DESIGN AND DEVELOPMENT OF A COMBINED COFFEE DEHULLING AND POLISHING MACHINE

BY

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

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DECLARATION

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

.... 28-01-2011 ....

Enyumah, Ajah Gabriel Date

CERTIFICATION

This is to certify that the project entitled "Design and Development of a Combined Coffee Dehulling and Polishing Machine" by Enyumah, Ajah Gabriel meets the regulations governing the award of the degree of Bachelor of Engineering (B. ENG.) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

Engr. Dr. Agidi Gbabo Supervisor	25/01/2011 Date
Engr. Dr. A. A. Balami Head of Department	26-01-11 Date
External Examiner	13/01/2011 Date

DEDICATION

This project work is dedicated to God Almighty the creator of the universe and to my beloved parents.

ACKNOWLEDGEMENT

I give thanks to my heavenly father, the almighty God for his infinite mercies and guidiance upon my life. To my loving and caring father Mr Ajah Joseph Enyumah and to my late mother Mrs Janet Ajah for bringing me to this world. Also I appreciate my amazing siblings for there unrelenting support and prayers towards my academic advancement.

My special appreciation goes to my supervisor, Engr. Dr. Agidi Gbabor for his advice, corrections and guidiance throughout my research work, may God bless you . much gratitude goes to the entire staff of Agricultural and Bioresources Engineering department of the Federal university of technology minna, who in one way or the other have contributed to my success. To my friends; you all were ever faithful and encouraging. Finally, to the members of Anglican student fellowship for your love and prayers.

ABSTRACT

A combined coffee bean dehulling and polishing machine was developed. the two units; the dehulling and polishing unit were incorporated in a single machine in order to prevent the drudgery associated with the traditional method of dehulling and separation of the hull from the dehulled coffee bean seed. The first unit of the combined coffee dehulling and polishing machine consist of a hopper in which the coffee bean seed is being fed through into the machine. Also the dehulling cylinder which houses the dehulling shaft that performs the dehulling. while the second unit of the machine, consists of the polishing drum, and brushes which were attached to the dehulling shaft. The performance of the machine was evaluated following the optimum operating condition of the length of the dehulling shaft which is 1m, and the speed of rotation of the dehulling shaft which is 500rpm. This also is the working speed for the rotating brushes attached to the rotating shaft in the polishing unit of the machine. Based on this condition, it is expected of the machine to work optimally at a rate of 180kg/hr.The result shows that the performance of the machine were 56.67% and 64.66% respectively for the dehulling and the polishing unit. This was obtained at a dehulling head of 500rpm as the speed of the dehulling shaft.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of study

The coffee tree averages from 15-30ft, in height. The tree typically begins to bear fruits 3-5years after being planted and continues to produce for 10-20 more years, depending on the type of plant and the area. The coffee dehulling and polishing machine is a machine that plays an obvious role in the dehulling and polishing processes of the coffee bean. During the dehulling process, the shell of the coffee berry is broken via mechanical friction or abration. (www.wikipedia.com)

Coffee was first discovered growing wild in the highlands of what is known as Ethiopia where legend has it that a young goatherd named Kaldi discovered it.

One evening, Kaldi let its goat out into the fields to feed, Kaldi's goats did not return home. The young man searched for them and found them the next morning, leaping and dancing with reckless abandon and apparent glee round a stand of shiny, dark-leafed shrubs with bright red berries. He soon decided that it must be the berries that caused such reckless behaviour in his otherwise responsible goats, and so he sampled the berries himself. In no time, he too was dancing gleefully with his goats around the green-leafed shrubs.

Soon, we are told, a wise and learned monk or imam came along, trudging sleepily on his way to prayer. The imam rubbed his eyes and took in the scene before him Kaldi and his goats-dancing gleefully about a stand of shiny, dark-leafed shrubs with red berries. Being both a curious and learned man, he gathered some of these berries, himself, and on returning home he studied them. In his experiments with the bright red berries, he roasted them, and sampled the resulting beverage. He shared what he found with the rest of his fellow monks, and soon none fell asleep at prayers! And so coffee spread from place to place creating a more gleeful and wakeful world. (www.google.com)

1.2 Statement of the problem

Coffee processing is faced with enormous challenges in Nigeria because of the energy required. The combined coffee dehulling and polishing machine is the answer to the cry of farmers, without the dehulling process, it would be impossible for any coffee farmer to sell his harvest of coffee beans.

The combined coffee dehulling and polishing machine would increase the volume and quantity

of the harvest, and it saves time and energy.

1.3 Objectives of the project

Researches have been carried out in the past on the coffee tree and coffee berry but little of the combined coffee dehulling and polishing machine is known in this part of the country despite the substantial quantity of coffee grown in Nigeria.

The aims of this project are thus;

(1) To design and develope a combined coffee bean dehulling and polishing machine using locally available and affordable materials.

(2) To carry-out performance test on the machine

1.4 Justification of the project

Coffee is one of the most popular beverages in the world, but this seed is faced with a major challenge in this part of the world. In Nigeria, there is high degree of drudgery in the shelling of the coffee bean by manual means, which involves much man-power.

The locals or natives who are in the coffee business see the dehulling of the coffee bean as a hurricane task. This project which is basically on the design and fabrication of a combined coffee bean dehulling and polishing machine would give the locals a soothing relief as it takes care of the drudgery and other difficulty experienced in the dehulling process of the coffee bean.

The dehulling machine breaks the shell of the coffee bean using mechanical friction or abrasion faster and better than the manual methods adopted by locals involved in the coffee business. All the shells of the coffee bean are more nearly removed without the coffee bean being damaged or crushed as it is a common experience without the use of the machine, and this leads to the improvement of its quality and quantity thereby leading to the increase of profit being made

1.5 Scope of study

The scope of this study is basically on the design and fabrication of a combined coffee bean dehulling and polishing machine or a coffee dehuller as it is commonly called.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Historical background

Coffee was first discovered growing wild in the highland of what is now known as Ethiopia where legend has it that a young goatherd named kaldi, discovered it. Everyday, Kaldi would set his goats to grazing in the hills that surrounded his village And every evening his royal goats will return home. One evening Kaldi's goats did not Return home, the young man searched for his herd all through the night and as morning Broke He found them, leaping and dancing with reckless abandon and apparent glee Round a stand of shiny, dark-leafed shrub with bright red berries. Kaldi took in the Scene before him, amazed. He soon decided it must be the berries that caused such Reckless behavior in his otherwise responsible goats, and so he sampled the berries Himself. In no time, he too was dancing gleefully with his goats around the green Leafed shrubs.

What ever the true story, around 1000 AD the neighbouring Arabs began to boil the dried Crushed seeds to make a hot drink. Due to religious, medical, and commercial Considerations, the spread of the bean through Arabia and subsequently Europe And America was impeded by prohibitions and powerful restrictions on the export of trees And cultivatable seeds. (Clifford and KC, 2004)

There are two major types of coffee grown, they are,coffea Arabica and robusta. Coffea Arabica can be grown in the optimum temperature between 15 to 24^{o}C, Coffea arabica is of higher quality than robusta and commands a higher price. Furthermore, Coffea Arabica also gives good flavor and aroma products.

Coffea canephora (robusta) can be grown in the optimum temperature between 24 to 30 ^{0}C. Robusta contains higher caffeine than arabica does.

2.2 Coffee Processing

coffee is prepared from berries of coffee trees by a relatively complex series of process steps carried out entirely within the producing countries. The fundamental purpose of coffee processing is the recovery of the beans, by removing the various covering layers and drying to produce beans with moisture content below 12%. Dry process and wet process, are similar processes including grading, cleaning and polishing are performed (Clarke, 1985; Varnam and Sutherland, 1994).

Dry processing method in the dry processing, the fruit are allowed to remain on the tree until the fully ripe stage. After harvesting, coffee berries are laid out in the solar to dry until 12% of moisture content in the final beans. The dry method is simpler and cheaper, but the coffee product is usually lower quality than the product from wet processing (Sivetz, 1963; Clarke, 1985; Varnam and Sutherland, 1994). The coffee during the drying period, which lasts 8-10 days in favorable conditions, solar drying is subject to the vagaries of atmospheric conditions, together with the possibilities of growth of both desirable and undesirable microorganisms generating substances from the drying pulp, affecting subsequent flavor of the coffee brew made from the coffee after roasting (Clarke, 1985). Silva et al. (2000) reported of the microbial population associated with dry processing of arabica coffee including 32 species of bacteria, 24 species of yeasts, and 8 species of filamentous fungi. They include groups, which contain many fermentative bacteria and yeasts, cellulolytic bacteria, and pectinolytic bacteria, yeasts and filamentous fungi. Hot air drying is widely used in large scale operations in Brazil and also in Africa. Hot air can be used for the entire drying process, which is reduced in length to 3 days. The time which the coffee is maintained at a given temperature during drying process is just as important in its effect on quality. Overheating during drying produces sour or cooked flavors in the brewed coffee (Sivetz, 1963).

2.2.1 WET PROCESSING METHOD

This process is more sophisticated than the dry process, and by general consent leads to better quality coffee and commands a higher price (Clarke, 1985). Only ripe berries should be used for wet processing, classification by flotation in water is most convenient and involves at least two stages, first to remove stones and dirt, and second to separate cherries. Pulping involves mechanically 'tearing off' the skin and soft pulpy part of the berry. This stage is considered to be the most important stage in wet processing before fermentation. Fermentation procedure is necessary to remove any residual adhering pulp and the mucilaginous layer. If the mucilage remains present during drying, there is the risk of undesirable fermentation, which is detrimental for the quality of the coffee (Clarke, 1985).

2.3 CHEMICAL COMPOSITION OF COFFEE BEANS

2.3.1 Caffeine

Caffeine is an important factor in determining the bitter character. The caffeine content of green beans varies according to species. Robusta coffee contains 2.2% on a dry matter basis (dm), and arabica 1.20% dry matter basis (Varnam and Sutherland, 1994). Roasting process lead to loss of caffeine, but in practice the loss is small (Sivetz, 1963).

2.3.2 Trigonelline

Trigonelline, the N-methylbetaine of pyridine-3-carboxylic acid, is found in all commercial and some wild species. The compound is present in arabica at levels of 1.0% dry matter basis and in robusta at levels of 0.7% dry matter basis. Green bean processing, de-waxing and decaffeination procedures have little effect upon the trigonelline content, but roasting causes progressive destruction (Clifford, 1985; Varnam and Sutherland, 1994).

2.3.3 Chlorogenic acids

The chlorogenic acids (CGA) are ubiquitous in the plant kingdom. They are a family of esters of quinic acid (QA). Analysis of the CGA content is difficult, but it is generally recognized that robusta coffee has a higher content than arabica coffee. Reported levels for robusta are 7.0-10.5% dry matter basis and for arabica is 5-7.5% dry matter basis. The levels of CGA appear to be dependent on species and are unaffected by differences in agronomic practice or method of processing (Varnam and Sutherland, 1994; Flament, 2002).

2.3.4 Proteins and free amino acids

Crude protein contents calculated from total nitrogen contents must be corrected for caffeine and ideally also for trigonelline nitrogen. If such corrections are made there does not seem to be any significant difference between the protein contents of arabica and robusta (approximately 10% dry matter basis), or any significant effect that can be attributed to the method of green coffee processing (Clifford, 1985; Flament, 2002).

2.3.5 Carbohydrates

This is an essential class for the formation of aroma compounds, mainly by caramelization of the low molecular weight sugars and by Maillard reaction with the amino acids. The total amount of carbohydrates represents about 50% dry matter basis of green coffee. The composition is complex with a range of different poly-oligo- and monosaccharides, subdivided into reducing the non reducing sugars.polysaccharides are important constituent of coffee beans and comprises 40-45% of dry matter basis. Sucrose is the major free sugar, the quantity present varying according to cultivar, state of maturity, processing applied and storage conditions.

2.3.6 Lipids

The terms crude and total lipids refer to all material extracted by a specified, usually non polar solvent, and may include non lipid substances such as caffeine (Clifford, 1985). The lipid component of green coffee beans comprises coffee oil, which is primarily presented in the endosperm and coffee wax, which is present on the outer layer. Arabica coffee contains 15% dry matter basis oil and robusta 10% dry matter basis. The oil contains triacylglycerol and considerable proportions of other lipid components. There is no significant difference between arabica and robusta coffee, with respect to fatty acid composition (Varnam and Sutherland, 1994).

2.3.7 Coffee volatiles composition

The volatiles compounds of coffee are largely responsible for the aroma. Green beans are often thought to have no agreeable flavor or aroma, but a large number of volatiles are present. Many of these compounds increase in concentration during roasting, while the concentration of other volatiles falls due to degradation. Aroma of coffee developed during roasting process. Upon roasting, the Maillard reaction, Strecker degradation, pyrolysis, and other chemical reactions produce a large number of different volatiles. More than 800 different compounds from wide range of chemical classes have been identified in roasted coffee (table 2.1) (Varnam and Sutherland, 1994; Flament, 2002; Schenker et al., 2002)

Cigarette fillers and other tobacco products have often been described wherein some or all of the tobacco has been replaced by various substances, generally for the purposes of reducing costs or to give a smoke essentially free of nicotine where that is desired. However, few of these substitute ingredients provide a pleasant, flavorful smoke. It is also known that reconstituted tobacco or tobacco material usually in the form of sheet and prepared from waste or scrap tobacco parts or dust may be used as a substitute for or may be blended with tobacco leaf by employing as a binder naturally occurring tobacco pectins. A number of patents describe such products, for example, various Hind et al. patents, notably U.S. Pat. Nos. 3,385,303, granted May 28, 1968; U.S. Pat. No. 3,409,026, granted Nov. 5, 1968; U.S. Pat. No. 3,435,829, granted Apr. 1, 1969 and others.(Campa,C,.Ballester,2004)

While these patents describe products which provide satisfactory smoking articles, the basic desire or concept taught by these patents is to use only tobacco parts having, of course, the usual amount of nicotine and expected flavor normally found in tobacco. This invention relates to a smoking product and more particularly to smoking products which comprise coffee bean by-products and particular methods for making them. One aspect of the invention is the manufacture of a smoking product utilizing the coffee bean hulls or different parts of the hulls after the coffee beans have been removed. Another aspect of the invention is the preparation of a smoking composition in which various components of the coffee bean hulls are blended with either tobacco or non-tobacco.(campa,C.,Ballester,2004)

Still another aspect of the invention is the chemical treatment of coffee bean hulls and particularly components having pectinaceous elements to release the coffee pectins and to use such released pectins as a binding agent with the treated hulls or parts to form a sheet It has been discovered that a coffee product, and particularly coffee bean hulls or specific parts thereof which are available as by-products from coffee processing, can be added to tobacco or even a non-tobacco filler to provide a pleasant and unique flavor to the smoke without introducing additional nicotine thereto. In addition, as a substitute for tobacco, or as an added component to tobacco or other smoking materials, the use of coffee bean hull.

Coffee bean hulls, after the coffee beans have been harvested and removed, comprise in general four components which may be identified from the outermost part to the inner lining as consisting of an outer rind or exocarp, a pulp or mesocarp, a parchment or endocarp.

According to the present invention, any one or more of the coffee hull components in dried and comminuted form may be used as a tobacco substitute or replacement, or blended with other smoking substances to produce a desirable smoking product having a unique and satisfying flavor. As an example, one may blend the parchment or chaff from coffee bean hulls with tobacco to the extent of from 5 to 30 percent by weight of the tobacco. By doing so, the side stream smoke and the main stream smoke of the smoking article.

As another composition, one may mix as much as 20-25 percent by weight of coffee bean chaff with non-tobacco materials such as cellulose or hemicellulose and a known binding material such as used in the tobacco art to form a sheet which is then cast, dried and cut into typical particulate material similar in physical characteristics to smoking tobacco. While the dried coffee bean hulls or selected components thereof may be used as a filler alone or as filler components without further treatment as described above, it is an advantageous and important aspect of the invention to chemically pretreat particular coffee bean hull components before using them in a smoking product. It has been found that the coffee bean hulls contain pectinaceous material which is concentrated in the outer rind, the pulp and the silver skins or chaff. The chemical treatment of these materials encompasses the use of certain pectin-releasing agents capable of breaking down the pectinaceous elements to release the pectins therefrom so that they may act as a pectin binder on the treated hulls. An advantage of releasing the pectins and depositing them on the treated hulls to bind them into a coherent sheet or other form is that there is no need for separation of the released pectins from the remaining components, rather the whole may be cast or otherwise used directly alone or in admixture with tobacco or other substance.

The naturally occurring pectins in the coffee bean parts, or what might more accurately be called here the protopectins, consist of calcium and/or magnesium salts of polymers of galacturonic acid, the divalent calcium and/or magnesium atoms acting as cross-links between acid chains thus making the polymers water-insoluble. The coffee protopectins, for the purposes described here may be considered somewhat similar to tobacco protopectins, differing therefrom mainly in the degree of cross-linking and chain lengths. Thus, in accordance with the present invention, a smoking product usable in a smoking article may be prepared from coffee bean hulls bonded together by pectins which had been released therefrom after destroying the protopectin cross-links by a chemical reaction.

In the chemical treatment step, the coffee bean hulls are reacted with an aqueous solution of a non-toxic reagent which is capable of reacting with and destroying the calcium and magnesium cross-links in the naturally occurring pectinaceous substances. After the calcium and magnesium cross-links are destroyed, the pectins are liberated sufficiently from the hulls to become available for use as a binder through the washing action of the treating solution. tHe pectins are then dissolved or dispersed in solution, or are at least sufficiently released from the interstices of the hull mass so that they form a coating on the surface thereof. Pectins which are dissolved or dispersed in the treating solutions, are thereafter precipitated or deposited from the solution, so that they become available for use as a binder material. Describing the pectin-releasing procedure in greater detail, the release of the pectins from the coffee hulls or any of its pectinaceous containing components is achieved by treating them with a solution of a reagent capable of destroying the alkaline earth metal cross-links holding the pectinaceous material. The reagents that are used are in part disclosed in U.S. Pat. Nos. 3,353,541, 3,409,026, 3,411,515 and 3,420,241, and include precipitating agents for the divalent cations binding the pectins which form relatively insoluble salts, or sequestering agents for the divalent ions, or agents which partially insolubilize and partially sequester the divalent ions, or acids which solubilize the divalent cations as soluble salts of calcium and magnesium and allow them to be washed out while leaving the pectins in the insoluble acid form. When employing the latter type of reagent, the slurry must subsequently be made alkaline, As one embodiment of the pectin-releasing step, an aqueous slurry of the pectinaceous coffee bean substances is contacted with a reagent having monovalent cations and mono or polyvalent anions, which acts by forming a precipitate with the calcium or magnesium ions. Such a reactant can be a monovalent metal salt of the formula M_nX wherein M is a monovalent inorganic cation, n is an integer having a value of 1, 2, or 3 and X is an anion which may be monovalent or polyvalent, such that the calcium salt of the formula Ca_pX_q is essentially insoluble in the treating solution and p and q are integers corresponding Monovalent cations which are effective include the alkali metals such as sodium, potassium and lithium, as well as the ammonium ion. The anion portion of the molecule may be $CO_3^{=}$, PO_3^{-}, $PO_4^{=}$, $HPO_4^{=}$, $H_2PO_4^{-}$, and the like. For example, the compound M_nX could be sodium carbonate, (Na_2CO_3), since sodium is a monovalent inorganic cation and calcium carbonate is essentially water insoluble. Additional representative examples of precipitating agents are the orthophosphates, metaphosphates as well as the carbonates of sodium, potassium, lithium and ammonium. Specifically, for example, when ammonium orthophosphate is used, the precipitate is calcium and/or magnesium ammonium phosphate. The concentration of the reagent may be from about 0.008 to about 0.40 mols, preferably from about 0.038 to about 0.27 mols per 100 g of coffee material. The pH of this reaction should be between about 5.8 and about 10 and the temperature may be as high as 400° C. but should, preferably, be between about 25° C. and about 135° C. and the reaction time from a period of about 1 minute to about 24 hours. Among the precipitating agents which may be employed are the alkali metal carbonates, for example, sodium carbonate and potassium carbonate, the alkali metal phosphates, particularly, the alkali metal orthophosphates and the ammonium orthophosphates, such as ammonium orthophosphate, sodium orthophosphate, ammonium dihydrogen orthophosphate, potassium dihydrogen orthophosphate, diammonium monohydrogen orthophosphate, disodium monohydrogen orthophosphate. In a second embodiment of a pectin-releasing operation, a cross-link destroying reagent may be used which acts by sequestering the calcium or magnesium, thereby removing the calcium or magnesium atoms by forming a complex therewith. Suitable reagents of this type include any sequestering agent which will form a complex or chelate with the calcium and/or magnesium, thereby removing the calcium and/or magnesium and making them unavailable for recross-linking with the pectin. Illustrative of such sequestering agents are amino acids such as ethylenediamine tetraacetic acid, ethylenediamine N, N-diacetic acid, aminobarbituric acid, 2-aminobenzoic acid, beta-aminoethylphosphonic acid or beta-aminosulfinic acid. Various polyphosphates may also act as sequestering agents such as the tetrametaphosphates, hexametaphosphates and trimetaphosphates, pyrophosphates and tripolyphosphates, representative examples including sodium hexametaphosphate, tetrasodium pyrophosphate and pentasodium tripolyphosphate. Another good sequestering agent is nitrilotriacetic acid. Additionally, many naturally occurring amines and peptides are also effective as sequestering agents for calcium and/or magnesium, and of these, alanine, aspartic acid, glycine, glycyl-glycine, glutamic acid.

The reaction mechanism which occurs when a sequestering agent is employed is the formation of a calcium or magnesium chelate and these ions are no longer available to recombine with the pectic ions. The conditions for carrying out this type of reaction involve the maintenance of a pH between about 4 and about 10 and the temperature should, preferably, be between about 0° C. and about 145° C. for a period of from about 1 minute to about 24 hours. A concentration of 0.015 to 0.20 mols of sequestering agent per 100g.

A preferred type of precipitation which is described in substantial detail in my copending application, Ser. No. 104,459, filed Jan. 6, 1971, involves the use of certain organic acids together with ammonium hydroxide, a particularly preferred acid being citric acid which furnishes citrate ion capable of reacting with available cations to form calcium or magnesium citrates that are relatively water-insoluble. To obtain the desired reaction, it must be carried out under alkaline conditions, preferably using ammonium hydroxide in an amount to react with the citric acid to form ammonium citrate, and to provide an alkaline environment in the slurry mixture above about pH 8 and preferably about pH 9 or somewhat higher. About 0.025 to about 0.10 mols of citric acid and about 0.15 to about 0.50 mols of ammonium hydroxide per 100 g of coffee material may be used. The temperature for this type of operation may be from about 25° to about 135° C. with the reaction.

A cross-link destroying reagent may also function partially as a precipitating reagent, in accordance with the first embodiment of this invention, and partially as a sequestering agent, in accordance with the second embodiment of this invention. This is a favorable type of reaction and the reagent that is preferred for this purpose is diammonium monohydrogen orthophosphate (DAP). The reagent is used in an amount of about 0.01 to about 0.40 mols per 100 g of coffee material and in an alkaline environment provided by adding a base, preferably ammonium hydroxide, the mixture being held in the neighborhood of about pH 7.1 to about pH 9.0. The temperature-time conditions for operating the cross-link precipitation-sequestering step with DAP involves holding the reaction.

In the third embodiment of pectin release, the cross-link destroying reagent comprises an acid treatment which forms the released but insoluble free pectic acid and relatively soluble salts of the cross-linking metals. Generally the acid is an inorganic acid, such as hydrochloric acid, phosphoric acid, sulfuric acid or a similar acid, which will form soluble calcium and magnesium salts. The acid may be employed as 0.025 N to 5.0 N solutions, but is preferably employed as 0.5 N to 1.0 N solutions. The exact dilution and amount to be employed will vary with the particular acid which is used, it only being necessary that sufficient acid be present to convert the calcium and magnesium present in the tobacco being treated to the calcium and magnesium salts of the acid. The acid treatment is preferably conducted at a temperature of from about -1° C. to about 50° C. The acid treatment comprises reacting the coffee hulls or parts with the acid until the resulting mixture has a pH of from about 1.0 to about 2.5 Preferably the pH is brought to from about 1.0 to about 1.7. This treatment will generally be conducted from about 10 minutes to about 24 hours, depending in part on the size of the coffee hull particles.

Resins.

The mixture resulting from the inorganic acid treatment is generally followed by a water washing step. This water washing step is conducted at a temperature of from about 15° to about 35° C. and, preferably, distilled water is employed. When this wash step is employed, sufficient water should be used to remove the calcium and magnesium salts of the acids, which salts are formed in the above-described treatment; thus, there should be at least two volumes of water per volume of the mixture resulting from the acid treatment. The wash water is separated from the tobacco by any suitable means, for example, by conducting the wash in a centrifuge, filter press, or any other apparatus from In the above-described inorganic acid treatment, the pectic acid that is formed in the reaction is substantially insoluble. To bring it to a soluble form for release, it must be reacted with an alkaline material before it is in condition for release from the coffee hull cell structure. Thus, the acid treated pectins are placed in condition for release by bringing the mixture resulting from the acid treatment, and, preferably, after the water wash described above, to a pH of from about 5.0 to about 10.5 and, preferably, from about 6.3 to about 8.5, by the addition of an alkaline material. Suitable alkaline materials include ammonium hydroxide and alkali metal hydroxides, for example, sodium hydroxide, potassium hydroxide and lithium hydroxide, and alkali metal salts, such as sodium bicarbonate, sodium carbonate, sodium phosphate, and similar salts to convert the pectic acid to a soluble form. The alkaline material may be any water-soluble compound containing monovalent inorganic cation and capable of producing hydroxide ions when dissolved in water. The temperature of this step may be from about -1° C. to about 45° C., but is, preferably, from about 15° to about 35° C. Another method for carrying out a pectin-release step which has been described in my previously mentioned application and which is adaptable to the treatment of coffee bean hulls or components thereof when these substances contain natural acids or salts in sufficient amounts to effect the desired reactions. By this method the protopectin cross-links may be removed or destroyed by merely adding an excess of ammonia to the coffee slurry, preferably in the form of ammonium hydroxide. The precise reactions taking place have not been established but it is believed that the natural citric acid, phosphates and sulfates, react with the calcium pectates when the pH is in the alkaline range, thus liberating the pectins as ammonium pectates in sufficient amount to act as a binder. Conditions for this type of operation involves the use of sufficient ammonium hydroxide to provide a pH in the slurry of about pH 7.8 to 10.0, preferably about pH 9, a temperature of 35° to 135° C., preferably about 90° C. and a reaction time of 10 minutes to about 24 hours, preferably about 2 hours. It should be mentioned that while the pectin-releasing operation is being carried out under conditions conducive to a satisfactory yield of released pectinaceous binding agent, it may be desirable or necessary to agitate or beat the slurry of coffee parts and reagent to facilitate the release of the pectins and if necessary to reduce the fibrous slurry to the desired consistency and fineness. A "Valley" beater or the like may be employed for this When the pectin-releasing operation is terminated and the coffee hull pectins have been liberated to the extent desired, the slurry may be sprayed, extruded or cast on a plate or moving belt to form a sheet of coffee bean solids with coffee pectins as a binder. While no additional materials need be added to the slurry before drying, other additives may be incorporated in the slurry if desired. For example, preservatives, or organic acids for flavor or aroma which may in themselves be of coffee origin, may be added. Plasticizers, such as glycols and polyglycols, and humectants, such as glycerin, may also be added, if desired. In addition, the gel strength of the pectins can be regulated by partial precipitation to control such rheological properties as viscosity, fluidity and elasticity. Other additives or dispersants may be added in small amounts to regulate slurrying qualities, provided, however, that such substances are not added in large enough quantities to adversely affect the flavor or aroma of the final product. Furthermore, the coffee pectins can be combined or augmented with water-soluble gums or water-dispersible gums commonly used as binders such as methyl cellulose, sodium carboxymethyl cellulose, guar gum, locust bean gum, or alginates, although it is preferred

The final sheet product from treating the coffee bean hulls in accordance with the methods of the present invention may be dried and then cut into particulate material similar in physical form to ordinary smoking tobacco and so used, preferably mixed with tobacco.

In general, the coffee-derived smoking product of the invention may be used alone as a smoking product or blended with other smoking substances in a matrix in amounts of from about 5.0% to about 70 % by weight of the matrix filler whether that be a tobacco or a non-tobacco material but preferably constituting from 15 to 50% by weight of the matrix.

As a smoking product filler it produces an acceptable smoke characterized by an unusaul and different flavor. (Clifford,M.N.2003)

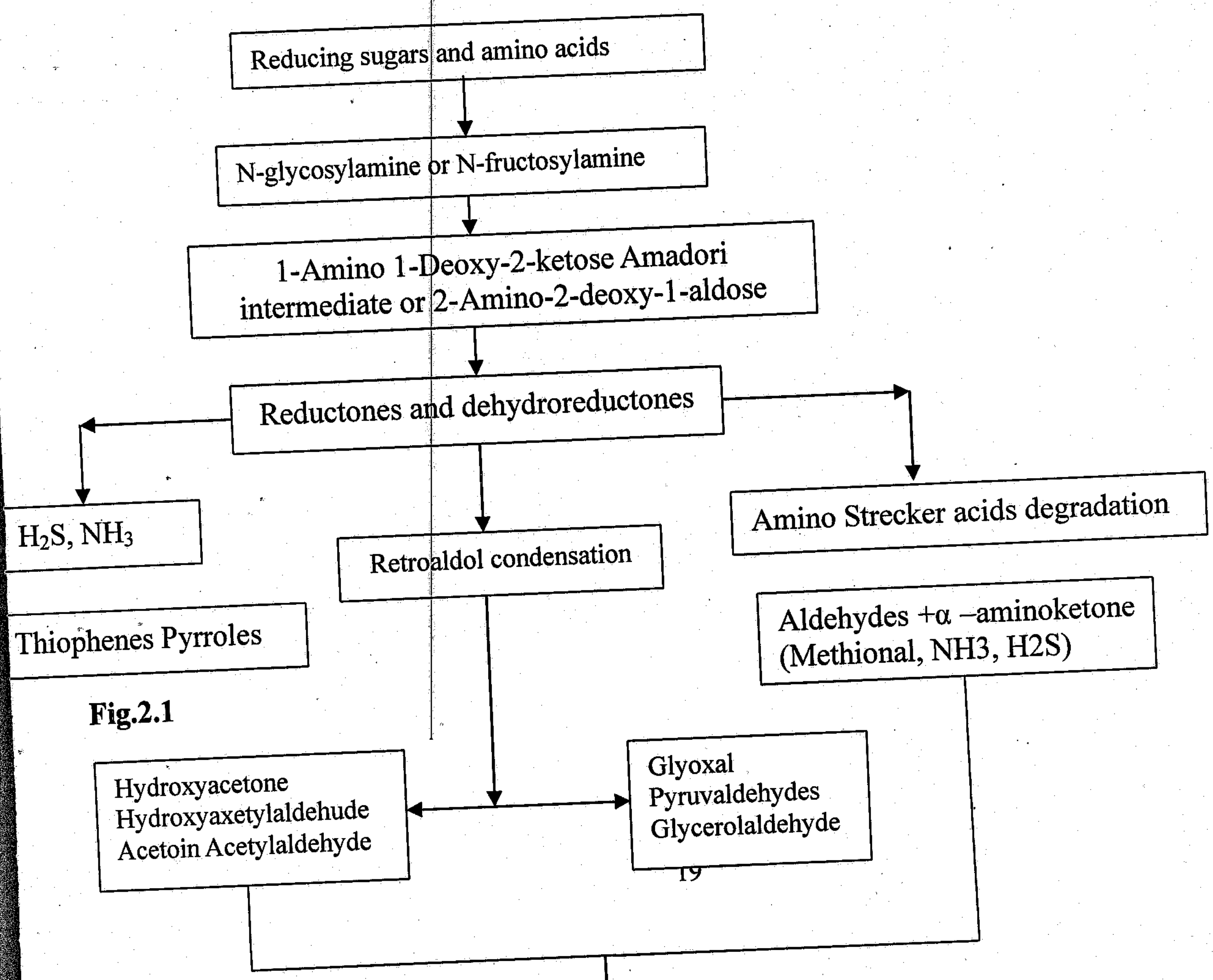

Fig.2.1

Volatile compounds	Aroma quality
Acetic acid	Pungent
4-methoxy-benzaldehyde	Grass,hay,sweet,mint
2,3-Butanedione	Butter
β –Damascenone	Fruits, flowers, honey, tea
2,5-Dimethylpyrazine	Roasty, nuts
2,6-Dimethylpyrazine	Sulphur-like, nuts
2-Ethyl-5-methylpyrazine	Musty, burnt
2-Ethyl-3,5-dimethylpyrazine	Earthy, roasty, potatoes
4-Ethylguaiacol	Flowers, spicy
2-Ethyl-3-methylpyrazine	Roasty, nuts
2-Ethyl-5-methylpyrazine	Caraway
2-ethyl-6-methylpyrazine	Cheese, caraway
2-Furfurylthiol	Roasty, sulphur-like,coffee
Guaiacol	Smoky, phenolic, spicy
Hexanal	Grass
Furanol	Roasty, sweet, caramel
Methional	Potato-like, sweet
2-methylbutane	Caramel, nuts, malt
3-methyl-2-buten-thiol	Green, amine-like
4-vinylguaiacol	Spicy
2,3-pentanedione	Butter
3-hydroxy-4,5-dimethyl-2 (5H)-Furanone	Seasoning-like

Modified from coffee research institute (2001) and schenker et al. (2002)

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Modified from coffee research institute (2001) and schenker et al. (2002)

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

3.1.1 Machine capacity

The assumed machine capacity is 3kg/min

The equivalent in hour is 180kg/hrs

3.1.2 Major parts of the machine

The following are the major parts of the machine. They are;

(1) The frame design of the machine

(2) The hopper

(3) The dehulling drum

(4) The polishing drum

(5) The auger

3.1.3 The frame design of the machine

The frame design was designed using an angle iron of 40x40mm (dimension) it was cut to a length of 800mmx200mm to form the top resting platform for the machine's cylinders and bearings. The same angle iron was cut to a length of 600mm to form the standing legs for the frame. Also the base of the frame was re-enforced using the same angle iron to increase the strength and stability of the frame.

The electric motor mounting point was designed with the angle iron to form a platform that suitably seats the electric motor.

3.1.4 The Hopper

The hopper is made up of mild steel sheet of 1mm thickness, it serves as the feeding inlet for the coffee bean. The mild steel sheet was cut to a length of 160mm to form the total length of the hopper and 200mm to form the diameter of the hopper.

3.1.5 Dehulling drum

The dehulling drum was made from mild steel sheet rolled into a cylindrical shape with diameter of 75mm and a total length of 450mm. Mild steel was chosen for the design of the dehulling drum because of its strength and durability.

3.1.6 Polishing drum

The polishing drum was made of mild steel which was cut and rolled into a cylindrical tube of 160mm diameter with a total length of 250mm.

3.1.7 The Auger

The auger comprises of a central shaft and a square rod was coiled around the auger to form a spiral ring along the length of the shaft which is 1000mm equivalent to 1m in meters.

The spiral ring known as the auger coiled around the shaft together with the effect of the rotating shaft transports the coffee bean that is fed into the machine along the length of the dehulling drum into the polishing drum.

The auger is also responsible for the dehulling of the coffee bean fed into the machine for dehulling.

3.1.8 Principle of operation of the machine

The combined coffee dehulling and polishing machine is made up of two units. They are; The dehulling unit and the polishing unit.

The coffee bean is fed into the machine through the hopper, the coffee bean drops from the hopper into the cylindrical first cylindrical chamber, known as the dehulling drum.dehulling is achieved by the rotation of the auger and this rotating effect forces the coffee bean against the walls of the cylinder. The effect of the impact of the auger and the cylinder on the coffee bean breaks the husk to expose the coffee bean and the continous rotating effect of the auger transports the coffee bean into the second cylindrical chamber known as the polishing drum.

In the polishing drum, there are sets of brushes which scrubs off the inner coating off from the dehulled bean by friction and rubbing effect, as the combined effect of friction of the brushes and the polishing drum walls. That is the effect that actually causes the polishing to take place. In the polishing drum the coffee hull is expelled out through the perforated holes made under the polishing drum, creating the hull outlet, while the polished coffee bean exits through the polished grain outlet at the end of the polishing drum cylinder.

3.2 Methodology

3.2.1 Design of the major parts of the machine

3.2.2 Design parameters

The following parameters are some basic details of the coffee seed. These information made the design calculations carried out on the important parts of the machine possible. They include;

(1) True density of the seed = 1226.5kg/m^3

(2) Seed width = (6.5-9.5mm)

(3) Seed length = 10-18mm

The assumed machine capacity is 3kg/min which is equivalent to;

3x60 = 180kg/hour

3.2.3 Expression of the machine capacity in volumetric rate

This calculation is carried out in order to determine the volumetric rate of the coffee seed that can be dehulled per hour.

Using the formula for density;

$$\rho = \frac{M}{V} \quad \ldots 3.1$$

$$V = \frac{M}{\rho} \quad \ldots 3.2$$

Where $\rho = density$

M = mass

V = volume (Douglas, 2006)

Density of the coffee seed was obtained as 1226.5kg/m and mass assumed as 3kg

Therefore volume = 3/1226.5

Volume = 0.00254m³/min

Expression of the capacity in volumetric rate;

Volume x 60min

0.00245x60 = 0.147m³/hr

3.2.4 Determination of the screw diameter for the auger

Determination of the screw diameter is carried out in order to the actual minimum Diameter that is needed to be added to the shaft diameter.

The screw diameter was determined using the formula below;

$$C_{MPH} = (D^2 - d^2) \times p \times N \times 60$$

Where;

C_{MPH} = Capacity of the machine in m/hr

D = Diameter of the screw of the auger

D = diameter of the shaft

P = pitch of the auger

N = speed of the auger in rpm (R.S.Khurmi and Gupta , 2005)

Where;

$C_{MPH} = 0.147\ m^3/hr$

$d = 25mm = 0.025m$

p = 20mm = 0.02m

N = 500

To obtain the screw diameter for the auger

$0.147 = (D^2 - 0.025^2) \times 0.02 \times 500 \times 60$

$0.147 = (D^2 - 0.025^2) \times 600$

$0.147 = (600D^2 - 6.25 \times 10^{-4} \times 600)$

$0.147 = 600D^2 - 0.375$

$600D^2 = 0.147 + 0.375$

$D = \sqrt{8.7 \times 10^{-4}}$

D = 0.0295m

3.2.5 Shaft design

The shaft is a rotating machine element which is used to transmit power from one point to another. The shaft is being designed on the basis of strength, rigidity and stiffness. when designing for the shaft, the fact that the shaft may be subjected to twisting and bending moment was put into consideration.

Formula for shaft design calculation;

$\sigma = 16T/\pi d^3$

$d = \sqrt[3]{16T/\sigma\pi}$ (R.S. Khurmi and Gupta, 2005)

where ;

d = the shaft diameter in mm = 25mm

τ = the torque of the shaft Nm = 36.287Nmd

σ = the maximum permissible work stress in N/m

$d = \sqrt[3]{16} \times 36.287 \times 10^3/28\pi = \sqrt[3]{6,600.29}$

d = 18.758mm

For factor of safety,

Take 20% of the calculated diameter and add it together with the calculated shaft diameter.

$20/100 \times 18.758$

$0.2 \times 18.758 = 3.75$

Therefore, the total shaft diameter = 18.758 + 3.75 = 22.509mm

Then the calculated result, a 25mm diameter shaft is chosen for this design by standard.

3.2.6 Torsional deflection of the shaft

The torsional deflection of the shaft is being determined to know the angle of deviation Of the shaft and to make sure this angle of deviation is minimal.

Formula;

$\alpha = 584\tau l/D^4 G$ (R.S. Khurmi and Gupta, 2005)

Where;

α = the anngular shaft deflection in degrees

L = the length of the shaft = 1000mm

D = the modulus of elasticity of steel = 80,000N/mm

But D = 2.26 × $4\sqrt{\tau}$

$\tau = (\frac{D}{2.26})^4$

$\tau = (\frac{25}{2.26})^4 = 14973.60\text{Nmm}$

$\alpha = 584 \times 14973.60 \times 1000/(25)^4 \times 80{,}000 = 1/3.125\times10^{10}$

$\alpha = 0.28^\circ$

3.2.7 Critical speed of the shaft

The critical speed of the shaft is determined in order to provide a normal working speed That will dehull the coffee bean without crushing it. And if the dehulling speed of the Machine is too slow, it helps you determine the required speed needed by the machine In order to provide the required machine efficiency.

Formula;

$\omega_s = \sqrt{\frac{48\pounds I}{ML}}$ (R.S.Khurmi and Gupta, 2005)

Where;

I = moment of inertia

ω_s = the critical speed of the shaft

£ = the modulus of elasticity of steel = 0.2N/m^2

m = the mass of the shaft

L = the length of the shaft = 1m

Steel material = 7840 kg/m^3

Length of the shaft = 1m£

$V_s = \pi r^2 L$

$\pi (0.0125)^2 \times 1 = 4.909 \times 10^{-4} m^3$

Density = mass/volume

Mass of the shaft = $7840 \times 4.909 \times 10^{-4}$

= 3.85kg

$I = \pi d^4/64 = \pi (0.025)^4/64$

$I = 1.917 \times 10^{-8} m^4$

$\omega_s = \sqrt{48 £ I/Ml}$

$= \sqrt{48} \times 0.2 \times 1.917 \times 10^{-8}/3.85 \times 1$

$\omega_s = 2.186 \times 10^{-4}$ rad/sec

3.3 Power Requirement of the machine

The power requirement calculation is carried out in order to determine the power Required to dehull the coffee bean to it's expected efficiency.

(1) power required to drive the shaft

(2) power required to dehull the coffee seed

(3) power required to drive the pulley

3.3.1 power required to drive the shaft

Formula;

$P_s = W_s \times R_s$ (R.S.Khurmi and Gupta, 2005)

W_s = weight of the shaft

R_s = the radius of the shaft

W_s = mass × gravity

Where mass of the shaft = 3.85kg

$W_s = 3.85 \times 9.81 = 37.77N$

$R_S = \frac{D}{2} = \frac{0.0295}{2} = 0.0148m$

$P_S = 37.77 \times 0.0148$

= 0.558w = 0.000559kw

3.3.2 power required to dehull the coffee seed

This is the power required to dehull the coffee bean without crushing the coffee bean

$P_{h=T_\omega}$ (R.S.Khurmi and Gupta, 2005)

Where;

T = torque of the shaft = 36.287Nm

ω = angular speed of the shaft = 52.30

$P_h = 36.287 \times 52.36$

= 1.899KW

3.3.3 power required to drive the pulley

This is determined, considering the weight of the pulley of the shaft in order to provide An electric motor that can withhold the weight of the pulley by propelling the pulley to Provide the machine with the required speed to carry out the dehulling of the coffee bean

$P_P = W_p \times R_p$ (R.S.Khurmi and Gupta, 2005)

where;

W_p = weight of the pulley

R_P = radius of the pulley

mass of pulley = 3.6kg

w = mg

where; m = mass =3.6

g = gravity = 9.81

= 3.6 × 9.81

= 35.316N

P_p= 35.316 × 0.09

= 0.0032KW

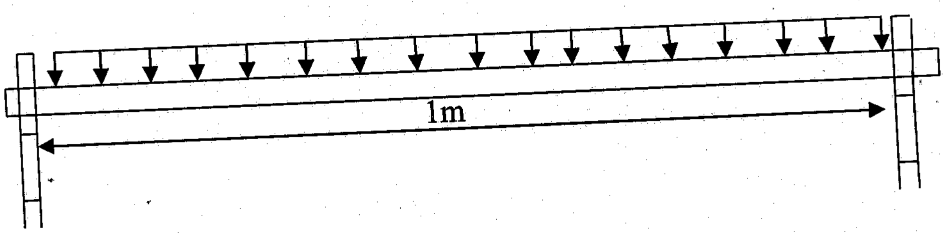
The total power = $P_S + P_S + P_P$

Total power = 0.00559KW+1.899KW+0.0032KW

Total power = 1.9027KW

Therefore, 3 H_P electric motor is used for this design.

3.3.4 Determination of shear forces reactions at the bearings and bending moment



Where;

Mass of the shaft = 3.85kg

Weight per unit length of the shaft = W = mg

Where m = mass = 3.85

g= gravity = 9.81

$$W = \frac{3.85 \times 9.81}{1m}$$

W = 37.769N/m

$R_A \frac{w \times l}{2}$

Where;

R_A = reaction at the first bearing (A)

R_B = reaction at the second bearing (B)

W = weight per unit length of the shaft

Therefore; $R_A = R_B = \frac{37.769 \times 1}{2}$

= 18.88N

Therefore; $R_{A=18.88N}$

$R_{B=18.88N}$

$B_M A = B_M B = 0$

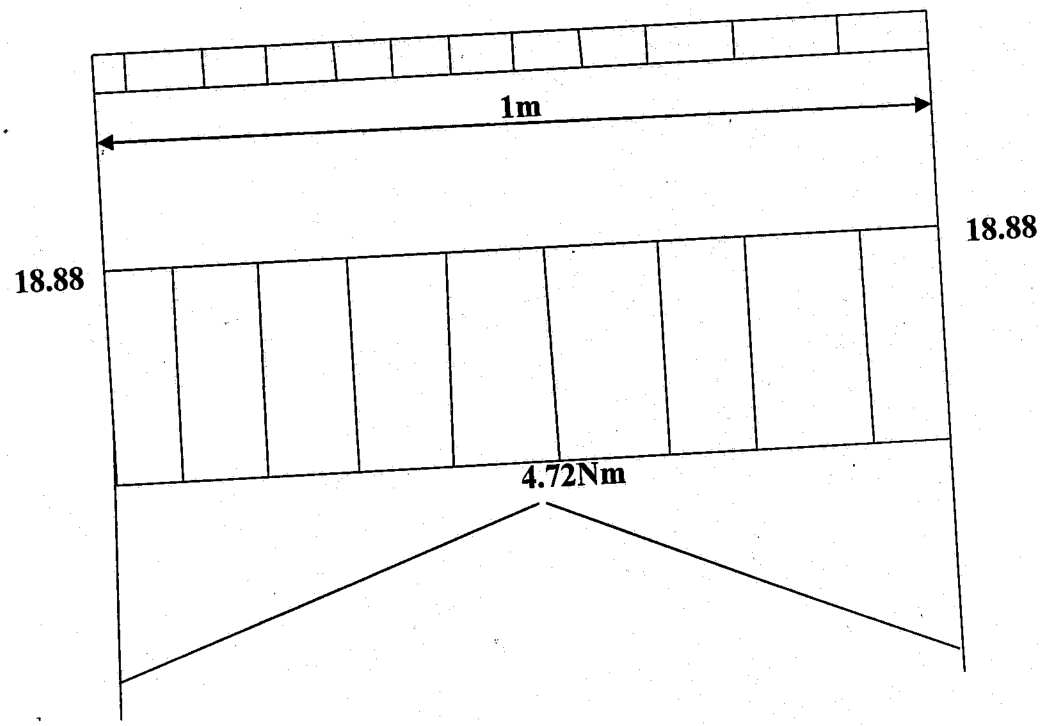
Where; $B_M A = B_M B$ are the bending moment at bearing (A) and bearing (B) respectively equal to zero.Type equation here.

$B_M C = \frac{w \times l}{8}$

Where; $B_M C$ is the bending moment at the centre of the shaft

$B_M C = \frac{37.769 \times 1}{8}$

$B_M C = 4.72$Nm



3.4 Design for the belt pulley

The design of the belt is carried out in order to be able to determine the length of the belt so that, the belt length will not be too short or too elongated. this is also done in order to ascertain the appropriate length that will provide the expected working capacity that is required of the machine.

To design for the belt, the following equation is used;

$N_1 d_1 = N_2 d_2$ (R.S.Khurmi and Gupta, 2005)

$N_{1=}$ The speed of the motor = 1500

N_2 = The speed of the driving shaft = 500

d_1 = The diameter of the motor pulley = 60

d_2 = The diameter of the shaft pulley = ?

Therefore; $d_2 = N_1 d_1 \div N_2 d_2 = \frac{1500 \times 60}{500}$

d_2 = 180mm

3.4.1 Determination of the belt length

This is carried out in order to know the exact length of the belt to be used on the machine So that it will not be too shortened or too elongated.

The belt length can be determined using this formula;

$L = 2c + \frac{\pi}{2}[(d_1 + d_2) - (d_2 - d_1) \div (4c)$ (R.S.Khurmi and Gupta, 2005)

Where; L = Length of the belt

d_1 = the diameter of the small pulley (motor pulley) = 180mm

d_2 = the diameter for the large pulley (shaft pulley) = 60mm

$\pi = 3.14$

C = the centre of the pulley belt = ?

To calculate for the centre of the pulley, C

Using the formula; $C = (d_2 - d_1) \div (2) + d_1$

Therefore; $C = (\frac{180-60}{2}) + 60$

C = 120mm

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

$L = 2(120) + \frac{3.14}{2}[(240) - (0.25)]$

L = 240 + 376.60

L = 616.60mm

3.4.2 Belt speed calculation

This is carried out in order to know the exact thickness to be used on the pulley to avoid

Failure of belt.

The belt speed calculation is carried out using this formula;

$V = \frac{\pi N1d1}{60}$ (R.S.Khurmi and Gupta, 2005)

Where; V = Velocity of the belt

N_1 = Speed of the motor = 1500

d_1 = Diameter of the motor pulley = 60mm = 0.06m

$\pi = 3.14$

$V = \frac{3.14 \times 1500 \times 60}{60}$

$V = 4.173 m/s$

3.4.3 Angle of contact or lap of belt between pulleys

This is carried out to ensure the proper gripping of the belt around the two pulleys.

Formula for calculating angle of contact is;

$\theta = (180 - 2\alpha)\, \alpha^{\pi}/180$ where;

$\alpha = \sin^{-1}(\frac{d2-d1}{2c})$

θ = Angle of contact

C = the approximate centre distance = 120mm

d_2 = the large pulley diameter or shaft pulley = 180mm

d_1 = the smaller pulley diameter or motor pulley = 60mm

Therefore; $\alpha = \sin^{-1}(\frac{180-60}{2\times120}) = (\frac{120}{240})\ \alpha = \sin^{-1} 0.5$

$\alpha = 30$

$\theta = (180^0 - 2(30)) \times {}^{\pi}/{}_{180}$

$\theta = 2.09 \text{rad}$

3.4.4 Determination of the torque transmitted from the motor to the shaft

The importance of calculating the torque transmitted from the motor to the shaft is to avoid the counter effect on the shaft . this also helps the shaft to overcome the resistance due to the twisting and turning effect of the shaft.

3.4.4.1 power delivered to drive the shaft

This is the power delivered from the electric motor to the shaft

From the total of the motor = 2kw

It is a fact that there would be power losses up to 5% of the total power as a result of the slip and of the belt. (R.S.Khurmi and Gupta, 2005)

Therefore; $^5/_{100} \times 2 = (0.5 \times 2) = 0.1kw$

Torque $= \frac{power\ delivered\ to\ drive\ the\ shaft}{angular\ speed\ of\ the\ shaft}$

$T_S = \frac{PS}{WS}$

Where; $W_S = \frac{2\pi N2}{60}$

$W_S = \frac{2\pi \times 60}{60}$

Where N_2 is the speed of the shaft = 500

$W_S = 52.36 rad/sec$

$T = 1.9 \times 10^3 \div 52.36 = 36.287 N_m$

CHAPTER FOUR

4.0 Development , Testing, Discussion of Result and cost Analysis

4.1 Development

All the parts of the combined coffee dehulling and polishing machine were developed from stainless steel material, except for the main frame which was developed from mild steel.

The choice of stainless steel for the dehulling cylinder, where the dehulling is carried out and the polishing, drum where the separation of the coffee bean seed from it's hull is carried out is to present the food material in a clean and hygienic condition. And because of it's high resistance to rusting and corrosion. The choice of mild steel was made for the main frame of the machine, in order to provide adequate strength and rigidity needed by the machine the hopper was developed using stainless steel. the dehulling cylinder that houses the dehulling mechanism is made from stainless steel.

4.2 Testing of the Machine

After the development of the machine, the testing of the machine was carried out in order to fulfil the second aim of this work, a performance test was carried out using 6kg of coffee bean. The sample was later divided into two equal parts. Each of 3kg. the machine was first ran under no load condition, using a motor of 3hp with speed of 1500rpm and shaft speed of 500rpm. This was carried out in order to determine the smoothness of the working parts of the machine. After this was done, the performance test was as well conducted and the results obtained were recorded in table 4.1

4.2.1 Results

For the first sample tested;

Total mass dehulled = 3kg

Dehulled coffee bean = 1.7kg

Mass of the hull = 0.51kg

Mass of undehulled bean = total mass of coffee bean – (dehulled coffee bean + mass of the hull)

Mass of undehulled coffee bean = 3 – (1.7+0.51)

Mass of undehulled coffee bean = 3 – 2.21

Mass of undehulled coffee bean = 0.79

Dehulling efficiency = $\frac{mass\ of\ dehulled\ coffee\ bean}{total\ mass\ of\ coffee\ bean\ dehulled} \times \frac{100}{1}$

Dehulling efficiency = $\frac{1.7 \times 100}{3}$

Dehulling efficiency = 56.67

For the second sample tested;

Total mass dehulled = 3kg

Dehulled coffee bean = 1.94kg

Mass of the hull = 0.55kg

Mass of undehulled bean = ?

Therefore; total mass of coffee bean – (dehulled coffee bean + mass of the hull)

Mass of undehulled coffee bean = 3 – (1.94+0.55)

Mass of undehulled coffee bean = 3 – 2.49

Mass of undehulled coffee bean = 0.51kg

$$\text{Dehulling efficiency} = \frac{\text{mass of dehulled coffee bean}}{\text{total mass of bean dehulled}} \times \frac{100}{1}$$

$$\text{Dehulling efficiency} = \frac{1.94}{3} \times \frac{100}{1}$$

Dehulling efficiency = 64.66

Table 4.1 Result Presentation.

Mass of sample	**Dehulling Time**	**Dehulling efficiency**
3kg	78seconds	56.67
3kg	81seconds	64.66
Average	79.5seconds	60.67

4.3 Discussion of Results

The variation in dehulling time is as a result of the physical make-up of the coffee bean hull, which varies in hardness. Due to the creeping and slipping effect of the belt in between the driving pulleys, the machine experienced power loss as a result of this creeping and slipping effect of the belt in between the pulleys. Therefore, there was loss in the power required to dehull the coffee bean.

The result reveals that;

For the first sample, the 3kg coffee bean sample was dehulled at a timing rate of 78secs with an equivalent in dehulling efficiency of 56.67% Also, for the second sample, the 3kg coffee bean sample was dehulled at a timing rate of 81secs with an equivalent in dehulling efficiency of 64.66%

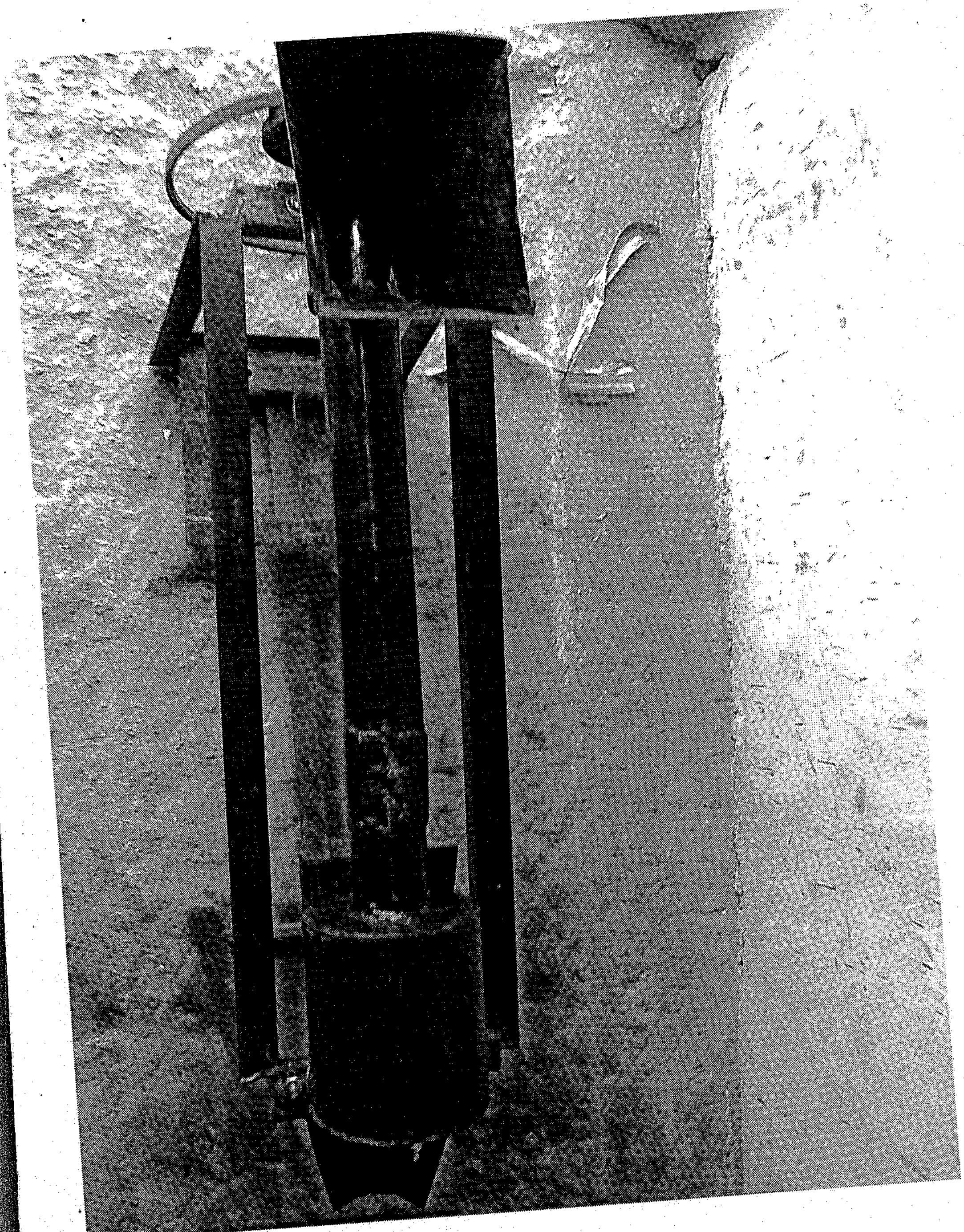


Fig.4.2 Top view

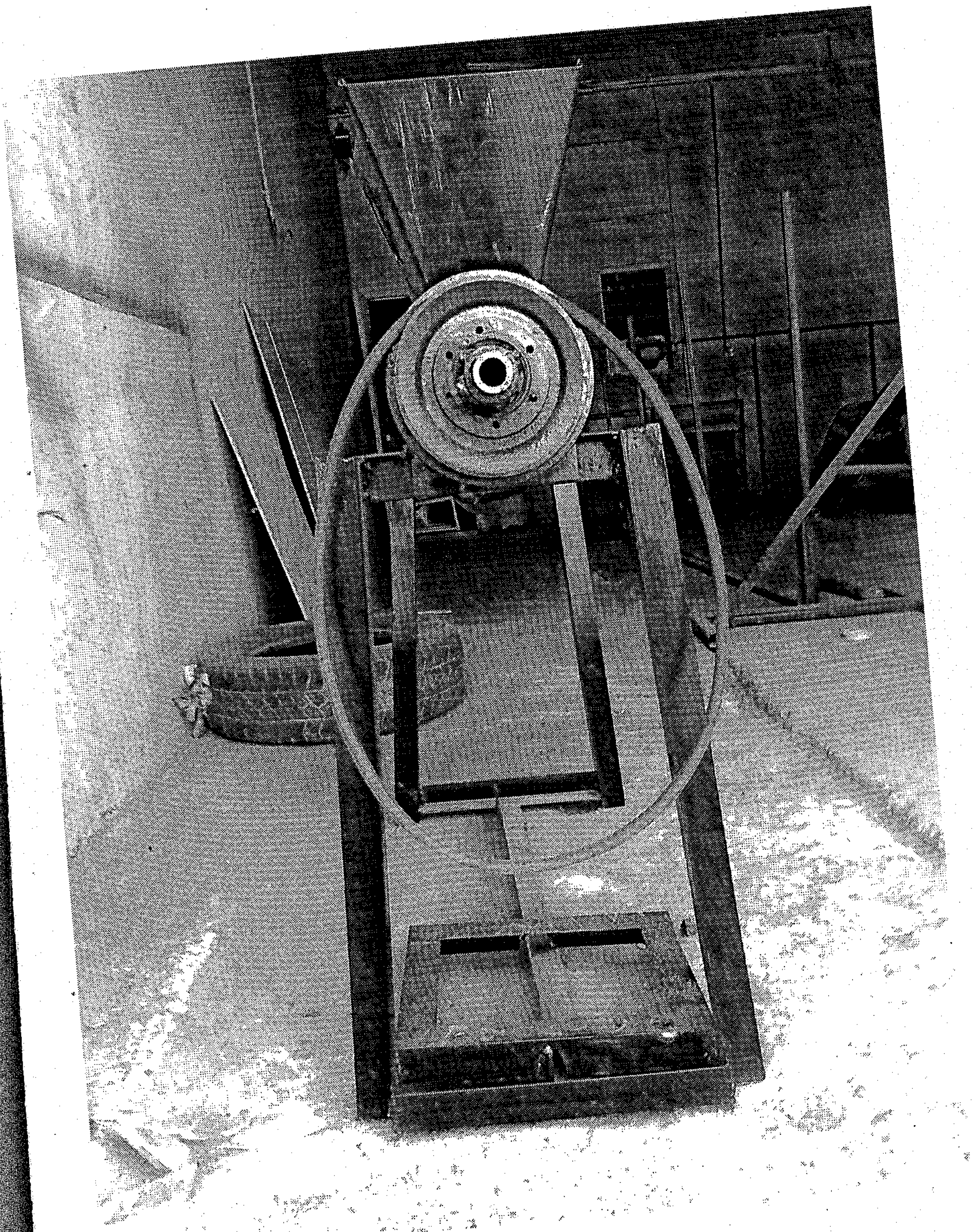


Fig.4.2 Side view

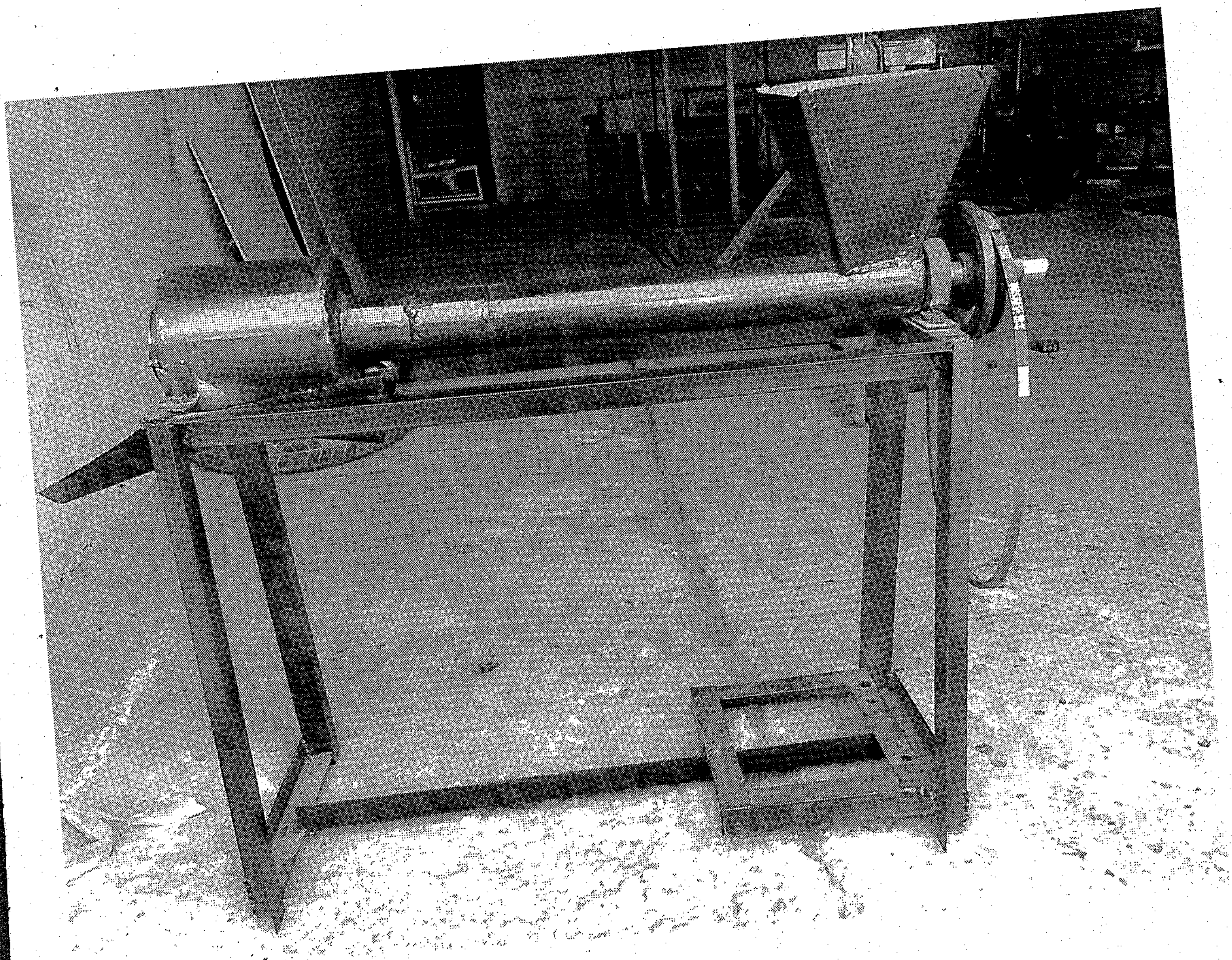


Fig 4.3 Front view

4.4 Cost Analysis

The cost analysis is carried out to know the following cost involved in the developing of the machine. They include; the material cost, the labour cost, and the overhead cost and total cost which is the sum of the material cost, the labour cost and the overhead cost.

4.4.1 Material cost

This is the cost of all the materials used in the development of the combined coffee dehulling and polishing machine for simplicity and clearity.

4.4.2 Labour cost

Taking a direct labour cost of 25% of the material cost

4.4.3 Overhead cost

This include all other expenses incurred apart from material and labour cost, taking an overhead cost of 20% of the material cost

4.4.4 Total cost

The total cost of developing the combined coffee dehulling and polishing machine is the sum of all the material cost, labour cost and overhead cost. Total cost = material cost + labour cost + overhead cost.

Table 4.2 Sumary of Cost Analysis

Material	Quantity	Cost	Amount
Angle iron	2	2,200	4,400
3 inch pipe	2m	1,200	1,200
Polishing drum	1	2000	2000
Mild steel plate	$^1/_4$ sheet	1000	1000
Bearings	2	1000	2000
Bearing housing	2	300	600
Shaft	1meter	2000	2000
Auger rod	1meter	800	800
Brush	2	500	1000
Brush holder	2	250	500
Bolts & nuts	1dozen	240	240

Paint	1litre	1200	1200
Thunner	2bottles	150	300
Electrode	$^1/_2$pack	600	600
Large pulley	1	1500	1500
Small pulley	1	600	600
Total amount			19,940

Material cost = 19,940

Labour cost = 60% of material cost = $\frac{60}{100} \times \frac{19940}{1}$

Labour cost = 11,964

Overhead cost = 25% labour cost

Overhead cost = $\frac{25}{100} \times 11{,}964$ = 2,991

Total cost = material cost + labour cost + overhead cost

Total cost = 19,940+11,964+2,991

Total cost = 34,895

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The combined coffee bean dehulling and polishing machine was designed, developed and tested. From the results, it shows that the dehulling efficiencies were 56.67% at a timing interval of 78seconds and 64.66% at a timing interval of 81seconds respectively .The design and development of this machine will help reduce the time involved in dehulling the coffee bean. Unlike what is obtainable by the use of the local method, the machine is cheaper and easily affordable unlike the highly sophisticated ones, that have been previously done,it is easy to use and the parts are easily accessable. The use of the combined coffee dehulling and polishing machine is energy saving and it requires a lesser man power.

5.2 Recommendation

The dehulling chamber must be tilted in order for the seed to fall under gravity into the machine. More research work on the coffee bean and the coffee dehuller needs to be carried out for greater availability of a high quality dehulled coffee bean.

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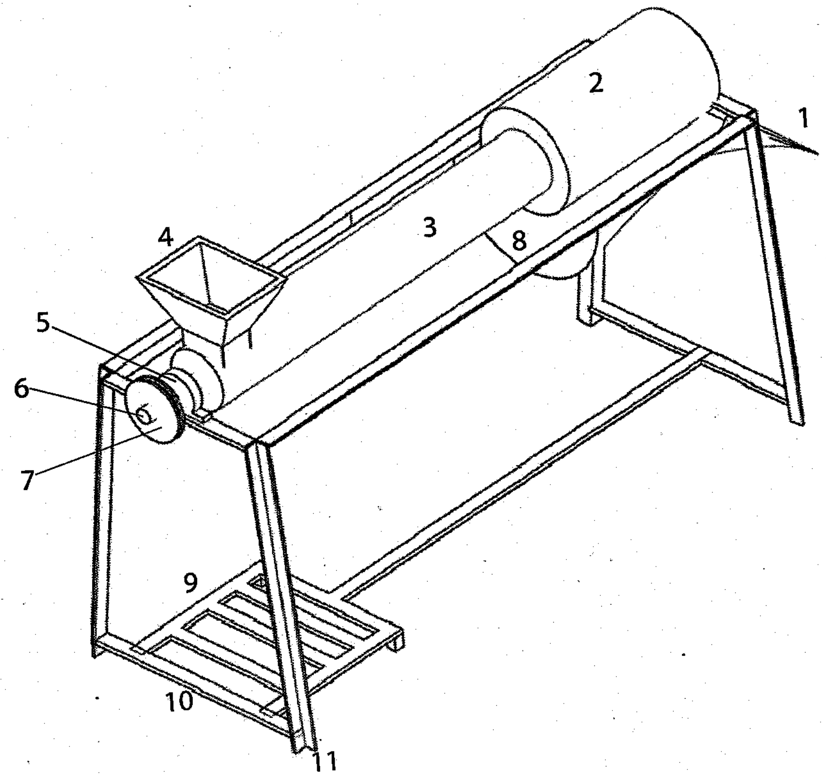
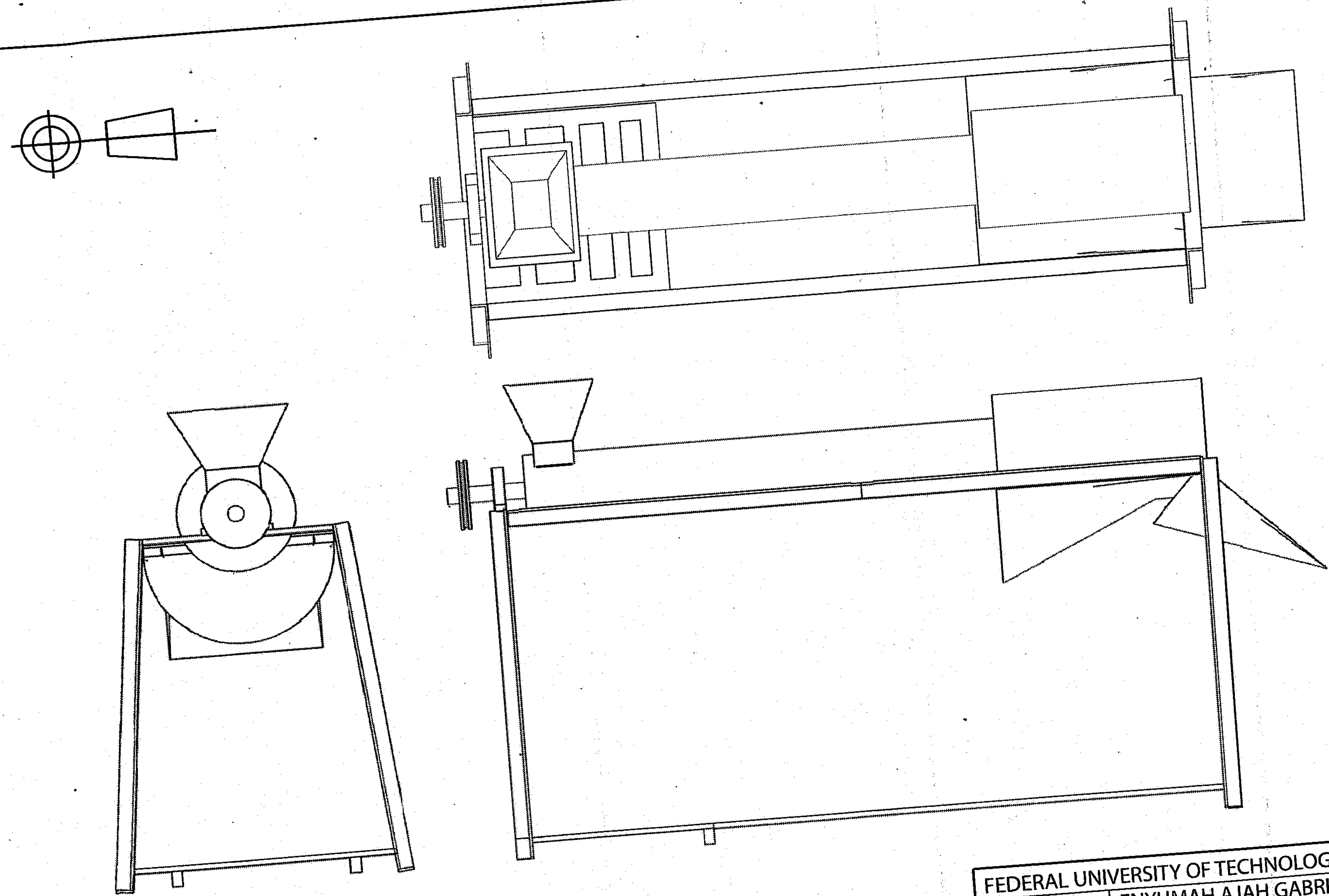


s/no.	PART DESCRIPTION	qty.
11	FRAME MEMBER	1
10	BRACE	1
9	ENGINE SEAT	1
8	HULL OUTLET	1
7	DRIVEN PULLEY	1
6	CENTRAL SHAFT	1
5	PILLOW BLOCK	2
4	HOPPER	1
3	DEHULLING DRUM	1
2	POLISHING DRUM	1
1	POLISHED GRAIN OUT	1

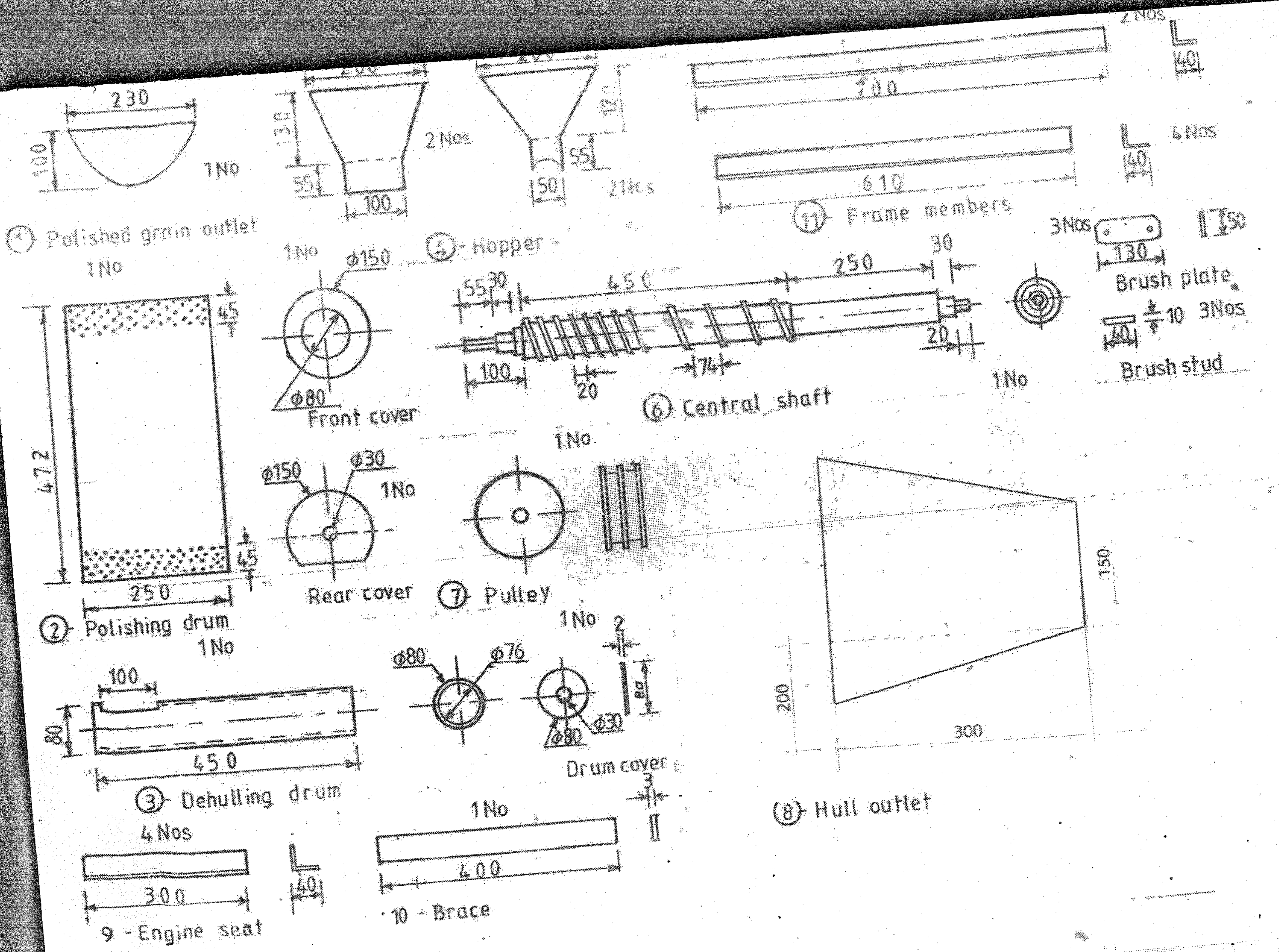
SCALE: 1:7.5
All dimensions in mm

ISOMETRIC PROJECTION OF COMBINED COFFEE BEAN
DEHULLING & POLISHING MACHINE



ORTHOGRAPHIC PROJECTION OF COMBINED COFFEE BEAN DEHULLING & POLISHING MACHINE

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA	
NAME	ENYUMAH AJAH GABRIEL
DEPT.	AGRIC & BIORESOURCES ENGN.
SUPERVISOR	DR. AGIDI GBABO
TITLE	DESIGN & DEV. OF COFFEE DEHULLER



230
100
1 No
1 Polished grain outlet
2 Nos
55
100
50
2 Nos
5 Hopper
700
2 Nos
40
610
4 Nos
40
11 Frame members
3 Nos
130
Brush plate
50
10
3 Nos
40
Brush stud
1 No
Ø150
Ø80
Front cover
55
30
450
250
30
20
100
20
74
6 Central shaft
1 No
472
45
45
250
2 Polishing drum
1 No
Ø150
Ø30
1 No
Rear cover
1 No
7 Pulley
150
200
300
8 Hull outlet
100
80
450
3 Dehulling drum
1 No
Ø80
Ø76
2
80
Ø30
Ø80
Drum cover
3
4 Nos
300
40
9 - Engine seat
1 No
400
10 - Brace