**PEPPLE IBIM OBIEDIMA**

**16/ENG06/088**

**MECHANICAL ENGINEERING**

**MEE 510**

DESIGN AND FABRICATION OF A MONOBLOC MACHINE FOR THE PRODUCTION OF GUM FROM CASSAVA STARCH

1. Product/ project design



1. Materials selection

The materials used was grouped into:

1. Materials for fabrication of the machine:
2. 3mm mild steel plate
3. Electric motor
4. Shaft
5. Bearing
6. Electrical control unit
7. 2 inches angle iron
8. Materials used for the production of gum from cassava starch:
9. Starch
10. Dilute Hydrochloric acid (HCl)
11. Urea
12. Sodium formaldehyde
13. Sodium tetraborate decahydrate or borax.
14. Factors considered in choosing the material:
15. Cost of the materials
16. Environmental consideration
17. Chemical properties
18. Physical properties
19. Design specifications:



1. Details drawing





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| --- | --- | --- | --- |
| **Material** | **Description** | **Quantity** | **Price** |
| 3mm plate | Mild steel | 2 | 37,000 |
| Electric motor | Induction motor | 2 | 60,000 |
| 2 inches angle iron | Mild steel | 9 | 13,500 |
| Cutting and grinding disc | - | 8 | 8,000 |
| Painting | - | - | 6,000 |
| Shaft | Mild steel | 3 | 15,000 |
| Bearing | 25mm pillow bearing | 4 | 10,000 |
| Control unit | Electrical connections, heating element | - | 40,000 |
| Transport | - | - | 15,000 |
| Logistics | - | - | 15,000 |
| Workmanship  | - | - | 30,000 |
| **Total**  |  |  | 249,000 |

1. BEME
2. Design calculation

The mono-bloc mixer-extruder concept was adopted and the detailed designs were carried out as follows:

* + 1. **Monobloc Machine Parts Design**

The machine consists of two sections. The first section has a change-can mixer that incorporates a heating jacket. The design of the mixer comprises several steps as outlined below:

1. Selection of a suitable vessel material and size:

an aluminum pot was selected as the mixing vessel. The vessel is well rounded with smooth surfaces.

1. Selection of blade materials:

The blade was made of two materials, steel and Perspex. The steel bars were welded to anchor impeller frame while the Perspex bars were bolted to the steel bars. The Perspex bars (since it can be adjusted) ensured maintenance of very small clearances between the vessel surface and the vertical and horizontal pitched blades.

1. Selection of mixing speed:

The production of dextrin gum involved heating starch slurry with excess acid until dextrinization was attain. For a controlled process, it was desired that the mixing should take place in the laminar zone, it was necessary to consider the impeller speed with respect to the viscosity of the mixture in the mixer and also on the intended discharge rate.

For fluid mixing, Reynolds Number was defined as (McCabe et al.,2001)

$Re=\frac{nD^{2}ρ}{μ}$ (1)

Where

Re = Reynolds number

n = Revolutions per minute

D = Impeller Diameter

ρ = Density

µ = Viscosity F

The power needed by the impeller is given by the relation as:

$Re=N\_{P}n^{3}D^{5}ρ$ (2)

Where Np = power number

For Re<10, flow is in the laminar range and density plays no factor and

$$N\_{p}=\frac{K\_{L}}{Re}$$

KL = 44.5 for four pitched blade turbine mixer

Hence, $P= K\_{L}n^{2}D^{3}μ$ (3)

Where P = Power.

**ii) Design of the extruder**

Two factors determined the design considerations of the screw extruder and these were the screw size and rotational speed(rpm) of the screw. The choice of screw size depends on the screw diameter, shaft diameter, radial clearance and pitch type of helical flight. The conveying of gummy substances may not be characterized by the presence of lumps and as such the screw size has no limitation of any kind and may depend on the projected throughput. The throughput may thus depend on the size of feed chute and discharge port size. A screw conveyor casting of internal diameter, ‘d’ was selected based on the size of the casing desired of the machine, the conveyor trough is taken to be maximally filled to 30% of its volume.

The cross-sectional area of moving bed of paste (gum) is given as

$A\_{x}= \frac{(d\_{x})^{2}A}{d}$ (4)

Where Ax = Cross sectional area of moving bed of paste (gum) at 30% height

A = Cross sectional area of moving bed of paste at 50% height

d and dx are the respective heights for A and Ax

 $A= \frac{πd^{2}}{2}$

Where

U = Average velocity

λ = Screw pitch

N = Revolutions per minute

Volumetric throughput of the screw conveyor of the screw extruder is given by the relation

 $V^{\&}=A\_{X}λN$ (5)

Or

 $V^{\&}=A\_{X}U$

Where V&= Volumetric throughput of screw extruder

Ax = Cross sectional area of moving bed of paste (gum) at 30% height

λ = Screw pitch

N = Revolutions per minute

Mass flow rate of gum;

$M^{\&}\_{s}=ρV^{\&}\_{s}$ (6)

M&s= Mass flowrate in screw extruder

ρ= Density

V&s = Volumetric flowrate of the screw extruder

For a ribbon flight screw extruder, the capacity factor CFf of the flight (Thompson 1973) is

CFf =1.15 (7)

Hence, the modified mass flowrate is

$M^{\&}\_{g}=\frac{M^{\&}\_{s}}{CF\_{f}}$ (8)

M&g = mass flowrate of gum

M&s= mass flowrate in screw extruder

CFf = capacity factor

Power requirement for the extruder motor is given as

 $P\_{T}=P\_{gum}+P\_{friction}$

PT= Power required to transport gum

Pgum = Power to transport gum freely

Pfriction = Power to overcome friction during gum transportation

Where, $P\_{friction}=50D\_{sc}L$

Dsc = Screw diameter

L = Screw length

 $P\_{gum}=F\_{S}F\_{m}gm\_{g}L$

Where, FS = Screw factor =1.7

Fm = Material factor =1.8

L = Screw length

g = Acceleration due to gravity

Power required by extruder motor is given as

 $P\_{motor}=\frac{P\_{T}F\_{0}}{η}$

Where p = Power required by extruder motor

F =Overload factor

P = Power to transport gum in the extruder

η = Drive efficiency.

1. Design process/ manufacturing
2. The laboratory experimental design of the gum production:

Some quantity of the cassava starch mass was put into a plastic bath and water added to obtain a ratio 2:1 of starch to water. 0.3M HCl was then added to the suspension formed to obtain slurry made up of starch suspension/acid ratio of 1:1, by volume. The slurry was then stirred thoroughly to form a uniform slurry, and sodium tetraborate decahydrate i.e. borax (10% by weight of the starch present) added.

After dextrinization has been completed, the sample mixture was allowed to cool to room temperature (with progressive mixing). Gum adjuncts such as urea (3% by volume of mixture) and sodium formaldehyde (10% by volume of mixture) were added to increase water resistance and shelf life respectively. After sufficient mixing at room temperature, the gum was discharged manually through a swing gate valve into a ribbon screw extruder where additional mixing was done prior to actual extrusion of the gum into small plastic bottles. Thereafter, each sample was inspected for quality.

1. The fabrication of the machine:

The machine was fabricated in the workshop with the materials that have also been listed above

The frame was fabricated first with the allocated measurements using the 2 inches angle iron, the cooking chamber and mixer was fabricated with the 3mm plate, then the electric motor and other components were welded. The electrical component was then connected (i.e. control element) and also the heating element. The machine was then painted for a beautiful finishing, then the efficiency of the machine was tested.