike of 10cm × 10cm spacing is used.

The cutting blade is made of mild steel with height H = 12.5cm $\sin 60$ = 10.8253cm

Diameter = 4cm

Volume of each cutting blade = nr^2 (length) (3.20)

$$= \frac{4^2}{2} \times 12.5$$

$$= 8 \times 12.5$$

$$=100 \text{ cm}^3$$

Mass of each cutting blade = Volume × Density of mild steel (3.21)

$$= 100 \times 7850$$

$$= 785000K$$

3.12 Motor-Cylinder Design Calculation

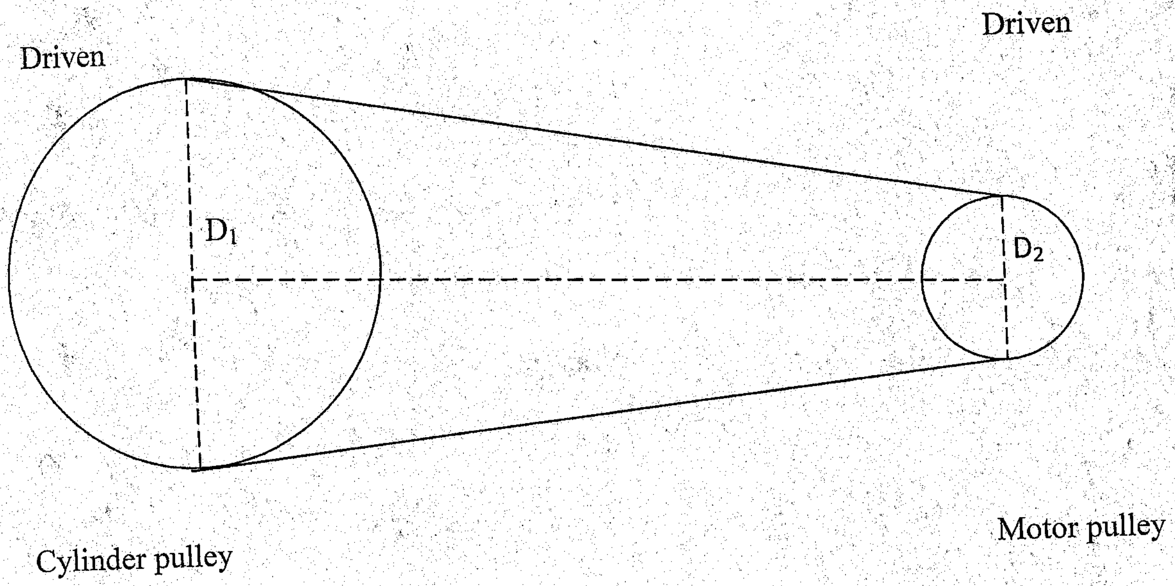


Fig3.2: Motor-Cylinder Pulley Belt Arrangement

$D_1/ D_2 = N_1/N_2$ (3.22)

Where,

D_1 = diameter of motor pulley = 12cm

D_2 = diameter of the shaft driven pulley =?

N_1 = Speed of electric motor = 1450 rpm

N_2 = Speed of rotating shaft = 2000 rpm

From the equation;

$$\frac{D_1}{D_2} = \frac{N_1}{N_2} \quad (3.23)$$

$$D_1 N_2 = D_2 N_1 \quad (3.24)$$

$$D_2 = \frac{DN}{N}$$

$$= \frac{12 \times 1450}{2000}$$

= 8.7cm

= 9.0cm

If the diameter of the shaft driven pulley is 9cm

Speed of Shaft = $\frac{\pi \times 0.09 \times 1450}{4}$ (3.25)

= 410.031*m/s*

3.13 Angular Velocity of Motor-Cylinder Belt

$W_2 = \frac{2 \times \pi \times 1450}{60}$ (3.26)

= 151.863 *rad/s*

$W_1 = \frac{2 \times \pi \times 200}{60}$

= 209.467 *rad/s*

3.14 Power on Motor-Cylinder Belt

Power = torque × angular velocity

$P = \tau w$ (3.27)

Torque on motor - pulley to accelerate the cylinder = tm = $w_2 r_2$ (3.28)

Where

r_2 = radius of motor-pulley

Hence,

Power = tm $w_2 = w_2^2 r_2$ (3.29)

Therefore, power delivered by the motor

$Pm = (151.863)^3 \times 0.12 / 2$

= 1383.742 watts

For efficiency of 95%

$$= \frac{95}{100} \times 1383.742$$

= 1314.555 watts

Power required driving the shaft,

$$P_s = w_1^2 r_1 \qquad (3.30)$$

Where,

r_1 = radius of shaft of pulley

$$P_s = (209.467)^2 \times \frac{9}{2}$$

= 197443.908 watts

3.15 Centre-Distance of Motor-Shaft Pulley

The centre-distance is obtained from the relation CD = max (2R, 3r + R) (3.31)

Where, CD = Centre distance

R = Radius of large pulley

R = Radius of small pulley

From the equation above, two centre distances will be obtained, but the larger is chosen.

That is $CD = \max\left(\frac{2\times1.12}{2}, \frac{3(0.09)}{2} + \frac{0.12}{2}\right)$

CD = max (0.120, 0.195)

CD = 195mm (which is equal to the larger centre distance)

Note: the centre-distance should not be greater than three times the sum of the sheave diameters or less than the diameter of the larger pulley.

3.16 Angle of Contact of Motor-Shaft Pulley

$\emptyset_L$ = Angle of contact of large pulley = $\pi + 2\sin^{-1}\frac{(D-d)}{2CD}$ (3.32)

$= \pi + 2\sin^{-1}\frac{(120-90)}{2(195)}$

$= 11.965°$

$\emptyset_S$ = Angle of contact of small pulley = $\pi - 2\sin^{-1}\frac{(D-d)}{2CD}$ (3.33)

$= \pi - 2\sin^{-1}\frac{(120-90)}{2(195)}$

$= -5.681°$

3.17 Length of Motor-Shaft Pulley

Length of belt, $L = \frac{\pi}{2}(D_1 + D_2) + 2CD + \frac{(D_1 - D_2)}{4CD}$ (3.34)

According to Khurmi and Gupta (2005)

$= \frac{3.142}{2}(120 + 90) + 2 \times 195 + \frac{(120-90)^2}{4 \times 195}$

$L = 438.28mm$

The length correction factor $K_L = 0.84$ (from tables)

$L = 438.28 \times 0.84$

$L = 368.158mm$

3.18 Determination of Weight of Pulley

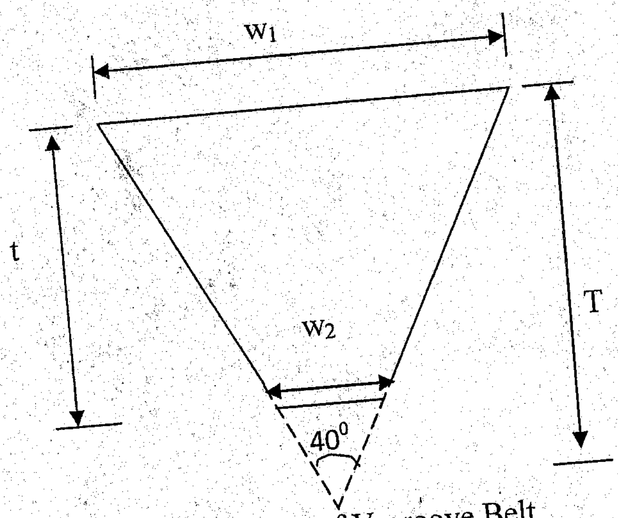


Fig3.3: Cross-Section of V-groove Belt

Width of the belt; $w_1 = 13mm$

Nominal depth of the belt; $t = 8mm$

Sleeve groove angle = 40^0

Density of the leather belt = $\rho = 970Kg/m^3$

(Shaun series)

From the above,

$$\beta = \left(\frac{180-40}{2}\right) = 70^0 \qquad (3.35)$$

Actual depth of the belt, $T = \frac{1}{2} \times 13 \times \tan 70$

$T = 17.859mm$

$$w_2 = \frac{t \times w_1}{T}$$

$$= \frac{8 \times 13}{17.854}$$

$w_2 = 5.83mm$

The cross-sectional area of the belt can be calculated as;

$A = \left[\frac{w_1 + w_2}{2}\right] t$ (3.36)

$= \left[\frac{13 + 5.83}{2}\right] 8$

$= 9.415 \times 8$

$= 75.32 mm^2$

$= 73.32 \times 10^{-6}$ m

$M = P \times A$ (3.43)

$M = 970 \times 75.32 \times 10^{-6}$

$M = 73060.4 \times 10^{-6}$

$M = 0.730604 Kg/m$

3.19 Determination of Weight on Cutting Blade

Area of each rod $= \frac{\pi d^2}{4}$ (3.37)

$= \frac{3.142\ (0.04)^2}{4}$

$= 1.2568 \times 10^{-3} m^2$

Length of the blade = 12.5cm = 0.125m

Volume of the blade = $1.2568 \times 10^{-4} m^3$

Weight of blade = (W) = $\rho v g$

$= 7850 \times 1.2568 \times 10^{-4} \times 9.81$

$= 9.678 N$

For 18 cutting blade

$W = 18 \times 9.678$

$= 174.212N$

Weight of cylinder (3.38)

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

D = 49.5cm = 0.495m

d = 44.5cm = 0.445m

Area (A) $= \frac{3.142(0.495^2 - 0.445^2)}{4}$

= 0.0369185

$A = 3.692 \times 10^{-2} m^3$

V = 49cm = 0.49m

$V = Al = 3.692 \times 10^{-2} \times 0.43$

$V = 1.58756 \times 10^{-2} m^3$ (3.39)

Weight (W) $= \rho v g$

$= 1222.56N$

Weight of Low Density Polyethylene (LDPE)

For a feed rate of 5*Kg*/hr

Amount broken per second

= 5/3500 = 1.388Kg (3.40)

Breaking Force F = 3.9943wgRN

wg = weight of grain (Kg)

R = particle radius (m)

N = Breaking speed (*rpm*)

(Khurmi and Gupta, 2008)

$F = 3.9943 \times 1.388 \times 1.8 \times 10^{-2} \times 1450$

$= 144.70Kg$

Total cutter weight = 174.212 + 1222.56 + 1447.0

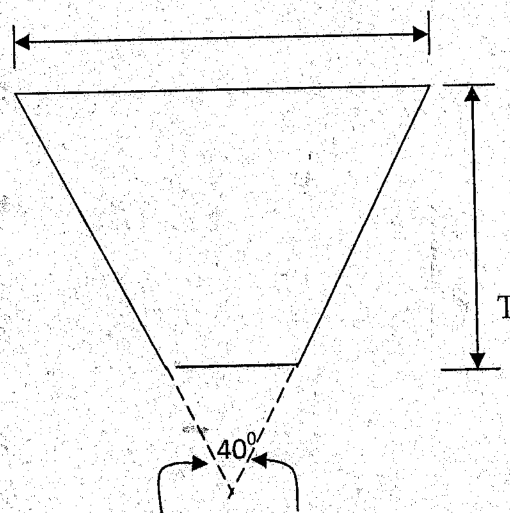
F = 2843.772N

3.20 Belt Selection

V – Belt (based on the usual load of drive 0.75 – 5kw power)

3.21 Determination of the Maximum Power of Belt

Calculation of the belt speed



For V – belt A, the following are the data of the sections:-

Usual load of drive = 0.75 – 5kw

Recommended minimum pulley pitch diameter, d = 0.09m, N1 = 1450m

Normal thickness, T = 8mm

Weight per meter = 0.100kg

Belt speed, $S = \lambda dpN_1$ (3.41)

Required fan speed = 2000rpm (selected)

Belt speed, S = λdpN₁

$$S = \frac{\lambda(0.09 \times 1450)}{60} = 6.833m/s$$

Required fan speed = 360 rpm

1. Speed ratio; $Vs = \frac{n_1}{n_2} = \frac{1450}{2000} = 0.725$ (3.42)

2. Small diameter connection factor for arc of contact variation; Fb = 1.14 (Based on speed ratio range) (design data PSG TECH., 1982).

3.22 Determination of Length of Belts

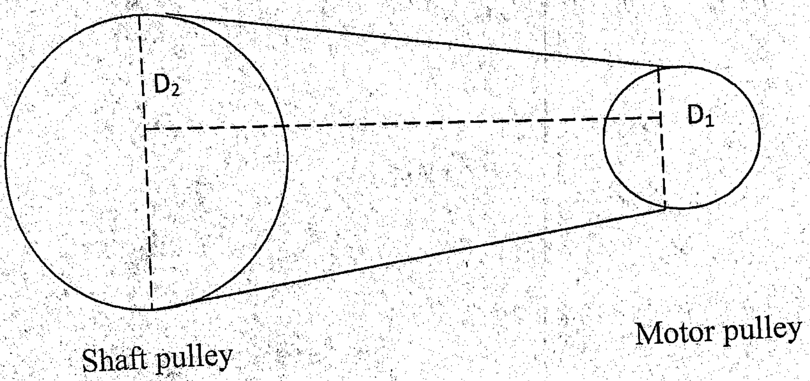


Fig:3.4 Motor- Shaft Belt

D_2 = diameter of the shaft pulley

= 12cm

D_1 = diameter of the motor pulley

= 8cm

Centre to centre distances, C = minimum

100mm = 0.1m

Nominal Pitch Length,

$$L = 2C + \frac{\pi}{2}(D_1 + D_2) + \left[\frac{(D1 + D2)^2}{4C}\right] \quad (3.43)$$

$$L = 2 \times 100 \times \frac{\pi}{2}(120 + 900) + \left[\frac{(120-900)^2}{4 \times 100}\right]$$

$$= 200 \times \frac{2100\pi}{2} + \frac{90000}{400}$$

$$= 200 + 3299.1 + 225$$

$$= 3724.1mm\ (max)$$

3.23 Determination of Stress on Cutting Blade

Torque (T) = Fr (3.44)

Where,

r = distance to the neutral axis = 0.018

$T = 2843.772 \times 0.018$

$= 51.1879 Nm$

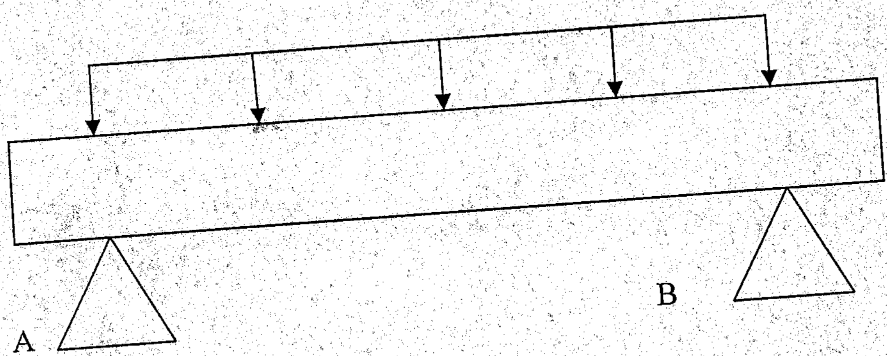


Fig3.5: Beam diagram of shaft (4.45)

$R_A = R_B$

$\frac{2843.772}{2} = 1421.886$

$W = \frac{2843.772}{0.49} = 5803.616 N/m$

3.24 Shear Force Diagram of Cutting Shaft

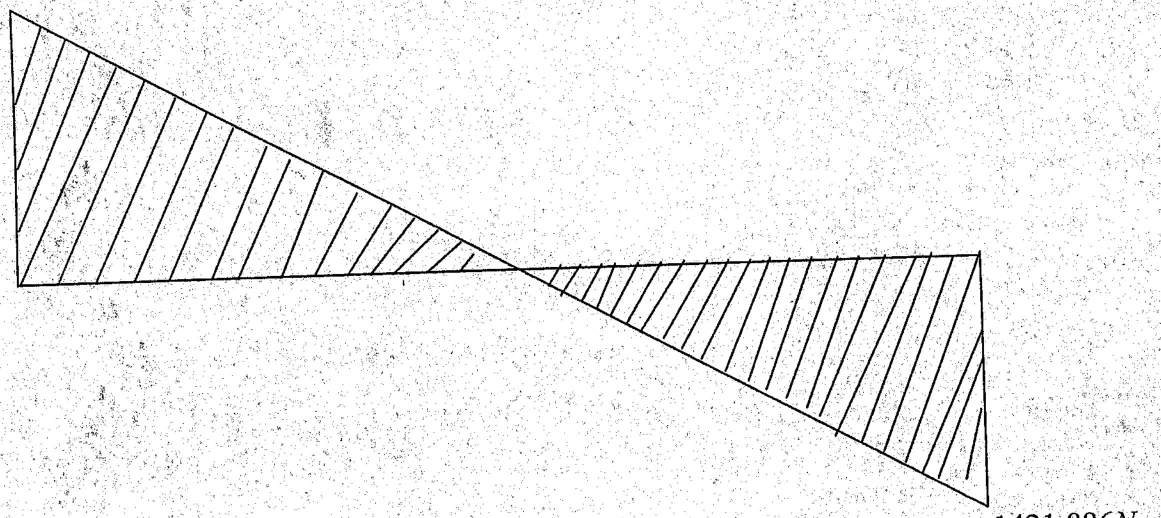


Fig.3.6 Shear Force Diagram of Cutting Shaft

$$S.F = \frac{wl}{2} - wx \tag{3.46}$$

Maximum shear force at B

$$\frac{wl}{2} = \frac{5.803.616 \times 0.49}{2} = 1421.886Nm$$

Maximum shear force at A

$$-\frac{wl}{2} = \frac{-5.803.616 \times 0.49}{2} = -1421.886Nm$$

3.25 Bending Moment of Shaft

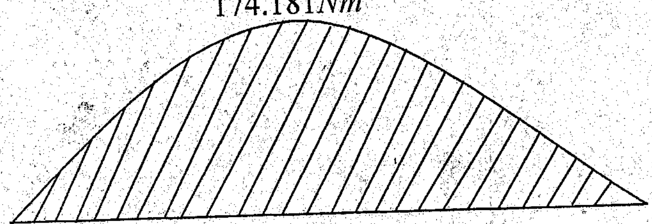


Fig. 3.7 Bending moment diagram of the cutting shaft

$$M = \frac{wl^2}{8} \quad (3.47)$$

$$\frac{5803.616 \times 0.49^2}{8}$$

M = 174.181*Nm*

Maximum shear on shaft

$$S = 16 \times 0.495 \sqrt{\frac{174.181^2 + 4(0.989)^2}{\pi(0.495^2 - 0.445^2)}}$$

S = 3590.06*Nm*

3.26 Power Demand at Shaft

$$P = \tau\omega \quad (3.48)$$

$$\omega = \frac{2\pi N}{60}$$

$$\omega = \frac{2 \times 3.142 \times 1450}{60}$$

$\omega = 151.86$

$$P = 51.1879 \times 151.86 \quad (3.49)$$

P = 7773.565*W*

For the cutting blade

$$W = 1447N \quad (3.50)$$

$W = {}^{9.678}/_{0.1}$

W = 96.78*N/m*

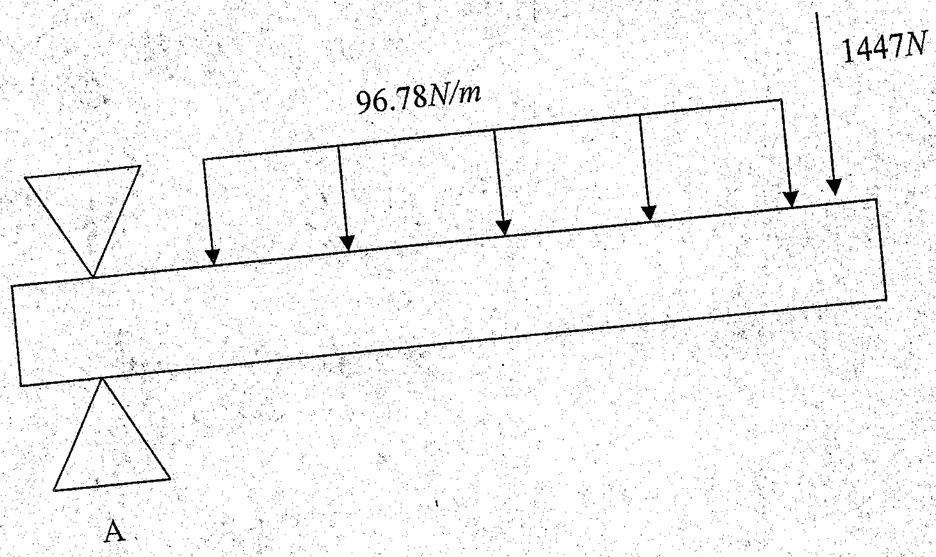


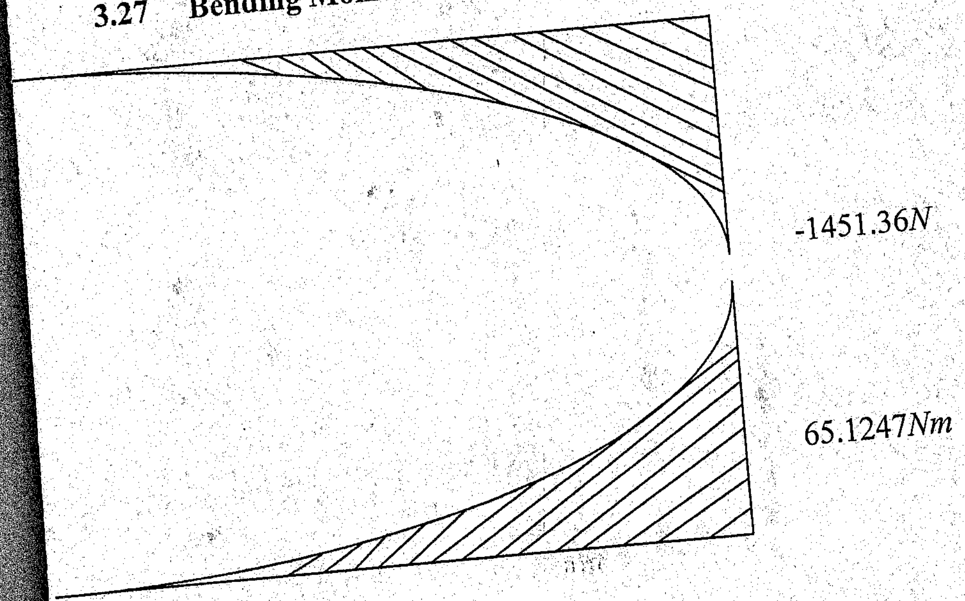
Fig. 3.8 Shear force diagram of shaft (3.51)

S.F. = $-W - wx$

$= -1447 - 96.78 \times 0.045$

$= -1451.36N$

3.27 Bending Moment Diagram



(3.52)

$$M = Wx + \frac{wx^2}{2}$$

$M = 1447 \times 0.045 + \frac{9.678 \times 0.045^2}{2}$

$M = 65.1247 Nm$ (3.53)

$Z = \frac{\pi d^3}{32}$

$= \frac{3.142 \times 0.045^3}{32}$

$= 8.9473 \times 10^{-6}$ (3.54)

Shear stress

$S = \frac{F}{A}$

$S = \frac{1451.36}{1.2568 \times 10^{-3}}$

$= 1154805.856 N/m^2$

Maximum stress

$S_{Max} = \frac{1}{2}\sqrt{\left(\frac{65.1247}{8.9473 \times 10^{-6}}\right)^2 + (1154805.856)^2}$

$= 1.3335 \times 10^{12}\ N/m^2$

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Presentation of Results

Table 4.1 shows the stages and conditions of materials during the recycling process.

Time (mint)	Stages	Form
0 – 30min	Melting	Semi solid
30 – 55min	Melting	Liquid
55 – 95min	Cooling	Solid (lumps)
95min – 100min	Cutting	Solid (pellet)

The total time taken for the recycling process was 1hour 40minutes.

4.2 Melting efficiency

$$\text{Efficiency} = \frac{Tr}{Ta} \qquad (4.1)$$

Were, T_r = theoretical time required for melting (Janssen. 2009)

T_a = actual time used in melting

Since T_r = 45minute

T_a = 55minute

Therefore $\frac{45}{55} \times 100$

=81.8181

=81%

4.3 Cooling efficiency

According to Janssen 2009, Cooling of polyethylene takes 50% period of melting

C_r = cooling rate

C_a = actual time used in cooling

Therefore

$$\frac{Cr}{Ca} \times 100$$

$$= \frac{22.5}{43} \times 100 \quad (4.2)$$

=52.32558

= 52%

4.4 Cutting efficiency

Since the material feed into the hopper is 5kg

The output after grinding is 3.6kg

$$\text{Efficiency} = \left(\frac{output}{input}\right) \times 100 \quad (4.3)$$

$$\text{Efficiency} = \left(\frac{3.6kg}{5kg}\right) \times 100$$

=72%

4.5 Discussion of Results

Melting of the polythene (used water sachets) was carried out after it has been cleaned washed and drained of water. Presence of water on the polythene will increase the melting time and reduce machine efficiency. Normally, hydrocarbons reacts with heat to give a black coloration this explains the change in colour of the molten polyethylene however additives or chemical can be used to work on colours. Initially, it was observed that melting took a longer time because heat from the heating element has not circulated to all the area of the hopper. It took 55min. for the polyethylene to totally melt and turn into liquid. According to Janssen (2009), polyethylene should take 45mins to melt a study of the result shows that the heating period will decrease with time of use.

According to Janssen 2009, the optimum time of agglomeration is approximately 50% of the melting process. By the design of the cooling chamber, the early stage of cooling are faster than the later stage and it gets to a time when the liquid gets heated up and can no longer perform the cooling operation as the temperature of the water increases due to heat dissipation, the time taken for the molten polyethylene to cool increases with time. It took about 43minute to solidify. After the material was cooled, it then drop to the cutting chamber were the size was reduced to pellet form by the 12.5cm blade, powered by a 2hp motto. The ready polyethylene drops into a recovery tray after it has been reduced to a desired size which is determined by a wired mash placed under the recovery unit.

The performance evaluation of the machine carried out showed that it has an efficiency of 65.7%: taking the average of the heating, cooling and the recovery efficiencies.

It was observed that polyethylene reduces in volume and increases in weight after melting. It was also discovered by examination that the recovered polyethylene can be used as raw material in fertilizer producing companies as well as plastic companies.

4.6 Cost Analysis

The total cost of fabricating this low-density polythene recycling machine is subdivided into three, which includes:

1. Material Cost
2. Labour Cost
3. Over head Cost

4.6.1 Material Cost

The table 4.2 below shows the various materials purchased and used for the project work based on their present market value.

s/No.	Materials	Specification	Quantity	Amount=N=	Price=N=
1	Mild steel sheet	Gauge 16	4	5500	22000
2	Heating element	2000 watt	2	1000	2,000
3	Solid shaft	3.5cm	1	4000	4000
4	Electrode	8mm metal	3 packet	900	1800
5	Paint	Enamel grey green	4 liter	2500	5000
6	Angle iron	$1^1/_2$ inch	2 length	1500	3000
7	Sheet	Gauge 14	3	5100	15,300
8	Angle iron	2 inch	3	1600	3200
9	Stainless steel electrode	8mm metal	2	1300	2600
10	Wires	2.5mm	4 yards	400	1600
11	Plug	13 amps	3	100	300
12	Rock wool	-	1 carton	18000	18000
13	Angle iron	1 inch	2	1300	2600
14	Iron rod	10mm	2	1000	2000
15	Quarter rod	2.5mm	5	800	4000
16	Connector	-	2	200	400

17	Stainless steel	Gauge 14 thick	Quarter	21,300	21,300
18	Pulley	12mm	2	500	1000
19	Belt	-	1	800	800
20	Electric Motor	2hp	1	23000	23000
21	Ball bearing	3.65B	2	400	800
22	Silicon oil	-	1	2000	2000
23	Transportation				21530
24	Miscellaneous				13770
	Total				172, 000

Table 4.2 cost of materials used for the fabrication of a low density polythene recycling machine.

It is necessary to mention here that the prices were valid as at the time of costing and fabrication, and subjected to change depending on the market trend and periodic inflation rate.

4.6.2 Labour Cost

Labour cost involves the cost of cutting, machining, welding, and painting. It takes about 20% of the material cost. (source: Chukwu 1987)

Therefore,

$$\text{Labour cost} = \frac{20}{100} \times 172,000 \qquad (4.4)$$

$$= 34400$$

4.6.3 Over Head Cost

This involves the cost of transportation and other miscellaneous. It takes about 10% of the material cost. (Chukwu 1987)

$$\text{Over head Cost} = \frac{10}{100} \times 172,000 \qquad (4.5)$$

$$= 17,200$$

4.6.4 Total Cost

Total cost = Material Cost + Labour Cost + Overhead Cost (4.6)

=172000 + 17200 + 34400

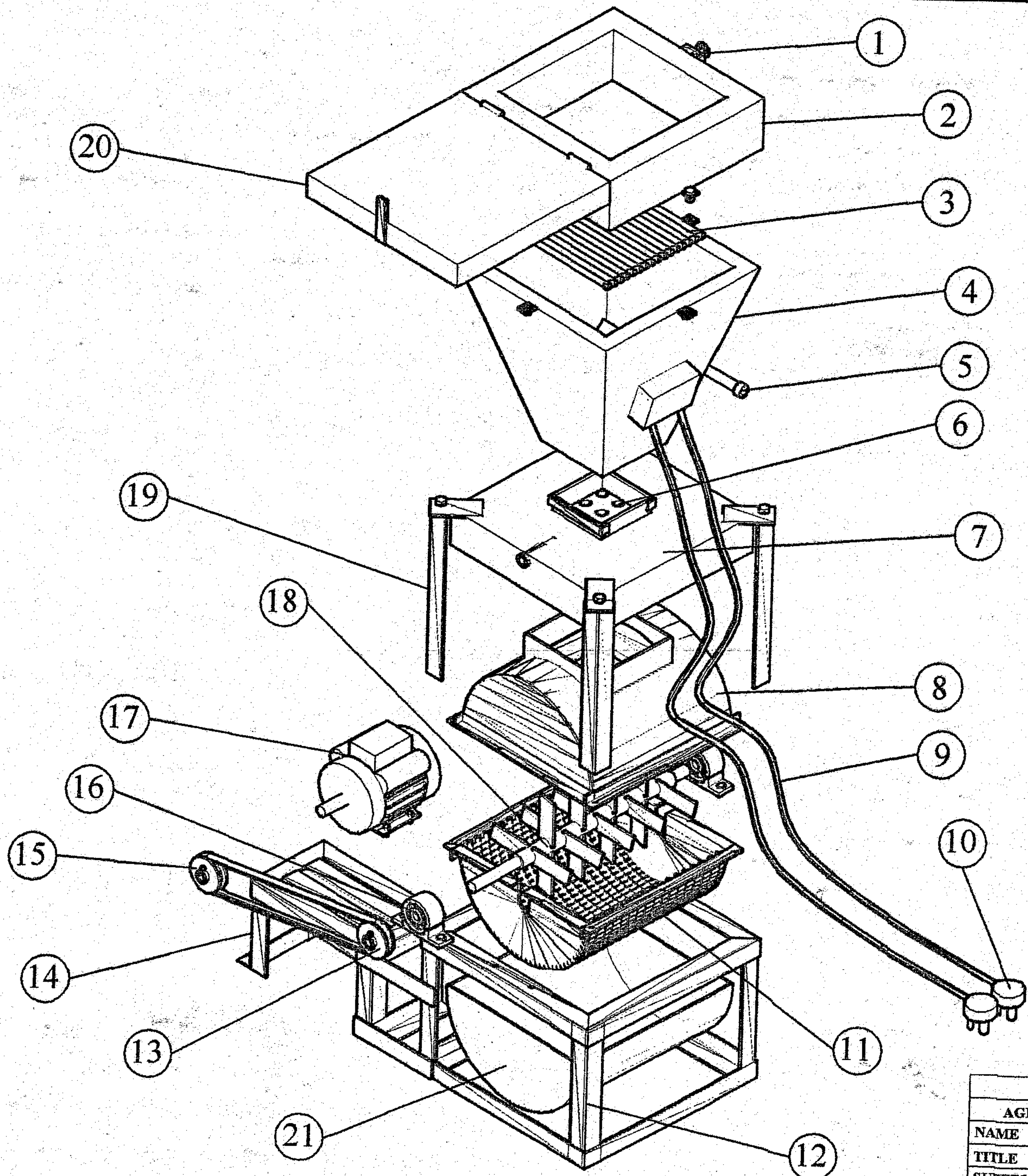
=N= 22360

4.7 Economic Analysis of the LDPE Recycling Machine

In analyzing any investment economically, the true worth of the investment is regarded as how much income it will generate and how soon after the original capital outlay (chukwu, 1987). Therefore, it is desirable that any investment generates large share of total income in the early years of its life.

For the LDPE recycling machine, the income is viewed as producing a new product and reducing environmental pollution.

Within the limit of time and the completion time of this project work, a full economic analysis could not be made but it is assumed it is more economical as it saves and reduces environmental pollution.



ITEM	DESCRIPTION	MATERIAL
21	COLLECTOR	MILD STEEL
20	COVER	MILD STEEL
19	FRAME	MILD STEEL
18	SHAFT	MILD STEEL
17	MOTOR	
16	BEARING	MILD STEEL
15	BELT	RUBBER
14	MOTOR FRAME	MILD STEEL
13	PULLEY	ALUMINUM
12	MACHINE FRAME	MILD STEEL
11	SCREEN	MILD STEEL
10	PLUG	PLASTIC
9	WIRE	COPPER
8	CONCAVE	MILD STEEL
7	COOLING CHAMBER	MILD STEEL
6	MOULD	STAINLESS STEEL
5	STOPPER	MILD STEEL
4	HOPPER (HEATING CHAMBER)	MILD STEEL/STAINLESS STEEL
3	IRON ROD	MILD STEEL
2	HOPPER	MILD STEEL
1	LOCK	MILD STEEL

PARTS LIST

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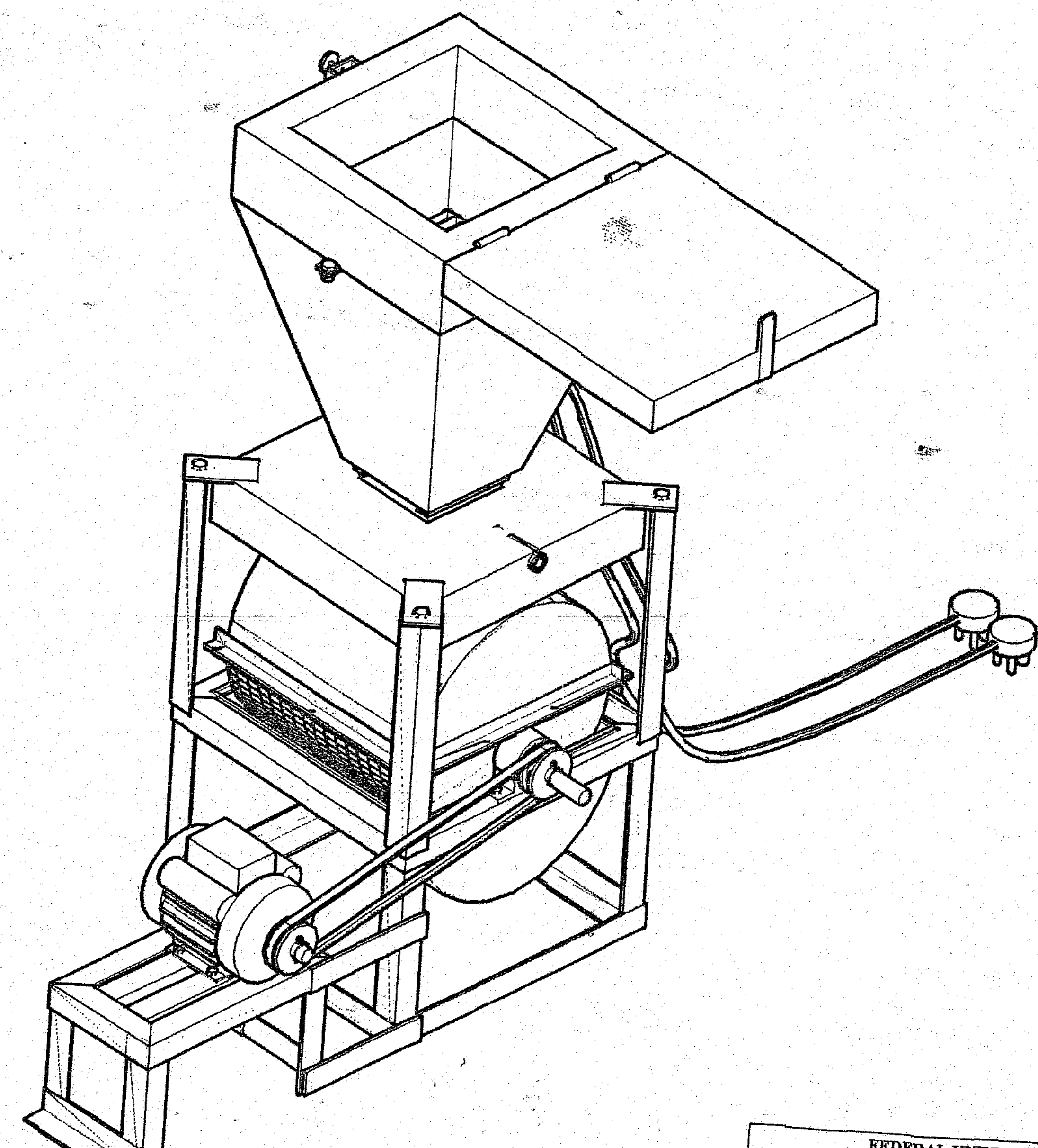
NAME	EKEH UDOCHUKWU	2005/21594EA
TITLE	DESIGN AND DEVELOPMENT OF LOW DENSITY POLYETHYLENE (LDPE) RECYCLING MACHINE	
SUPERVISED BY	ENGR. DR. O. CHUKWU	SIGN:



ISOMETRIC VIEW

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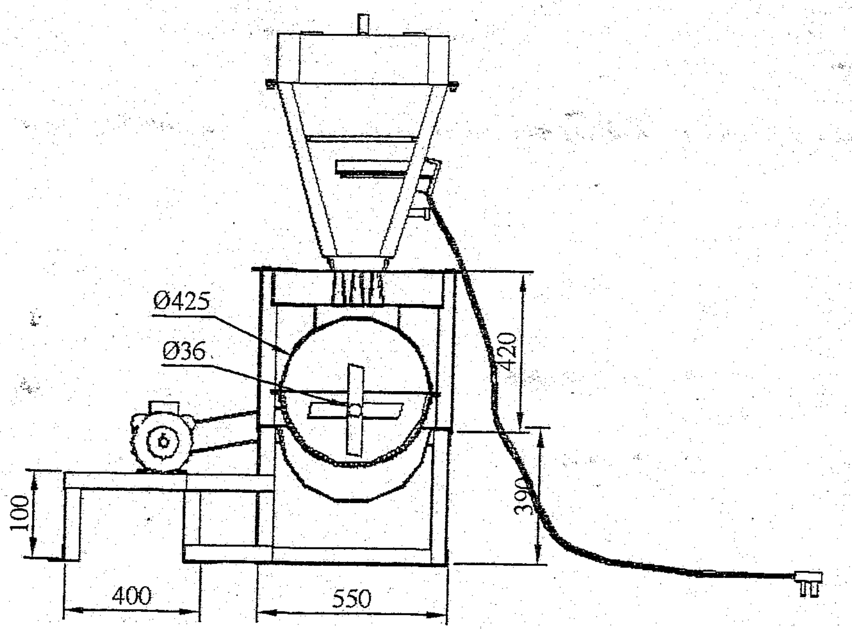
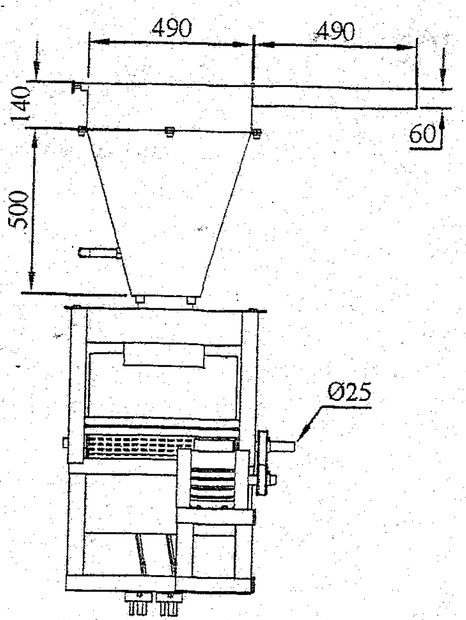
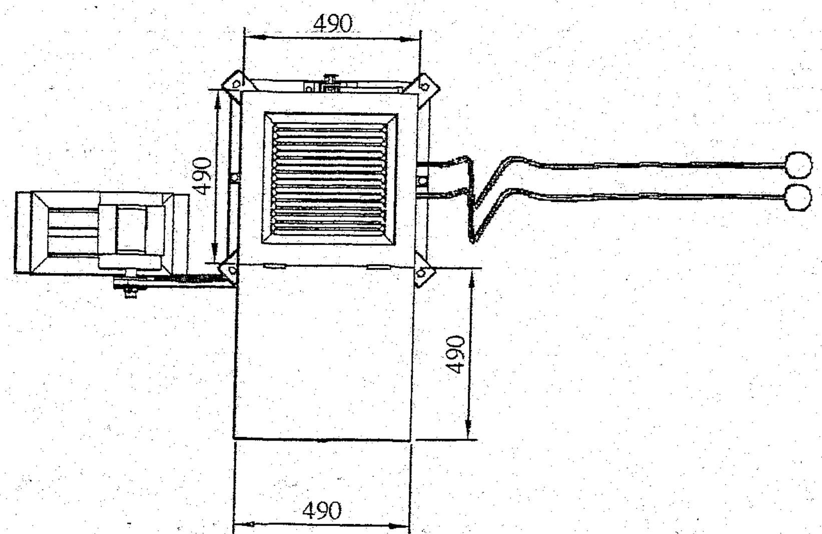
NAME	EKEH UDOCHUKWU	2005/21594EA
TITLE	DESIGN AND DEVELOPMENT OF LOW DENSITY POLYETHYLENE (LDPE) RECYCLING MACHINE	
SUPERVISED BY	[illegible]	







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[illegible]	[illegible]	[illegible]	

CHAPTER FIVE

5.0 Conclusion and Recommendations

5.1 Conclusion

The performance evaluation of the developed machine was carried out and a calculated efficiency of 65.7% was obtained for the whole system. The coolant which got hot over time made cooling process longer than calculated however recommendations has been made towards that.

It can be concluded therefore, that the performance of the developed recycling machine is satisfactory as accessed from the results obtained.

5.2 Recommendations

The following recommendations are therefore made for future development:

An external recycling water system should be integrated into the cooling chamber this is to maintain the cooling rate over a particular period of time and prevent the coolant from getting hot over time.

A thermostat should be integrated into the machine heating chamber this will help regulate the heat supply to the chamber.

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