# ‘Design & Fabrication of Paddy Threshing & Winnowing Machine at Low Cost & Low Weight’

submitted in partial fulfillment of the requirements of the course

CL 724 – Technology Design and Development Laboratory

By:


**Aniket Hulage (183100026)**

**Shreeharsha B S (18307R002)**

**Mayur Bhongade (183020032)**

**Shantanu Darveshi (183020057)**

**Indian Institute of Technology, Bombay**

# Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will cause for disciplinary action by the Institute and can evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Aniket Hulage (183100026)

Date:

Shreeharsha B S (18307R002)

Mayur Bhongade (183020032)

Shantanu Darveshi (183020057)

Acknowledgement

Any accomplishment involves the guidance and effort of many. We take this opportunity to sincerely thank all those who were involved in the successful completion of our project.

Firstly we would like to thank TATA Center for Technology and Design, IIT Bombay for having such a great learning course in our curriculum. We would also like to thank Prof. Santosh Noronha and Prof. Arindam Sarkar for giving us the opportunity to work on this project.

Also, we are grateful to Bhushan, Chetan, Rohan and Jatin who were always there to help us and guide us throughout the project. We would also like to thank Gayathri Thakoor Ma'am for supporting and guiding us whenever needed.

Last but not the least, we pay our gratitude to IIT Bombay and also to our friends who have given us an unbiased and honest opinion whenever required.

Aniket Hulage (183100026)

Shreeharsha B S (18307R002)

Mayur Bhongade (183020032)

Shantanu Darveshi (183020057)

# Abstract

This report briefly explains the work done in making the paddy threshing and winnowing machine for common farmer purpose.

The project is divided into five sections project identification and content, design, manufacturing, project evaluation, and review. Initially the guidelines for selecting project were finalized and need identification was done. While searching for the project, it is observed that, commercial threshing & winnowing machines that are available in market are with high cost, bulky, high weight, high maintenance, energy efficient, difficult to move in field. This scenario encouraged us to improve the condition by developing a solution which will serve the implied purpose of threshing & winnowing, within the constraints with little effect on the productivity. After identifying the problem, the project objectives were defined which will help us to achieve target and in a systematic manner .then data on various threshing techniques was collected. Then the material on winnowing data, methods, and applications was collected. Out of them, type of threshing and winnowing was selected, with some modifications suitable for the purpose.

The second part of the project is dedicated to detailed designing of the concepts. The conceptual model of the thresher was prepared to get idea about how the things could be put together. Conceptual model was followed by preliminary design. Preliminary design was analyzed using ANSYS 15.0.

Third phase of the project comprises material survey, material procurement and actual fabrication.

Final stage of the project includes project evaluation and review. Here product development system for the project was analyzed and actual costing was prepared. Some technique like network diagram, actual activity charts for the project and process evaluation was also used.

The major features of the thresher are its innovative design and cost effectiveness for the same type. Comparing the newer product with the existing one, it is found that this product can be promoted in view of its improved efficiency. This project has a societal quotient and will have positive impact on agricultural industry, if practiced at large scale.

# CONTENTS

## SECTION II – DESIGN

# LIST OF FIGURES / FIGTURES

# LIST OF TABLES

# LIST OF SYMBOLS / ABBREVIATIONS

| Symbol | Name |
|---|---|
| HP | Horse power |
| ASME | American Society of Mechanical Engineers |
| RPM | Revolutions per Minute |
| W | Watt |
| $\omega$ | Angular velocity |
| Rad | Radian |
| N | Newton |
| m | Meter |
| T | Torque |
| P | Power |
| I | Mass Moment of Inertia in kg.m2 (M.I.) |
| r | Radius |
| D | Diameter |
| H | Height |
| $P_{cr}$ | Critical buckling load in N |
| E | Young's modulus of elasticity |
| $L_e$ | Effective length |
| b | Breadth |
| d | Depth |
| $F_{r1}$ | Radial load |
| $Fr_2$ | Radial load |
| $L_{10}$ | Life of bearing in million revolution |
| $L_{10h}$ | Life of bearing in hours |
| $C_1$ | Dynamic load carrying capacity |
| $C_2$ | Dynamic load carrying capacity |

| | |
|---|---|
| $C_0$ | Static load |
| FMEA | Failure mode effect analysis |
| RPN | Risk priority number |
| S*O*D | Severity* occurrence*detection |
| BOM | Bill of material |
| MS | Mild steel |
| STD | Standard |

## SECTION I

# PROJECT IDENTIFICATION

# AND CONTENT

## SECTION CONTENTS

# CHAPTER 1

# PROJECT IDENTIFICATION

## 1.1 BACKGROUND

Taking the reference from the definition of the project, it was decided to undertake a project which comprises all aspects of the project management. The idea was to undertake a project having all aspects of project management, from the need identification, idea generation, selection and comparison of the ideas, conceptual and preliminary design, engineering and CAD drafting, analysis, final design, market survey and costing, purchasing, inspection, fabrication, testing, modifications. Hence all the areas of project management are covered in the project like Planning, Organizing, Controlling and Directing. The outcomes of this work will be also beneficial form Entrepreneurial point of view as well.

Keeping all the above things in mind, the flaws were searched in various fields, where one can apply knowledge gained from the academics and also would be able to utilize the best of quality and ability to tackle the things in most appropriate manner. So searching started for the potential problems which could be solved at student level itself. So keeping in mind requirements of the project, search for the problem was started, which would include all above things, i.e. from engineering design to the fabrication. First search was conducted in the laboratories so that some instruments or testing rig can be. But there, there was not any potential project and survey for the project was continued.

Finally the problem was identified for which the solution would be project and that will fit into the predefined framework of the project. All the stages that get followed, while commencing the project, are explained in all upcoming chapters. All aspects of the project management are tried to cover in this project.

## 1.2 PROBLEM IDENTIFICATION

The survey was carried out in Nanapeth and Bohari-ali area, Pune. It was observed that thresher machines available in market are large in size, and bulky. Following photographs gives the idea of current situation.

Fig .1.1- Hindustan Industries thresher Fig .1.2- MOHINI Industries thresher

It is a known fact that in the rural area, most of the farmers do threshing and winnowing operations manually resulting in the human fatigue. This scenario affects the yield output & productivity. Following Figures gives the idea about it.

Fig .1.3- Threshing operation in general

Fig .1.4- Paddy threshing

Fig .1.5- Winnowing operation

Fig .1.6- Paddy winnowing

| | |
|---|---|
| COST OF MACHINE | Rs 20000-Rs 30000 |
| MINIMUM COST | Rs 12000 |
| WEIGHT OF MACHINE | 150-200 kg |
| MINIMUM WEIGHT | 125 kg |

Table 1.1 Market survey

Machine cost is relatively high as compared to the standard of living of ordinary farmer. To carry, heavy weight machines in farm, to maneuver them, great amount of work has to be done. Space constraints also come into account, if we take farmer's home into account, so dimensional constraints are involved in model design.

So it is a potential problem in the field of threshing and winnowing. After intensive survey and visit to field sites, a need to build an arrangement for threshing and winnowing within observed constraints was spelled.

Then the literature survey is carried out in the field of threshing and winnowing and found that, there are various arrangements, which will be helpful for this purpose. Here the problem was size of machine, cost of machine, weight of machine, human fatigue and space constraints for heavy machine. So decision was taken to solve them.

## 1.3 PROBLEM IDENTIFIED

From all of observations above, the problem was identified and certain arrangement development must be done which will helpful to serve the implied needs of the threshing and winnowing, on the farm.

1. Detailing about the objectives of the project is depicted in the chapter no. 4.

2. Major tools used for this were Brainstorming and Data Collection.

# CHAPTER 2

# THRESHING & WINNOWING - AN OVERVIEW

After identifying the problem, collection of data on the threshing and winnowing for their various aspects, was done to find out the suitable type, which will suit as solution to the problem

## 2.1 DEFINITION AND SCOPE OF THRESHING & WINNOWING

### 2.1.1 Threshing

Threshing is the process of loosening the edible part of cereal grain (or other crop) from the scaly, inedible chaff that surrounds it. It is the step in grain preparation after harvesting and before winnowing, which separates the loosened chaff from the grain. Threshing does not remove the bran from the grain.

Threshing may be done by beating the grain using a flail on a threshing floor. Another traditional method of threshing is to make donkeys or oxen walk in circles on the grain on a hard surface. A modern version of this in some areas is to spread the grain on the surface of a country road so the grain may be threshed by the wheels of passing vehicles.

Hand threshing was laborious, with a bushel of wheat taking about an hour. In the late 18th century, before threshing was mechanized, about one-quarter of agricultural labor was devoted to it.

Industrialization of threshing began in 1786 with the invention of the threshing machine by Scotsman Andrew Meikles. Today, in developed areas, it is now mostly done by machine, usually by a combine harvester, which harvests, threshes, and winnows the grain while it is still in the field. The cereal may be stored in a threshing barn or silos. A Threshing Bee is a festival held in communities to commemorate this process. The event is often held over multiple days and includes flea markets, hog wrestling, and dances.

### 2.1.2 Threshing machine

The threshing machine, or, in modern spelling, threshing machine (or simply thresher), was first invented by Scottish mechanical engineer Andrew Meikles for use in agriculture. It was devised (c.1786) for the separation of grain from stalks and husks. For thousands of years, grain was separated by hand with flails, and was very laborious and time consuming, taking about one-quarter of agricultural labor by the 18th century. Mechanization of this process took much of the drudgery out of farm labor.

### 2.1.3 History of threshing machine

The Swing Riots in the UK were partly a result of the threshing machine. Following years of war, high taxes and low wages, farm laborers finally revolted in 1830. These farm laborers had faced unemployment for a number of years due to the widespread introduction of the threshing machine and the policy of enclosing fields. No longer were thousands of men needed to tend the crops, a few would suffice. With fewer jobs, lower wages and no prospects of things improving for these workers the threshing machine was the final straw, the machine was to place them on the brink of starvation. The Swing Rioters smashed threshing machines and threatened farmers who had them. The riots were dealt with very harshly. Nine of the rioters were hanged and a further 450 were transported to Australia.

Early threshing machines were hand-fed and horse-powered. They were small by today's standards and were about the size of an upright piano. Later machines were steam-powered, driven by a portable engine or traction engine. In 1834, John Avery and Hiram Abial Pitts devised significant improvements to a machine that automatically threshes and separates grain from chaff, freeing farmers from a slow and laborious process. Avery and Pitts were granted United States patent #542 on December 29, 1837. [2]

### 2.1.4 Wind Winnowing

Wind winnowing is an agricultural method developed by ancient cultures for separating grain from chaff. It is also used to remove weevils or other pests from stored grain. Threshing, the loosening of grain or seeds from the husks and straw is the step in the chaff-removal process that comes before winnowing.

In its simplest form it involves throwing the mixture into the air so that the wind blows away the lighter chaff, while the heavier grains fall back down for recovery. Techniques included using a winnowing fan (a shaped basket shaken to raise the chaff) or using a tool (a winnowing fork or shovel) on a pile of harvested grain. Winnowing can also describe the natural removal of fine material from coarser sediment by wind or flowing water, analogous to the agricultural separation of wheat from chaff.

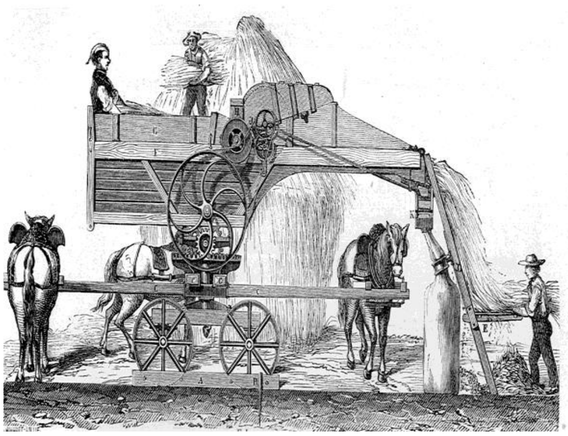

Fig .2.1- threshing in work

Fig .2.2- winnowing in work

### 2.1.5 Factors affecting the selection of the threshers

The selection of the thresher requires the attaining the proper balance between the production problem, the capabilities of the thresher available and the human element involved. The ultimate aim is to arrive at highest crop yield with minimum cost input. Thresher factors to be taken into consideration include the following.

1. **Adaptability** The load carrying characteristics of the thresher should fit for requirement.

2. **Flexibility** Wherever possible, thresher should have flexibility to handle more than one crops

3. **Load capacity** Thresher selected should have great enough load carrying capacity to do the job effectively, yet should not be too large and results in excessive operating costs.

4. **Power** Enough power should be available to do the job.

5. **Speed** Rapidity of the movement of paddy bundle, within the limit of production process, or plant safety should be considered.

6. **Space requirements** The space required to install or to operate thresher is the important factor in the selection of the thresher.

7. **Supervision required** As applied to thresher selection, this refers to the degree of automatically designed into the thresher.

8. **Ease of maintenance** Thresher selected should be easily maintained at reasonable cost.

9. **Environment** Thresher selected must conform to any environment regulations.

10. **Cost** The consideration of the cost of the thresher is an obvious factor in its selection.

## 2.2 PRINCIPLES OF THRESHING

A good practice in threshing is to follow some principles to bear on the solution of threshing problems or the design of threshing systems. These principles of threshing are briefed as follows

1. **Planning principle**

All kinds of threshing operations should be the result of a deliberate plan where the needs, performance objectives and the functional specification of the proposed methods are completely defined.

2. **Standardization principle**

Threshing methods, equipment, controls and software should be standardized within the limits of achieving overall performance objectives and without sacrificing the needed flexibility, modularity and throughout anticipation of the changing future requirements.

3. **Work principle**

Threshing work should be minimized without sacrificing the productivity.

4. **Ergonomics principle**

Human capacities and limitations must be recognized and respected in the design of threshing task and equipment to ensure safe and effective operations.

5. **Unit load principle**

Unit load shall be appropriately sized and configured in way which achieves threshing and inventory objectives at each stage in the chain.

6. **Space utilization principle**

Effective and efficient use must be made of all available space.

7. **System principle**

Threshing operations and storage activities should be fully integrated to form the coordinated operational system.

8. **Automation principle**

Threshing operations should be mechanized and/or automated where feasible to improve operational efficiency, increase responsiveness, consistency, and predictability.

9. **Environmental principle**

Environmental impact and the energy consumption should be considered as the criteria when designing or selecting the alternative equipment and the threshing system.

10. **Life cycle cost principle**

A thorough economic analysis should account for the entire life cycle of all threshing equipment and resulting systems.

## 2.3 IMPORTANCE OF USING THRESHERS

The foremost importance of the threshing by machine is that it helps productivity and thereby increases the profitability to the farmer. Many farmers go out of business competition at market because of quality of threshing operation. In many instance it is seen that, competitors are using same or similar threshing equipment and one who uses the improved quality thresher, stays ahead of their competitors. A well-designed thresher system attempts to achieve the following

- Improve the efficiency of the threshing system and farmer can supply right quantity of threshed crops, at right place, at right time, most economically
- Cut down the indirect labor cost
- Reduce damage of grains during threshing

- Maximize of space utilization as compact threshers occupy less space as compared to conventional threshers
- Reduce overall cost
- Improve customer services
- Increase in the market value for the products

## 2.4 PROBLEM DEFINITION

To design and fabricate paddy thresher and winnower at low cost and low weight which is portable and compact. In addition to this, following dimensions must be incorporated in it. These are well designed, balanced, reliable, rigid in construction, easy to fabricate.

Combine unit of paddy thresher and winnower will be designed with following specifications[1]

1. **Desired capacity** - 50 kg/hr.

2. **Weight** less than 30 kg

3. **Cost to farmer** less than 6500 Rs.

4. **Dimension constraints (floor area)** - 1m×1m

5. **Dimension constraints (height)** - 1.5m

# CHAPTER 3

# STUDY OF PADDY THRESHERS AND WINNOWERS

As per the definition of the problem, paddy thresher and winnower for the given purpose is selected. A rigorous study started on the threshers by collecting the detailed information on the various types of threshers, their capacity and area of application, suitability, which will help to select type of thresher for the identified problem.

## 3.1 INTRODUCTION

### 3.1.1 Thresher Specification

During farm testing and discussions with farmers, a number of key factors were identified which are important to consider when evaluating the suitability of a small-scale threshing machine.[3]

1. **Threshing Rate**

The primary aim of threshing machines is to reduce the labor required for the threshing process. Farmers indicated that the overall threshing rate is more important than the rate per person, as paddy must be threshed as soon after harvesting as possible. Once threshing rate is accurately determined, this may be used for an economic analysis of the threshing method.

2. **Threshing Losses**

IRRI defines threshing losses as scattering loss, threshing loss and grain breakage (IRRI, 2009). While these losses may be significant for industrial scale machines, it was found that detailed measurement of these factors was not practical or particularly informative when testing small-scale machines. The farmers themselves are a good judge of threshing quality and therefore can be asked to evaluate the output and threshing loss instead of using quantitative measurements.

3. **Versatility**

Hand threshing is relatively insensitive to a range of variables such as the paddy variety, length or moisture content. These variables may affect the performance of threshing machines, and therefore machines should be tested under a range of operating conditions and paddy should be characterized as far as is practically possible.

4. **Output Quality**

Output quality is determined by the amount of chaff/straw and dummy grains mixed with the paddy. Generally it was found that farmers do not mind additional dummy grains being mixed with the paddy, as these will absorb moisture during paddy storage and will not significantly increase winnowing time. However machines which winnow out the straw will reduce the time required to collect the paddy post threshing.

5. **Portability**

Portability is a key factor for access to farms which may not have direct road access, and to enable farmers to share or lend out a machine.

6. **Power Source**

Electric motors are cheaper to run than diesel motors, and many farmers have subsidized electricity rates and single phase supplies. Due to power cuts and off the grid farms, it is useful if the machine has a back-up power source, such as pedaling. To save the cost of buying a new motor, consider testing existing motors available on a farm, for example a tiller.

7. **Ease of use**

Factors such as if women can use the machine, the ease of collecting the paddy (scattering) and the effect of the machine on the rest of the threshing process should be considered. For example, feed in threshers required sudis to be untied prior to threshing and output a pile of mixed straw. Some farmers may wish to maintain the sudis bunches as this is how straw is sold.

8. **Safety**

Exposed rotating parts are common on threshing machines, and users should be warned to tie back loose clothing and take relevant precautions.

9. **Cost**

Both the purchase and running cost of the machines should be considered, as well as the cost of additional components such as motors. Farmers will often inquire if there is a government subsidy when considering purchasing machinery. [7]

Other factors to consider are the availability of spare parts and ease of machine maintenance. The quality and finish of the machine has also been identified as important if farmers. Farmers may not be willing to invest in a machine which is built from, and looks like, a collection of recycled materials.

## 3.1.2 Threshing Methods

Small-scale mechanical threshing methods may be grouped into two categories; hold on threshers and feed in threshers. Both types of thresher were tested, alongside hand threshing.

1. **Hand Threshing**

Traditionally, a group of farmers and laborers will beat bundles of straw called "sudis" over a wooden board.

2. **Hold-on thresher**

Holds on threshers consist of an open rotating drum with teeth which will comb the sudis, stripping the paddy from the straw shoots. The drum may use peg teeth or wire hoops to comb. The operator grips the base of the sudi and holds the straw against the drum to be threshed.

**Fig.3.2 – Model 1 machine**

**Fig 3.3 – Selco Foundation machine**

Two hold on threshers were tested; an open drum machine with wire hoops which was bought from West Bengal, and an enclosed, peg-tooth machine designed by the Selco foundation and built locally. Each machine was powered by a 1/2hp electric motor, and the Model 1 machine may also be powered by pedaling. Drums are about 3ft long.

3. **Feed-in thresher**

The crop is fed into a feed-in thresher, and the straw circulates between a rasped drum and the casing, causing the paddy to fall through a grate into a collection chute. Feed-in threshers may be tangential flow, or axial flow. [4]

# CHAPTER 3

# STKEHOLDER ANALYSIS

This section describes our methodology used in identifying, interacting and obtaining insights from stakeholders. While choosing our project we did know the ground reality of farmers and the problems they face in threshing and winnowing, so our interaction with then was crucial for need validation.

For the purpose of our analysis we contacted 6 small scale farmers near Nagpur. These farmers are engaged in rice cultivation. The method of interaction were telephonic interviews, wherein we asked the farmers a common set of questions and their responses were recorded. The questions were.

- What crops do you grow?
- How much land (in acres) do you cultivate?
- Do you own the land or do you lease it?
- Do you own a threshing machine or do you rent it?
- What are the problems that you face while threshing and winnowing?

The farmers in our sample space all owned the land they cultivated, and as mentioned above, relied on rice cultivation as the main source of sustenance. While the medium scale farmers (land holding>4 acres) said they own a threshing machine, the small scale farmers said they rent the machine during harvest. The insights from the latter category were most beneficial since our machine is targeted towards farmers with low landholdings and low income.

From our discussion we identified 2 major problems that were faced by farmers during threshing and winnowing. First, the rental shops are present in the town so the farmers have to go there pick up the machine and return it. The weight of the machine is around 200-250 kg so moving it by hand is not possible so the farmers rent a tractor just for transportation of the machine for which they incur additional cost. Second, We asked the farmers why do they continue to rent when it would be cheaper to buy the machine in the long run. The response was that the machines are too expensive, typically ₹40,000+.

When we asked them would they be interested to buy a machine that was light weight and cheaper than the ones currently in the market they said they would be interested only if the price was less than ₹20,000.

Our solution addresses both these issues. The weight of our machine is less than 50kg, and the cost of manufacturing the prototype was around ₹15,000. Much of the cost that we incurred was from having to laser cut some key components that were too complex to be cut by hand. If the production is done on an industrial scale the cost will certainly decrease even further.

# CHAPTER 4

# PROJECT CONCEPT AND DETAILING

## 4.1 APPROXIMATE COSTING OF THE PROJECT

Before going to actual fabrication, estimation of the cost for all the components is done. The purpose is to make the threshing unit cost effective without compromising the design features.

Table 4.1 Approximate Project Cost

| **Sr No.** | **Component/material** | **Cost(Rs.)** |
|---|---|---|
| 1 | Motor | 1200 |
| 2 | Belts | 300 |
| 3 | Bearings (2 no.) | 200 |
| 4 | Wire mesh (3 no.) | 200 |
| 5 | Angle plates | 500 |
| 6 | Laser cutting | 1000 |
| 7 | Press fitting | 500 |
| 8 | Manufacturing cost | 1000 |
| 9 | Labor cost | 500 |
| 10 | Material cost | 1000 |
| 11 | Miscellaneous | 500 |
| | **Total** | **6950** |

## 4.3 PROCESS FLOW CHART

Activity chart helped in dividing whole project work in various activities by completing which the project will be completed successfully within a time frame. The activities are planned and a process flow chart is prepared to get an idea how the things could be completed without disturbing other activities. The process flow chart prepared is shown below.

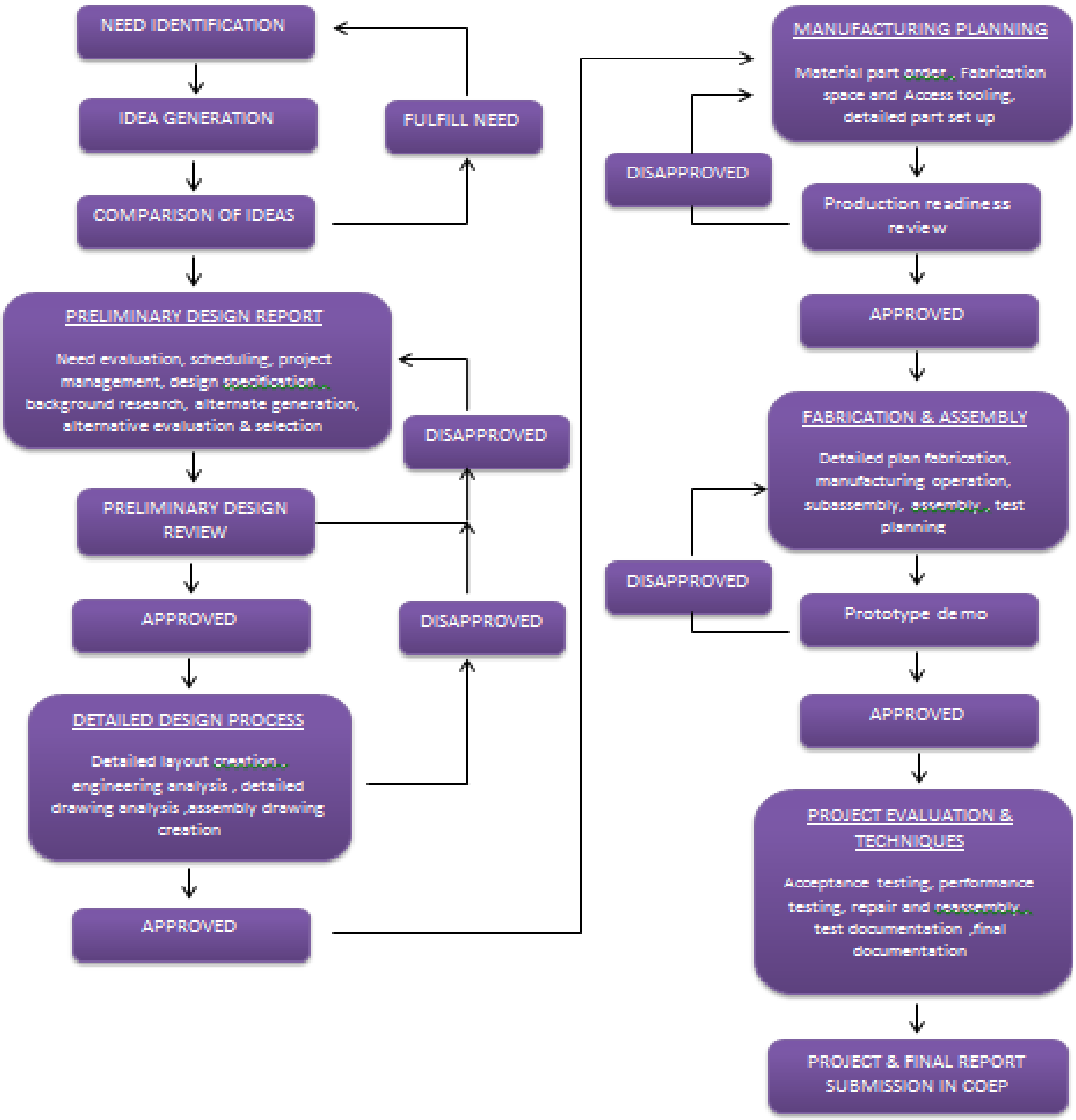


Fig .4.1. Process flow chart

## SECTION II

# DESIGN

## SECTION CONTENTS

1. DESIGN AND ENGINEERING CONTENT
2. ANALYSIS
3. BILL OF MATERIALS

# CHAPTER 5

# DESIGN AND ENGINEERING CONTENT

## 5.1 BRIEFING OF DESIGN CONTENT

Design of thresher includes designing the critical components which are taking direct and indirect loading. The design is done to reduce the overall cost and weight of the machine. Final design is done on the basis of material suitability as well as availability.

Another important thing in design is to selection of standard components which will be directly purchased from the market.

### 5.1.1 Details of design of various parts and components [1]

1. **Cutting pin**

**Purpose** This component does the cutting action. It will separate paddy grains from the paddy bundle.

**Design Details** According to design data book for thresher machine, the selection of cutting pins depends on the type of crop to be threshed, the diameter of drum and the speed of rotation of drum. Here standard screws were selected. These screws will be welded to strips upside down by special welding process.

2. **Strips**

**Purpose** It is the rotating part on which the cutting pins will be welded

**Design Details** The optimization of the diameter of the strips drum is done on basis of power available at the output of unit pulley. The minimum number of strips is determined by guess as 8 and then it is crosschecked with the optimized diameter of the drum. If the diameter of the drum comes to be more or less, the no. of strips will be increased or decreased accordingly. The thickness of the drum strips is determined to make possible the welding of screws unit. Surveys are done to find out availability of thickness of the sheet metal in market and it is selected as 1 mm. Here the consideration is made to remain the weight of strips low to avoid overloading and slipping of belts

3. **Side disc**

**Purpose** To fix the strips welded with screws to form the rotating drum.

**Design Details** All the strips are to be fixed to the discs by nut and bolt arrangement. A provision is made to fit the rotating shaft through holes made at centers of disc. A half keyway will be made in that part. The thickness of the disc is selected as 1mm.

4. **Side casing plates**

**Purpose** To act as a fixed support to the rotating drum.

**Design details** The side casing plate should be rigid enough to withstand vibrations created due to rotation of the drum and to resist the buckling. The various direct and indirect loads coming on it are found. Using Euler’s theory of buckling, its thickness is verified for safety with the selected thickness. The side cutting plates are to be fixed to the base table strips by nut bolt arrangement.

5. **Weld bearing disc**

**Purpose** To accommodate the bearing on the shaft.

**Design details** The bearing may be fitted to the side disc itself but it will need the thickness equal to the thickness of the bearing. And it will increase the overall weight of the assembly. So the idea of to use side plates of less thickness and weld bearing disc to accommodate the bearing was finalized.

6. **Unit pulley**

**Purpose** To transmit power with required reduction ratio.

**Design details** The thickness of the unit pulley must be equal to the thickness of the motor pulley which was equal to 10 mm. The diameter of unit pulley is determined from reduction ratio. To make is easy from manufacturing point of view and make it as lighter as possible, material is removed much as possible without compromising strength.

7. **Electric motor**

**Purpose** To provide power for threshing and rpm for winnowing operation

**Design details** It is a standard component and its selection is the most important point in the design procedure. To keep price of model below 7000 such a motor has to be selected which will be of low cost and satisfies desired objectives.

From the design data book available for the for the paddy thresher machine, the maximum speed limit of the rotating drum should lie between 700 to 900 rpm for smooth grain separation without much damage to the grains. According to the survey made, the various motor available are

Table 5.1 Comparison of various motors

| | Raison | Samrat | Sagar | Export | Himalaya |
|---|---|---|---|---|---|
| Power requirement | 1/12HP | 1/16 | 1/20 | 1/20 | 1/12 |
| Volts | 220/230 | 220/230 | 220/230 | 220/230 | 220/230 |
| Ampere | .75 | .60 | .50 | 0.60 | 0.75 |
| RPM | 8500 | 2800 | 6000 | 450 | 9000 |
| Price(Rs.) | 1500 | 4000 | 3000 | 2000 | 1200 |

Out of the available motors, Himalaya motor is selected which provides the necessary torque required for the operation.in the case of other motors, either their cost was more or the power requirement is high.

8. **Motor bases**

**Purpose** To mount the motor in such a way that the motor should move forward and backward to adjust bet tensions.

**Design details** There are two motor bases 1 and 2. The motors mounted on the abase 1 and this combined unit is then assembled to the base 2. The arrangement is made movable .The holes are made at places to fix the motor position by nut bolt. Slots are made to remove the extra material without compromising its strength.

9. **Hollow Shaft**

**Purpose** To support rotating drum and transmit power.

**Design details** Various loads coming on the shafts are determined and diameter is found by ASME standards methods. It comes to be very less (5.49 mm). So the shaft of greater diameter available in the market is used.

10. **Filter unit**

**Purpose** To separate threshed paddy grains from the husk and to collect them separately.

**Design details** the grains should be separated from husk in at least 3 stages. Each stage must have different size of filter meshing decreasing size of holes from up to down. Also to give vibrations to the filter to help the filtering action, the lower end of the filter assembly is set free and the winnowing box is attached at the end. Winnowing box is fitted with the winnowing fan driven by the motor. To make additional use of gravity aiding the filtering action the filters are arranged at slope of some degrees in zigzag manner. The arrangement is made like dust removal, lock plate etc., to remove the husk stored in the each filter unit time to time .The angle is chosen such that the height of the unit will not increase more.

11. **Base Table**

**Purpose** To mount whole threshing and winnowing assembly.

**Design details** Table is made of strips to reduce overall weight. Also the strips should withstand the overall weight of threshing unit, motor etc. There should not be more vibrations in the table. It should be rigid enough in static and vibration failure.

12. **Bearing**

**Purpose** To reduce the friction &smooth noiseless operation..

**Design details** The design and selection procedure of the bearing depends upon the diameter of the shaft, static and dynamic load, load factor etc.

13. **Washers**

**Purpose** To absorb the vibrations due to motor and other rotating parts.

**Design details** The speed of motor at input is high which creates a lot of vibrations in assembly. To reduce these vibrations, the rubber washers of 1mm thickness, cut to the shapes are used at the bottom.

.

## 5.2 DETAILED DESIGN

Based on the background of the criticality of every component and conceptual model, design of each critical component and structure of the thresher unit is started. Following parts of the unit are critical and are designed before their selection.

1. Threshing drum

2. Hollow shaft

3. Belt

4. Side casing plate

5. Bearing Selection

6. Winnowing Fan selection

7. Unit pulley

### 5.2.1 Design of Threshing Drum

Power of motor = 1/12 HP = $746\times\frac{1}{12}$ = 62.17 W

Assuming loss factor of motor = 0.1

Actual power available = 0.9 × 62.16 = 55.95 W

For belt drive, Transmission efficiency = 90% [1]

∴ **Power available at rotating unit pulley = 0.9 × 55.95 = 50.36 W**

Output RMP of the drum = 800 rpm (problem statement)

∴ Output rpm for which pulley to be design = 800 rpm

Rated RPM of motor = 9000 rpm

Actual rpm of motor = 8895 rpm (on measurement)

Use factor = 1.1[1]

RPM of motor on loading = 8895/1.1 = 8086

∴ Reduction ratio = 8060/800 ~ 10

∴ **Reduction ratio selected = 10**

Power = torque × ω

$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 800}{60} = 100.53$ rad/s

Torque available at unit pulley is

$T = \frac{50.36}{100.53} = 0.50$ N-m

## 5.2.2 List of rotating parts

Strips, side discs, nut bolts, hollow shaft, screws, these are the rotating parts of threshing drum. These parts have considerable mass moment of inertia. So their mass moment of inertia is taken account while writing energy equation.

$P = \frac{1}{2} I\omega^2$

$\therefore\ 50.355 = \frac{1}{2} \times I \times \omega^2$

$\omega = 100.53$ rad/sec

$\therefore\ I = \frac{50.355 \times 2}{100.53^2} = 9.96 \times 10^{-3}$ kg-m$^2$

The sum of mass moment of inertia of all rotating parts must be equal to calculated value of

$I = 9.96 \times 10^{-3}$ kg-m$^2$

**1. M.I. for strips**

The H / D ratio for drum = 1.2[1]

r = D / 2 is to be optimized.

Let no. of strips = 8

Thickness of one strip = 1 mm

Length = H = 1.2 × D=2.4 × r

Width = r / 5

Volume of one strip = $2.4 \times r \times r / 5 \times 1 \times 10^{-3} = 0.48 \times r^2 = 4.8 \times r^2 \times 10^{-4}$

Mass of strips = density × volume = $(7850 \times 4.8 \times r^2 \times 10^{-4}) \times 8 = 30.144 \times r^2$

M.I. of strips = $MR^2 = 3 \times 10^{-5} r^2 \times r^2 = 30.144 \times r^4$

**2. M.I. for plane side discs (2 no.s)**

Mass = $(7850 \times \pi \times r^2 \times 1 \times 10^{-3)} \times 2 = 49.32 \times r^2$

M.I. of side discs = $MR^2/2 = 24.66\times r^4$

**3. M.I. for nut bolt**

M.I. of nut bolts = 10% of M.I. of discs = $2.466 \times r^4$

**4. M.I. of cutting pin**

M.I. of cutting pin = 20 % of M.I. of strips = $6.03 \times r^4$

**5. M.I. of hollow shaft**

Average radius of shaft = (8+5) / 2 = 6.5 mm

Mass = Area × Length × Density = $\pi \times (64\text{-}25) \times 240 \times 10^{-9} \times 7850 = 0.230$ kg

M.I. of hollow shaft = $MR^2 = 0.23 \times 6.5^2 \times 10^{-6} = 9.72 \times 10^{-6}$ kg-m$^2$

Total M.I. = $3\times10^{-5} \times r^4 + 2.466 \times 10^{-11} \times r^4 + 2.466 \times 10^{-12}\times r^4 + 6 \times 10^{-6} \times r^4$

$+ 9.72 \times 10^{-6} = 9.96 \times 10^{-3}$

r = 0.112 m = 112 mm

So r = 100 mm is selected to avoid overloading on motor.

∴ Mass of strips = $30.144 \times r^2 = 0.30$ kg

Mass of plane disc (2 no’s) = $49.32 \times r^2 = 0.49$ kg

Mass of nut bolts = 10% of plane disc = 49 gm[1]

Mass of hollow shaft = 0.23 kg

Mass of cutting pins = 20% of strips = 60 g[1]

Assuming allowances and clearance for assembling the drum on the frame

Total length of the shaft = 240 + (40 + 40) +30 = 350 mm

Mass of shaft = 336 gm

We used a custom made unit pulley. Through continuous optimization of the pulley in ANSYS, the weight of unit pulley = 700 gm

Mass of drum = Mass of strips + mass of side plates + mass of nut-bolts + mass of cutting pins = 1.13 kg

### 5.2.3 Design of side casing plates based on buckling

Cross section of the casing plate = $300 \times 0.8$ mm$^2$

Total load on the casing plates = mass of shaft + mass of drum + mass of unit pulley + mass of hands (2.5kg) = 4.666 kg

∴ Weight on each plate = 2.333 kg.

Let additional weight of 200 gm on the plate near to the unit pulley, weight carried by the plate = 2.533 kg × 9.81 = 25 N

Here the case is of one end fix and other end is free

∴ $L_e = 2 \times L = 2 \times 135 = 270$ mm

$P_{cr} = \frac{\pi^2 EI}{{L_e}^2}$

$I = b \times d^3 / 12 = (300 \times 0.8^3 / 12) \times 10^{-12} = 1.28 \times 10^{-11}\ m^4$

∴ $P_{cr}$ = 28.88 N which is more than the total weight coming on the plate

∴ The cross section 300×0.8 mm$^2$ is safe.

### 5.2.4. Design of hollow shaft

From the procedure applied according to ASME standard for steel(maximum shear stress theory), the diameter of shaft comes to be 5.49 mm which is to less so a hollow shaft of inner diameter 10mm and outer diameter 16mm, available in the market is selected.

### 5.2.5. Bearing Selection and design [1]

Bearing type Single row deep groove ball bearing

Diameter = 10 mm

Rpm = 800

Expected life = 2500 hours

There is no axial load

Radial load $F_{r1} = \sqrt{1.85^2 + 1.355^2} = 2.29 \times 9.81 = 22.50$ N

$Fr_2 = \sqrt{0.35^2 + 0.085^2} = 0.36 \times 9.81 = 5.53$ N

Dynamic load capacities are

$P_1 = F_{r1} = 22.5$ N

$P_2 =$ Fr2 = 5.53 N

$L_{10} = \frac{6onL10h}{10^6}$ = 120 million revolution

Considering load factor = 1.2 (Light weight with impact loading)

$C_1 = P_1 \times L_{10}^{1/3} \times 1.2 = 133$ N

$C_2 = 5.53 \times 120^{1/3} \times 1.2 = 32.73$ N

From bearing catalogue

Bearing No.61800 (C = 1480 N, $C_0$ = 630 N) is suitable as both bearing.

## 5.3 ERGONOMICS PRINCIPLES IN DESIGN

Manual threshing task may expose the worker to physical risk factors. If these tasks are performed repeatedly or over a long period of time, they can lead to fatigue and injury. Injury to the back, shoulder, wrist, hands, or the other parts of the body may occur. Injuries may include damage to muscles, ligaments, nerves etc. The main risk factors or conditions, associated with the development of injuries include

1. Awkward postures (e.g. bending)

2. Repetitive motions (e.g. frequent left right motion of hand)

3. Static posture (e.g. maintaining a fixed posture for a long period of time)

Repeated and continuous exposure to one or more of these factors may lead to fatigue and discomfort. Overtime, injury to the back, shoulder wrist, hands or other parts of the body may occur. Injuries may include damage to muscles, ligaments, nerves etc. This thresher design focus on reducing manual handling risk.

### 5.3.1 Hand operated Threshing and winnowing Equipment Design fundamentals

**1. Not too wide**

Hand operated threshing machine should be maximum 300 mm wide so that the working region is within a limit of the worker.

**2. Not too high**

Maximum height of 1200 mm is recommended to make the work done in sitting or standing position.

**3. Not too light**

The overall weight of the assembly should not too low so that the 4 legs of the table will remain steady under operating condition even though there are vibrations.

**4. Not too heavy**

This is the main objective of the project not to make product too heavy. Any manually operated machine which is too heavy to move conveniently remains unused or people may suffer problem. [6]

## 5.4 ERGONOMIC CONSIDERATIONS APPLIED IN CURRENT DESIGN

1. The working height of unit is made up to the waist of normal human being so that the worker can work either in sitting or standing position.

2. Arrangement is done in front casing so that operator can work with keeping his hands comfortably on the plates and his hand will not go inside the working area to avoid injury due to rotating parts

3. Upper safe mesh is provided to see the worker what is going on inside.

4. Belt drive is selected for easy maintenance and replacement

5. Nut bolt arrangements are used to assemble/dissemble the unit easily.

6. Special arrangements are made in filter unit to remove dust easily and time to time.

7. The whole unit is made portably light weight.

8. Sharp edges are removed.

9. Adequate space provision is considered for the operator to work on the unit and for movement of paddy bundle.

## 5.5 AESTHETIC CONSIDERATION IN DESIGN

Judgment of aesthetic value can become link to judgment of economic and moral value of the project.

So it is essential to design aesthetic in a project in order to get market value and to sell a product in market.

Color is a factor in design that can greatly affect the mood of the target market and therefore a design’s appeal.

### 5.5.1 Color code

1. **Yellow** -Caution

Possible use conveying brightness and energy.

2. **Black** - Elegance and sophistication

Possible use conveying classic or sleek design

3. **Grey** - A conservative outlook

Possible use to suggest straightforwardness of plain.

# CHAPTER 6

# ANALYSIS

## 6.1 PROCEDURE FOR ANALYSIS

After finishing the design of threshing and winnowing unit as briefed in previous chapters, the unit is checked for any failures by doing analysis of it. This analysis was done by using ANSYS WORKBENCH 15.0.It helped in analyzing the structural parts with the option of material selection and its properties.

.

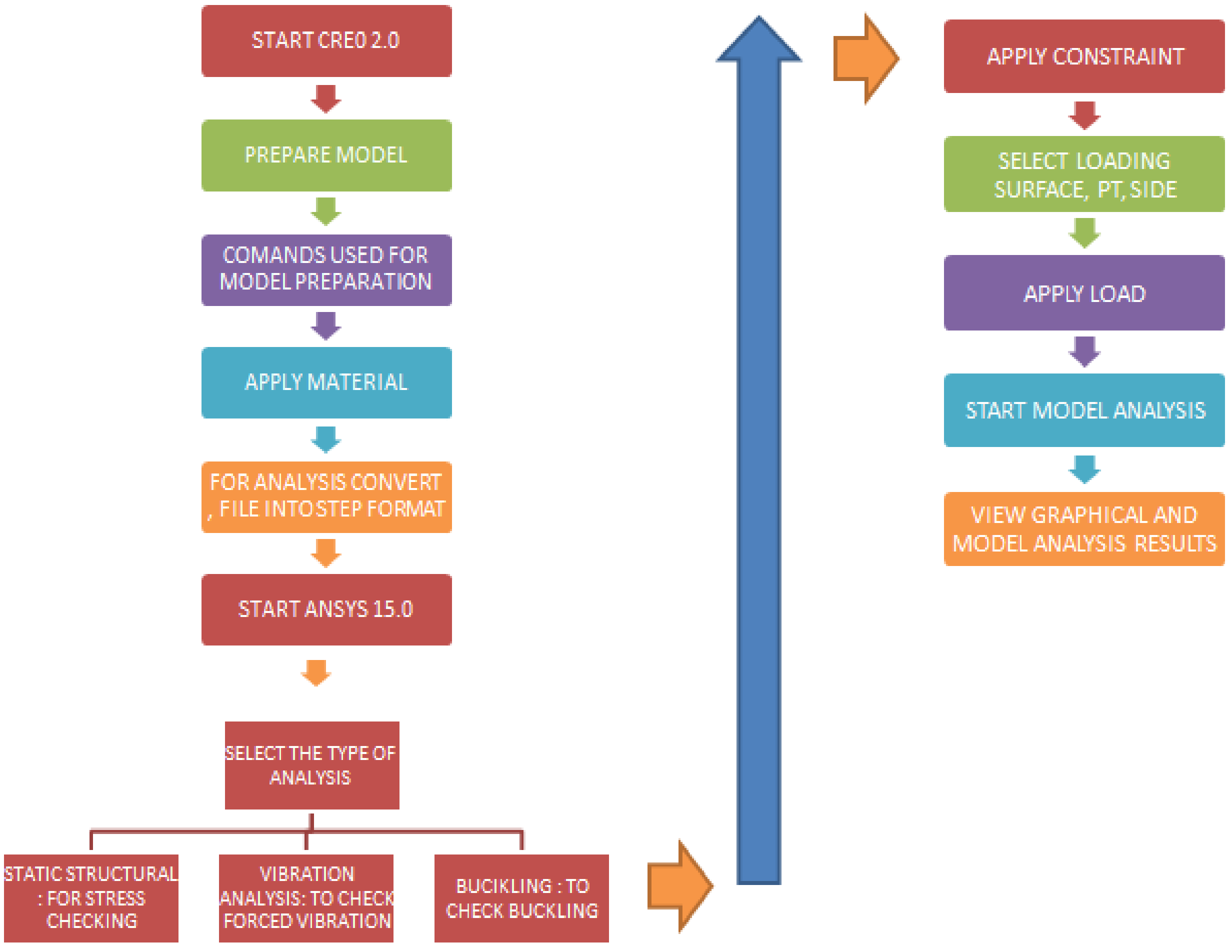


Fig .6.1 . Procedure for Analysis

## 6.2 RESULTS

Based on the process explained above, the analysis of the unit is carried out. The results obtained are shown in the figures below.

The various constraints, types of loads, point or the surface where the load is needed to apply, fixed surface in the structure etc. were specified

As seen in the Figures below, we found that design is safe for all conditions. All the stresses coming on the unit were within the safe range. On the top left side of each drawing, the scale of stresses is provided which helps to interpret the colors obtained in the results.

3 methods: stresses induced by Von Mises method, displacement method, maximum principle stress method.

### 6.2.1 Vibration analysis of model

For doing the vibrational analysis of the model , four legs of the table base were given the fixed constraints and the natural frequency of the model is found .There are 4 modes of vibrations in which, each mode have one specific natural frequency. Those frequencies can be seen in figures. The care taken while designing the model that the resonance should not occur. On this principle, diameter of the unit pulley is designed and the reduction ration is calculated as 10.

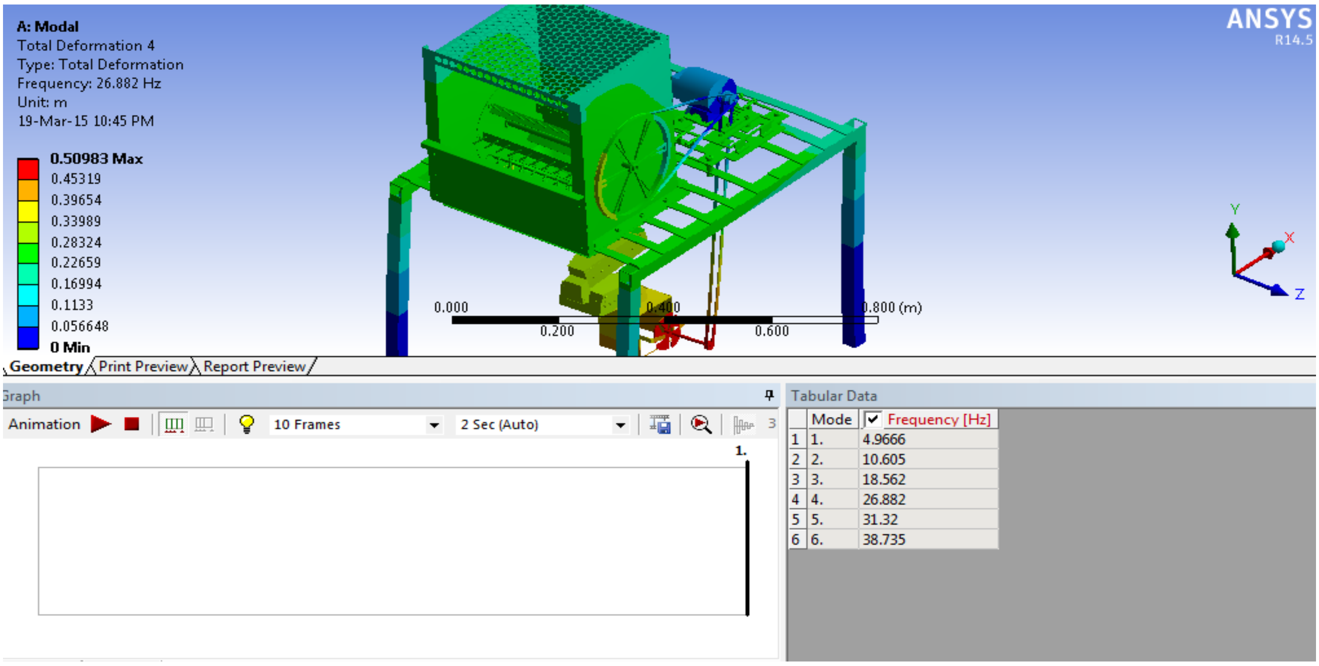


Fig 6.2 . Vibrational Analysis Mode -1

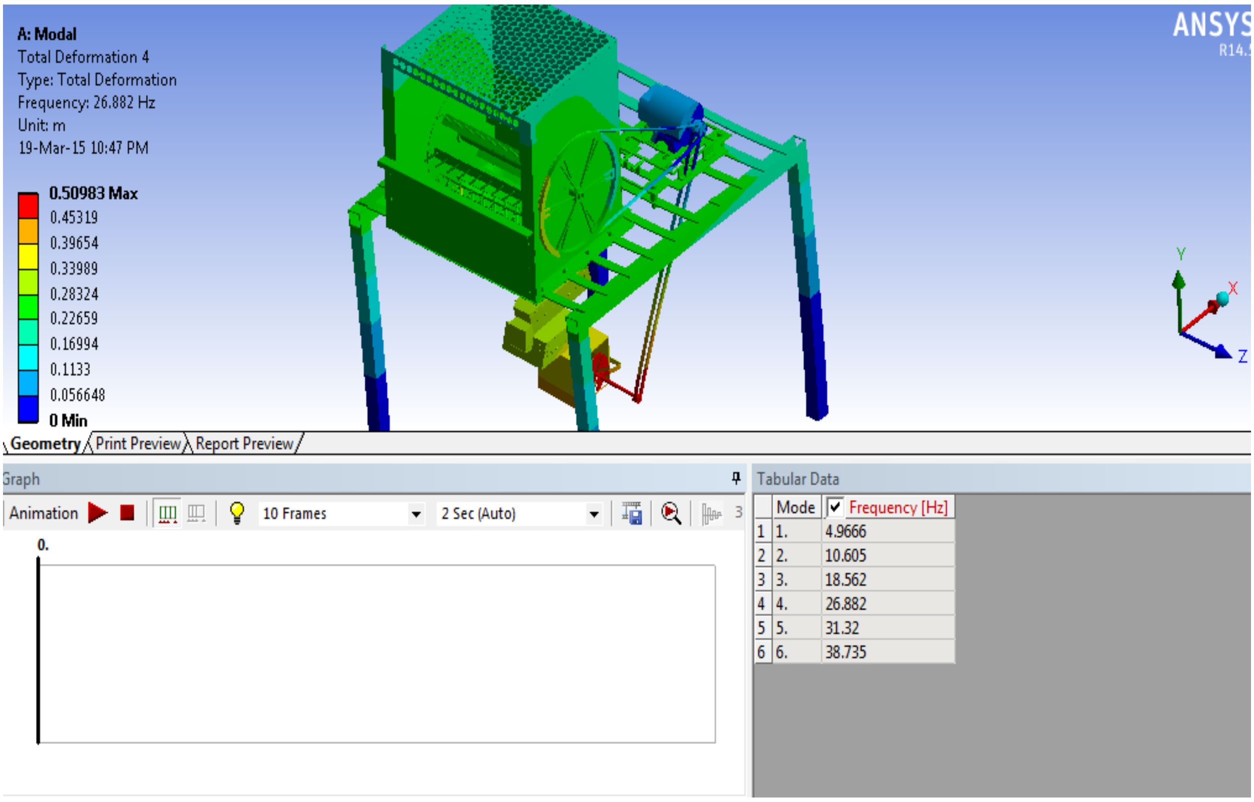


Fig 6.3. Vibrational Analysis Mode -2

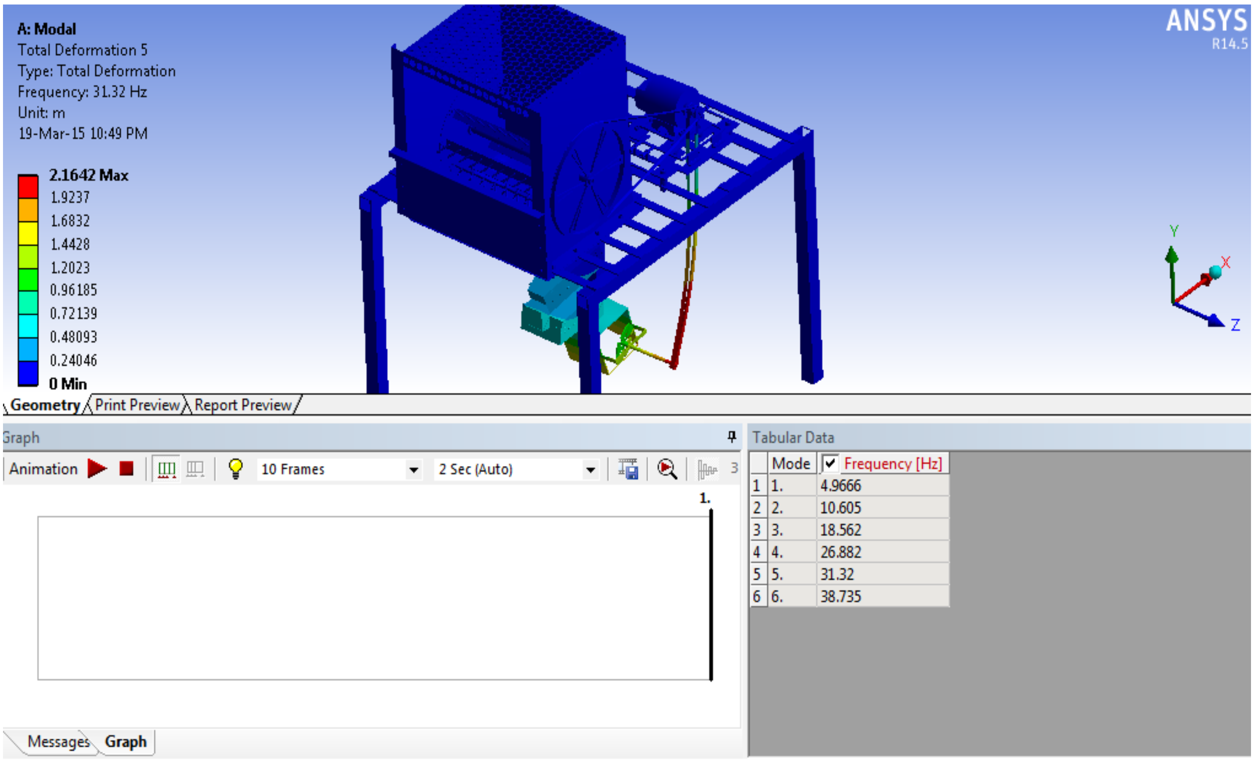


Fig 6.4. Vibrational Analysis Mode -3

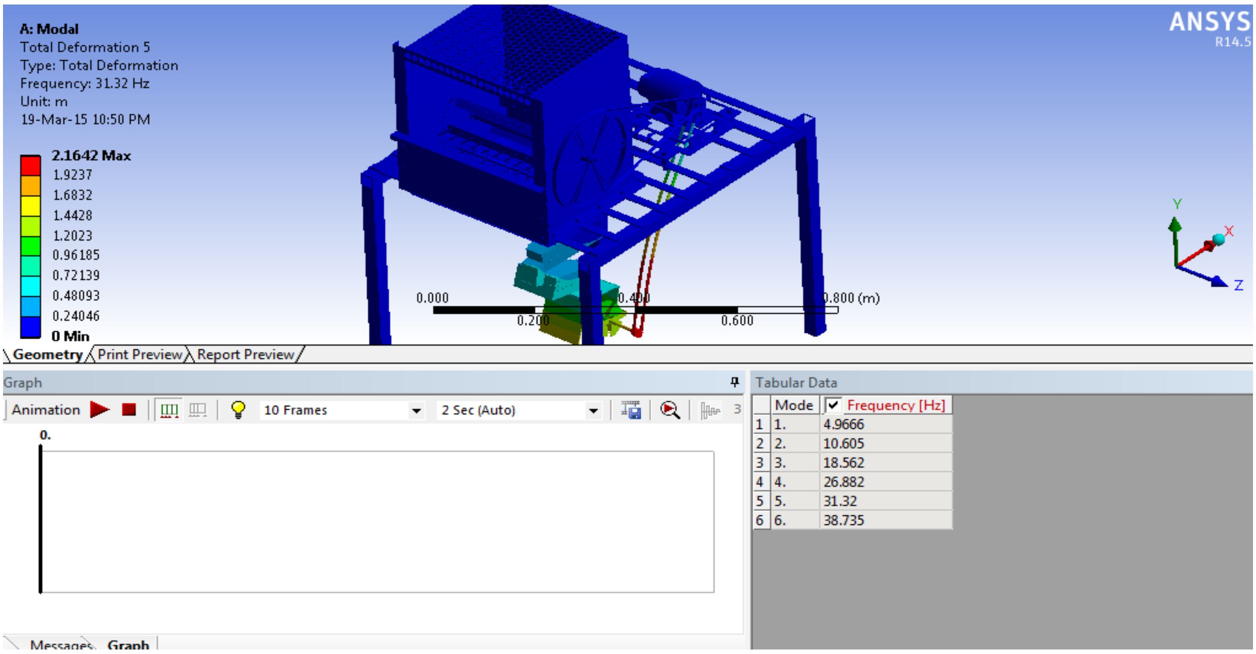


Fig 6.5. Vibrational Analysis Mode -4

### 6.2.2 Buckling analysis of side casing

While doing the buckling analysis, the weights of drum, hollow shaft, unit pulley and hand weight coming on the casing plate are considered. The bottom surface of the casing, attached to the base, is given a fixed constraint and the above forces are applied. Buckling deformations are shown in the figure . They are found to be in limits and design is safe.

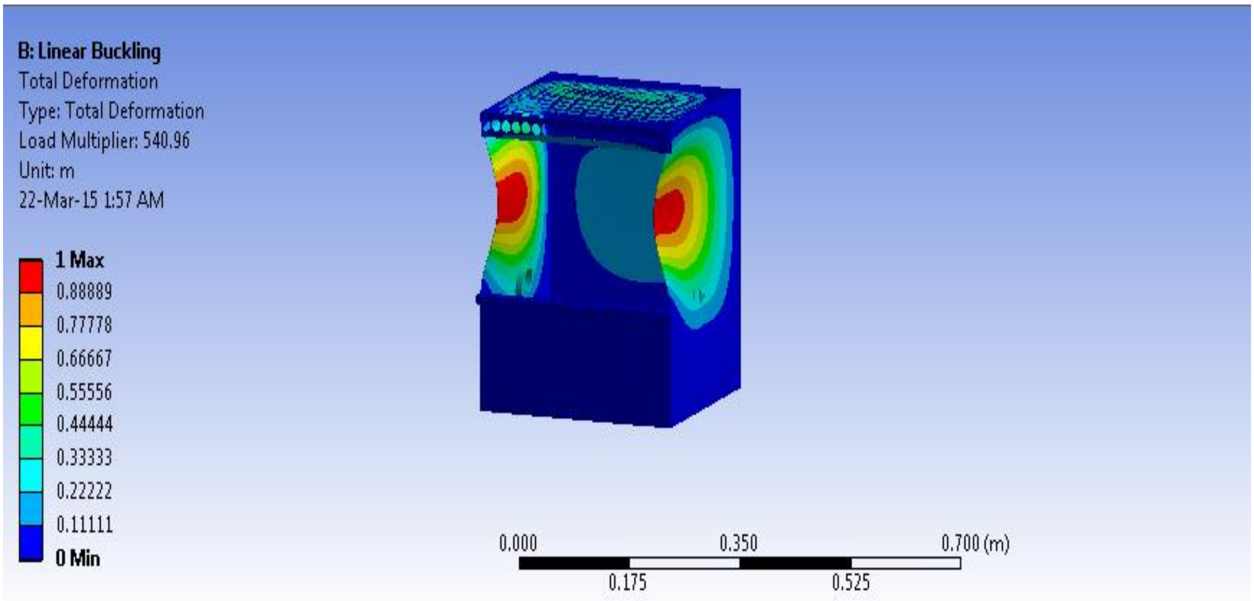


Fig 6.6. Buckling analysis of side casing

### 6.2.3 Stress analysis of base

While doing stress analysis of base table, bottom of the table base is given fixed constrain, weights of threshing unit, casing, hand, motor assembly are applied at respective points and Von Mises stresses & deformation are found out. It is found to be more than safe so decision was taken to reduce the weight of the base by making holes in it. Total deformation is shown in the figure.

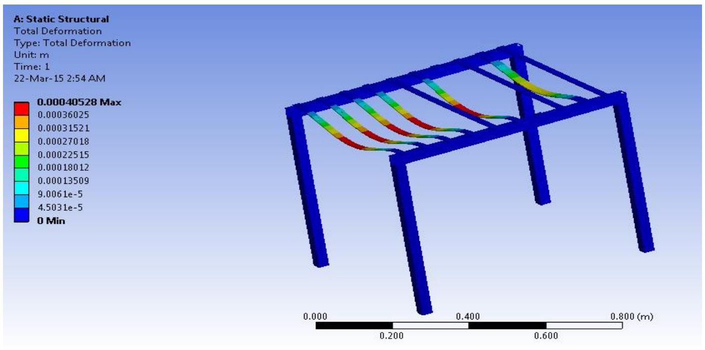


Fig 6.7. Deformation analysis of model base

### 6.2.4 Motor base 1 analysis

While doing motor base 1 analysis, bottom of the base is given fixed constrain, weight of motor along with pulleys is applied and stresses were checked. They are found in limits. To reduce the weight of the motor base 1, slots are made wherever material requirement is not essential, thus making it light weight.

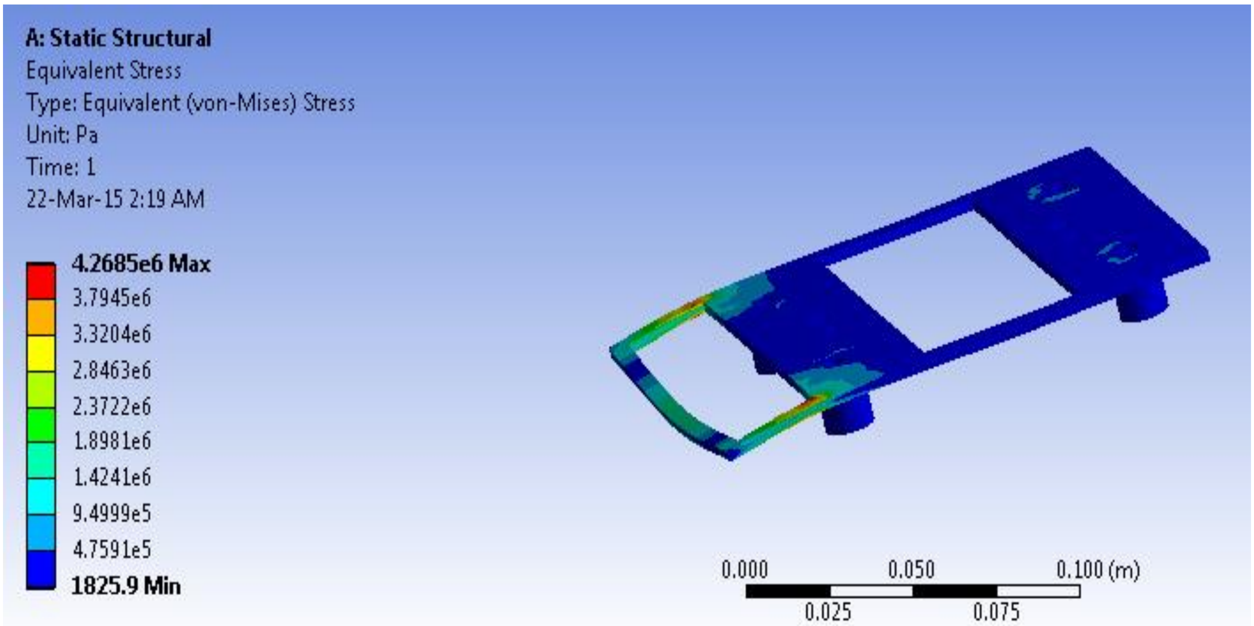


Fig 6.8. Motor base 1 analysis

### 6.2.5 Motor base 2 analysis

While doing motor base 1 analysis, bottom of the base is given fixed constrain, weight of motor along with pulleys and motor base 1 is applied and stresses checked. They are found in limits. To duce weight, slots are made wherever material requirement is not essential, thus making it light weight.

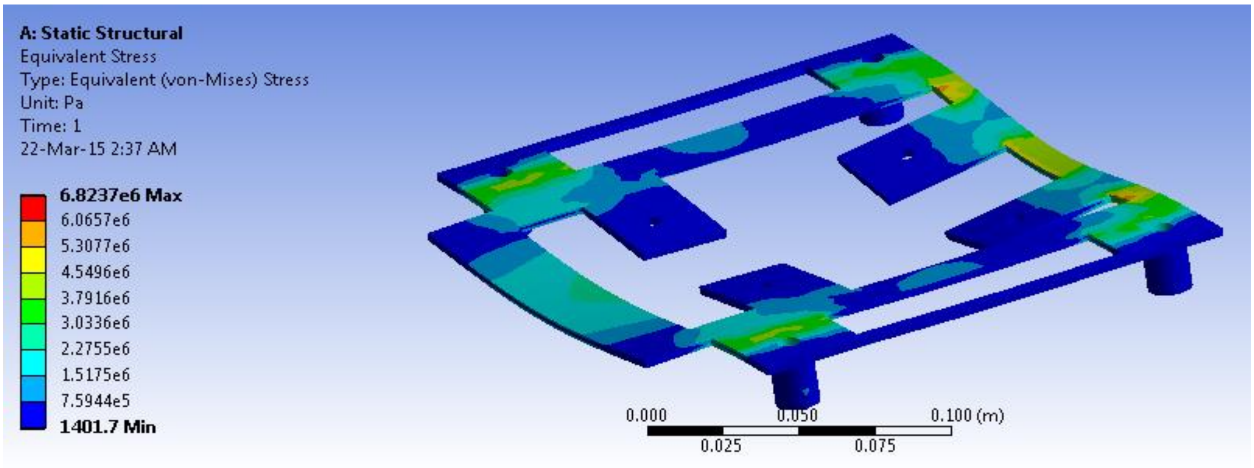


Fig 6.9. Motor base 2 analysis

### 6.2.6 Nut rest analysis

While doing analysis, bottom is given fixed constraint and weight of motor assembly is applied on edge. Stresses and deformation are checked. They are found to be in limits.

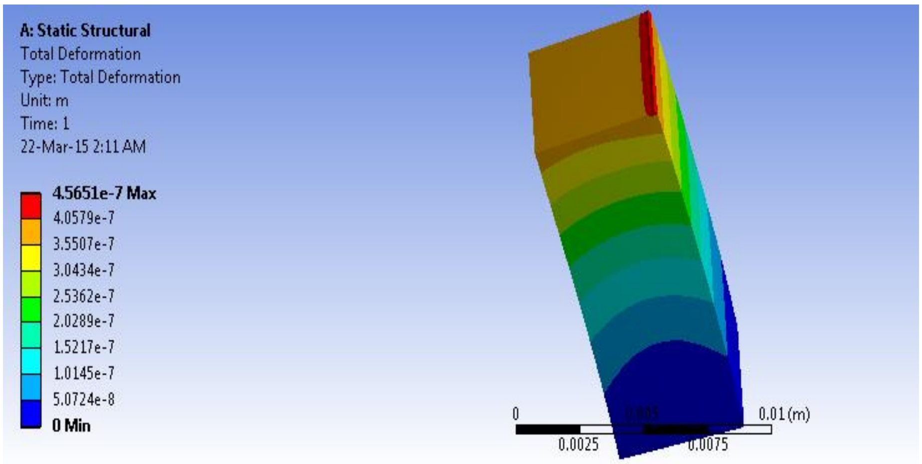


Fig 6.10. Nut rest analysis

### 6.2.7 Hollow shaft analysis

While doing hollow shaft analysis, ends of the shaft are fixed, weight of threshing drum and self-weight is applied and stresses are checked. They are found in limits.

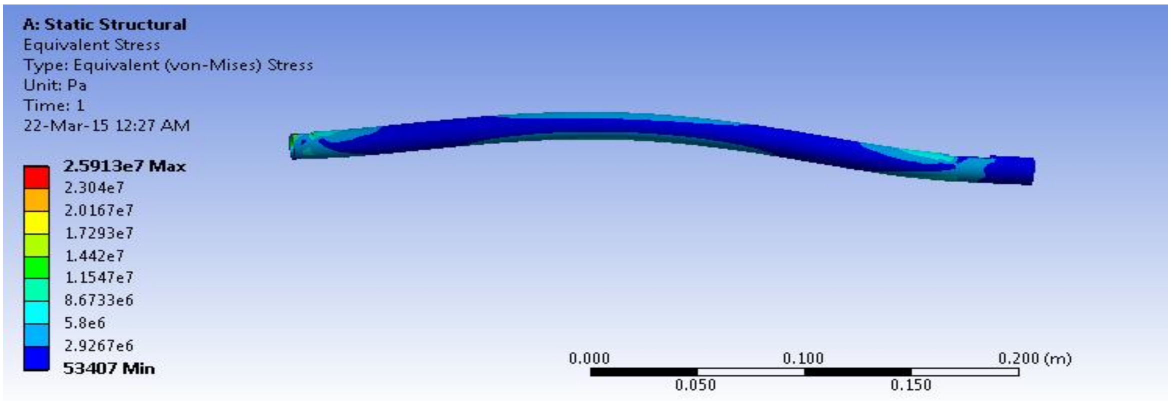


Fig 6.11. Hollow shaft Analysis

### 6.2.8 Side disc analysis

While side disc analysis, central surface connected to the bearing is fixed, radial force acting on the drum is applied tangentially and stresses are checked. They are found to be safe.

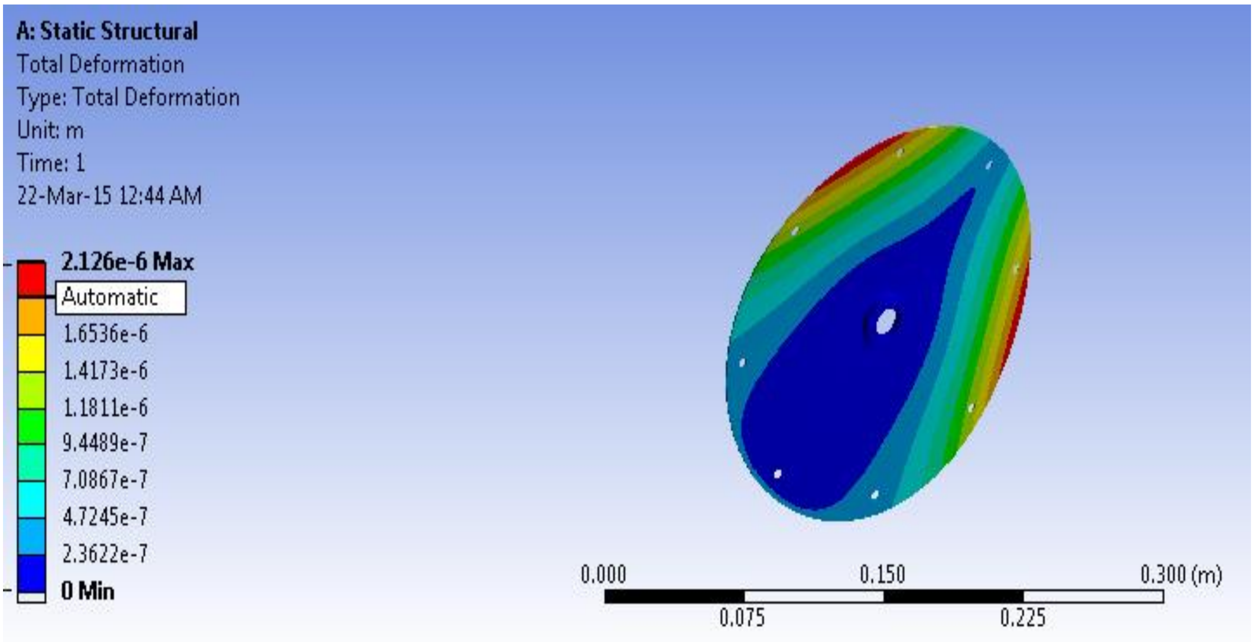


Fig 6.12. Side disc Analysis

### 6.2.9 Strips analysis

While doing strips analysis, one end of the strip is given fixed constrain, force which produces torque for threshing drum is applied tangential to other end and stresses are checked. They are found in limits.

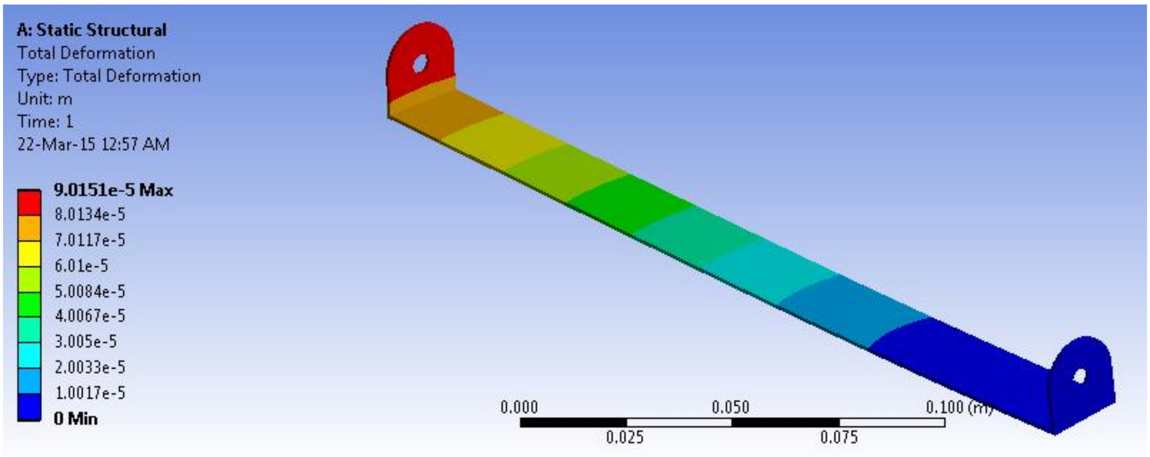


Fig 6.13. Strip Analysis

### 6.2.10 Unit pulley analysis

In unit pulley analysis, central bearing surface is given fixed constraint, belt tension along with self-weight is applied and stresses are checked. They are found in limits. To reduce the weight of unit pulley, slots are made wherever material requirement is not essential and different thickness at different place is used, to make it light weight.

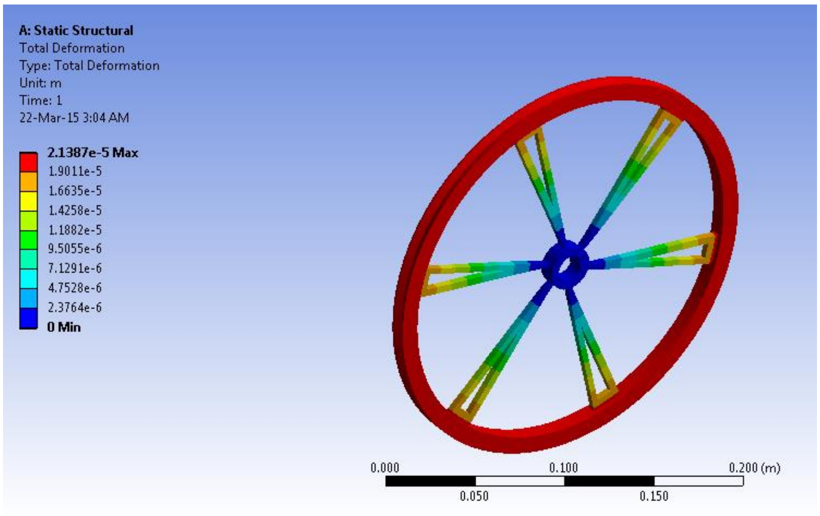


Fig 6.14. Unit Pulley Analysis

## 6.3 CONCLUSION

From the results obtained in ANSYS, we have concluded that thresher and winnowing unit design is safe from the analytical point of view and stresses generated are low in value and within the range of safety. Further we carried out Failure Mode Effect Analysis (FMEA) which will validate the design from the application point of view.

# CHAPTER 7

# BILL OF MATERIAL

To make this unit safe for its operation and its function, analytical (engineering based) as well as practical approach has to be considered to the design and selection of the components. Hence the results obtained from the analytical (engineering based) design and modification recommended by FMEA design are merged, and final bill of material is prepared which includes the parts and components which have little or no chances of failure. This BOM is briefed here.

Table 7.1. Bill of Material

| Sr. No. | Component | Specifications /Function | Quantity | Material |
|---|---|---|---|---|
| 1. | Motor | 1/12 hp, 9000 rpm, 230 v. 0.75 a | 1 | Std part |
| 2. | Motor belt | V shaped laced joint | 2 | Leather |
| 3. | Motor base 1 | Have arrangement of belt tighten/lose | 1 | MS plate |
| 4. | Motor base 2 | Permanent lock with unit base | 1 | MS plate |
| 5. | M6 bolt | Tightening purpose | 8 | Std part |
| 6. | M8 bolt | Tightening purpose | 4 | Std part |
| 7. | Nut rest | Helpful to slide motor base 1 | 4 | MS plate |
| 8. | Unit base | To provide rigidity to unit | 1 | MS plate |
| 9. | Strips | To fit cutting pin by welding | 8 | MS plate |
| 10. | Cutting pin | Cutting action | 68 | Std part |
| 11. | Side disc | To fix strips welded with screws | 2 | MS plate |
| 12. | Side casing plate | To act as a fixed support to the rotating drum | 2 | MS plate |
| 13. | Weld bearing disc | To accommodate the bearing on the shaft | 2 | MS |
| 14 | Unit pulley | Speed reduction | 1 | MS PLATE 10mm |
| 15 | Hollow shaft | Support drum and transmit power | 1 | Plain carbon steel c10 |
| 16 | Filter mesh | Grain filtering action | 3(Sizes 10mm,8mm,5mm) | MS WIRE 1mm |
| 17 | Winnowing fan | Axial flow fan | 1 | Std part |
| 18 | Belt | Laced joint v-belt | 2 | Leather |
| 19 | Upper front mesh | Safety | 1 | MS plate |

# CHAPTER 8

# EQUIPMENTS USED

For making our machine the following tools were used:

1. Makita (TCTD Lab)
2. Drilling Machine (TCTD Lab)
3. Power Drill (TCTD Lab)
4. Drilling Machine (Tinkerer's Lab)
5. Shear Cutter (TCTD Lab)
6. Lathe Machine (TCTD Lab)
7. Grinder Tool (TCTD Lab)
8. Sheet Metal Cutter (TCTD Lab)
9. Metal Bending Machine (F1 Shed)
10. Gas welding (N1 Shed)
11. Laser cutter (TCTD Lab)
12. 3D Printer (TCTD Lab)
13. Reciprocator (TCTD Lab)
14. Spirit Level
15. Gas and Electric Welding Machine

# CHAPTER 9

# CONCLUSION

While accomplishing the task of building a manually fed combined threshing and winnowing unit at low cost and low weight, various aspects of project management are followed. The principles of threshing as defined under threshing machines are satisfied. Quality circle techniques such milestones (activity) chart, process flow chart, etc. are used. Standardization is the key factor which helped in collecting the raw material and standard components from the market. As standardization of the bill of material saved a lot of time which could have required for searching substandard and custom made parts. It was also helpful as the standard parts are directly used without compromising strength and performance of that particular part.

Ergonomic of the unit is looked after by providing proper arrangements, finishing all rough edges and cut sections, by ensuring a suitable factor of safety for designing all the parts which will ensure safe and effective operation of unit.. Effective and efficient space utilization is ensured by taking into consideration of space required.

All these principles are also applied in the field of design so that outcome of the design would be most fitted in the frame of ideal equipment. While carrying out the whole project, major tools of quality circle are used which found helpful in the identification of problem, tackling that problem and coming down to a simplest, measurable, achievable, reliable and time bound solution.

Finally to conclude the project, it can be said that, the unit of required specifications has been designed and made to operational condition. It will serve the purposes specified in the objectives. All efforts have been taken to make it cost effective. Easy operation of the unit is ensured without much difficulty.

# CHAPTER 10

# FUTURE SCOPE

## 13.1 SCOPE FOR FUTURE MODIFICATIONS

1. Aluminum can be used to reduce weight further.

2. Making more industry oriented.

3. For eliminating human efforts, electrical driven arrangement can be provided.

## BIBLIOGRAPHY

1. V.B. Bhandari, Design of Machine Elements, Tata McGraw Hill Publishing Company Ltd, 7 West Patel Nagar, Delhi-110008

2. R.S. Khurmi , A Textbook of Machine Design, S. Chand and Eurasia Publishing House, (pvt) ltd , New Delhi

3. O.P. Khanna, Project Management

4. Dr. Hira and Gupta, Operation Research.

## WEBLIOGRAPHY

1. http //irri.org

2. http //en.wikipedia.org/wiki/Threshing_machine

3. http //www.farmcollector.com/equipment/how-a-threshing-machine-works.aspx

4. http //nif.org.in/innovation/low-cost-paddy-threshing-machine/449

5. https //www.youtube.com/watch?v=MxXGS8nxZTo

6. http //uppervalleyseedsavers.pbworks.com/w/page/50322278/Grain%20Threshers

7. http //www.fao.org/docrep/t1838e/t1838e0p.htm

## SOFTWARES USED

1. MS –Office

2. AutoCAD 2010

3. Creo 2.0

4. ANSYS 15.0

5. Pro-E/Wildfire 5.0