



# AMERICAN JOURNAL OF FOOD SCIENCE AND TECHNOLOGY (AJFST)

VOLUME 1 ISSUE 1 (2022)



Indexed in



PUBLISHED BY: E-PALLI, DELAWARE, USA

## Conceptual Design of Animal Feed Chopper with Medium Capacity

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### Article Information

**Received:** August 15, 2022

**Accepted:** August 28, 2022

**Published:** September 04, 2022

### Keywords

*Design Concept, Animal  
Feed, Chopper, Silage  
Making*

### ABSTRACT

Agriculture is the backbone of Ethiopia economy directly or indirectly and most of its population is residing in rural areas. The majority of rural community is engaged in agricultural crop production, cattle farming and poultry production. To prepare feed for animals, the conventional feed cutting machines are intensively used which do not have friendly operation. Chopping of animal feed is considered as a labour intensive processing operation in animal production system. Traditionally, animal feed, especially crop residue are chopped manually by a sickle in the farms of Ethiopia. It is a labor intensive, less efficient and time consuming operation. Keeping in view, the drawbacks of the traditional chopping, this study has been carried out for the design animal feed chopper machine in order to reduce the above mentioned. Engine operated animal feed chopper has been designed for chopping of crop residue and hay. The machine was designed with the following main components: feeding hopper, feed roller, rotating blade, casing with fixed knives welded on it, a screen and stands. The machine was seated treatment based on the design concepts and designed up to capacity 300 kg /hr. This machine was design keeping in view its multifunctional operation like for the cutting of maize stacks, sorghum stack, agricultural crop biomass etc. The provision was provided to run this machine at variable speeds for different jobs/applications and to achieve variability in particle sizes. The economic production of designed animal feed chopper machine was simple and its cost 10,618.45ETBirr.

### INTRODUCTION

Ethiopia has higher livestock population than any other country in Africa. According to Alemayehu (2002), livestock production contributes up to 80% of farmers' income and about 20% of agricultural GDP in Ethiopia. Besides this, the increase in human population and decrease in land productivity results in the increase in demands for arable land. For this reason, scarcity of animal feed and inadequate grazing land are the major problems in the country. It is needless to say in Ethiopia, traditionally livestock are mainly dependent on natural pasture and crop residue. Therefore grazing is the common practice in the country. The grazing situation is exacerbated by the high density of cattle, with stocking rates of four times the recommended levels being reported in certain areas. This results in the decrease in livestock feed, both in quality and quantity, in the latter part of the dry season. Usually residues from cereals are the main sources of feed, but these are low in nutrient content, and have poor digestibility and palatability. For this reason, livestock tend to lose their weight, and this, in turn, leads to the decrease in market value, draft power output, disease resistance and amount of milk from milking cows. In recent years, many farmers are engaged in fattening activities because of the opening of some livestock commercial channels to other countries, and also there is a great demand for local consumption. Therefore this activity needs more attention to get a better return from the sector. In addition, in some parts of the country, there is a long dry season, while in the other part there is a bimodal rainfall pattern with two relatively short dry

seasons. One of the options to overcome a feed shortage during these dry seasons is to preserve excess fodder grown in rainy season in the form of silage. In Ethiopia, fodder making has never become a common practice. This is because without chopping compacting the material is difficult; and chopping is done manually with hand tools and so it consumes more labor. Therefore, to make silage making attractive to farmers, chopping should be simple to apply and not too labor-intensive. In addition to assisting compaction during silage making, chopping has a great advantage in silage making to increase the surface area to volume ratio of fodder to facilitate the fermentation process by making free the cell juice and expelling the air. As stated above, farmers in Ethiopia use farm residues of cereals as a feed source during the dry season. This residue has low palatability; to increase the palatability, farmers in Ethiopia can practice manual chopping, but it is too labor intensive.

Even though Ethiopia has a huge number of livestock population, the economic productivity is minimal than technically possible. Among the many factors which contribute to this low economic productivity, feed shortage is the one. Whether other factors are favorable or unfavorable for livestock production, the availability of feed greatly affects the livestock productivity. Therefore, to increase the productivity of livestock, there has to be a means to alleviate feed shortage during the latter part of the dry season. Silage making when fodder is in excess and chopping farm residues to use as a supplement of livestock feed are the options. But the non-availability of an attractive chopping mechanism, for farmers to make

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silage and chop farm residues, poses a challenge. Hence the objective of this project was to design of animal feed chopper with the capacity of 300 kg/hr to assist farmers in silage making and chopping farm residues to use as feed for livestock.

### General objectives

- > To design of animal feed chopper with the capacity of 300 kg/hr
- Specific objectives
  - > To develop function structure component parts of the chopper
  - > To prepare 3D and 2D drawing of the chopper
  - > To prepare exploded drawing of chopper machine

## MATERIALS AND METHODS

### Design procedure/Steps

This project study was carried out after studying different research reports. Both primary and secondary sources of information have been exploited to conduct the study. The design steps used for animal feed chopper were:

- > The gathering required information which is associated with agricultural operation for chopping systems.
- > Lists of design requirement
- > The conceptual design of an appropriate system to meet their needs.
- > Prepare the selection matrix for each concepts
- > Rank the concepts
- > Combine the concepts to make one product concept
- > Select one or more products concept
- > Using objective tree analysis, select one best product concept and analysis for each parts
- > Modeling (using Solid work).

### Design Aspects

The main design aspects considered during chopper development were cost and complexity of fabrication, energy requirement, ergonomic factor, maintainability, material strength, kinematics and style. Considering these design aspects tangential feed type chopper (hammer mill), without blowing fan and conveyor, was selected for this project. The machine is based on the principles of hammer mill by which size reduction is accomplished by the cutting effects of rotating knives against small stationary knife plates welded in the casing. Since the knives are swinging there is less likelihood of risk even if hard inert material accidentally gets into the chopping chamber. Feed enters into the chamber from the top of the chopper, and size reduction is done by the rotating knives; and finally, the output is discharged from the bottom of the machine. The knives cut the stover and other residue until they become small enough to pass through the bottom screen. Fineness of chopping is controlled by the screen size. It is obvious that the smaller the screen size, the more work will be required to reduce the particles to the desired size. Generally, the technology is simple in construction and easy to manipulate, and the replacement of parts does not cost much.

## Design Concept

### Concept generation

The concept generation process begins with a set of customers need and target specification and results in a set product concepts from which we make the final specification. Introducing low cost automation was to overcome problems with the current manual or traditional method. In this mechanism there are a numbers of uncertain chopping machines such as hand operated chop. The concept of the work is,

- > Observe the manual methods to identify the important process variables.
- > Quantify the important method
- > Investigate all areas of automated forming.
- > Produce a specification for a low cost automated system.
- > Refined design of the machine, as this plays a major role in rural area. The above considering point we can design the semi-automated machine which replace manual process.

### Design Requirements

The system was more probably chosen search for by fulfilling the following general design requirement.

- > Simplicity of technology
- > High efficiency with its capacity of 300kg/hr
- > Low maintenance and repair cost
- > Small in size to transport from place to place
- > Less number of component
- > More accurate system as possible
- > Safe and easy to operation
- > Low manufacturing cost
- > Easy to assemble and Maintainability and also power sources

### Concept selection

Concept selection is process of evaluating concepts with respect to customers need and other criteria, comparing the relative strength and weakness of the concepts for further investigation, testing, or developing.

### Option Selection of the concept

The following possible alternative options will have deal in the variant evaluation. After constructing the decision tree the system may follow the shaded region as follow. The selection was based on the availability source and simple system.

The option selection of the concepts was:

- > High efficiency, Simplicity of technology and economy concept
- > Animal feed chopping techniques (traditional, manual and engine operated chopping system) and
- > Selection of power sources (A= Generator, B= Solar energy, C= Engine and D= Manual operation)
- > Power transmission system (V- Belt driving, gear driving, chain and sprocket)

## Functional structure

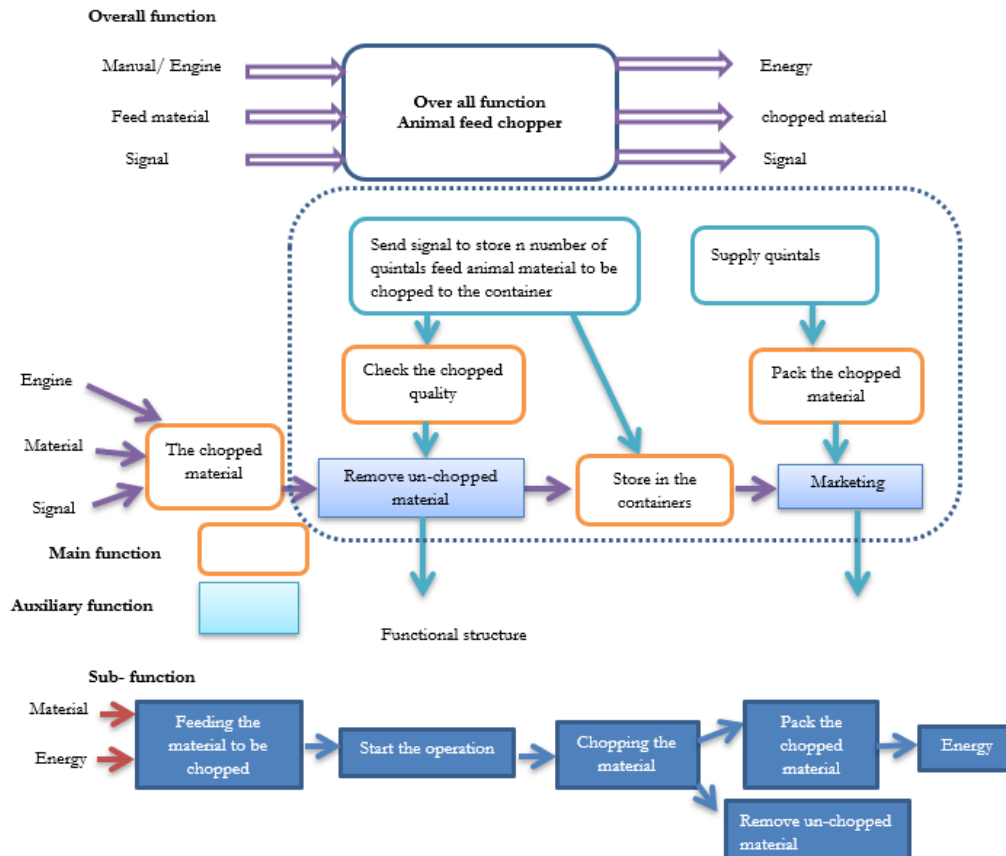


Figure 1: Functional structure

Table 1: Selective system option

| Required power      | Generator          | Solar energy   | Engine                | Manual operation |
|---------------------|--------------------|----------------|-----------------------|------------------|
| Chopping techniques | Tradition method   | Manual method  | Engine method         |                  |
| Power supply system | Chain and sprocket | Gear driving   | V- Belt driving       |                  |
| Feeding system      | Belt convey        | Manual feeding | Gravity and vibration |                  |

## Evaluation of Concept of selection design criteria

### Selection of design criteria

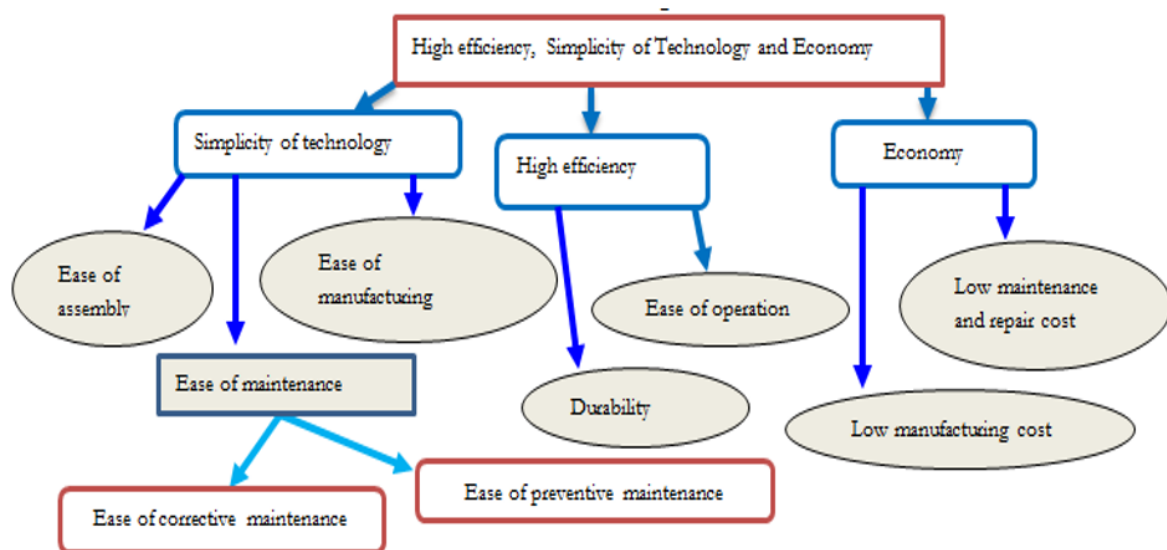


Figure 2: Structure of the objective Tree

### Weighting Evaluation Criteria of the objective tree

According to the weighting evaluation putting assigning of weighting factors for each criterion by overall “O” letters. Weighting evaluation based on the structure of the objective tree

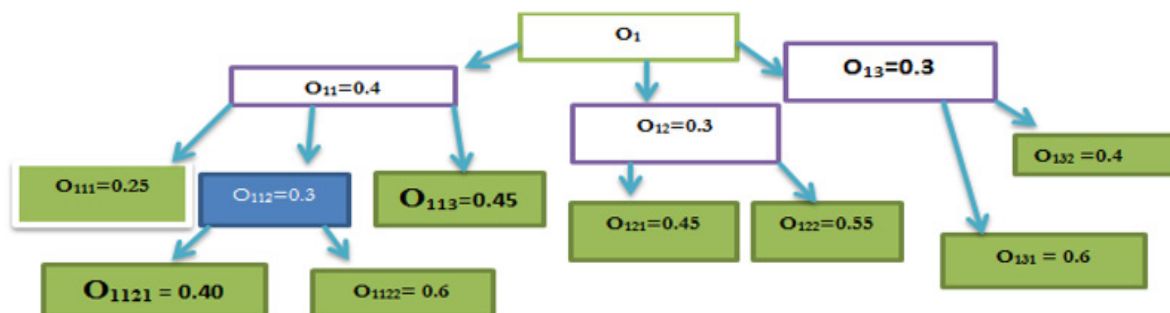


Figure 3: Assignment of weighting factor for each criterion

Table 2: Determination of weighting factors of the ending branches and Compiling

| No | End branches      | Sub weighting factor | Overall weighting factor |
|----|-------------------|----------------------|--------------------------|
| 1  | O <sub>111</sub>  | 0.25 x 0.4           | 0.10                     |
| 2  | O <sub>1121</sub> | 0.4x0.3x0.4          | 0.048                    |
| 3  | O <sub>1122</sub> | 0.6 x 0.3 x 0.4      | 0.072                    |
| 4  | O <sub>113</sub>  | 0.45 x 0.3 x 0.4     | 0.054                    |
| 5  | O <sub>121</sub>  | 0.45 x 0.3           | 0.135                    |
| 6  | O <sub>122</sub>  | 0.55 x 0.3           | 0.165                    |
| 7  | O <sub>131</sub>  | 0.6 x 0.3            | 0.18                     |
| 8  | O <sub>132</sub>  | 0.4 x 0.3            | 0.12                     |

### Assessment of values and Determination of Overall Values

The values are expressed in points of use value analysis

approaches by giving 1 for more important criterion and 0 for less important criterion in a given pair of criteria to be evaluated.

Table 3: Weighted and Un-weighted Overall Values Determination

| Criteria | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Un weighted Over all | Weighted over all |
|----------|---|---|---|---|---|---|---|---|----------------------|-------------------|
| 1        |   | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 4                    | 4/28 (0.143 )     |
| 2        | 0 | - | 0 | 0 | 0 | 1 | 1 | 0 | 2                    | 2/28 (0.071 )     |
| 3        | 0 | 1 | - | 0 | 0 | 1 | 0 | 0 | 2                    | 2/28 (0.071 )     |
| 4        | 1 | 1 | 1 | - | 1 | 1 | 1 | 1 | 7                    | 7/28 (0.25 )      |
| 5        | 0 | 1 | 1 | 0 | - | 0 | 1 | 1 | 4                    | 4/28 (0.143 )     |
| 6        | 1 | 0 | 0 | 0 | 1 | - | 1 | 0 | 3                    | 3/28 (0.107 )     |
| 7        | 0 | 0 | 1 | 0 | 0 | 0 | - | 0 | 1                    | 1/28 (0.036)      |
| 8        | 1 | 1 | 1 | 0 | 0 | 1 | 1 | - | 5                    | 5/28 (0.179 )     |
| Total    |   |   |   |   |   |   |   |   | 28                   | 1                 |

Un-weighted Overall Value was calculated by:

Weighted Overall Value was calculated by:

$$Ovi = \sum_{j=1}^n V_{ij} \dots \dots \dots (1)$$

$$Owvi = \sum_{i=1}^n WV_{ij} \dots \dots \dots (2)$$

### Comparing Concept Variants

Table 4: Satisfaction for achieving the criteria in Percentage

| Satisfaction (%) | Description                                                                           |
|------------------|---------------------------------------------------------------------------------------|
| 100              | Excellent, Complete satisfaction, objective satisfied in every aspect                 |
| 85               | Very Good, Extensive satisfaction, objective satisfied in all of important aspect     |
| 70               | Good, Considerable satisfaction, objective satisfied in the majority of aspects       |
| 50               | Fair, Moderate satisfaction, a middle point bin complete and no satisfaction          |
| 25               | Bad, Minor satisfaction, objective satisfied in some but less than half of the aspect |
| 10               | Failure, Minimal satisfaction ,objective satisfied to very small extent               |
| 0                | No satisfaction, objective is not satisfied in any aspect                             |

### Showing concept variant result in decision matrix of chopping techniques

Three animal feed chopping techniques are considered

to chop maize stack, sorghum stack with different range of output within the specified time according to their capacity. These concept variant are Traditional

feed chopping, Manual operated feed chopping and engine operated feed chopping machine. A = Traditional chopping, B= engine operated chopping machine and C= manual operated feed chopping.

From the table 4 the maximum value of concept variant is 84.68 at B. Therefore Engine operated animal feed chopping machine was the final selection.

Power supply is one type of the input needed to operate chopper machine. There are four concept variant are

considered to chopping 300 kg/hr within different duration of time according to capacity of device to generate power.

These concept variant are Generator, Solar energy, Electric motor and manually operated. Let denoting A= Generator, B= Solar energy, C= Engine/ motor and D= Manual operation. After the result of overall satisfaction is known for each concept variant then making decision applied.

**Table 5:** Decision making matrix for feed chopping technique

| Criteria alternative | 1               | 2     | 3     | 4     | 5     | 6     | 7     | 8     | Overall Satisfaction |
|----------------------|-----------------|-------|-------|-------|-------|-------|-------|-------|----------------------|
| <i>owvi</i>          | 0.143           | 0.071 | 0.071 | 0.25  | 0.143 | 0.107 | 0.036 | 0.179 |                      |
| A                    | %               | 25    | 70    | 25    | 10    | 80    | 70    | 70    | 20                   |
|                      | % × <i>Owvi</i> | 3.575 | 4.97  | 1.775 | 2.5   | 11.44 | 7.49  | 2.52  | 3.58                 |
| B                    | %               | 85    | 80    | 90    | 95    | 65    | 80    | 75    | 90                   |
|                      | % × <i>Owvi</i> | 12.15 | 5.68  | 6.39  | 23.75 | 9.3   | 8.56  | 2.7   | 16.11                |
| C                    | %               | 80    | 85    | 60    | 75    | 85    | 85    | 50    | 80                   |
|                      | % × <i>Owvi</i> | 11.44 | 6.035 | 4.26  | 18.75 | 12.15 | 9.10  | 1.8   | 14.32                |

**Table 6:** Decision of Matrix for selecting the best power supply devices

| Criteria alternative | 1               | 2     | 3     | 4     | 5     | 6      | 7     | 8     | Overall Satisfaction | Rank   |
|----------------------|-----------------|-------|-------|-------|-------|--------|-------|-------|----------------------|--------|
| <i>owvi</i>          | 0.143           | 0.071 | 0.071 | 0.25  | 0.143 | 0.107  | 0.036 | 0.179 |                      |        |
| A                    | %               | 25    | 25    | 10    | 20    | 30     | 90    | 10    | 40                   |        |
|                      | % × <i>Owvi</i> | 3.575 | 1.775 | 0.71  | 5     | 4.29   | 9.63  | 0.36  | 7.16                 | 32.5   |
| B                    | %               | 10    | 80    | 50    | 20    | 80     | 40    | 20    | 60                   |        |
|                      | % × <i>Owvi</i> | 1.43  | 5.68  | 3.55  | 5     | 11.44  | 4.28  | 0.72  | 10.74                | 42.84  |
| C                    | %               | 80    | 95    | 80    | 90    | 85     | 85    | 100   | 80                   |        |
|                      | % × <i>Owvi</i> | 11.44 | 6.745 | 5.68  | 22.5  | 12.155 | 9.095 | 3.6   | 14.32                | 85.535 |
| D                    | %               | 60    | 80    | 75    | 80    | 75     | 60    | 75    | 70                   |        |
|                      | % × <i>Owvi</i> | 8.58  | 5.68  | 5.325 | 20    | 10.725 | 6.42  | 2.7   | 12.53                | 71.96  |

Here as shown in the table, the maximum rating is 85.53 and hence concept variant C was selected as the best concept or alternative. Therefore Engine was the most appropriate power supply needed to operate animal feed chopping machine. The other concept variant take into

consideration is power transmission system. Power is transmitted from the motor to elements of the machine by using mechanical devices such as belt, chain and gear. Denoting A= Belt drive, B= chain drive and C= driving by gear. From this decision matrix, the best concept

**Table 7:** Decision Matrix for selecting the best transmission system

| Criteria alternative | 1               | 2     | 3     | 4    | 5     | 6     | 7     | 8     | Overall Satisfaction | Rank  |
|----------------------|-----------------|-------|-------|------|-------|-------|-------|-------|----------------------|-------|
| <i>owvi</i>          | 0.143           | 0.071 | 0.071 | 0.25 | 0.143 | 0.107 | 0.036 | 0.179 |                      |       |
| A                    | %               | 95    | 90    | 75   | 65    | 85    | 75    | 70    | 80                   |       |
|                      | % × <i>Owvi</i> | 13.58 | 6.39  | 5.32 | 16.25 | 12.15 | 8     | 2.52  | 14.32                | 78.55 |
| B                    | %               | 70    | 60    | 60   | 70    | 60    | 65    | 70    | 90                   |       |
|                      | % × <i>Owvi</i> | 10.01 | 4.26  | 4.26 | 17.5  | 8.58  | 6.95  | 2.52  | 16.11                | 70.19 |
| C                    | %               | 50    | 70    | 80   | 85    | 70    | 65    | 55    | 40                   |       |
|                      | % × <i>Owvi</i> | 7.15  | 4.97  | 5.68 | 21.25 | 10.01 | 6.95  | 1.98  | 7.16                 | 65.15 |

variant was concept A. It was 78.55; therefore belt drive was chosen to transfer the power from Engine or motor to the parts of the chopping machine.

The other concept variant take into consideration is feeding system. Denoting A= manual feeding, B= belt conveyor and C= gravity and vibration

**Table 8:** Decision Matrix for selecting the best feeding system

| Criteria alternative | 1               | 2     | 3     | 4    | 5     | 6     | 7     | 8     | Overall Satisfaction | Rank  |
|----------------------|-----------------|-------|-------|------|-------|-------|-------|-------|----------------------|-------|
| <i>owvi</i>          | 0.143           | 0.071 | 0.071 | 0.25 | 0.143 | 0.107 | 0.036 | 0.179 |                      |       |
| A                    | %               | 95    | 90    | 75   | 65    | 85    | 75    | 70    | 80                   |       |
|                      | % × <i>Owvi</i> | 13.58 | 6.39  | 5.32 | 16.25 | 12.15 | 8     | 2.52  | 14.32                | 78.55 |
| B                    | %               | 70    | 60    | 60   | 70    | 60    | 65    | 70    | 90                   |       |
|                      | % × <i>Owvi</i> | 10.01 | 4.26  | 4.26 | 17.5  | 8.58  | 6.95  | 2.52  | 16.11                | 70.23 |

|   |          |      |      |      |       |       |      |      |      |       |     |
|---|----------|------|------|------|-------|-------|------|------|------|-------|-----|
| C | %        | 50   | 70   | 80   | 85    | 70    | 65   | 55   | 40   |       |     |
|   | % * Owvi | 7.15 | 4.97 | 5.68 | 21.25 | 10.01 | 6.95 | 1.98 | 7.16 | 64.15 | 3rd |

From this decision matrix, the best concept variant was concept A. It was 78.55; therefore manual feeding was chosen in terms to economic visibility of the chopping.

#### Design and Analysis of Animal feed chopper

Animal feed chopper was driven by motor and makes the driving of main shaft by belt. Under the high-speed rotation with cutter making the feed become filiform and powder, the feeds will be outflow from the material outlet through outlet parts of the chopper. Feed chopper are made up of feeding part, Cutting and throwing part, transmitting part, and safety device, so it was reasonably structured safe and reliable.

o Feeding part is feed rollers.  
o Cutting structure made up of motion knife and locking bolt.

o Transmitting structure mainly consist of belt, gears, pulley

Selection of motor consider the design requirements (capacity given 300kg/hr)

From the literature survey known that the torque of the motor must be between 30-80Nm was sufficient for feed chopper. For this project the selected net torque 50Nm and speed requirement 240rpm. Therefore, the Power requirement for the animal feed chopper was calculated by the following formula.

$$p = (2\pi N T) / 60 \dots \dots \dots (3)$$

Where, P = power, kW

N = number of revolution (rpm)

T = torque, Nm

$$p = (2\pi \times 240 \times 50) / 60$$

$$= 1.25 \text{ kW, therefore we have to select 2}$$

$$\text{HP} = 2 \times 0.746 = 1.5 \text{ kW was sufficient}$$

#### Design and selection of pulley diameters

The pulleys used in the drive system were made of cast iron. Pulley diameters were selected based on the need to reduce the engine speed to the required one. The pulleys must be in perfect alignment in order to allow the belt to travel in a line normal to the pulley faces. The pulleys may be made of cast iron, cast steel or pressed steel, wood and paper. The cast materials should have good friction and wear characteristics. The pulleys made of pressed steel are lighter than cast pulleys, but in many cases, they have lower friction and may produce excessive wear (Sharma & Mukesh, 2010). In our case the pulleys are generally made of cast iron, because of their low cost. The rim is held in place by web from the central boss or by arms or spokes. The following equation was used to determine pulley diameters.

#### Design of hub

The hub of a pulley is one of the most important components part. It gives support to the spokes and the shaft. The diameter of the hub was calculated using following formula. The outside of the hub is given by Nisbett & Richard (2011).

$$D = 1.50d + 25.0 \dots \dots \dots (7)$$

$$D_h = 1.5d + 25$$

$$= 1.5 \times 30 + 25$$

$$= 70 \text{ mm}$$

Where:

D = outside diameter of hub, mm

d = diameter of shaft, mm

The length, L, of hub is given by Nisbett & Richard (2011)

$$L = (\pi \times d) / 2 \dots \dots \dots (8)$$

$$L = \pi / 2 \times d = \pi / 2 \times 30 \text{ mm}$$

$$= 47 \text{ mm}$$

Let us use two belts in order to increase the speed of the chopper and then we have two pairs of pulleys. The speed of the first pulley in the twice of the second pulley, take assume  $N_1 = 25.57 \text{ rpm}$ . Then, the speed ratio was calculated  $N_1 = 25.57 \text{ rpm}$ ,  $d_1 = 180 \text{ mm}$ ,  $d_2 = 90 \text{ mm}$ . Then the speed of the second pulley  $N_2$  can be found the following relation

$$N_2 / N_1 = d_1 / d_2, N_2 = N_1 \times d_1 / d_2 = 25.57 \times 180 / 90 = 51.14 \text{ rpm}$$

#### Determination of pulley weight

Circular shape was used in the construction of the chopper pulley. The weight of the pulley was calculated as follows.

$$A_p = (\pi d^2) / 4 \dots \dots \dots (9)$$

$$= (\pi \times 0.18^2) / 4 = 0.025 \text{ m}^2$$

Where,  $A_p$  = area of pulley material

d = Diameter of pulley, m

The volume of pulley material was computed using the following equations (ITSI-SU, 2011);

$$V_p = A_p \times t \dots \dots \dots (10)$$

$$= 0.025 \times 0.0039 \text{ m}$$

$$= 9.92 \times 10^{-5} \text{ m}^3$$

Mass of pulley material was computed using the following equations. The density of cast iron pulley ( $\rho$ ) = 7200kg/m<sup>3</sup> (ITSI-SU, 2011)

$$M_p = V_p \times \rho \dots \dots \dots (11)$$

$$= 9.92 \times 10^{-5} \text{ m}^3 \times 7200 \text{ kg/m}^3$$

$$= 0.714 \text{ kg}$$

Weight of pulley material was computed using the following equations (Gat, 1988)

$$W_p = M_p \times g \dots \dots \dots (12)$$

$$\text{Weight of larger pulley, } W_{p1} = M_{p1} \times g = 0.714 \text{ kg} \times 9.81 \text{ m/s}^2 = 7.004 \text{ N}$$

$$\text{Mass of smaller pulley, } M_{p2} = \rho \times v = \rho \times (\pi d^2) / 4 \times t = 7200 \times (\pi \times 0.09^2) / 4 \times 0.00345 = 0.158 \text{ kg}$$

$$\text{Weight of smaller pulley, } W_{p2} = M_{p2} \times g = 0.158 \text{ kg} \times 9.81 \text{ m/s}^2 = 1.55 \text{ N}$$

#### Determination of torque transmitted by the pulley

A first drive cast iron pulley transmits 96.98W at 25.57rpm. The diameter of largest pulley is 180mm and has smooth straight arms of elliptical straight arms of cross-section in which the major axis is twice the minor axis. Find the dimensions of the arm if the allowable bending stress is



15MPa. Mention the plane in which the major axis of the arm should lie.

Let  $b_1$  = minor axis, and

$b_2$  = major axis =  $2b_1$

Known that the torque transmitted by the pulley

$$\begin{aligned} T &= (P \times 180) / 2\pi N \dots \dots \dots (13) \\ &= (96.98 \times 180) / (2\pi \times 25.57) \\ &= 17456.4 / 160.58 = 108.7 \text{ Nm} \end{aligned}$$

Maximum bending moment at the hub end,

$$\begin{aligned} M &= 2T/n \\ &= (2 \times 108.7 \text{ Nm}) / 1 = 217.42 \text{ Nm} \end{aligned}$$

And section modulus,

$$\begin{aligned} Z &= \pi / 32 \times b_1 (b_2)^2 \dots \dots \dots (14) \\ &= \pi / 32 \times b_1 \times (2b_1)^2 \\ &= \pi / 32 \times 4b_1^3 = (\pi b_1^3) / 8 \end{aligned}$$

Known that the bending stresses,  $\sigma_b$

$$15 = M / Z = (217.42 \times 8 \times 10^3) / (\pi \times b_1^3) = (1739.34 \times 10^3) / (\pi \times b_1^3)$$

$$b_1^3 = (1739.34 \times 10^3) / (15 \times \pi) = 36.93 \times 10^3 \text{ mm}^3$$

$$b_1 = 33.3 \text{ mm}$$

$$b_2 = 2b_1 = 2 \times 33.3 = 66.6 \text{ mm}$$

A first driven cast iron pulley transmits 96.98 watt at 51.14 rpm. The diameter of this pulley was 90 mm and has full arms of elliptical straight arms of cross-section in which the major axis is twice the minor axis. Find the dimensions of the arm if the allowable bending stress is 15 MPa. Mention the plane in which the major axis of the arm should lie.

$$\sigma_b = 15 \text{ MPa} = 15 \text{ N/mm}^2$$

Let  $b_1$  = minor axis, and

$b_2$  = major axis =  $2b_1$

Known that the torque transmitted by the pulley,

$$\begin{aligned} T &= (P \times 90) / 2\pi N = (96.98 \times 90) / (2 \times \pi \times 51.14) = 8728.2 / 31.16 = 27.18 \text{ Nm} \end{aligned}$$

Maximum bending moment per arm at the hub end,

$$M = 2T/n = (2 \times 27.18) / 1 = 27.18 \text{ Nm}$$

And section modulus,

$$Z = (\pi b_1^3) / 8 \dots \dots \dots (15)$$

Known that the bending stress,  $\sigma_b$ ,

$$15 = M / Z = (27.18 \times 8 \times 10^3) / (\pi b_1^3) = (217.44 \times 10^3) / (\pi b_1^3)$$

$$b_1^3 = (217.44 \times 10^3) / (15 \times \pi)$$

$$= 4616.56 \text{ mm}^3$$

$$b_1 = 16.65 \text{ mm}$$

Therefore,  $2b_1 = 2 \times 16.65 \text{ mm} = 33.3 \text{ mm}$

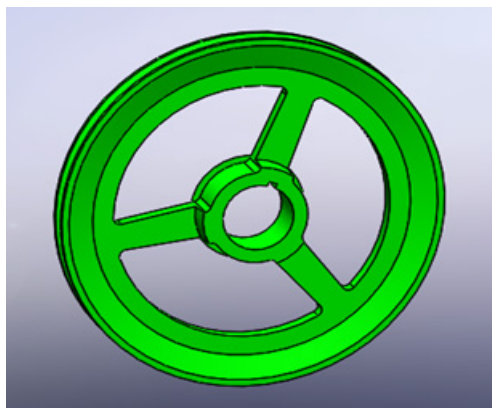


Figure 4: Chopper pulley 3D view

## Selection of the drive belt

V-belt and pulley arrangements were used in this work to transmit power from the engine to the roller shaft. The main reasons for using the v-belt drive was its flexibility, simplicity, and low maintenance costs. Additionally, the v-belt has the ability to absorb shocks there by mitigating the effect of vibratory forces (Khurmi & Gupta, 2005).

## Determination of belt contact angle

The belt contact angle is given by the following equation (Khurmi & Gupta, 2005).

$$\varphi = \sin^{-1} ((R-r)/L) \dots \dots \dots (16)$$

$$\varphi = \sin^{-1} ((180 \text{ mm} - 90 \text{ mm}) / 1203.13)$$

$$= \sin^{-1} (0.0748)$$

$$= 4.29^\circ$$

The angles of wrap for the smaller and larger pulleys are determined by the following equation:

$$\alpha_1 = 180^\circ \sin^{-1} ((R-r)/L) \dots \dots \dots (17)$$

$$= 180^\circ \sin^{-1} ((180 \text{ mm} - 90 \text{ mm}) / 1203.13)$$

$$= 180^\circ \sin^{-1} (0.0748) = 171.42^\circ$$

$$\alpha_2 = 180 + 2 \sin^{-1} ((R-r)/L) \dots \dots \dots (18)$$

$$= 180 + 2 \sin^{-1} ((180 \text{ mm} - 90 \text{ mm}) / 1203.13)$$

$$= 180 + 2 \sin^{-1} (0.0748) = 188.58^\circ$$

Where:  $R$  = radius of larger pulley, mm;

$r$  = radius of smaller pulley, mm;

$\alpha_1$  = angle of wrap for the engine pulley, degree;

$\alpha_2$  = angle of wrap for the roller shaft pulley, degree;

$C$  = is the center distance between the two center pulleys. Therefore, by using the above equations the determined values of  $\varphi$ ,  $\alpha_1$  and  $\alpha_2$  were 4.290, 171.420 and 188.580 respectively.

## Determination of belt length

The length of belt appropriate to drive the system was calculated using the equation given below by Shigley (2001). Assume the distance between driver pulley and driven pulley, 180 mm according to frame structure. Center distance ( $C$ ) of driven pulleys was given by:

$$C = 90/2 + 225 + 90/2 = 387 \text{ mm}$$

$$L = 2C + \pi/2 (D_1 + D_2) + (D_2 - D_1)^2 / 4C \dots \dots \dots (19)$$

$$L = \pi/2 (90 \text{ mm} + 180 \text{ mm}) + 2 \times 387 \text{ mm} + (180 \text{ mm} - 90 \text{ mm})^2 / (4 \times 387 \text{ mm})$$

$$= 423.9 \text{ mm} + 774 \text{ mm} + 5.23 \text{ mm}$$

$$= 1203.13 \text{ mm}$$

Where:  $L$  = belt length, m;

$C$  = center distance between pulleys, m;

$D_2$  = pitch diameter of driven pulley, m;

$D_1$  = Pitch diameter of driver pulley, m.

Since the calculated length of v belt is equal to the closest standard belt the exact center distance is also correct. Therefore, center distance was equal to 387 mm. Speed of the belt was calculated by using the following equation as given by (Khurmi & Gupta, 2005).

$$V = 1 + (\pi \times D_1 \times N_1) / 60 \dots \dots \dots (20)$$

$$= 1 + (\pi \times 0.18 \text{ m} \times 25.57 \text{ rpm}) / 60 = 1 + 0.24 = 1.24 \text{ m/s}$$

Determination of belt Tensions

Power requirement for animal feed chopper was 1.5 kW.

As losses in between pulley arrangement is considered, i.e.,



such that belt pulley power transmission efficiency is 85-95%. To determine tensions on the tight and slack sides of the belt the following equations was used (Khurmi & Gupta, 2005). Calculate belt tension and width: Design a rubber v-belt to drive a machine with 96.98W at 25.57 rpm and fitted with a pulley 180mm diameter.

Allowable stress for belt,  $\sigma = 2.1 \text{ Mpa} = 2.1 \times 10^6 \text{ N/m}^2$

Density of rubber,  $\rho = 1000 \text{ kg/m}^3 = 1000 \text{ kg / m}^3$

Angle of contact driver pulley,  $\theta = 165^\circ = 165 \times \pi / 180 = 2.88 \text{ rad}$

Coefficient of friction between belt and pulley,  $\mu = 0.3$

Power transmitted (P)

$$P = (T_1 - T_2) \times V \dots \dots \dots (21)$$

$$96.98 \text{ W} = (T_1 - T_2) \times 1.24 \text{ m/s}$$

$$T_1 - T_2 = 96.98 \text{ W} / (1.24 \text{ m/s}) = 78.2 \text{ N} \dots \dots \dots (22)$$

We Know that,

$$2.3 \log T_1 / T_2 = \mu \times \theta$$

$$= 0.3 \times 2.88 = 0.864 \text{ rad}$$

$$\log T_1 / T_2 = 0.3756 \text{ rad}$$

$$T_1 / T_2 = 2.375 \text{ N} \dots \dots \dots (23)$$

From equations (22) and (23),

$$T_1 = 135.1 \text{ N}$$

$$T_2 = 56.87 \text{ N}$$

Let  $b$  = Width of the belt in meters, and  $t$  = thickness of the belt in meters. Assuming thickness of the belt,  $t = 10 \text{ mm} = 0.01 \text{ m}$ , cross-sectional area of the belt

$$A = b \times t = b \times 0.01 = 0.01b \text{ m}^2$$

The mass of the belt per meter length,

$$m = \text{Area} \times \text{length} \times \text{density}$$

$$= 0.01b \text{ m}^2 \times 1.203 \text{ m} \times 1000 \text{ kg/m}^3 = 12.03b \text{ kg/m}$$

According to Khurmi & Gupta, 2005 torsional moment ( $T_c$ ) due to single belt tensions was determined using the following equation.

$$T_c = m \times V^2 \dots \dots \dots (24)$$

$$= 12.03b(1.24)^2 = 18.5b \text{ N}$$

The maximum tension in the belt

$$T = \sigma_{\max} \times b \times t \dots \dots \dots (25)$$

$$= 2.1 \times 10^6 \times b \times 0.01$$

$$= 21000b \text{ N}$$

And tension in the tight side of belt ( $T_2$ ),

$$56.87 \text{ N} = T - T_c$$

$$= 21000b - 18.5b \text{ N}$$

$$= 20981.5b \text{ N}$$

$b = 56.87 \text{ N} / 20981.5 \text{ N} = 0.0435 \text{ m} = 43.5 \text{ mm}$ . Therefore, the standard width of the belt  $b$  is 50 mm.

Where:  $T_c$  and  $T$  = the centrifugal and maximum tension of the belts (N);

$T_1$  and  $T_2$  = tension in the tight and slack sides (N);

$\sigma_{\max}$  = maximum safe normal stress (N/mm<sup>2</sup>);

$m$  = mass per unit length of belt (kg/m) and

$v$  = is speed of belt (m/s).

Feeding hopper design

Hopper, use as a feeding unit is part of animal feed chopping machine that serves material cutting into the blade housing. The cutting material is fed manually through the hopper from the top side. Hopper or Feeding Trough is used to feed fodder such as maize stack, cutting grass etc. Hopper decides capacity of feed cutter. The

main purpose of hopper is providing direction to fodder and bring contact with cutting blade. The hoppers house the materials and deliver the materials to the feed roller at regulated feed rate. The hopper has a shape which facilitates loading, maximum volume utilization and reliable and complete gravity discharge through its outlet. The volume of the hopper was calculated by the following equation:

$$V = h/2 (A_1 + A_2 + \sqrt{A_1 A_2}) \dots \dots \dots (26)$$

$$A_1 = 354 \text{ mm} \times 152 \text{ mm}$$

$$= 53,808 \text{ mm}^2$$

$$A_2 = 270 \text{ mm} \times 98 \text{ mm}$$

$$= 26,460 \text{ mm}^2$$

$$V = 460 \text{ mm} / 2 (53,808 \text{ mm}^2 + 26,460 \text{ mm}^2 + \sqrt{53,808 \text{ mm}^2 \times 26,460 \text{ mm}^2})$$

$$V = 0.00143 \text{ m}^3$$

Where,  $V$  = volume of hopper, mm<sup>3</sup>,  $h$  = height, (460mm)

$A_1$  = base area of truncated cone, top of hopper, mm<sup>2</sup>

$A_2$  = base area of truncated cone, bottom of hopper, mm<sup>2</sup>

### Determination weight of feeding hopper

Trapezoidal shape was used in the construction of the animal feeding hopper. The weight was calculated as follows. Mass of

feeding hopper material was computed using the following equations (ITSI-SU, 2011)

$$M_f = A_f \times t \times \rho_f \dots \dots \dots (27)$$

$$M_f = 0.08 \text{ m}^2 \times 1.5 \times 10^{-3} \text{ m} \times 7850 \text{ kg/m}^3$$

$$M_f = 0.945 \text{ kg}$$

Weight of feeding material was computed using the following equations (Gat, 1988)

$$W_f = M_f \times g \dots \dots \dots (28)$$

$$= 0.945 \text{ kg} \times 9.81 \text{ m/s}^2$$

$$= 9.272 \text{ N}$$

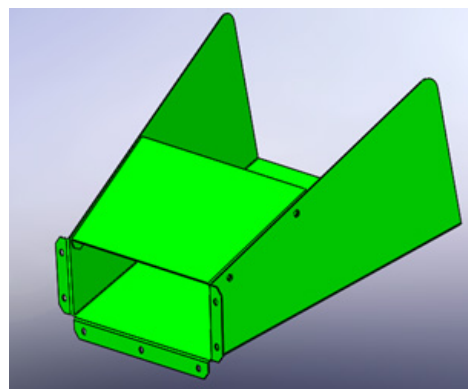


Figure 5: Feeding Hopper 3D view

### Main frame

Main frame is generally consists of four legs and made up of angle iron. The whole machine was mounted over the legs. The minimum height of the stand is approximately 550mm from the ground level for easy feeding of the crop in standing posture of the user. All detail dimension was described under the appendix, only the isometric view was drawn in the below figure.

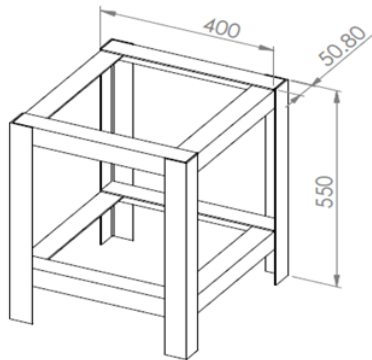
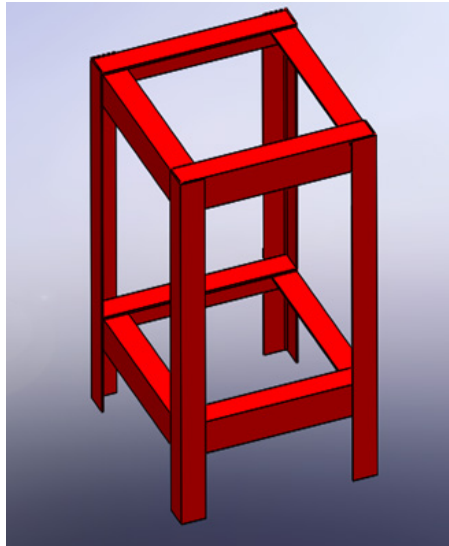


Figure 6: Main frame 3D views (all dimension in mm)

### Design of shaft

This shaft made up of mild steel carbon which is use for fitting the pulley and transmitting the motion of the feeder roller through the worm and gear. The main shaft was strictly attached with the pulley in its center whereas the other end is supported on a block through bearings. The length and diameter of the main shaft was calculated below. The shafts were designed on the basis of strength rigidity and stiffness. In designing shafts of the basis of strength, the following cases may be considered that is the shaft will be designed by considering the following.

### Shaft subjected to a twisting moment

To find the diameter of the shaft when the shaft was subjecting moment (torque) only

$$T/J = \tau/r \dots \dots \dots (29)$$

Where: T = Twisting moment or torque acting on the shaft.

J = Polar moment of inertia of the shaft about the axis of rotation.

$\tau$  = Torsional shear stress and

r = Diametric distance from neutral axis to the outer most fiber.

The allowable shear stress for the shaft material was calculated as

$$\tau = \sigma_u / 2fs \dots \dots \dots (30)$$

$$= 560 \text{ Mpa} / (2 \times 3.5)$$

$$= 560 \text{ Mpa} / 7 = 80 \text{ Mpa}$$

Where,  $\sigma_u = 560 \text{ Mpa}$  for carbon steel

fs = factor of safety 3.5

From the equation

$$T = \pi / 16 \tau d^3 \dots \dots \dots (31)$$

The diameter of the shaft by considering twisting of the shaft

$$T = \pi / 16 \tau d^3 = 50000 \text{ Nmm} = \pi / 16 \times 80 \times d^3,$$

$$d^3 = (50000 \times 16) / (80 \times \pi), d = 14.27 \text{ mm}$$

Shaft subjected to bending moment

When the shaft is subjected to bending moment only, then the maximum stress was given by

$$M/I = \sigma_b / y \dots \dots \dots (32)$$

Where

M = bending moment

I = moment of inertia of cross sectional of shaft

$\sigma_b$  = bending stress

y = distance from neutral axis to the outer most fiber

For round solid shaft, moment of inertia is found by

$$I = \pi / 64 d^4 \text{ and } y = d/2 \text{ substitution in equation (32)}$$

$$M = \pi / 32 \sigma_b d^3 \dots \dots \dots (33)$$

The maximum bending moment of the carbon steel was, M = 424320 Nmm. Substituting the above values to determine diameter of the shaft

$$M = \pi / 32 \sigma_b d^3$$

$$424320 \text{ Nmm} = \pi / 32 \times 160 \text{ Mpa} \times d^3$$

$$d^3 = (424320 \times 32) / (\pi \times 160) = 27013.05,$$

$$d = 27013.05 = 30 \text{ mm}$$

Therefore, for the design we should have to taking the maximum of the two 30mm > 14.27mm, the diameter of the shaft was, d = 30mm.

Mass of shaft was calculated by the following equation

$$M = \rho \times V \dots \dots \dots (34)$$

Shaft made up of carbon steel with density of 7853 kg/m<sup>3</sup>.

$$V = A \times L = (\pi d^2) / 4 \times L$$

$$= (\pi \times (0.03)^2 \times 0.7) / 4$$

$$= 4.95 \times 10^{-4} \text{ m}^3$$

Mass of shaft material was computed using the following equations (Gat, 1988)

$$M_s = 4.95 \times 10^{-4} \text{ m}^3 \times 7850 \text{ kg/m}^3$$

$$= 3.885 \text{ kg}$$

The weight of the shaft was estimated using the following equations

$$W_s = M_s \times g$$

$$W_s = 3.885 \text{ kg} \times 9.81 \text{ m/s}^2$$

$$= 38.12 \text{ N}$$

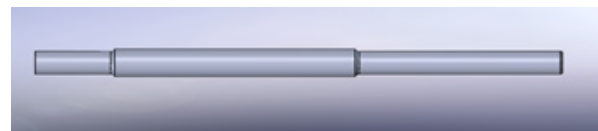


Figure 7: Design of chopper shaft

### Design of Gear

The gears are used to transmit power .By changing the gear used; the speed can be adjusted to obtain various cutting lengths. These gears are used to transmit the

power from main shaft to feeding rollers. Assume that the speed of lower roller was = 55 rpm Let power transmitted = 1.5 Kw. Let take input out- put = 240 rpm

Out -put speed =55 rpm

The gear was made from hard steel material having ultimate bending stresses ( $\sigma_{ut}=700 \text{ N/mm}^2$ ), Number of teeth on gears was calculated by the following formula.

$$T_2/T_1 = N_1/N_2 \dots\dots\dots(35)$$

$$T_2 = N_1/N_2 \times T_1$$

$$T_2 = 240/55 \times T_1, \text{ Assume, } T_1 = 16 \text{ teeth, } T_2 = 240/55 \times 16 = 70 \text{ teeth}$$

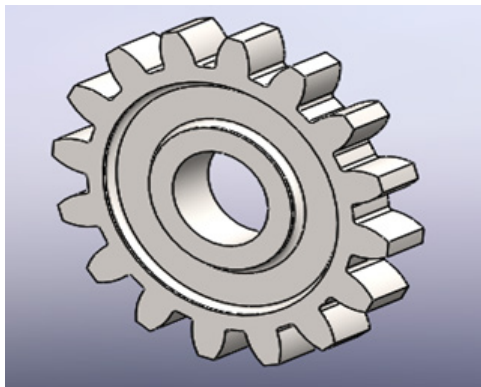


Figure 8: Design of 3D view of Gear

### Chopper Blade

These blades are made up of High carbon steel or alloy steel. The function of the blade is to cut the silage material that can be chopped into smaller pieces suitable for animal feed. There are four cutting blades used in this machine

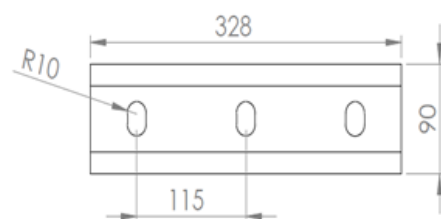
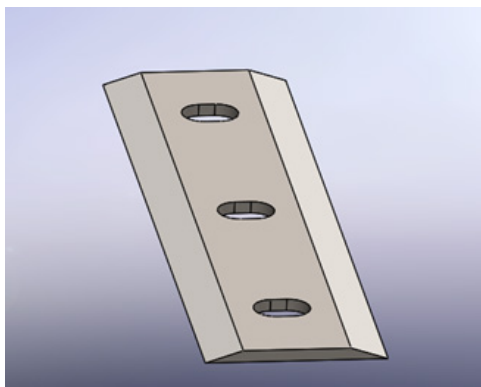


Figure 9: 3D view chopper blade

### Estimation of Force required in cutting chopper blade

Estimation of Force required in cutting chopper blade was calculated by the following formula (Khope & Modak., 2013)

$$F = A \times N_s \times S \dots\dots\dots(36)$$

Where, F = force required in cutting the silage

A = cross section area of individual stem

$N_s$  = number of stem at a time in throat

S = shear strength of material

### Housing/upper cover

Housing covers the cutting sharp edge. Housing protects the person from not touching the cutting edges accidentally.

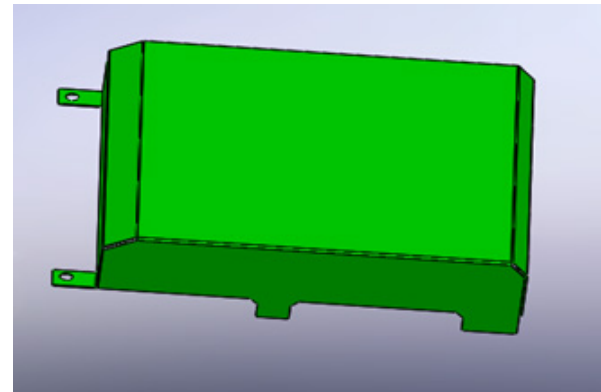


Figure 10: 3D view housing or upper cover

### Feeding Roller

There are two feed rollers, upper feed roller and lower feed roller, present in the fodder chopper. These rollers are made up of cast iron and have teeth on its periphery. The chopped material was first feed to the rollers, which in turn grip the material and then it move forward to the cutting blade. The lower feed roller was fix while the upper feed roller is spring loaded which can move up and down depending upon the quantity of silage being fed.

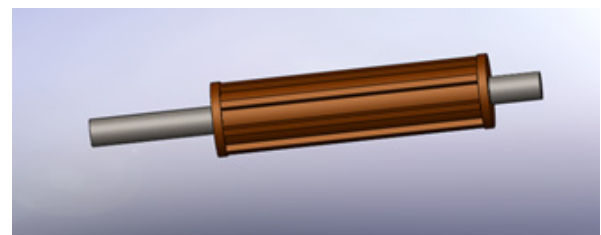


Figure 9: 3D view chopper blade

### Joints

A joint is a rigid rod that allows the rod to bend in any direction, and is commonly used in shafts that transmit rotary motion. It consists of a pair of hinges located close together, oriented at  $90^\circ$  to each other, connected by a cross shaft.

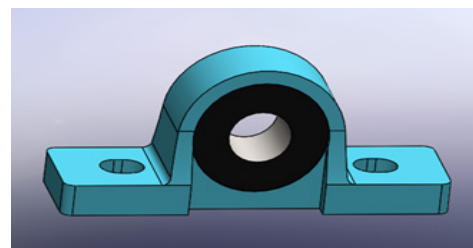


Figure 12: 3D view UCP bearing or joint

### Chopper rotor with its assembly

These are made up of hard metal steel plates. These rotor acts as the rotating member of the silage cutting mechanism

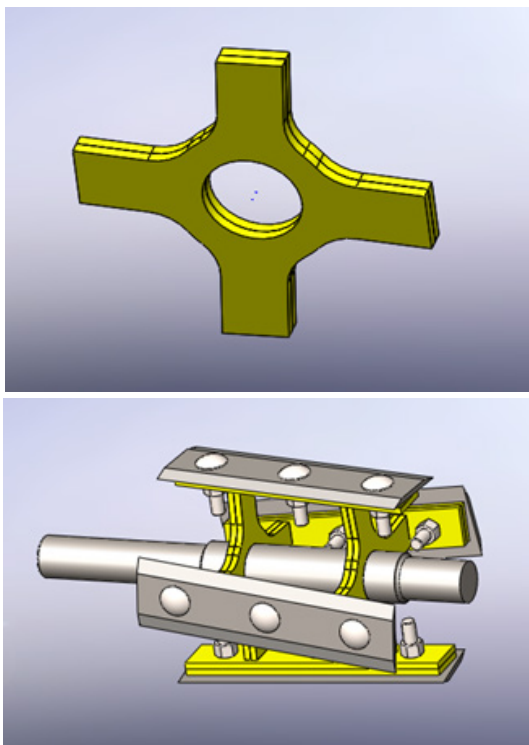


Figure 13: 3D view chopper rotor with assembly

### Working Principle of animal feed chopper

Engine drives the main shaft with the help of belt drive. Gears, Pulleys and blades are mounted on the main shaft. Main shaft drives the blade and gears mounted on it. Power was transmitted to the feeding roller with the help of gear system. Silage was entered through the hopper to feeding roller. Feeding roller moves the silage to the cutting head. Blades cut the silage into uniform small pieces and throw the final product outside the machine.

### Measurements

The following items were measured and estimated during evaluating the forage chopper under the studied parameters:

### Theoretical and actual lengths of cut

The theoretical lengths of cut  $L_{th}$  was calculated using the following equation according to (Telang, 2016; Sankpal et al., 2017).

$$L_{th} = (60000 V_f) / (\lambda_k n_c) \dots \dots \dots (37)$$

Where:

- $L_{th}$  = Length of cut, cm
- $V_f$  = Feed velocity, m/s (peripheral speed of feeding mechanism);
- $n_c$  = Cutter head rotational speed, rpm, and
- $\lambda_k$  = Number of knives on the cutter head.

### Cutting efficiency

The cutting efficiency of the animal feed chopping was

calculated as follows

$$\eta_c = L_{th} / L_{ac} \times 100 \dots \dots \dots (38)$$

Where,

- $\eta_c$  = Cutting efficiency, %
- $L_{ac}$  = Actual length, (mm) and
- $L_{th}$  = Theoretical length, (mm).

### Feed Chopper capacity

The theoretical capacity  $T_{th}$ , in ton per hour, was expressed by the following relationship

$$T_{th} = (\rho_f \times A_t \times L_c \times \lambda_k \times \eta_c) / (6 \times 108) \dots \dots \dots (39)$$

Where:

- $T_{th}$  = Theoretical capacity, kg/s;
- $\rho_f$  = Density of forage in the thereat, in kg/m<sup>3</sup>;
- $A_t$  = Thereat area, in cm<sup>2</sup>;
- $L_c$  = Theoretical length of cut in mm;
- $\lambda_k$  = Number of knives on cutterhead, and
- $\eta_c$  = Speed of cutter head, rpm.

### Cad Drawing Of The Parts And Its Assembly

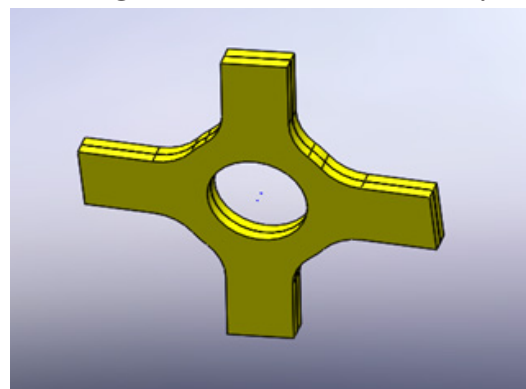


Figure 14: Inlet

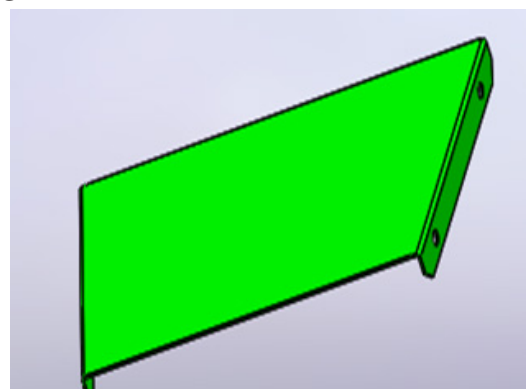


Figure 15: Inlet top cover

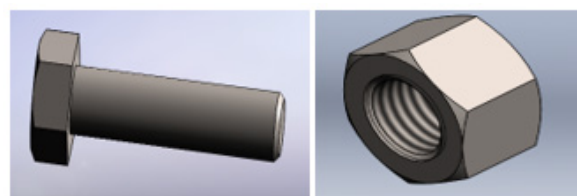
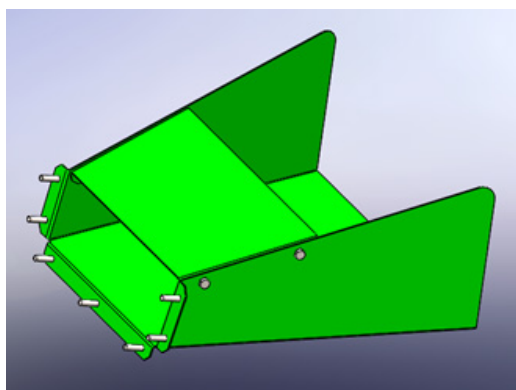
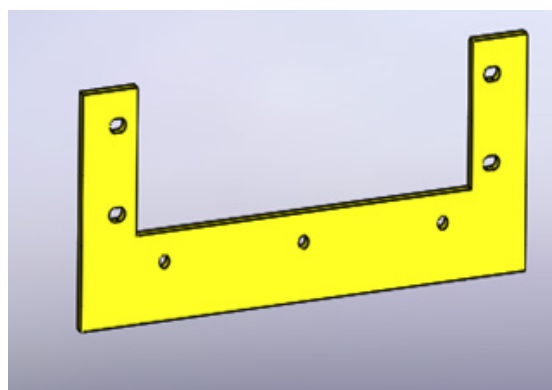


Figure 16: Bolt and nut

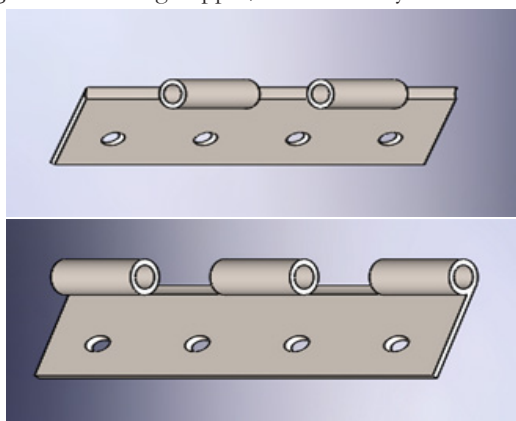




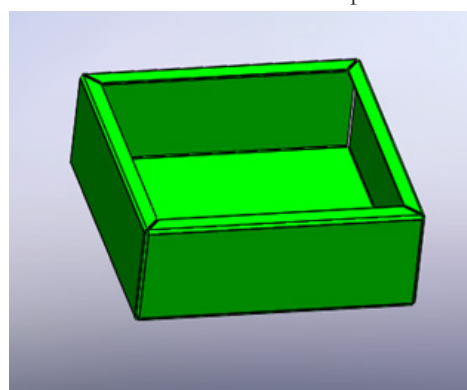
**Figure 17:** Feeding hopper/inlet assembly



**Figure 22:** Enclosure main front inlet panels



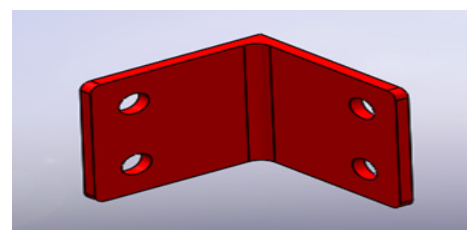
**Figure 18:** Hinge flange



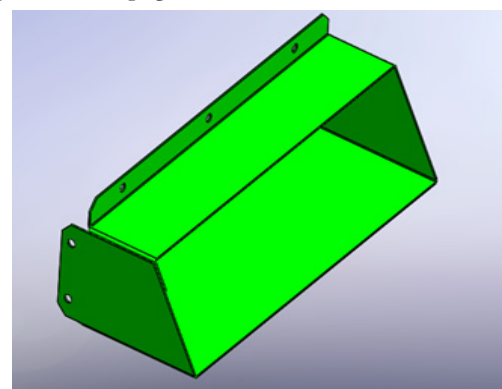
**Figure 23:** Electronic enclosure



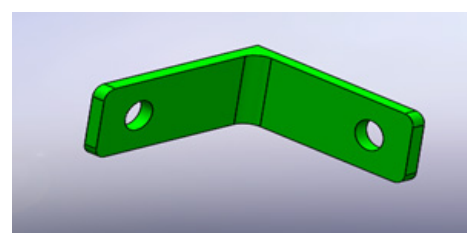
**Figure 19:** Hinge pin



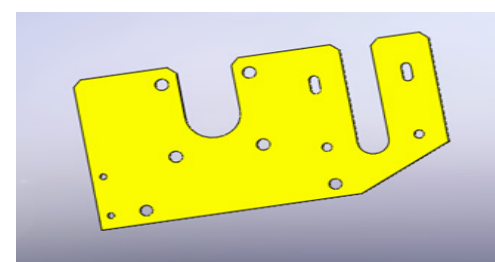
**Figure 24:** Guard mount



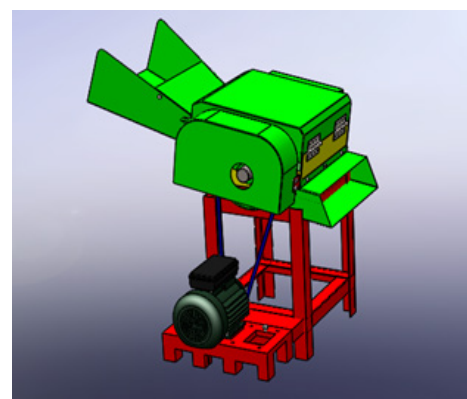
**Figure 20:** Outlet



**Figure 25:** Electronic enclosure mount



**Figure 21:** Enclosure main side panels



**Figure 20:** Main assembly of animal feed chopper with pulley guard

### Methods of manufacturing for each part and assembly

For constructing of products materials are needed. All these processes used in manufacturing concern for changing the ingots into usable products it includes as shaping processes, machining processes, metal forming processes, joining processes, surface finishing processes and processes effecting change in properties. Therefore, animal feed chopper was manufacturing by the following method given in tables below:

| S. no | Components          | Methods of manufacturing pats                  |
|-------|---------------------|------------------------------------------------|
| 1     | Main Shaft          | facing, Grinding, boring and turning           |
| 2     | Feeding hopper      | Bending, welding and joining                   |
| 3     | Feed Rolls          | Casting, rolling and shaping                   |
| 4     | Housing/upper cover | Bending, drilling and joining                  |
| 5     | Feed roll Shaft     | Rolling, grinding and slotting                 |
| 6     | Gears               | Grooving, Casting and shaping                  |
| 7     | Pulley              | Shaping, Rolling and machining                 |
| 8     | Chopper Blade       | Grinding, shaping, punching and drilling       |
| 9     | Main Frame          | Sawing, drilling, cutting, welding and joining |
| 10    | Chopper rotor       | Shaping, rolling,                              |
| 11    | Pulley guard        | Bending, drilling and joining by bolt and nut  |
| 12    | Hinge flap          | Rolling                                        |
| 13    | Engine setting      | Joining by bolt and nut and drilling           |
| 14    | Outlet              | Bending, welding and joining by bolt and nut   |

**Table 9:** Technical Specifications of animal feed chopper

| S. no | Type               | Specification                                   |
|-------|--------------------|-------------------------------------------------|
| 1     | Number of Gear     | 02                                              |
| 2     | Number of rollers  | 02                                              |
| 3     | Number of blades   | 04                                              |
| 4     | Width chopper      | 1042 mm                                         |
| 5     | Height chopper     | 950 mm                                          |
| 6     | Capacity           | 300 kg/hr                                       |
| 7     | Approx. Weight     | 120 kg                                          |
| 8     | Engine speed       | 240 rpm                                         |
| 9     | Types of belt used | V-Belt drive                                    |
| 10    | Feeding hopper     | Length 450 mm,<br>Width 250mm,<br>Height 235 mm |
| 11    | Frame              | 550 mm in long, 430 mm in wide                  |

### Estimation of production costs

In designing and manufacturing a technology, cost

analysing is one important factor to assure the reliability and affordability of that technology. For a given system, the cost of a subsystem (performing one function) can be estimated from individual components or functional groups. These costs are added together to give the total system costs. The cost estimating technique starts from a set of engineering drawings for components of an assembly, and calculates the cost of each operation involved in component manufacturing, assembling and finishing. To minimize the cost of manufacturing processes, eliminating unnecessary operations has a great effect on it. This can be achieved through proper planning, following sequence of operation and grouping of individual operation or group of operations in succession. Grouping operations has the following advantages;

- Reduced fixed cost
- Reduced labour cost
- Less handling
- Reduced setup time
- Smaller in process inventory

Depending on the types of manufacturing process, total cost of the designed machine was determined by considering the following. The main elements of cost analysis includes

- Direct material total cost
- Standard items cost
- Direct Labour cost
- Operation cost

### Direct Material Total Cost

To determine the total cost of direct materials used in the manufacture of the animal feed chopper a material balance and flow sheet should be developed. Once the materials balances established, raw material prices must be assessed and identified. Therefore the materials and their current cost needed to manufacture the chopper were studied from the current markets.

### Cost summary of the animal feed chopper without Engine

**Table 9.1:** Cost summary of the animal feed chopper without Engine

| 1                        | 2                                  | 3                   | 4                 | 5                            | 6                                |
|--------------------------|------------------------------------|---------------------|-------------------|------------------------------|----------------------------------|
| Raw material cost (Birr) | Material wastage 2.5 % of 1 (Birr) | Machine cost (Birr) | Labor cost (Birr) | Over- head cost % 5 of 3 & 4 | Production cost (1+2+3+4+5) Birr |
| 10,136.8                 | 253.42                             | 27.37               | 190               | 10.868                       | 10,618.450                       |

### CONCLUSION AND RECOMMENDATION

Animal feed chopping machine was simple in construction as there is not so much complication in design. It is also important that velocity ratio can easily be determining

measuring number of teeth on gears. The machine was designed in such a way that it was requiring minimum space to install. As the motor was placed inside the machine stand not outside the machine, the space was considerably saved. Frame and machine stand, it can be handled safely without injury. Blades were provided with double sharpening edges. The machine was provided with motor sliding arrangement and the cutting blades can be easily chopping by operator for sharpening purpose. Machine has reduced noise and weight due to gears arrangement and compact design. Machine has casters for portability. It is also noted that the optimum results could be obtained using a capacity of has 300kg/hr chopping cutting rate. The overall dimensions of the designed animal feed chopper machine were 950mm in height, and 1042 mm in width. Economic production of designed animal feed chopper machine was simple and its costs 10,618.45 EBirr.

The following recommendation should be carried on:

- > The proposed animal feed chopper machine for feed should be fabricated and evaluation to complete the processing of feed production in small productive farms.
- > Testing of the designed animal feed chopping machine should be carried out in the actual field condition for small farms development.

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## APPENDIX

