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DESIGN AND DEVELOPMENT OF A SEMI – CONTINUOUS BENISEED OIL AND EDIBLE CAKE PROCESSING PLANT

BY

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A **PRELIMINARY DESIGN** REPORT ON ***PHASE TWO***
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ABSTRACT

Modern oil expellers have been imported and are presently in use in Nigeria. However, there is need for modifications and local production of these in order to eliminate or reduce the problem of shortage of spare parts, maintenance personnel and the cost of importation. Many local fabricators have attempted to develop expellers without recourse to the design specifications, which are vital inputs. This has invariably led to the development of expellers with low oil recovery and high residual oil in cake.

In the light of the above, a cottage - scale oil expeller was designed based on the results of some determined physical and mechanical properties of three beniseed accessions (Goza 25, Yandev 55 and E8). It has a barrel of 87mm diameter and a special wormshaft length of 900mm rotating at a speed of 45rpm through a 7.5kW electric gear reduction motor. The throughput was estimated as 100kg beniseed per hour. It can be used for other oil-bearing seeds such as groundnuts, castor beans and melon seeds.

For improved oil recovery and efficient cake utilization, a semi – continuous pre-extraction plant was also designed. It consists of a cleaner, debittering equipment and mechanical dehuller.

The cleaner is an air – screen type with a capacity of 200kg/h. It employs the use of a set of vibratory screens of mesh numbers 10 and 20 as well as a blower which is driven by a 1.5kW electric motor.

The debitterer has a concentric arrangement of 3 cylindrical vessels with the most outer vessel being a flame jacket below which a system of 4 industrial gas burners are mounted for heating the water jacket vessel directly from the bottom and radially from the flame jacket. The water/steam jacket is connected to the cooking chamber through piping network into steam spargers – one directly below and the other in the middle of the chamber.

The dehuller consists of 3 blades, each in a disc form having saw – teeth periphery and a shaft driven by a 2.5kW motor. It has a capacity of 10kg of undehulled beniseed with the addition of 60 litres of water per batch of 3 minutes. Separation of the hull from the seed is carried out by mixing the blend seed with saline water and allows to settle. The degree of salinity of the water is about 15%.

A - 100litre per hour filter press was also designed for clarifying the mechanically expressed oil. The press is made of 6 solid square plates and 6 hollow square frames of dimensions 300mm x 300mm x 25mm. This is to be cast, machined and packed in alternating arrangement on a steel framework. A selection of grades of filter media and a gear pump driven by a – 1.5kW electric motor will be utilised.

CHAPTER ONE

1.0 INTROCUCTION

1.1 BENISEED PLANT'S INFORMATION

Area of Growth	Middle Belt and Some Northern States of Nigeria
Major States of Production	Benue, Taraba, Plateau, Nassarawa, Kogi, Katsina, and Jigawa
Type	Annual, herbaceous, mucilaginous and erect Characterized by bell – shaped flowers and opposite leaves
Planting	Seed is sown at the on set of the early rains in March - April. By broadcasting or drilling in rows 30cm apart at a rate of 10kg/ha on well prepared, weed free seedbed
Growth	Matures within 80 to 85 days after planting, depending on the varieties and reaches height of 0.6 to 0.8m with a well developed root system
Seed	The seed is housed in an axial capsule, which is 3 to 4cm long, with 4 segments each containing 20 to 25 pear – shaped, ovate, small flat seeds. The seeds have been classified into three main varieties based on their characteristics. These are white, black, and red or brown varieties. The white variety is rich in oil (50 to 60%) and contains lower levels of hull than the black and red varieties. It is found in some parts of Nigeria. The black variety has an oil content of about 48% while the red yields about 46% oil. Both varieties are found in India but not so popular in Nigeria. The hull accounts for about 20%of the seed weight.
Composition (%)	Fat, 43.0 – 56.8; Carbohydrate, 21.6 – 25.3; Moisture, 4.1 – 6.5; Protein, 17.6 – 26.4; Crude Fibre, 6.3 – 8.6; Ash, 4.8 – 5.3.
Energy	590Kcal/100g.
Temperature Requirement	23 to 30^{o}C
Rainfall Requirement	625 to 2250mm/yr
Soil Requirement	Well – drained fertile soils of barry texture and neutral reaction
Harvesting	Early crop is harvested in July to August while late crop is harvested in November to December
Area under Cultivation	80,000ha/yr
Yield	Between 300 and 900 tonnes/ha

Production Profile	Growth from 64,000 to 70,000 between 1996 and 1998
International Outlook	360,000 metric tones per annum ex-world; Nigerian sharing about 10% of the export
Products' Utilisation	Seeds are used for toppings on breads, ethnic dishes, and infant weaning food. Oil is used for edible purposes, manufacture of soap, insecticides and paints. Cake is an excellent supplement for animal feed
Market Price	₦4000 to ₦6000 per 100kg bag depending on the location and times of sales

1.2 OBJECTIVES OF WORK

The primary objective of this work is to design and fabricate an expeller that will be suitable for cottage-scale production of beniseed oil. In pursuance of this, the following secondary objectives arise:

- to determine some physical properties of beniseed including the linear dimensions, size, sphericity, bulk and true densities, porosity, thousand kernel weight, terminal velocity and coefficient of friction between it and different structural surfaces,
- to determine some of the mechanical and thermal properties of beniseed, these being the force required, resulting deformation and energy needed to rupture and express oil from the seed as well as the specific heat and thermal conductivities.,
- to apply the determined parameters in the design and fabrication of an oil expeller
- to design and develop a pilot plant for the debittering and dehulling of the seed and,
- to standardize oil expeller wormshaft design for various oilseeds.

1.3 ENGINEERING PROPERTIES OF BENISEED

The detailed results of the different experiments carried out to determine some engineering properties of beniseed are presented in phase one report submitted to the council (Olayanju 2003). The summarized results at the storage moisture content of 5.3% wet basis are as shown in Table 1.1.

Table 1.1: Some Engineering Properties of Three Beniseed Accessions

Beniseed Accession Property	**Goza 25** (Borno Origin)	**Yandev – 55** (Benue Origin)	**E8** (Kano origin)	**Mean** Value
Major diameter, mm	2.21	2.8	3.3	2.77
Intermediate diameter, mm	1.24	1.83	2.13	1.73
Minor diameter, mm	0.36	0.68	0.75	0.60
Geometric mean (size), mm	0.99	1.52	1.74	1.42
Sphericity	0.45	0.54	0.54	0.51
Bulk density, kg/m^3	721	688	674	694.33
True density, kg/m^3	998	1042	1050	1,030.00
Porosity, %	27.76	33.97	35.81	32.51
Thousand kernel weight, g	2.13	2.63	2.98	2.58
Coeff. of friction on Mild steel	0.58	0.51	0.41	0.50
Terminal Velocity, m/s	3.92	3.05	2.79	3.25
Rupture Force, N	7.14	7.73	8.92	7.93
Expression Force, N	29.9	29.4	28.3	28.80
Deformation, mm	0.12	0.23	0.17	0.17
Energy Required, mJ	0.6	0.7	0.6	0.63
Specific Heat, Cal/goC	0.422	0.429	0.431	0.427
Thermal Conductivity, mW/cmoC	1.021	1.026	1.034	1.027

1.4 DESIGN PARAMETERS

In order to obtain information on the design parameters of some vegetable oil expellers, questionnaires were sent out to manufacturers of oil expellers and oil processors within and outside the country. The addresses of some of these individuals and organisations are as shown in Table 1.2. The requested parameters were based on the theoretical capacity of an expeller with single flight in feed section. The received information was collated and briefly summarised in Table 1.3.

Table 1.2: Some manufacturers of small - scale oil expellers and oil processors

S/N	Name and address	S/N	Name and address
1.	Techo Quip Ltd. Techno Industrial Estate 15, Olushola Ikare Street Alake Bus Stop P. O. Box 5323, Ikeja, Lagos	2.	Indev Ltd. 3/5 Adebambo St. Obanikoro, Lagos Tel. 964498
3.	Chidi Aguba Nig. Ltd. 55, Western Avenue Surulere, Lagos	4.	Nucleus Ventures (Nig.) Ltd. Ariwoola Hs. Op. Olona Motors, Poly Rd, P. O. Box 19910, U. I. Tel: 02-2413501
5.	Ultra Unique Eng. Ltd. 36/38 Winners way, Off Basorun MKT Orita Basorun, Ibadan	6.	Nova Technologies Ltd. Ajibode Bus Stop, U.I., Ojoo Road Ibadan Tel (02) 8103960
7.	Lawod Metals Ltd. 9, Alekuwodo Road Okefia, Osogbo. Tel: 035 – 232241	8.	Tiny Tech Plants Tagore Road, Rajkot 360 000 2 India Tel: 91 – 281 477466
9.	Marthias Reinartz Neuss Industrie Str. 14, England Tel: 0482 – 29864	10.	Simon Rosedowns Ltd. CannonStreet, Hull, P.O.Box 100950 Fed. Rep. Germany Tel: 02101 – 272028

Table 1.3: Design specifications of some small - scale oil expellers

Name	Capacity, kg/h	Power reqd., kW	Wormshaft speed, rpm	Barrel dia., mm	Barrel length, mm / No of bars*	Overall dimension, L, B, H (mm)	Total weight kg
Table oil expeller (S)	30	2.25	-	58	*16	1060, 530, 890	203
Mini 40 oil expeller	40	2.25	120	62	234	760, 450, 550	250
Table oil expeller (Du)	40	3.75	-	69	*18	1060, 530, 890	208
Infant oil expeller	40	3.75	45	73	406	1625, 700, 1145	440
Table oil expeller (De)	50	3.75	-	78	*20	1140, 550, 960	230
Table oil expeller	55	3.75	-	80	*22	1140, 550, 960	255
Baby oil expeller (No 1)	56	5.60	33	-	610	2083, 610, 1370	1000
Baby oil expeller (SOL)	60	5.25	35	-	-	1880, 610, 1370	1000
Baby oil expeller (SDG)	72	7.5	22	-	-	2753, 1066, 2051	2400
Baby oil expeller (No 2)	83	7.5	-	89	686	2436, 1066, 2055	1500
Tiny tech oil expeller	100	7.5	-	124	*24	1960, 460, 500	1200
Young oil expeller (S)	180	11.25	22	126	762	2250, 1060, 2220	2500

1.5 PROCESS TECHNOLOGY

There are three main stages of beniseed oil production viz:

(i) Pretreatment stage: this involves processes such as cleaning, debittering, dehulling, drying and scorching.

(ii) Extraction stage: This stage involves the processing of the seed into oil and cake.

(iii) Post Extraction stage: This comprises the filtration, refining and packaging of the oil as well as the cake.

The sequence of the above stages is given in the flow chart (Figure1.1) and briefly described below:

1.5.1 Cleaning

The Federal Produce Inspection Service (FPIS) enforces FAO prescribed grades and standards recommended by International Commodities Board for beniseeds intended for export. The standard for the two types of beniseeds grown in Nigeria- the Kano and Benue varieties have the same quality standards termed as " Exportable Quality" which means beniseeds which contain:

(i) not more than 2% by weight of stones, literite and other mineral or vegetable extraneous matters and

(ii) not more than 5% by weight of seed other than sesamum indicum.

Beniseeds that fail to maintain this standard is rejected for export .

At the cottage scale level, the seeds are dry cleaned using two sieves of 2.5mm and 1.5mm apertures to remove dust, sand, dry leaves twigs and empty capsules of the fruits. The dry cleaned seeds are then washed in excess water to remove empty seeds as well as separation from stones. However, simple machines such as Air- screen cleaners and Specific gravity separators are available for medium scale processing.

Raw Beniseeds

↓

Cleaning

↓

Debittering

↓

Dehulling

↓

Hull Separation

↓

Drying

↓

Expelling

↓	↓
Oil	**Cake**
↓	↓
Filtering	Drying
↓	↓
Degumming	Milling/Peletizing
↓	↓
Packaging ---→	Storage

Figure 1.1: Flow Chart for Beniseed Oil and Cake Production
Adapted from Olayanju (2002)

1.5.2 Debittering

Beniseed has a bitter taste that remains even after dehulling and extraction. The bitterness contains alkaloids such as caffeine in coffee and tea. It is extractable in boiling water. In processing, the raw benniseed is cooked in excess water for about 20 minutes in a covered container. The water is drained off and the seed washed in two changes of cold water. This is cooked again for another 20 minutes to completely remove the bitterness.

1.5.3 Dehulling

Dehulling of beniseed is done in order to eliminate the Oxalate component of the hull because it binds calcium which would therefore not be available if the cake is used in infant food formulation. To dehull beniseeds, the seed is tempered by boiling in water for about 30 minutes or by the application of steam. The tempered seeds are poured into a mechanical dehuller consisting of 3 blades rotating in a container of excess water. The high speed of the blade brings about without breaking the seeds.

1.5.4 Hull Separation and Drying

Separation of the hulls from the seeds is done by draining the hull-kernel mass on a 1.2mm sieve and then poured into a container of brine (15% solution) and mixed thoroughly. This is allowed to stand for about 30minutes. The hulls sunk while the kernels float on water. The floating kernels were run off unto a sieve for draining. The wet kernels are dried in an open air or by using a tunnel dryer.

1.5.5 Roasting/Steaming

Preheating of the seeds is needed for three reasons: to facilitate oil extraction, to lower or increase the moisture of the nut, and to reduce the wear in the screw press. The temperature attained during cooking should not exceed 180^{0}C as otherwise the quality of the oil may be adversely affected.

1.5.6 Pressing

Pressing is normally done by using a single expeller of lower pressure but higher first-pass capacity. The pre-heated seed is fed into the expeller once at lower pressure (choke fairly wide open) and the press cake is then re-fed through at a higher pressure (choke narrowed). Most of the oil is expressed in the first pass, but a significant amount is yielded by the second pass.

1.5.7 Filtration

To remove impurities, which are insoluble in oil from the benniseed oil, filtration is done. This can be achieved by using an ordinary cloth stretched over a frame onto a tank of sufficient capacity. Alternatively, the mill may use a small chamber filter press with 12 plates attached to, by an oil pump.

1.5.8 Refining

Benniseed oil intended for industrial purpose needs to go through a refining stage which is the process of removing impurities which are soluble in oil through the method of neutralization, decoloration and deodorization.

1.5.9 Breaking-Up

The produced cake will probably need little or no further breaking up. A crusher or disc mill can be used to achieve this. This can then be loaded manually into bags. Generally, the cake will spoil readily after a few days unless it is properly treated packaged and stored.

1.6 PRODUCTION EQUIPMENT

The following equipment will be needed for a plant processing an average of 2 tonnes of raw beniseed materials per eight-hour working day (2TPD).

1.6.1 Mechanical Cleaner

A simple air-screen cleaner with a capacity of about 200kg/h can be utilised. It employs the use of a set of vibratory screens of mesh numbers 10 and 20 as well as a blower driven by a 2hp electric motor. In operation, the seeds are dropped unto the top scalping sieve by gravity and controlled by feeding mechanism. The top screen separates larger particles while the bottom- grading sieve separates undersized particles. The blown air removes lighter materials away from the falling seeds. The cleaned and sound seeds are delivered through a spout.

1.6.2 Mechanical Debitterer

The equipment is a concentric arrangement of cylindrical vessels with the most outer vessel being a flame jacket below which a system of four industrial gas burners are mounted for heating the water jacket vessel directly from the bottom and radially from the flame jacket.

The water vessel also has immersed in it the roasting/steaming vessel chamber and between them is the water jacket which is really the zone of active steam generation. The water/steam jacket is connected to the steaming chamber through piping network into steam spargers – one directly below and the other in the middle of the chamber. The steaming chamber itself houses the transferable steaming basket. The basket is constructed to metallic perforated sieve and stainless steel mesh and can be in multiple units.

1.6.3 Mechanical Dehuller

The mechanical Dehuller consists of the following main components:

(i) Three chopper blades, each in a disc form having saw-teeth periphery.

(ii) A main shaft that carries the blades and driven by an electric motor mounted on a vertical frame and

(iii) A main container with a gate value at the lower end for discharging the product after processing.

The capacity of the dehulling tank is 100litres and it is to process 10kg of beniseed with the addition of 60 liters of water per batch of 3 minutes.

1.6.4 Hull Separator

Separation of seed from the hull can be achieved by mixing the blend beniseed with saline water and allowed to settle. The degree of salinity of the water is 15%. The mode of separation followed the pattern of hull at the bottom, water column on top of the hull and clean seed at the topmost part. The ratio of the heights was 7:5:3. It is easy to collect the clean hull-free seed by decanting from the top column. The needed materials are:

(a) 250 liters cylindrical tank with 100mm diameter gate valve at the bottom used for the hull separation.

(b) Another 250 liters cylindrical tank can also be used to wash the clean hull-free seed after the separation exercise. The material of the two tanks can be plastic, galvanised or stainless steel.

1.6.5 Dryer for Dehulled Seed

The draining of water from the hull – free seed can be carried out by collecting it in a container having a bottom wire mash of about 500 microns. The size of this sieve is 1,000mm diameter x 500mm height. Further removal of trapped water in the seed can be done by spreading it under the draft of a ceiling fan, or by using an aspirator.

1.6.6 Roaster

It consists of a hand-rotated drum placed over a fire. Because of the rotating action of the drum, seeds are more evenly distributed. A seed scorching pan of about 100 cm diameter and 15 cm deep with a mechanically driven stirrer can also be utilized.

1.6.7 Oil Expeller

The expeller consists of a set of replaceable worms, a central shaft and a slotted bar cage, mounted on a rigid skid which holds down the reduction gear and the prime mover. It has a capacity of 125kg/h and a power requirement of 10hp.

1.6.8 Oil Filter Press

A frame and plate type, this equipment is built on sturdy frame, long enough to allow for expanded capacity. The filter medium is canvass and the locking system is with a capstan screw head. The plates are provided with individual values, which allows the filtrates to collect into a common draining system and storage.

1.6..9 Oil Neutralizer

This consists of a large steel cylinder with a cone shaped bottom; fitted with an agitator and heating coils. Steam heating is used in the coils to raise the oil temperature to about 95^0c. It is incorporated with an oil pump.

1.7 PROCESS PARAMETERS

1.7.1 Volume (Water) Profile – litres/5kg seed

Dry seed	9.0
Washed seed	12.0
Wet debittered seed	20.0
Dry debittered seed	8.0
First cooking (20min)	
Water for cooking	12.5
Bitter effluent	6.1
Water for washing	12.5
Drained water	9.3
Second Cooking (20mim)	
Water for cooking	12.5
Bitter Effluent	8.82
Water for washing	12.5
Drained water	9.87

1.7.2 Moisture Profile (% wb)

Dry raw seed	5.3
Wet debittered seed	55.4
Dry debittered seed	4.0
Wet dehulled seed	43.7
Dry dehulled seed	5.0
Steam tempered seed	12.0

1.7.3 Weight Profile (kg)

Weight of raw beniseed	5.0
Weight of dirt from dry cleaning	0.03
Weight of dirt from wet cleaning	0.18
Weight of wet cleaned seed	6.60
Weight of wet debittered seed	10.6
Weight of dry debittered seed	4.74
Weight of wet dehulled seed	62.0
Weight of dry dehulled seed	39.9
Weight of dry hull	4.0
Weight of wet debittered seed	10.6
Weight of expelled oil	19.9
Weight of dry cake	28.0

1.74 Temperature Profile (^{O}C)

Steam tempered seed	95.0
Hot air oven	65.0
Dry roasting	150.0
Wet roasting	95.0

1.8 MATERIAL BALANCES

Material balances are done over the complete process in order to determine the quantities of raw materials required and products produced. These are based on the law of conservation of matter, which can be written thus:

Material out = Material in+ Generation – Consumption – Accumulation

The process is under steady state conditions, therefore, accumulation is zero. Also, there is no chemical reaction; therefore, generation and consumption are also zero. Even where chemical reaction takes place, the total mass of the chemical species become constant. Thus the steady state balance becomes: Material out = Material in (Figure 1.2)

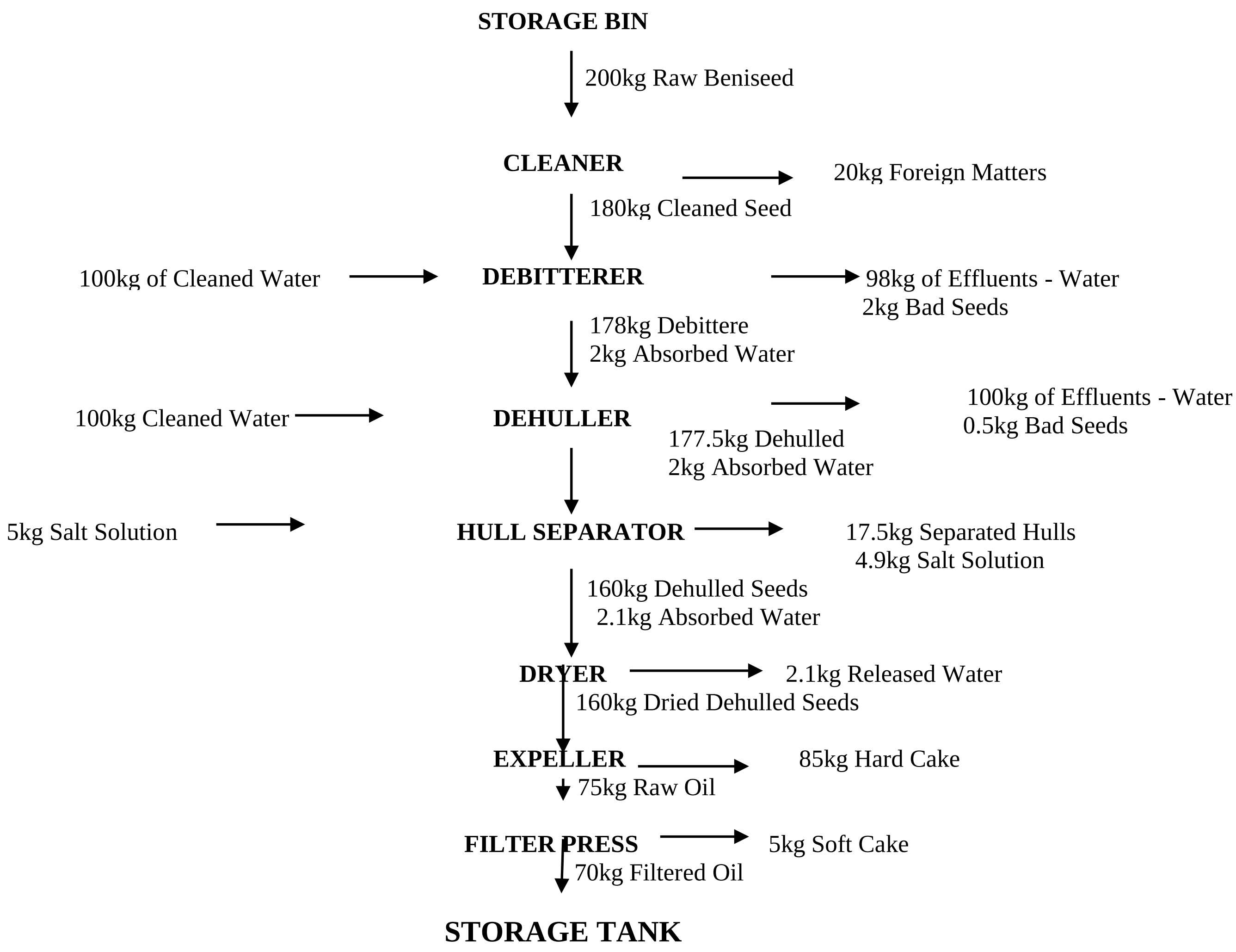


Figure 1.2: Material Balances of Beniseed Oil and Edible Cake

1.9 ENERGY BALANCES

As with mass, energy is conserved in all processes (except nuclear ones). The conservation of energy law can be written thus:

Energy out = Energy in + Generation – Consumption – Accumulation

This is basically a statement of ***the first law of thermodynamics.*** Under steady state conditions, accumulation is also zero. However, generation or consumption may not be zero depending on weather an exothermic or endothermic reaction is involved.

The rotation of the expeller screw provides input of mechanical energy. Part of this mechanical energy is dissipated in the forms of heats which causes temperature, chemical, and perhaps phase (latent heat) changes in the oilseed product. The remaining part goes to increase the pressure in the seed and its kinetic energy. An energy balance around the expeller provides a clearer understanding of the energy inputs and their distribution as described above.

Simply, the energy balance per unit of time is written as:

$$E_t = E + q$$

and

$$E_t = Q\rho\,(C_p dT + dP/\rho + \Delta H^o + \Delta H_{lf})$$

where

E_t = total energy added to expeller

E = mechanical energy dissipated

q = heat flux to seed (+) or loss (-)

Q = volumetric rate of flow; ρ = bulk density of oilseed

C_p = specific heat; dT = temperaturechange; d P = Pressure change

ΔH^o = heat of reaction per unit mass of seed, endothermic (+)

ΔH_{lf} = latent heat of fusion per unit mass of seed.

CHAPTER TWO

2.0 DESIGN FEATURES AND ANALYSIS OF OIL EXPELLER

2.1 Background Information

Although, beniseed is edible, the oil is the major component of the crop that is of general demand. The oil is a valuable, high-grade stable oil usually referred to as "Queen of oils" and is used as a substitute for olive oil in cooking and medicine (Johnson *et al.*, 1979; and Inyang and Ekanem, 1996). The usual method of beniseed oil extraction at domestic level involves pounding the seeds in a wooden mortar and treating them with hot water, which makes the oil to float to the surface from where it is skimmed off. This method is slow, with low oil yield, gives rise to unpleasant odour and bitter taste (UNIFEM, 1987).

Commercially, beniseed oil is produced either by extraction or expression. Extraction method is not suitable for cottage scale level because of the expensive solvent involved; the problem of separating the chemical used from the oil; and the fact that extraction might result in devaluation of the seed (Davies and Vincent, 1980). Therefore, expression method is preferred. Khan and Hannah (1983) described expression as the process of mechanically removing liquid out of solid containing liquid by the use of equipment such as plate presses, hydraulic presses and expellers. Plate and hydraulic presses are much more laborious, time consuming and less effective than screw presses/expellers (Oresanya and Koleoso, 1990; NCRI, 1995). An expeller is therefore preferred. However, most available expellers could not perform effectively with beniseed because of its small size (Olayanju, 2002).

2.2 Machine Features

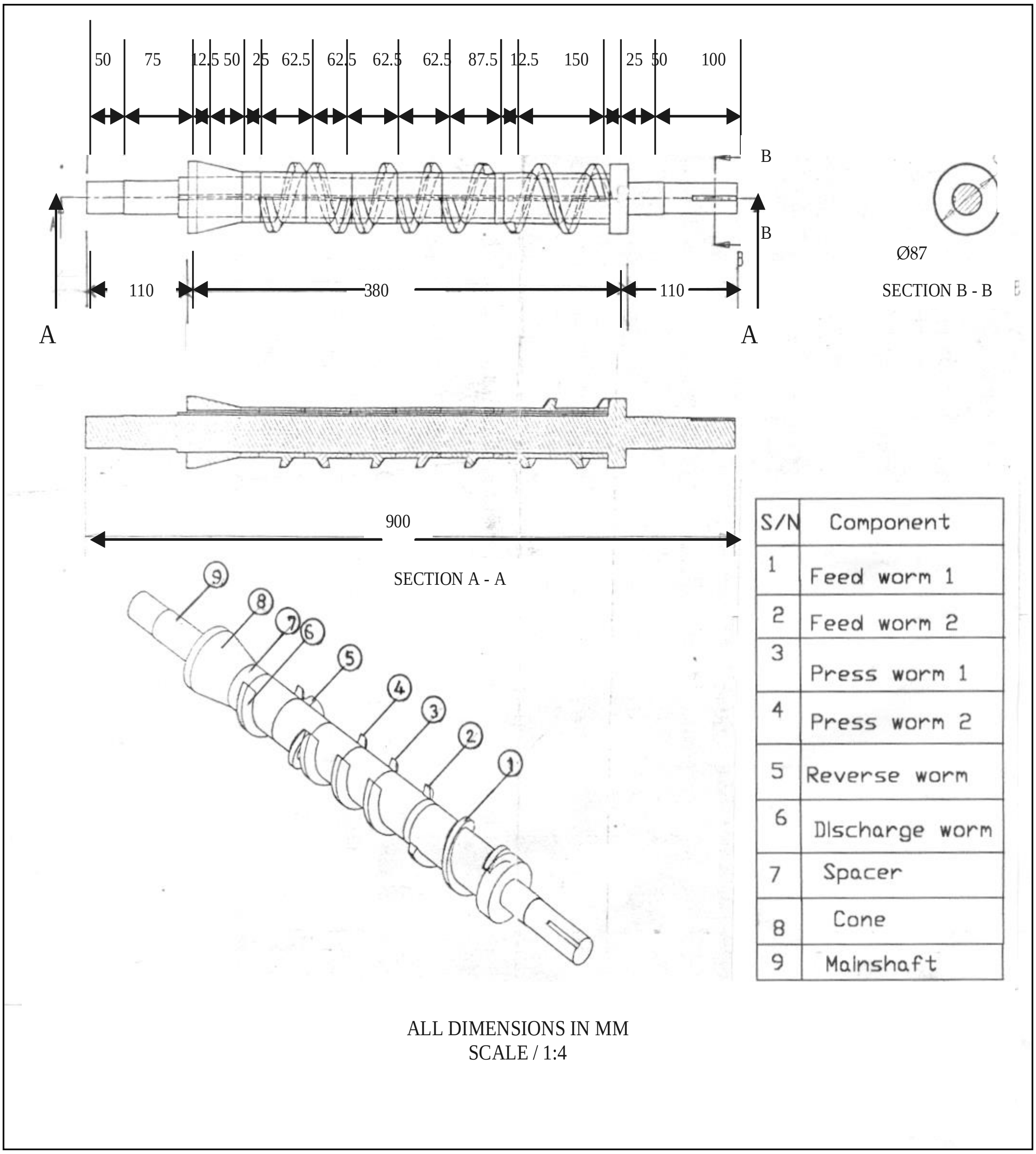
The oil expeller consists of seven main parts namely: the feeding assembly, the expression barrel, the worms and wormshaft assembly, the cone mechanism, the power transmission unit, the oil and cake troughs and the main frame. The expression chamber is made of twenty wear resistant bars arranged longitudinally to form a circular barrel with slots between them for oil drainage. The chamber is split into two halves. The top carries the hopper at the extreme right while the bottom part is welded to the frame for rigidity. The split parts are bolted together.

Six worms of different pitches were fitted on the main shaft (Figure 2.1). The fifth worm is in the reverse direction to enable proper squeezing of the cake before discharge. The worm flight design, along pressure and discharge section is such that the material does not wrap around more than 320^0 (Figure 2.2). This leaves an axial gap in the flight that enables the compressed material to slide in either direction relative to velocity generated by worm pitch. This balances the pressure over a group of worm section and reduces the tendency of material to lock in, individual section and rotate with the shaft. The unit is driven by a 0.75kW electric motor.

2.3 Design Assumptions

For simplicity of design, the following assumptions were made:

- In one revolution of screw, the charge of beniseed is advanced by one pitch of thread.
- There are negligible air spaces between beniseeds on entering the chamber.
- The maceration of oilseed was complete in the feed section leaving the homogenous mixture of oil and solids in the ram section.
- No pressure development would take place in the feed section. The pressure development and the expression of oil start at the beginning of the ram section.
- The temperature of oilseed mass remained constant in the ram section. In reality, the temperature would increase along the ram section due to shearing action of the shaft.



S/N	Component
1	Feed worm 1
2	Feed worm 2
3	Press worm 1
4	Press worm 2
5	Reverse worm
6	Discharge worm
7	Spacer
8	Cone
9	Mainshaft

Figure 2.1: Isometric and Orthographic Projections of the Special Worms and Wormshaft Assembly

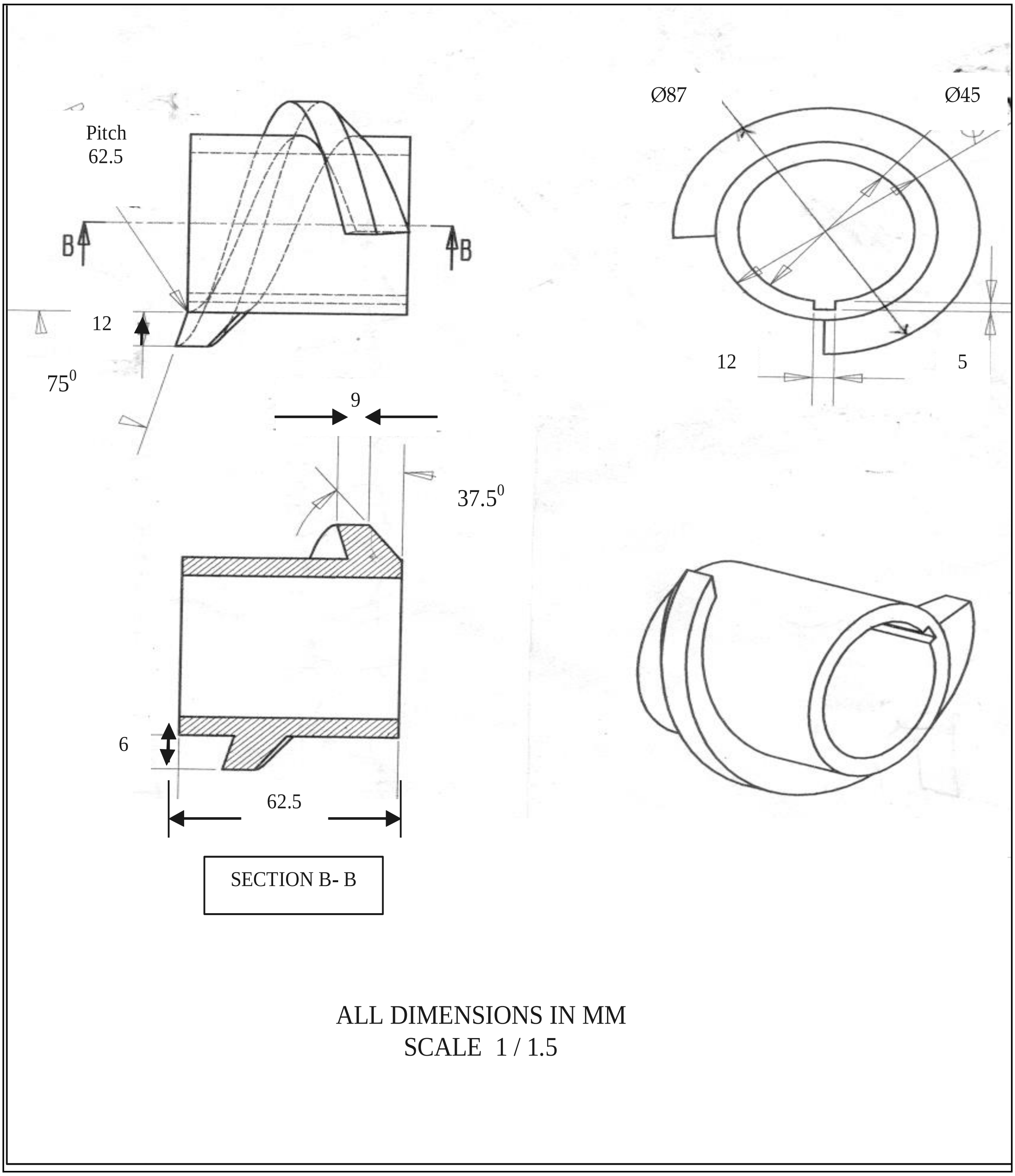


Figure 2.2 Isometric and Orthographic Projections of Expeller's Press Worm

2.4 Design Specifications

Based on the above assumptions, determination of some physical and mechanical properties of the seed, analysis of information received on the existing oil expellers and reviewed of standard literatures on oil expression (Olayanju, 2002), the following specifications were obtained and used in the design of a cottage scale oil expeller:

Required Capacity, Q_R = 100 - 125kg/h

Inner Diameter of Chamber, D_c = 50 – 100mm

Length (Chamber) to Diameter Ratio, L/D_c = 1:1 to 10:1

Length of Chamber at Feed Section, L_F = 0.1 to 0.5L

Length of Chamber at Compression Section, L_C = 0.1 to 0.5L

Length of Chamber at Discharge Section, L_D = 0.1 to 0.5L

Helix Angle of Worm, α = 10 – 20degrees

Worm Pitch, $P = \pi D \tan \alpha$

Worm Depth, H = 0.5P + 0.25mm

Worm Thickness, e = 0.37P

Compression Ratio, C = 1:1 to 5:1

Wormshaft Speed, N = 22 – 120rpm

2.5 Compression Ratio

Oil expeller works on the principle of a pressure differential applied to incoming oilseed against that applied to the discharge material. This may be termed as compression ratio. According to Shukla et. al.(1992), compression ratio, C.R. is defined as ratio of the volume displaced per revolution of the shaft at the feed section to the volume displaced per revolution of the shaft at the plug or discharge section. They gave the theoretical equation as:

$$C.R = \frac{(D_B^2 - D_F^2)}{(D_B^2 - D_D^2)} \qquad (2.1)$$

where,

D_B = Diameter of the expression chamber = 87mm

D_F = Diameter of the wormshaft at feed section = 62mm

D_D = Diameter of the wormshaft at Discharge section = 86mm

Therefore, $$C.R = \frac{(87^2 - 62^2)}{(87^2 - 86^2)}$$

$$= \frac{7569 - 3844}{7569 - 7396}$$

$$= 21.5$$

This is within the range specified for oilseed with high oil content.

2.6 Expeller's Design Capacity

The theoretical capacity of an expeller with single flight in feed section was given by Varma (1998) as:

$$Q = \pi DN \cos \alpha \, (P\cos \alpha - e) \, H \qquad (2.2)$$

where; Q = volumetric oil flow rate, mm^3/min

D = mean diameter of screw, mm

N = rotational speed of wormshaft, rpm

α = helix angle, degrees P = worm pitch, mm;

e = flight width, mm; H = flight height, mm

A computer program in basic language was written to evaluate the design capacity based on the above equation as follows:

```
10    INPUT "PI ="; PI
20    INPUT "INNER DIAMETER OF BARREL (IN MILLEMETRES) ="; D
30    INPUT "WORMSHAFT SPEED (IN REVOLUTIONS PER MINUTES) ="; N
40    INPUT "HELIX ANGLE (IN DEGREES) ="; ALPHA
50    INPUT "PITCH (IN MILLEMETRES) ="; P
60    INPUT "WORM THICKNESS (IN MILLEMETRES) ="; e
70    INPUT "WORM DEPTH (IN MILLEMETRES) ="; H
80    REM
```

```
90      REM ---------CALCULATION OF DATA QUANTITIES -----------------------------
100     REM
110     Q1 = PI * D * N
120     Q2 = COS (ALPHA)
130     Q3 = Q1 * Q2
140     Q4 = P * Q2
150     Q5 = Q4 – E
160     Q6 = Q5 * H
170     Q = Q3 * Q6
180     PRINT
190     PRINT “OUTPUT DERIVABLES
200     PRINT
210     PRINT “CAPACITY, Q (CUBIC MILLIMETRES PER MINUTE) =”; Q; “mm3/min”
220     END
```

In order to run the program, the following iterative values were used:

PI = 3.142;   D = 87mm;

ALPHA = 13degrees;   N = 70rpm

P = πDtan α = 3.142 * 87 * tan 13 = 62.5;

H = 0.2P + 0.25mm = 0.5 * 50 + 0.25 = 12.75

e = 0.5H = 0.5 * 12.75 = 6.38

Output Derivable

Capacity, Q = 5603493mm^3/min

= 5.603 x 10^6 mm^3/min

Volumetric flow rate, Q = 0.37m^3/h   for single start in 2 passes

Mass flow rate, m = Q ρ = 256.78kg/h   for average bulk density of 694kg/m^3

= 128.39kg/h   in a single pass

This can be taken as 125kg/h considering all loses in material and machine operation, which translates to 1 metric tonne/day.

2.7 Forces Acting on Screw Thread

The two main forces acting on the screw thread are those required to translate and compress the beniseed charge and the frictional force resulting from the screw's motion.

The wormshaft has six worms, each of which is subjected to pressure due to compression of beniseed kernels. This pressure increases from a minimum value at the feed end to a maximum at the discharge end. Consider a portion of the wormscrew as shown in Figure 2.3, under the static condition, the direction of elemental load, K on the unit length of the thread will be normal to the thread surface along line AO. When the screw is rotated so that the load is moved, the line of action AO will be rotated through the angle of friction, ϕ to BO. For equilibrium of forces, resolving the force BO vertical and horizontally, the component parallel to the axis of the screw, is given as

$$W = K\cos(\alpha + \phi) \quad (2.3)$$

Similarly, the component perpendicular to the axis of the screw.

$$F = K\sin(\alpha + \phi) \quad (2.4)$$

then, $$\frac{F}{W} = \frac{K\sin(\alpha + \phi)}{K\cos(\alpha + \phi)}$$

$$\Rightarrow F = W\tan(\alpha + \phi) \quad (2.5)$$

The friction angle,

$$\phi = \tan^{-1}\mu_s \quad (2.6)$$

where: μ_s = coefficient of static friction = 0.486 (Olayanju, 2002)

$$\therefore \quad \phi = \tan^{-1}(0.486) \cong 25^o$$

W is the axial force required to expel a great deal of the oil at the oil-point and has been determined to be 28.8N on the average. Based on the average size of beniseed (1.70mm) about 100 seeds are crushed at the considered feed end portion. Therefore a force of 2.88KN will be required to express the oil.

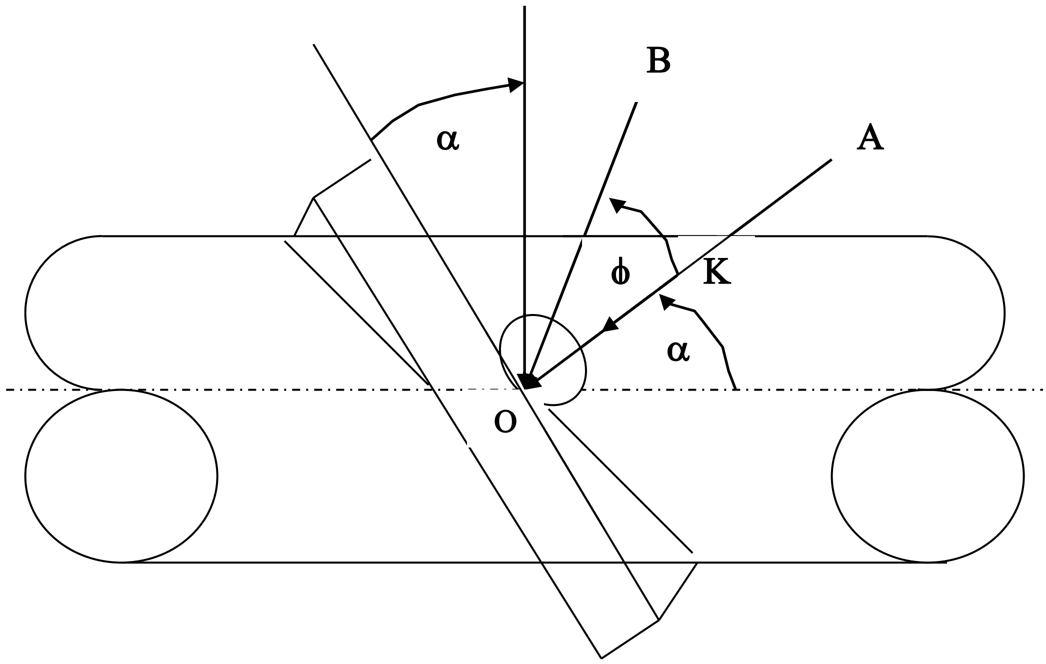


Figure 2.3: Forces Acting on Screw Thread

2.8 Torque on screw thread

Torque, T and axial load, W are related to each other through the following equation for advance against load (Hall, *et al.*, 1980):

$$T = W (R\tan(\alpha+\phi) + f_c r_c) \quad (2.8)$$

With the use of a well-lubricated bearing, the frictional force, fc at the collar will be neglected, thus, the quantity $f_c r_c$ will be zero. Hence, the equation becomes;

$$T = WR\tan(\alpha+\phi) \quad (2.9)$$

From equation (4), $F = W \tan(\alpha + \phi)$

$$\Rightarrow \quad T = FR \quad (2.10)$$

where: R = Mean radius $= \frac{D_m}{2} = \frac{(86 + 62) / 2}{2} = 37\text{mm}$ (2.11)

2.9 Power Requirement

The power input to the expeller is used to convey and heat the material for oil expression. The power drive mechanism incorporates the use of a reduction gear motor of ratio 12 to 1. This is coupled to the expeller shaft by pulley and belts arrangement. The chosen speed for the expeller N_e is 45rpm

$\therefore$ the angular speed, $\omega_e = 2\pi N/60$ (2.12)

The power input to the expeller can be computed as given below:

$$P_e = T\omega_e \quad (2.13)$$

A computer program was also written to obtain the above parameters as follows:

```
10    INPUT "PI=" ; PI
20    INPUT "AXIAL FORCE (IN NEWTON UNIT) ="; W
30    INPUT "WORMSHAFT SPEED (IN REVOLUTION PER MINUTE) ="; N
40    INPUT "FRICTION ANGLE (IN DEGREES) ="; TETHA
50    INPUT "HELIX ANGLE (IN DEGREES) ="; ALPHA
60    INPUT "MEAN RADIUS (IN METRES) ="; R
70    REM
80    REM ---------------- CALCULATION OF DATA QUANTITIES ----------------
90    REM
100   F = W * (TAN ((TETHA) + (ALPHA)))
110   T = F * R
120   OMEGA = (2 * PI * N) / 60
130   P = T * OMEGA
140   PRINT
150   PRINT "*******************"
160   PRINT "OUTPUT DERIVABLES"
```

```
170     PRINT "********************"
180     PRINT
190     PRINT "EXPULSION FORCE (IN NEWTON UNIT) =" ; F; "N"
200     PRINT "TORQUE (IN NEWTON METRE) =" ; T; "Nm"
210     PRINT "ANGULAR VELOCITY (IN RAD PER SEC) =" ; OMEGA; "rad/s"
220     PRINT "POWER REQUIREMENT (IN WATT UNIT) =" ; P; "W"
230     PRINT "EXPULSION FORCE (IN NEWTON UNIT) =" ; F; "N"
240     PRINT
250     END
```

INPUT PARAMETERS

PI = 3.142

W = 28800N

N = 70rpm

θ = 25degrees

α = 10degrees

R = 0.037m

OUTPUT DERIVABLES

EXPULSION FORCE, F = 13.65KN

TORQUE, T = 504.9Nm

ANGULAR VELOCITY, OMEGA = 7.33rad/s

POWER REQUIREMENT, P = 3.7KW

This power input to the expeller is utilized to heat the material, to convey the material for oil expression. To give allowance for power used in driving wormshaft and pulleys, a – 5hp electric reduction gear motor with a speed of about 140rpm is chosen.

Table 1: Bill of Materials for the Construction of the Designed Oil Expeller

Qty.	Material	Specifications	Rate (#)	Amount (#)
		MECHANICAL COMPONENTS		
2	Angle Iron	One Length, 100mm x 50mm^2	3600	7200
2	Angle Iron	One Length, 50mm x 50mm^2	2400	4800
1	Galvanized Metal Sheet	240cm x 120cmx 2mm	5200	5200
1	Mild Steel Solid Shaft	100cm long, θ65mm	5000	5000
6	Mild Steel Bar	10mm x 10mm x 1m	400	2400
1	Hollow Pipe	θ80mm x 25mm thick x 50cm long,	1000	1000
1	Driven Pulley	θ75mm Double Groove	500	500
1	Driving Pulley	θ300mm Double Groove	2200	2200
2	Pillow Bearings	θ30mm Inner Bore	3200	6400
2	Leather Belts	B35; V – Type	800	1600
1	Mild Steel Plate	120cm x 60cmx 5mm	5000	5000
1Pkt.	Mild Steel Electrode	Gauge 10	1200	1200
1Pkt.	Mild Steel Electrode	Gauge 12	900	900
24	Bolts & Nuts	M10 Hex. (50mm)	25	600
4	Cutting Stones	θ300mm Size	180	180
2	Grinding Stones	θ300mm Size	150	150
2	Hack Saw Blades	300mm Long	120	240
4	Drill Bits	3, 5, 7 & 10mm	110	440
		Sub Total		**#45,640**

ELECTRICAL COMPONENTS

Qty	Material	Specifications	Rate (#)	Amount (#)
1	Electric Gear Motor	3 – Phase, 10Hp @ 180rpm	120000	120000
1	Motor Starter	2 Buttons (ON & OFF)	5000	10000
1	Switch Gear Box	60Amp. (MEM)	5000	10000
15Pcs.	PVC Cables	3 - Core X 6mm X 1m	60	900
		Sub Total		**#140,900**

SPECIAL OPERATION

Casting of Wormshaft and Barrel	180,000
Fabrication (Bending, Rolling, Shearing)	50000
Sub Total	**#230,000**

TOTAL **#416,550 ≅ #420,000**

CHAPTER THREE

3.0 BENISEED AIR - SCREEN CLEANER

3.1 Design Conception

The first step was to survey numerous existing seed cleaners and graders and to identify both the features that are appropriate and those that should be modified in order to bring them to the level of a small scale but yet efficient processing of the beniseeds.

From the survey it was observed that seeds can be cleaned based on differences between the desirable seed and contaminants. Size is the most common difference among seeds (Classen, 1992). Sahay (1998) observed that the vibration screens separate products on the bases of difference in sizes of various constitute whereas air screen cleaners separate material on the basis of difference in size and weight. He stated further that seeds having difference in lengths are separated by disc and indented cylinder while materials with different shape are separated in spiral separator.

In order to remove contaminants from beniseed a sieving machine which incorporates an air blower is considered for the separation of oversize and undersize materials as well as the removal of light hulls and empty shells.

3.2 Machine Description

The machine consists of a hopper fitted above a screen box. The screen is made of a steel mesh of variable size with the holes at the top and bottom being 2.0 and 1.2 mm respectively. The screen box is inclined at about 5 degrees to the horizontal while it is suspended by four hangers which are oscillated by an eccentric unit (Figure 3.1). The disc has horizontal oscillating motion at the same time, a smaller vertical motion. These motions cause the seeds to travel downward to the screen and at the same time the seeds are thoroughly shaken.

Figure 3.1: Conceptual Design of a Beniseed Cleaner

Next to the screen is a vertical separation column connected to an air blower. The centrifugal blower is made of six plates attached to a bracket mounted on a shaft. The blower is driven by an electric motor, which also drives the screen box.

3.3 Design Features

The proposed air-screen cleaner has the following conceived specification.

- the normal input capacity shall be 200kg/hr.
- the holes of the top and bottom sieves shall be 2.0 and 1.2 mm respectively.
- Power requirement for the operation of the machine should be minimal.
- The component parts should be easily replaceable in case of any damage.

3.4 Design Assumptions

For simplicity of design, the following assumptions were made:

- A simple separating machine uses only one differentiating characteristics.
- The grains are assumed to be spheroid.
- The differences in the behaviour of seeds are caused by the difference in aerodynamics properties.
- At low Reynolds number, the inertia of the displaced air is negligible and the drag is due to viscous shear alone.
- Frictional effects are ignored.

3.5 Design Analyses

The design adopted is a combination of air stream and screen methods. The design analyses of each unit is as follows:

3.5.1 The Vibratory Screen

The machine mechanism shown in Figure 3.2 enables angular motion to be converted to linear motion. With the scotch yoke, since the drive pin fitted to the circular disc resembles the point Q in the Simple Harmonic Motion (SHM) Circle (Figure 3.3) and the slotted link is constrained to oscillate in a straight line between the limits shown, its motion is identical with the point P in the SHM circle. Thus the link itself and any attached mass will move with simple harmonic motion, if angular velocity, is constant.

A convenient amplitude of 40 mm is selected for the screen vibration, hence the driving pin has a diameter of 20mm as it is at a radius of 200 mm from the centre of the disc. The mass of the scotch yoke is about 1kg and it drives an additional mass of 3 kg made up of the screen box, the screens and the seeds. The disc to which the pin is attached runs at a speed of 240 rpm. Therefore, from SMH equation, the linear velocity,

$$V = \omega r \sin \omega t \qquad (3.1)$$

where,

ω = angular velocity

r = radius of driving pin

but $$\omega = \frac{2\pi N}{60} \qquad (3.2)$$

$$\frac{2\pi 240}{60} = 251.3 \text{ rad/s}$$

$$r = 200\text{mm} = 0.2\text{m}$$

The maximum velocity of the slide, Vmax occurs at midstroke when sin wt = 1

$$\therefore \; V_{max} = \omega r \qquad (3.3)$$

$$= 251.3 \times 0.2$$

$$= 5.03\text{m/s}$$

The maximum acceleration of the slide at the end of stroke

$$a_{max} = \omega^2 r \qquad (3.4)$$

$$= 251.3 \times 0.2$$

$$= 126.3\text{m/s}^2$$

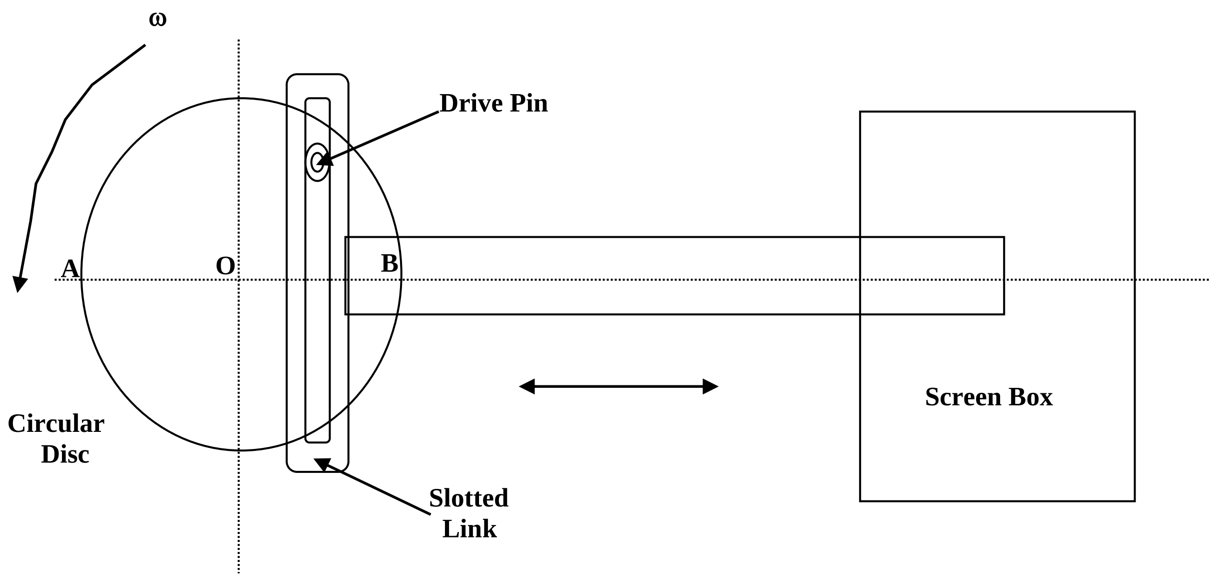


Figure 1: Scotch Yoke

The maximum force at the pin when friction has been neglected,

$$F = ma \quad (3.5)$$

$$= (1+3) \times 126.3$$

$$= 505.2N$$

The greatest shear stress in the pin result from the maximum force. Therefore

$$Lmax = F/A \quad (3.6)$$

where F = 505.2N and

$$A = \frac{\pi D^2}{4} \quad (3.7)$$

$$= \frac{\pi(0.02)^2}{4}$$

$$= 3.14 \times 10\text{-}4m^2$$

$$1max = \frac{505.2}{3.14 \times 10^{-4}}$$

$$= 1.6089MN/m^2$$

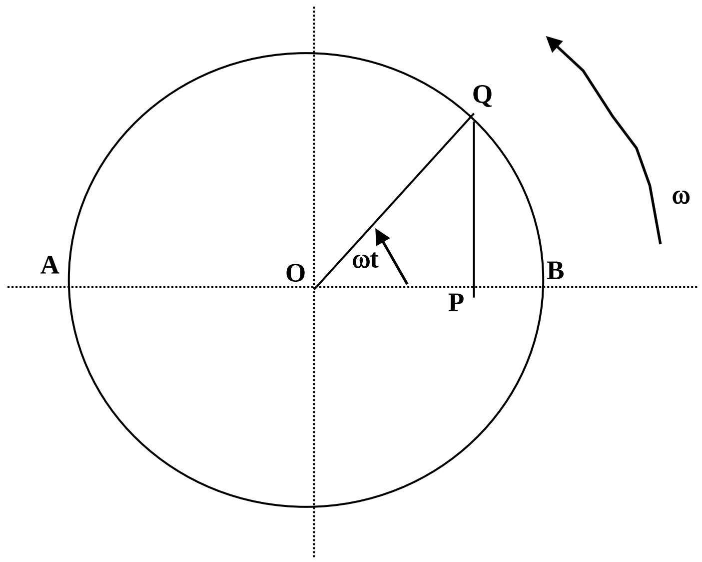


Figure 2: Simple Harmonic Circle

The torque output,

T = Fr

= 505.2 x 0.2 (3.8)

= 101.04Nm

Power requirement P = Tw (3.9)

= 7617.41W

= 101.04 x 25.13 = 2.539Kw = 3.4h.p

To give allowance for power use in driving the blower, A – 4hp electric motor rotating at a speed of about 1200 rpm is selected.

3.5.2 The Blowing Section

The blower must be capable of providing the required air velocity necessary for separation to take place. The capacity of the blower is a function of this velocity. Dimensions were calculated based on the Osborne formular as reported by Koya and Adekoya (1994):

$$Vo = \frac{0.4d\pi_2 b_2 NmDm}{60D_f Ao} \quad \ldots\ldots 3.10$$

where Vo = Air Velocity at outlet, m/s

d_2 = Diameter of fan, m = df

b_2 = Axial width of fan, m = bf

Dm = Diameter of pulley on motor, m

D_f = Diameter of pulley on fan, m

Nm = Speed of Motor in rpm

Ao = Outlet Area of fan, m2

From fluid mechanics (Continuity of flow)

$$A_1V_1 = A_2V_2 \quad \ldots\ldots 3.11$$

The inner radius of the housing must be such as to span fan diameter adequately without friction and it direct airflow through means of an exit which is to be attached to the air in let of the separator body. Parameters involved are size of air inlet, shaft size, bearing size, fan axial width and diameter.

Inner radius of fan casing is determined by the following relationship:

$$Rc = Ro\,(1-\sigma/360) \quad \ldots\ldots 3.12$$

where Rc = Radius of fan casing

Ro = Distance between shaft and pheriphery of blade

σ = Angle between the fan plates.

The blower is plate-type whose output dependent on blade geometry notational speed blade area. The peripheral speed of the blower air is

V = rw ………………………………………3.13

where

R = mean radius of blade (m)

W = angular velocity (rad/sec)

At 1200rpm and r = 10cm

$$V = \frac{2\pi 1200 \times 0.1}{6}$$

$$= 2.557 m/s$$

Theoretical Discharge

Q = AV ………………………………..3.14

With 100 mm diameter pipes

$A = X\pi r^2$

$= 2 \times B\ 142 \times (0.50)2 = 7.86 \times \pi^3 m^2$

$Q = 7.86 \times 10^{-3} \times 12.6$

$= 0.099 m^3/S$

$= 0.1 m^3/S$

This quantity is variable by means of shuttle valves on the pipes to suit the process having installation.

Table 3.1: Design Specifications for Vibratory Screen and Blower

S/N	Equation	Notation	Specification
1	$\omega = 2\pi N/60$	angular velocity	251.3 rad/s
2	$V = \omega r \sin \omega t$	linear velocity (at r = 0.2m)	50.2m/s
3	$V_{max} = \omega r$	maximum velocity of the slide at midstroke, when sin wt = 1	5.03m/s
4	$a_{max} = \omega^2 r$	maximum acceleration of the slide at the end of stroke	$126.3 m/s^2$
5	$F = ma$	maximum force of the pin when friction has been neglected	505.2N
6	$A = \pi D^2/4$	surface area of the screen at point of contact	$3.14 \times 10\text{-}4 m^2$
7	$L_{max} = F/A$	the greatest shear stress in the pin resulting from the maximum force	$1.6089 MN/m^2$
8	$T = Fr$	torque output	101.04Nm
9	$P = Tw$	power requirement	2.539Kw
10	$V' = r'w'$	blower's peripheral speed at 1200rpm and 0.1m blade radius	2.557m/s
11	$Q = A'V'$	theoretical discharge with 100 mm diameter pipes	$= 0.1 m^3/s$

BILL OF MATERIALS FOR THE CONSTRUCTION OF THE 200KG/H BENISEED AIR-SCREEN CLEANER

MECHANICAL COMPONENTS

Qty	Materials	Specification	Estimated cost (#)
3	Galvanized metal sheet	8ft x 4ft x 1.5mm	4,500
2	Black sheet metal	8ft x 4ft x 1.5mm	2,400
5	Angle iron (mild steel)	One length, 50 x 50mm^2	5,000
2	U-channel	One length, 100 x 50mm^2	4,000
2	Mild steel solid shaft	ϕ30mm, 1m long	2,400
1	Thick plate	4ft x 4ft x 5mm	2,500
1	Flat bar	100mm x 5mm, 1 length	2,500
4	Pilot bearings	ϕ30mm inner bore	6,000
2	Pulleys/on motor shaft	ϕ100mm, 160m DG	2,800
2	Screen.sieve.mesh(1.2/2.0”)	8ft x 4ft x 1mm	5,000
4pcs	Castor wheel		4,000
8pcs	Vee belts		2,400
1pc	Wire mesh for moving parts	8ft x 4ft x 1mm	1,500
		SUB TOTAL	**#45,000**

ELECTRICAL COMPONENTS

Qty	Material	Specification	Estimated cost (#)
1	Electrical motor	3 phase 2hp	15,000
1	Blower	(Direct driven)	15,000
1	Starter	Onloff (Mem)	5,000
1	Switch gear box	Mem 20Amp	5,000
10yrd	PCV cable	3-core x 2.5mm	1,000
		SUB TOTAL	**#41,000**

CONSUMABLES

10	Cutting stones	2,000
5	Grinding stones	1,000
2 pkt	M/S Electrodes (G10/12)	3,000
50pcs	Bolts & Nuts (MS,8,10,12	1,000
4pkt	Riveting materials	1,000
4	Hack saw blades	400
6	Drill bits (1mm/2/3,5,8,10,12	300
	SUB TOTAL	**#8,700**

SERVICES

1.	Flame cutting of 5mm/ms plate	5,000
2.	Slotting of 1.5mm Gal. Plate into screen	6,000
3.	Making of fly wheel, shaking disc, etc	4,000
4.	Shearing, bending, rolling	3,000
5.	Lop forming	2,000
	SUB TOTAL	**#20,000**

TOTAL = (45,00 + 41,000 + 8,700 + 20,000)

= #114,700

=======

CHAPTER FOUR

4.0 DESIGN CALCULATION OF BENISEED DEBITTERER

In conventional processing where oil is the major product, the whole seed is usually crushed and the oil is extracted. The by-product (cake) is usually fed to animals as a protein source (Inyang and Ekanem, 1996). However, the seed has a bitter taste that remains even after extraction. The bitterness contains alkaloids such as caffeine in coffee and tea and this is extractable in boiling water.

4.1 Equipment Features

The equipment (Figure 4.1) is a concentric arrangement of cylindrical vessels with the most outer

vessel (3) being a flame jacket below which a system of four industrial gas burners are mounted for heating the water jacket vessel (1) directly from the bottom and radially from the flame jacket.

The water vessel (2) also has immersed in it the roasting/steaming vessel chamber (1) and between them is the water jacket which is really the zone of active steam generation. The water/steam jacket (4) is connected to the steaming chamber through piping network into steam spargers – one directly below and the other in the middle of the chamber.

The steaming chamber itself houses the transferable steaming basket. The basket is constructed to metallic perforated sieve and stainless steel mesh and can be in multiple units. The baskets serve for steaming of the vegetable seed of seed mash inside the steaming chamber of VOSS and as the pressure or pressing chamber for the expulsion of issuing oil or better from the seed mash when placed under the pressure plate of the vertical motorized mechanical press (MMP).

Figure 4.1: Conceptual Design of Mechanical Debitterer

The part numbers are interpreted as follow:

1. - Pressure controller spring loaded valve discharge
2. - Conical air tight cover.
3. - Grain inlet.
4. - Hanger for sealing mechanism.
5. - Air tight sealing mechanism lock/handle.
6. - Overhead steam sparger.
7. - Exhaust for jacket steam.
8. - Product cooking basket.
9. - Steaming chamber ring steam sparger.
10. - Jacket discharge outlet.
11. - Product discharge outlet.
12. - Bottom steam sparger
13. - Jacket water inlet.
14. - In situ steam generating jacket.
15. - Jacket water outlet.
16. - Jacket side glass.
17. - Roasting chamber water side glass.
18. - Roasting/cooking chamber
19. - Gas combustion chamber
20. - Flue gas exhaust pipe.

TI. - Industrial thermometer..

PIC. - Pressure Gauge.

4.2 Basic Design Data

Bulk density of beniseed, p = 694.3kg/m3

Porosity, k = 32.51%

Specific heat, C = 0.422cal/goC

Thermal conductivity, Ct = 1.02mW/cmoC

Volume of water required for debittering, wdeb = 1V + 0.325V + 1V = 2.325V

Where, V = Volume of dry

Given a capacity of dry beniseed as 50kg/batch,

V = Mass/ Density = 50/0.6943 = 72litres

Therefore, Vwdeb = 2.32 x 72 = 168litres

Volume of debittering chamber can be standardized as

Vdcham = 1.6Vwdeb = 1.6 x 168 = 268.8 = 270litres

Similarly, Vbasket = 1.6Vben = 1.6 x 72 = 115.2litres

Taking the volume of debittering chamber as the volume of cup in steam / hot water jacketed heat exchanger, then, standard jacketed equipment has the following specifications:

Dcup = 600mm; Hcup = 1250mm; Vcup = 356litres

Djacket = 800mm; Hjacket = 1250mm; Vjacket = 628litres

Dbasket = 500mm; Hbasket = 660mm; Vbasket = 129.6litres

Diameter of jacketed Djkt = 800mm. Hjkt = 110mm

Diameter of roasting chamber Drc = 600mm. Hrc = 1250mm

This implies that the volume of the jackete is Vjk = $553 x 10^{-3} m^3$

While that of the roasting chamber is Vrc = $350 \times 10^{-3} m^3$. Hence the maximum, volume of water in the jacket is about 200 litres.

Since steam is to be generated for cooking of beniseed in the roasting chamber the energy requirement of the cooker will be

Q = m (ill”) = 200kg x 3210.

Where m = 200kg. 1” – enthalpy of steam @ 120^{o}C.1” = 27061

And of water @ 120^{o}C 1” = 503.76 = I” + 1” = 3210

= Q = 200 x 3210 =642,000KJ/kg.

Now the nominal gas consumption of low pressure gas burner is

0.5m^3/hr. Given caloric value of C_3 – C_4 gas as 95 – 105 or

100,000KJ/m^3 then energy supplied by 1 burner is 50,000KJ/hr. Four burners will therefore supply Q_b = 200,000KJ/hr.

However the heat capacity of beniseed is C_{pmal} = 422KJ/kg

and its density is S_{inav} = 694kg/m^3 then the quantity of seed that can be cooked by the steam is obtained from

$$Q_b = MC\ \Delta T = M\ X\ 25X\ (120\text{-}30) = MX\ 25\ x\ 80$$

$$M = \frac{Q_b}{25x80} = \frac{2000,000}{250x8} = \frac{202x421}{82} = 100kg$$

However given enthalpy of steam @ 100^{o}C I = 2205KJ/kg,

the quantity of steam that will supply heat load Q_b = 200,000KJ/hr.

$$Ms = \frac{Q6}{L} = \frac{200,000}{2,205\text{-}503} = \frac{200,000}{1,700} = 120kg$$

Therefore only 120kg of steam will be required and four gas burners will be sufficient to cook the seed/grain @ 100^{o}C. Hence, the jacket can be filled with water about half way to allow space for active steam generation.

4.3 Size of Roasting / Steaming Basket

The basket could contain up to100kg grain at once

Given Dbask Drc ^{but} = bask = 500mm H = 0.6 x Hrc = 0.6 x 110mm

= H_{bask} = 660mm then Vbask = $\frac{22}{7}$ x 0.52 x 0.66 = $\frac{22}{7}$ x $\frac{0.25 \times 0.66}{4}$

V_{bask} = 0.125m^3 = 125 litres. This can given a maximum grain weight of 125kg. This size of roasting basket is actually the optimum in terms of heat transfer.

Since the basket is going to be permanent inside the steam cooker there is no fear of unloading problems which is to be avoided by the use of well fitted discharge hopper below the basket.

4.4 Materials of Construction

Given the relationship between thickness of construction materials, operational pressure, diameter^{D} and material stress limit as

$$tmm = \frac{D.P}{20D,t} + dc = \frac{0.6 \times 0.5 \times 1000}{2 \times 240 \times 0.8} + 1mm$$

2mm for SS Sheet

where O_D – normal stress of materials which for soviet steel SS 3 – high carborn steel O_D = 380 but thermal stress factor for the same steel D_T = 240.

Q – welding efficiency Y = 0.8 P – pressure in atmosphere Mpa X10^3 (millimetre factor)

Dc – corrosion correction factor upto 30% addition basically.

Given D_{jut} = 800mm. Operating pressure P = 5atm,

O_T = 240 then for the MS jacket.

The required materials are as shown in Table 4.1

Table 4.1: Materials of Construction for Beniseed Debitterer

S/NO	MATERIAL DESCRIPTION	COMMERICAL SPECIFICATION	QUANTITY
1.	Stainless steel sheet	LXBXt (8x4) = 2.44 x	2 sheet
		1.2mm x 2m	
2.	Perforated stainless steel sieve plate	8x4’x1.5mmx0 =	1 sheet
3.	Stainless steel grating/net	0.5m	1 sheet
4.	Stainless steel mesh cloth M25	8’x4’xt =2mmx0 =	3 Metres
5.	Stainless steel Flanges 800 x 600	4mm2	
	x4mm MS	M25 high strength	4 Pieces
		DoutXDinxt =	
6.	Stainless steel pipe	495x500	1 Length
		+800x600x4mmx2m	4 Sheets
7.	Mild Steel – MS Plate	m	2 Sheets
8.	MS Sheet	DINXtXL =	
9.	U – Channel Iron	12.5mmx2mmx6m	1 Length
		8’x4’xt = 3mm	2 pieces
10.	High Pressure side glasses	8’x4’xt = 1.5mm	1 Length
11.	Chequered rod 1	50mmx40mmx6mm	1 Length
12.	Smooth rod	Hwater	1 Meter
13.	Flame tube MS Pipe	600mm x 300mm	1 Piece
14.	Hand hole with tope sight glass	t = 12.5mm	1 Piece
15.	Spring loaded contravelve	t = 12.5mm	1 Piece
16.	Thermometer industrial	DXt = 50mmX3mm	1 Piece
17.	Aneroid Berometer	10insX2insX5mm	4 Pieces
18.	Industrial gas burners	4-5 BarsX1in	2 Pieces
19.	Industrial gas regulator	discharge	Various 4Mt.
20.	Burners fittings with hose	0-200oC range	
21.	MS fittings/Steam fittings	0-10 bars	1
a)	2” elbow	ITALY	8
b)	Threaded steam socket ½”	ITALY	20
c)	Threaded steam nipples ½”	- ditto –	10
d)	Threaded steam valves ½”	- ditto –	10
e)	Threaded steam Tee ½”		8
f)	Threaded steam Elbow ½”	- ditto –	4
g)	Threaded steam Unions ½”	- ditto –	2 Lenghts
22.	Steam Pipe	- ditto –	1 Piece
23.	Air tight sealing mechanism	- ditto –	2m
24.	Steam Sealing rubber gaskets	- ditto –	1 Sheet
25.	Perforated MS plate	- ditto –	3 Packets
26.	Electrodes G12 MS/SSG 12	Dxt = 12.5mm x 3mm	
27.	Shearing, Rolling &		
	FABRICATION COSTS	T = 20mm	
		8’x4’xt = 1.50 = 8mm	
		G.12	
		#45,000.00	

NOTE: 1* - Item 1 can be replaced with Mild Steel Sheet 8’ X 4’ X 4mm/2 sheets.

CHAPTER FIVE

5.0 DESIGN OF A MECHANICAL DEHULLER

5.1 Background Information

In areas, where the cake is eaten by human beings, dehulling is necessary. This is because the hull contains undesirable oxalic acid (2-3%), which could complex with calcium and reduces its availability (Kinsella and Mohite, 1985). The hull also contains undigestible fiber, which imparts a dark colour to the cake.

According to Gupta (1998) dehulling also improves the nutritional and flavour characteristics of the cake and leads to the production of a glossy white product irrespective of the hull colour (black, white or red). From experiments on oil extraction, it has also been discovered that dehulling of beniseed leads to a higher oil yield, increased protein content, and reduced fiber content (Johnson et al., 1979; Olayanju, 2002).

However, the small size of beniseed makes its dehulling difficult. Various investigators have reported several dehulling methods. Toma et al., (1979) as reported by Oresanya and Koleoso (1990) used a lye solution to dehull 5 varieties of beniseed. They stated that 6% sodium hydroxide at 60^{o}C with seed to lye ratio of 1:3 (w/v) was sufficient to decorticate all the beniseed varieties in 10 seconds. Another method according to Moharam (1981) consisted of contacting beniseed with boiling solution of 0.6% sodium hydroxide at 96^{o}C for 1 to 2 minutes to facilitate the rupturing of the outer coat. The coat was then removed by washing. A yield of 85% of dehulled material on the weight of raw seeds was obtained.

Beniseed dehulling by alkali treatment is associated with the following problems: the difficulty of having to source the chemical locally, hazard of handling the alkali during processing, and high cost of processing (Odunfa, 1993). Tontisirin et al. (1980) subjected water soaked beniseeds to a rubbing action of two vertically mounted discs in order to peel off the hull, which was then separated by floatation in brine. Traditional method of dehulling beniseed involves soaking in cold water overnight followed by partial drying and rubbing against a rough surface. The hulls separated from the kernels are removed by winnowing (Gow-chin, 1990; Badifu and Abah, 1998). This method is laborious and suitable for handling only small batches of seed.

FIIRO as reported by Olayanju et al. (2000) had improved on these methods by developing a mechanical dehuller that can handle up to 10kg of beniseed per batch of 10 minutes. The machine consists of a shaft carrying three blades. The high speed of the rotating blades in excess water brought about the dehulling of the seed without breakage.

Separation of the hulls from the seeds is done by draining the hull-kernel mass on a 1.2mm sieve and then poured into a container of brine (15% solution) and mixed thoroughly. This is allowed to stand for about 30minutes. The hulls sunk while the kernels float on water. The floating kernels were run off unto a sieve for draining.

5.2 Machine Features

The dehuller consists of three chopper blades, each in a disc form having saw-teeth periphery. These are mounted on a main shaft of 20mm diameter and 1500mm long driven by a – 2.5kW electric motor rotating at a speed of 1500rpm. The shaft is placed in a tank of 400mm diameter and 1100mm deep, having a gate valve at the lower end for discharging the product after processing (Figure 5.1) The capacity of the dehulling tank is 100litres and it is to process 10kg of beniseed with the addition of 60 litres of water per batch of 10minutes.

The experience from the laboratory guided in the sizing of the separation tanks for the 100 litres dehuller (Figure 5.2). The tanks are 250 litres cylindrical tank with 100mm-diameter gate valve at the bottom used for the hull separation; and another 250 litres cylindrical tank can also be used to wash the clean hull-free seed after the separation exercise. The material of the two tanks is plastic. Galvanized or stainless steel can also be utilised.

5.2 Sizing of Dehuller Shaft

Data used are:

(i) Drive motor, 3h.p, 3-hase, 1500r.p.m.

(ii) Material of shaft is stainless steel of U.T.S. $480N/m^2$ and modulus of rigidity, G. of $80{,}000N/mm^2$.

Maximum twist of shaft is assumed to be 1^o or $\pi c = \frac{\theta}{180}$

Maximum shaft length = 1.5m = 1,500mm = L

Let the shaft diameter be Ds

From the stress theory,[5]

$T/J = \theta/L$

where T is torque

and J is polar moment of inertia for the shaft

$$J = \frac{\pi Ds^4}{32}$$

$$\therefore \quad T = \frac{JC\theta}{L} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5.1)$$

$$\text{Now } T = \frac{\pi Ds^4}{32} \times 80{,}000 \times \frac{\pi}{180} \times \frac{1}{1{,}500}$$

$$= 0.366D^4 \text{ N - mm}$$

Power, $P = \frac{2\pi NT}{60}$ watts, where T is in N - m and N is speed in r.p.m.

Horse Power of drive is 3 $\because P = 3 \times 746 = 2238$ W = Max. power

Maximum speed N = 1,500 r.p.m.

$$\text{Maximum Power Available} = \frac{2\pi NT}{\theta}$$

$$= \frac{2\pi \times 1500 \times 0.336Ds^4 w}{60 \times 1000}$$

$= 52.8 \times 10^{-3} Ds^4 = Ds = 14.3mm$

In order to play safe in practice, shaft diameter used for the dehuller is 10mm.

Figure 5.1: Conceptual Design of the Mechanical Dehuller

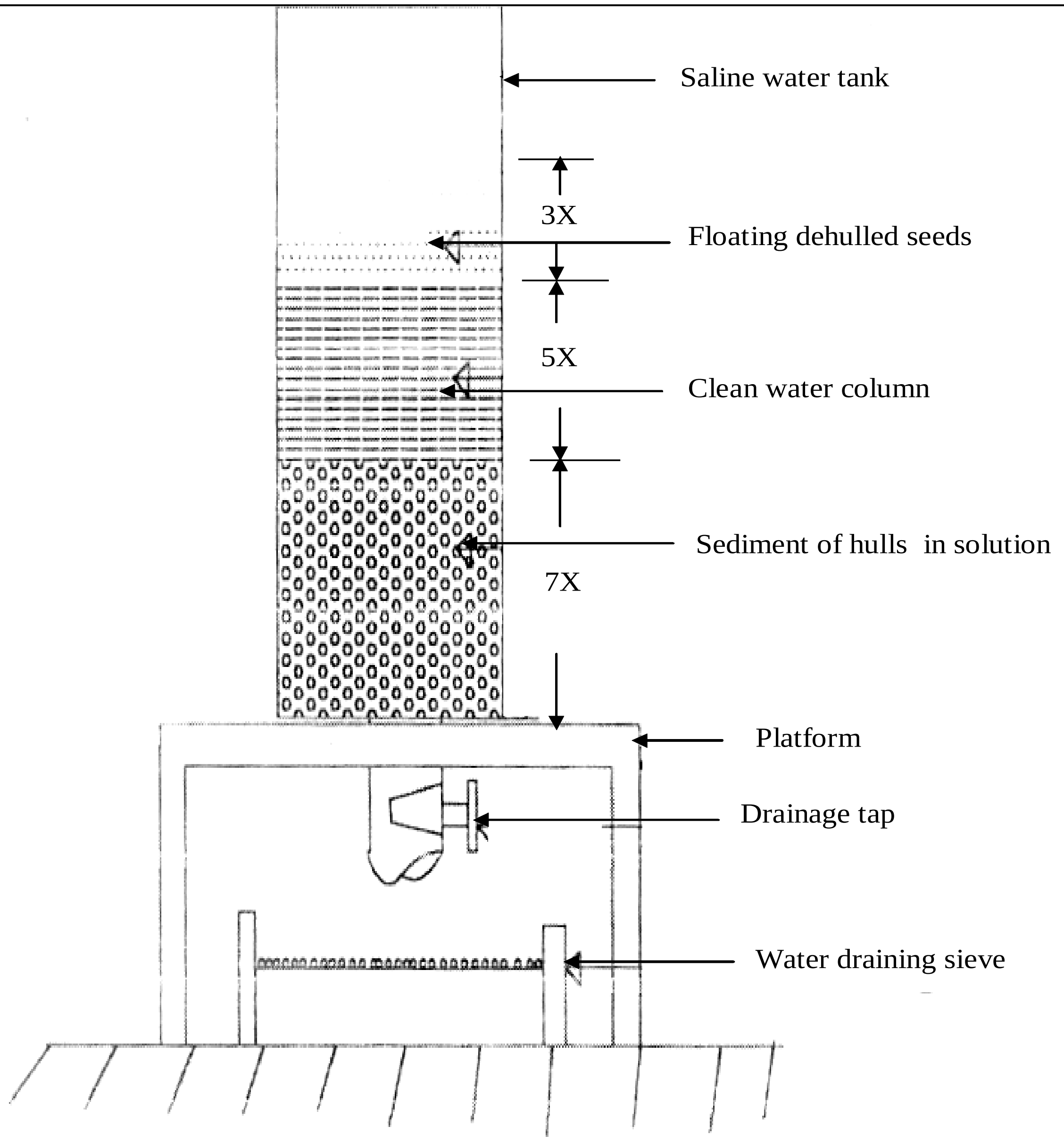


Figure 5.2: Separation of Seed from Hull using Brine

Components Description of the Dehuller

S/No.	Description	Materials	Process	Required Infrastructures
1.	Electric motor bracket.	Mild steel angle Iron and plate.	Shearing, cutting and welding	Guillotine,power arc saw and electric welder.
2.	Electric Motor 3hp, 1500rpm 3ph, 50hz.	Bought out item.	……….	……………
3.	Main container	Stainless steel sheet(2mm thick	Shearing, rolling and welding	Guillotine, plate bending roll and electric welder.
4.	Motor coupling	Mild steel rod	Turning, boring and drilling	Centre lathe and drilling m/c.
5.	Top Cover	2mm Stainless Steel sheet.	Shearing and welding	Guillotine,chisel
6.	Main Shaft	Stainless steel pipe	Cutting.	Power arc saw.
7.	Big blades	stainless steel sheet 2mm thick	Shearing, Cutting and bending	Guillotine, chisel and hammer.
8.	Main Frame	Mild steel angle and sheet	Shearing, cutting and welding	Gullotine, power arc saw and electric welder
9.	Small blades	stainless steel sheet 2mm thick	Shearing, Cutting and bending	Guillotine, chisel and hammer.
10.	Blind bush for main shaft.	Brass sunk into Mild steel bush	Turning boring and pressing.	Lathe and hydraulic press
11.	Discharge port.	100mm dia.G.S. Pipe and valve.	Welding,dicing and fitting	Electric welder, pipe dicing m/c pipe wrench
12.	Bottom plate frame.	Mild steel sheet	Shearing and welding	Guillotine and electric welder
13	Inner bracket	Stainlee steel angle iron	Cutting and welding	Power arc saw electric welder

CHAPTER SIX

6.0 DESIGN OF AN OIL FILTER PRESS

6.1 Background Information

Most mechanically expressed oils are generally not clear. This is because some of the fine solid particles formed by pulverization during pressure application become a solid solution with the extracted oil. As a result, the extracted oils are usually cloudy in appearance due to the suspended solid particles in the fluid. Even in some cases, the oil is in slurry form (Olayanju, 1999). Therefore, the mechanically expressed oils have to be filtered to obtain clear liquids, which can be packaged for domestic and industrial uses.

The usual method of removing small impurities from vegetable oil at cottage level is by using an ordinary cloth stretched over a frame onto a tank of sufficient capacity. The filtered oil is left in the tank for a few hours in order to allow the settling down of any other impurities still suspended in the oil. The oil is then transferred into tins or bottles via a funnel from a tap attached over the sediment layer. This is a slow process and finds little application in food industry (Svarosky, 1981). A post extraction equipment, the filter press will be needed to improve the quality of the expressed oil.

Moss and Durger (1979) as reported by Olayanju op. cit. stated that oil filtration can be achieved through pressure, vacuum and centrifugal forces applications. They observed that vacuum and centrifugal filtrations have high capital cost and produce cakes, which have high moisture contents and that they are best suited for materials that form a free draining cake.

Earle (1983) described the two commonly used pressure filters as the plate and frame; and the shell and leaf. He stated that the shell and leaf filters are best suited to routine filtration of liquor, which have similar characteristics. Jones et al. (1983) stated that plate and frame filter press is considered for commercial purposes because it has low capital cost, high flexibility for different foods, reliable and easily maintained.

6.2 Machine Description

The filter press is made of nine main components viz.; the filter plates, the end plates, the filter cloth, the screw shaft and follower, the operating handle, the standing frame, the filter pump drive and the piping materials. A – 1.5kW electric gear pump forces the oil into the press (Figures 6.1and 6.2).

The filtration chamber is made of 12 - filter plates (6 solid and 6 Hollow) cast, machined and arranged on a framework. Each solid plate has grooves on its surfaces for oil drainage after passing through the filter cloth (6.2). The filter plates was cast and the border had a thin - central portion, the surface of which is in the form of ridges or designs in relief, between which the oil can flow in spite of the pressure. This tends to force the cloth against the plate. There are 6 of them in all each having dimension - 300 x 300 x 25 mm^3.

The frames have similar machined borders but their interiors are opened. They are supported by two steel bars, which also serve as cross braces and absorb tensile force produced between the two end members by the pressure exerted in closing the press.

There is an electric motor and a gear pump coupled together with the aid of sprockets and chain. There are six taps on the filter plates discharging oil into a longitudinal trough through which the clear filtered oil is removed. Each face of every plate is covered with a filter cloth to create a series of cloth-walled chambers into which slurry can be forced under pressure.

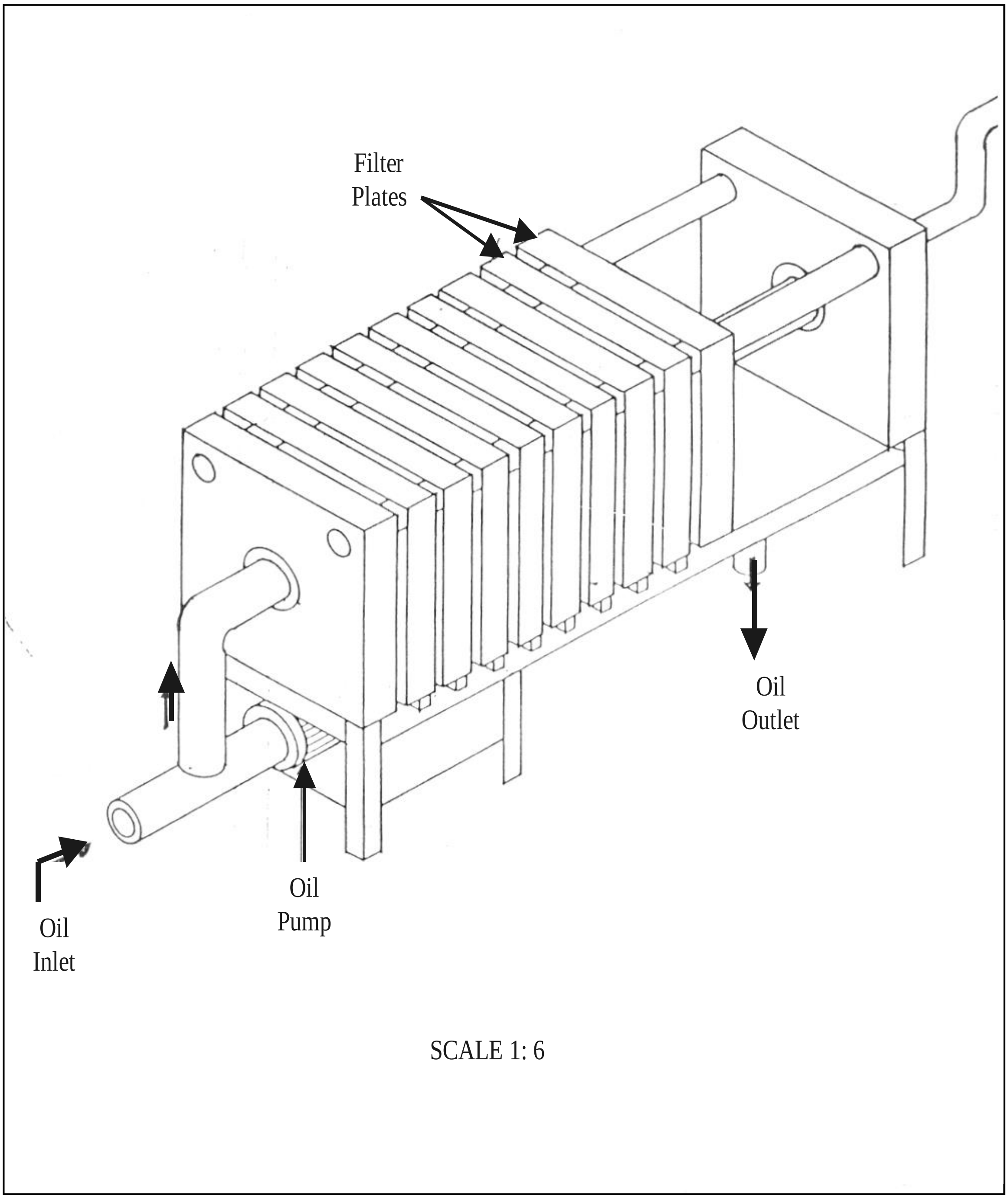
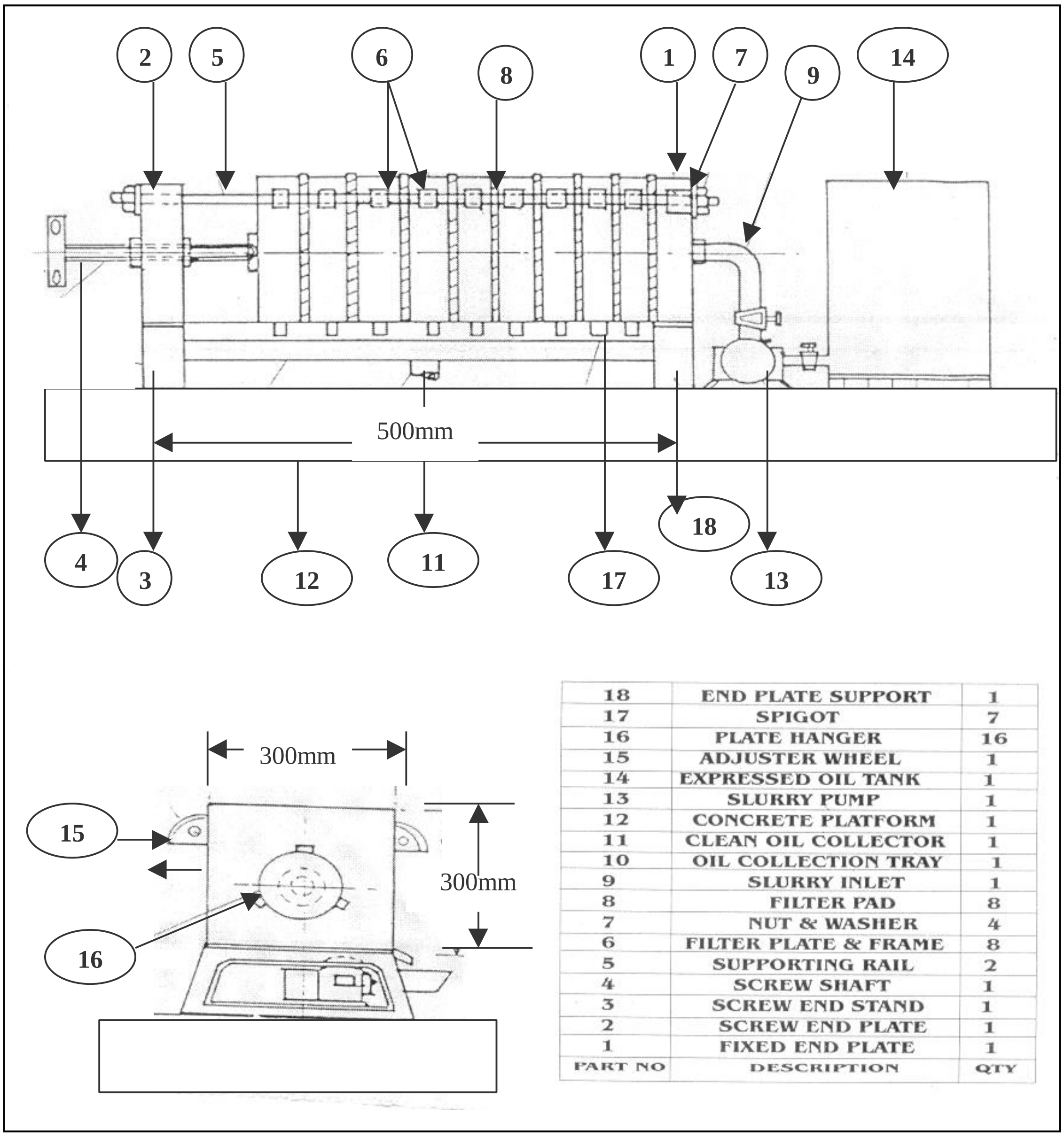


Figure 6.1: Isometric Projection of the Fabricated Oil Filter Press



PART NO	DESCRIPTION	QTY
18	END PLATE SUPPORT	1
17	SPIGOT	7
16	PLATE HANGER	16
15	ADJUSTER WHEEL	1
14	EXPRESSED OIL TANK	1
13	SLURRY PUMP	1
12	CONCRETE PLATFORM	1
11	CLEAN OIL COLLECTOR	1
10	OIL COLLECTION TRAY	1
9	SLURRY INLET	1
8	FILTER PAD	8
7	NUT & WASHER	4
6	FILTER PLATE & FRAME	8
5	SUPPORTING RAIL	2
4	SCREW SHAFT	1
3	SCREW END STAND	1
2	SCREW END PLATE	1
1	FIXED END PLATE	1

Figure 6.2: Orthographic Projection of the Fabricated Oil Filter Press

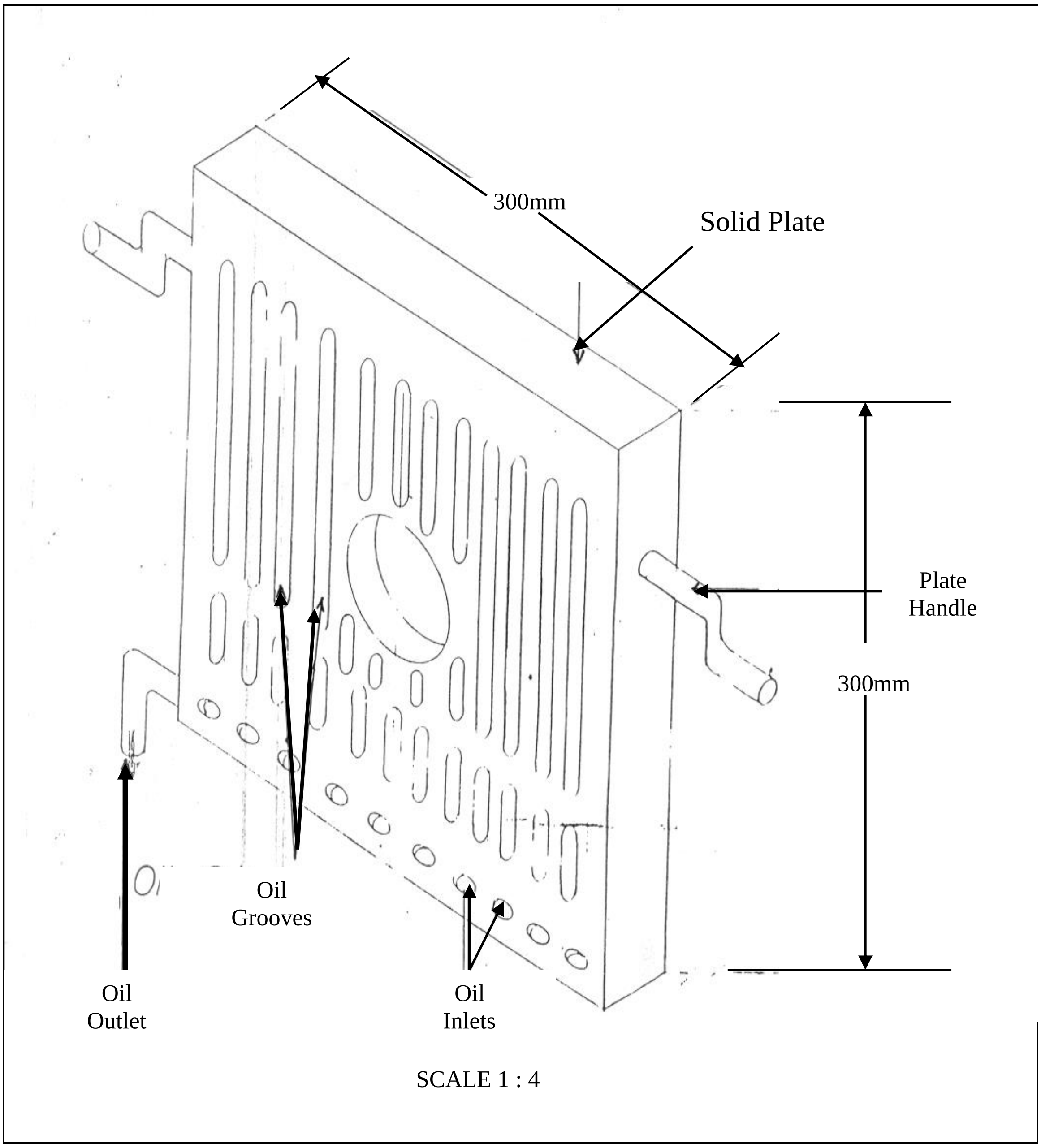


Figure 6.3: Isometric Projection of the Fabricated Oil Filter Plate

6.3 Design Analysis

At the beginning of plate and frame filter press operation, the whole pressure drop available is across the medium itself since as yet no cake is formed. Thus, Darcy's basic filtration equation can be applied.

$$Q = \frac{KA\delta P}{\mu L} \qquad (1)$$

However, as the cake becomes thicker and offers more resistance to the flow, the pressure developed by the pump becomes a limiting factor and the filtration proceeds at a nearly constant pressure (Tiller et al., 1979; Fellows, 1988). A modified Darcy's equation for constant pressure which gives a straight-line equation (Charles, 1975) is then applied.

$$\frac{tA}{V} = \frac{\mu r V_c V}{2\delta P A} + \frac{\mu r L}{\delta P} \qquad (2)$$

where:

Q = Oil flow rate, m^3/s

K = Permeability of the bed

A = Face area of the filter medium, m^2

V = the volume of filtrate, m^3

V_c = the fractional volume of filter cake in feed liquid volume, V

μ = the viscosity of the oil, Ns/m^2

r = the specific resistance of the filter cake, m^{-2}

L = the equivalent thickness and initial cake layer, m

δP = pressure drop which is a function of pump characteristics, KN/m^2

t = filtration time, s

In order to determine the design capacity of the press, a model filtration experiment was carried out on a filter cloth of area $0.023m^2$ to which slurry was fed at a constant rate.

For effective filtration, it is required that a – 12.5mm wide by 3.125mm deep slots be cut on the filter plate surface and a central hole of 37.5mm diameter be drilled on it. Therefore, a computer numerical control (CNC) part program for machining and drilling holes on the filter plate was written based on the standard recommended by CRISP (1998) and Potten (1986). Computer Program. The written program is of the form:

N010 G91

Incremental mode

N020 G21

Millimetre mode

N030 G00 X37.500 Y100.000 R0.100 Z-3.125 F10 M03

N040 G01 X0.000 Y275.000 M06

N050 G00 X-37.500 Y-175.000 M06

where,

N = Sequence number for the data block

G = Preparatory function

G00 = Point – to – point positioning at rapid or transverse rate

G01 = Linear interpolation

X = Amount of X axis travel, mm

Y = Amount of Y axis travel, mm

Z = Amount of Z axis travel, mm

R = Clearance plane for field cycles, mm

F = Feed rate or dwell, rpm

M = Miscellaneous function

M03 = Start spindle rotation to advance a right–handed screw into the workpiece

M06 = Stops spindle and coolant, and retracts tool to full retract position

In order to drill the central hole on the plate, the following points were considered:

- a stubby 50mm diameter drill was used so as to maintain good locational accuracy and eliminate the need for center drilling of the surface.
- the length of the drill was preset to the reference plane (R) 0.100 above the part surface.

The program for drilling the hole follows stage 1 of cutting the slots on the plate.

N060 G81 X175.000 Y 50.000 R0.100 Z-25.000 S3000 F5 M30

where: G81 = Spindle drilling operation command

S = Spindle speed, rpm

M30 = Stops spindle, coolant and feed after completion of all commands in the block.

From the result of the experiment (Table 6.1 and Figure 6.4), the slope of the graph is 215.7 and the intercept is 200. These are equivalent to $\mu rV_c/2\delta P$ and $\mu rL/\delta P$ in equation 2 respectively. These values were substituted in the equation as:

$$tA/V = 215.7\,(V/A) + 200$$

Rewriting the equation gives a quadratic equation in V/A as

$$215.7(V/A)^2 + 200(V/A) - t = 0 \qquad (3)$$

Solving the equation for a – 1hour (3600s) cycle at $A = 0.023m^2$

$$\frac{V}{0.023} = \frac{-200 + \sqrt{0.42^2 + 4 \times 215.7 \times 3600}}{2\,(215.7)}$$

$$V = 0.084m^3 = 84\text{litres}$$

A design capacity of 80litres / hour was therefore considered. The summary of the detailed design specifications as reported by Olayanju (2002) is as follows:

Design capacity of the press, Q = 80litres

Oil pump power requirement, P_f = 1.5kW

Speed of pump, W_p = 170rpm

Pressure difference, P = 2000KN/m^2 (20 bars)

Number of filter plates and frames, n = 6 (each)

Plate dimensions = (300 x 300 x 25) mm^3

The effective filtration area = 0.096m^2

Cake holding capacity per chamber per 25mm of chamber thickness, l = 1.2

Table 6.1: Determination of the average oil volumetric flow rate

Time, t (Sec)	Volume of filtrate, V (m^3)	$\frac{V}{A}$	$\frac{t}{V/A}$
180	0.020	0.869	207.1
330	0.035	1.530	215.7
480	0.050	2.170	221.2
600	0.060	2.600	230.8

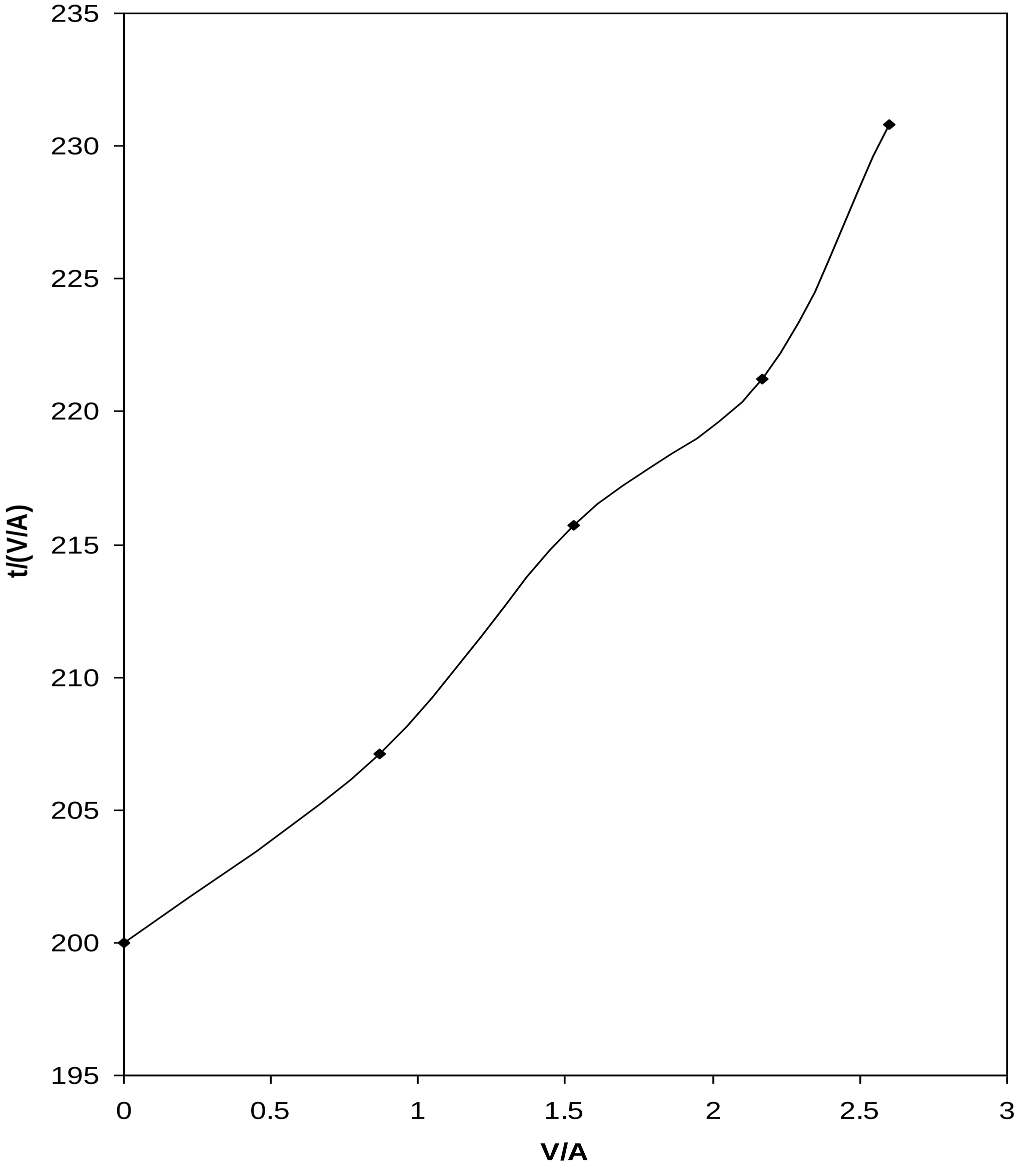


Figure 6.4: Graph of t/(V/A) against V/ A

Table 4.4: Bill of Materials for the Construction of the Designed Oil Filter Press

Qty	Material	Specifications	Rate (#)	Amount (#)	
	COMPONENTS TO BE CAST AND MACHINED				
6	Solid Plates	30cm x 30cm x 25mm	4500	27000	
6	Spacing Plates	30cm x 30cm x 25mm	2500	15000	
2	End Plates	30cm x 30cm x 50mm	3500	7000	
1	Back Plate	30cm x 30cm x 50mm	3500	3500	
1	Screw End Shaft/Nut	100cm long, θ50mm	5000	5000	
2	Supporting Rods	100cm long, θ50mm	1000	1000	
		Sub Total	**#58,500**		
	FABRICATION MATERIALS				
3	Angle Iron	One Length, 50mm x 50mm	1500	1500	
1	Galvanized Metal Sheet	240cm x 120cm x 1.8mm	3800	3800	
2Pkt.	Mild Steel Electrodes	Gauges 10 & 12	2100	4200	
12	Bolts & Nuts	M10 Hex. (50mm)	25	300	
4	Cutting Stones	θ300mm Size	180	180	2
	Grinding Stones	θ300mm Size	150	150	
2	Hack Saw Blades	300mm Long	120	240	
4	Drill Bits	3, 5, 7 & 10mm	110	440	
		Sub Total		**#11,170**	

Qty	Material	Specifications	Rate (#)	Amount (#)
		ELECTRICAL COMPONENTS		
1	Filter Pump	Gear; 2Hp @ 180rpm	26000	26000
1	Motor Starter	2 Buttons - ON & OFF	5000	5000
1	Switch Gear Box	20Amp. (MEM)	3600	3600
10Pcs.	PVC Cables	3 - Core X 6mm X 1m	60	600
		Sub Total		**#35,200**
		ACCESSORIES		
1	Pressure Gauge	0 – 100Psi	6000	6000
6	Outlet Taps	θ25mm Size	1000	6000
6	Connection Joints	(Circular, Elbow, Tee)	500	3000
2	Storage and Distribution Tanks	150 Litres (Plastic)	3100	6200
4yrds.	Filter Cloth		1200	4800
		Sub Total		**#26,000**
Machining of Plates and Screw				7500
Fabrication (Bending, Rolling, Shearing)				2500
		TOTAL	**#140,870 ≅**	**#150,000**

7.0 CONCLUSIONS AND FURTHER WORK

7.1 Achievements

The following achievements have been made on the project:

- Identification and procurement of different samples of beniseed
- Determination of some physical and mechanical properties of the seed
- Comparism of the obtained results with that of other oilseeds and cereals.
- Preliminary design analysis of the processing plant
- Material specification

7.2 Further Work

The following activities are to be carried out in the next phase:

- Detailed design analysis of the processing plant
- Industrial Comparism of the Designed Plant
- Material procurement
- Plant fabrication and performance evaluation
- Standardization of expeller's wormshaft for other oilseeds

7.3 Conclusions

The preliminary design of a beniseed oil expression plant was carried out based on the application of some determined properties, d, analysis of information received on the existing oil expellers and reviewed of standard literatures on oil expression.

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