

# Development of Working Prototype for Ragi Harvesting and Threshing



**Centre Name: Department Of Machinery Design**

**Course Name: M.Sc (Engg.) in Machinery Design**



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## **Certificate**

*This is to certify that the M. Sc (Engg.) Project Dissertation titled  
“To develop the working prototype to execute combined function of Ragi  
harvesting and threshing operation” is a bonafide record of the Group Project  
work carried out by Mr. P. Prabhakar, Mr. Chintan Upadhyay, Mr. Thomas  
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## DECLARATION

### **“To develop the working prototype to execute combined function of Ragi harvesting and threshing operation”**

The Project Dissertation is submitted in partial fulfilment of academic requirements for M.Sc (Engg) Degree from Coventry University in Machinery Design. This dissertation is a result of investigation of the project team. All sections of the text and results, which has been obtained from other sources, are fully referenced. We understand that cheating and plagiarism constitute a breach of University regulations and will be dealt with accordingly.

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## Abstract

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Chapter-1 introduces the cultivation of finger millet for which harvesting and threshing process is carried out manually. Understanding the functional requirement regarding current trends in finger millet harvesting and threshing, a prototype is needed to be manufactured. Understanding the basic objectives the machine should perform a concept design of the machine has been made in further chapters.

Field work and journals were used to understand the current trends of cultivation of finger millet crops which is shown in chapter-2. Market requirement study was carried out on the basis of literature survey which indicates the need of mechanization of harvesting process. Manual harvesting and threshing process requires more human power which involves inflexibility to the production. To meet the functional requirements several concept designs were developed which is shown in chapter-3. The final concept design was selected on the basis of its comparison with other designs and the design was modeled using Solid Works 2012 with proper dimensions of each component of prototype which is elaborated in chapter-4.

Different types of mechanisms used to obtain certain functions were explained in chapter-5. Dimensions of several components were calculated as per the functional requirement. MSC ADAMS the multi body dynamics analysis software was used to check the simulation of working prototype and kinematic analysis of different mechanism was carried out in chapter-5. Also, each and every mechanism is explained along with its assembly and manufacturing process.

Fabrication of the produced design was done mainly by welding, turning, boring processes. Power is transmitted to the machine by means of belt drives with the source of power from an engine with minimum power rating of 3hp.

Chapter-6 introduces the prototype which is developed to meet the requirements to do harvesting and threshing of the finger millet crop with proper specifications. The advantages of fabricated prototype are also mentioned in this chapter and its scope for the future work and its perspective is also noted down to enhance its functionality.

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## Chapter-1 Introduction

### 1.0 Introduction

Ragi is also known by the name finger millet. It is an important small millet food and fodder crop which is extensively cultivated in Asian countries like India, Malaysia, China and Nepal. In India it is cultivated over an area of 2.65 million hectare. Ragi has total production of about 2.9 million tonnes. Finger millet has outstanding properties as a subsistence food crop. Finger millet is harvested either manually by using sickle if it is intercropped with legumes or by reaper windrower if it is grown as single crop. It is estimated that harvesting and threshing of crops consume about one third of the total effort requirement of the production system<sup>[3]</sup>.

### 1.1 Aim of the Project

*“To develop the working prototype to execute combined function of Ragi (finger millet) harvesting and threshing operation”.*

### 1.2 Objectives

Based on the customer needs which are available in the finger millet harvesting area, different objectives were made to reach best final design. These objectives are listed down

- To carry out literature review to identify different trends in Ragi crop cultivation.
- To do market study on requirement of harvesting and threshing of ragi.
- To develop different concepts to meet functional requirement.
- To design and model and simulation of prototype.
- To manufacture the prototype as per the design.
- To incorporate the changes in prototype if necessary.
- To find out the further improvements required to be incorporated in the prototype by brainstorming.

### 1.3 Need of the project

In the present Scenario due to the gradual increase in population, there is too much of demands in the farm sector due to the scarcity of daily labors. The output from these labors is less productive due to manual operations adopted by them. Since heavy machines cannot be introduced due to affordability and limited area of cultivation, innovations in finger millet has been stand still for a long period of time. Thus understanding this need, it is very essential to bring in a machine which is cost effective, compact and easy to use for low end farmers.



## Chapter-2

### Literature Review

Various details are collected from literature survey to understand the present scenarios in finger millet harvesting and threshing. The survey has been carried out by going through various journals, magazines, articles, and information's from the internet.

#### 2.1 Introduction to Finger millet (Ragi)



Figure 2.1 Finger millet (Ragi)

##### 2.1.1 Finger millet cultivation:

Table 1 shows the major varieties of finger millet crop like C09, C13, C014, TR1 and PAIUR1 and their different seasons based on irrigated and rain fed cultivation method. The table 2 shows the detailed features of each variety of finger millet and the gross cultivation data of each variety.

Table 1 Recommended Verities

SEASON	CULTIVATION	VARIETY
DEC- JAN	IRRIGATED	C09,C13,C014,TR1
APRIL-MAY	IRRIGATED	C09,C13,C014
JUN-JULY	RAINFED	PAIUR1,C013,C014
SEP-OCT	RAINFED	PAIUR1,C013,C014

**Table 2 Different varieties with specifications**

<b>PARTICULARS</b>	<b>CO 9</b>	<b>CO 13</b>	<b>CO (Ra) 14</b>	<b>Paiyur 1</b>	<b>TRY 1</b>
<b>Type</b>	EX 4336 x PLR 1	CO 7 X TAH 107	Malawi 1305 x CO 13	Pure line selection from - PR 722	Selection from HR 374
<b>Duration (days)</b>	100-105	95 - 100	105-110	115-120	102
<b>Rainfed/ Irrigated</b>	Both	Both	Both	Rainfed	Kharif irrigated Sodic/ saline soils
<b>Irrigated -Grain yield kg/hectare</b>	4500	3600	2892	..	4011
<b>Rainfed-Grain yield kg/hectare</b>	3100	2300	2794	3125	..
<b>Straw yield kg/hectare</b>	8000	10000	8113	..	6800
<b>Rainfed</b>	6500	7500	8503	5750	..
<b>Stem</b>	Erect	Erect	Erect	Erect	Erect
<b>Height (cm)</b>	75-80	85 - 90	115-120	110	100
<b>Tillers</b>	5-8	3 - 5	8-9	1 - 3	5 - 7
<b>Days to 50% flowering</b>	65-70	55 - 60	72	80	78
<b>Ear size and shape</b>	incurved fingers	Open	top curved	Open	Incurved
<b>Fingers</b>	8-9	10 –17	9-12	6 - 8	5-8
<b>Ear length (cm)</b>	8	8-10	10-12	8	7.6
<b>Grain color</b>	White	Light Brown	Brown	Brown	Brown
<b>1000 grain wt (gms)</b>	2.7	1.7	3.1	2.7	2.74

### 2.1.2 Field preparation:

The field is prepared for channel irrigation as well as rain fed. Generally beds are prepared to  $(3 \times 1.5) \text{ m}^2$  rectangular plots. For irrigation 0.3m channel will be provided. Depth of the soil bed is about 0.15m from the top face of the boundary around the plot as shown in the Fig2.2.



**Figure 2.2 Land preparation**

### 2.1.3 Crop spacing:

The crop is initially grown in a small bed by sowing the finger millet and after 15 days the finger millet crop is planted in the prepared bed with the distance of  $(0.3 \times 0.1) \text{ m}^2$  as shown in the Fig 2.3.



**Figure 2.3 Crop spacing**

## 2.2 Present harvesting technique for finger millet

Presently for harvesting of finger millet manual procedures are adopted as the fingers will not mature evenly, the entire crop is not been harvested but only the fingers in the crop is separated from the straws of the crop and prepared for threshing as shown in Fig2.4.

Traditionally, finger millet harvesting is done manually using sickles which involves 25 man days/hectare. Scarcity of labor and higher wages during harvesting season is the serious problem. In Manual harvesting crop is harvested by hand, Here individual heads are cut off with a sickle leaving a few centimeters of stalk attached or the whole crop is harvested at base level



leaving a few centimeters of stubble on the ground. 200 man hours are required to harvest one hectare of finger millet. One man can harvest 0.005 hectare per hour with an efficiency of 99 percent.



**Figure 2.4 Manual Ragi harvesting**

### **2.3 Present threshing technique for finger millet**

The first procedure carried out in threshing process is finger drying in which the fingers are laid in ground and exposed to the sun. After uniform drying has taken place the fingers are now prepared for actual threshing operation which involves separation of millet from the fingers. As much innovation has not taken place in threshing manual procedure is adopted by the farmers as shown in the Fig 2.5.



**Figure 2.5 Present threshing techniques**

## Chapter-3

## Concept Design

### 3.3 QFD (Quality Function Deployment)

QFD is the method of transferring the user demands into design quality to implement characteristics forming quality and deploy procedures for achieving the design quality into subsystems and component parts to sequence the elements of the manufacturing process. In simple words it helps in transforming customer needs into engineering characteristics for a product. Main important needs of customers on the combined attachment for finger millet harvesting and threshing are long life, affordability, easy to use, less maintenance and safety.

QFD House of Quality - ragi harvesting and Threshing

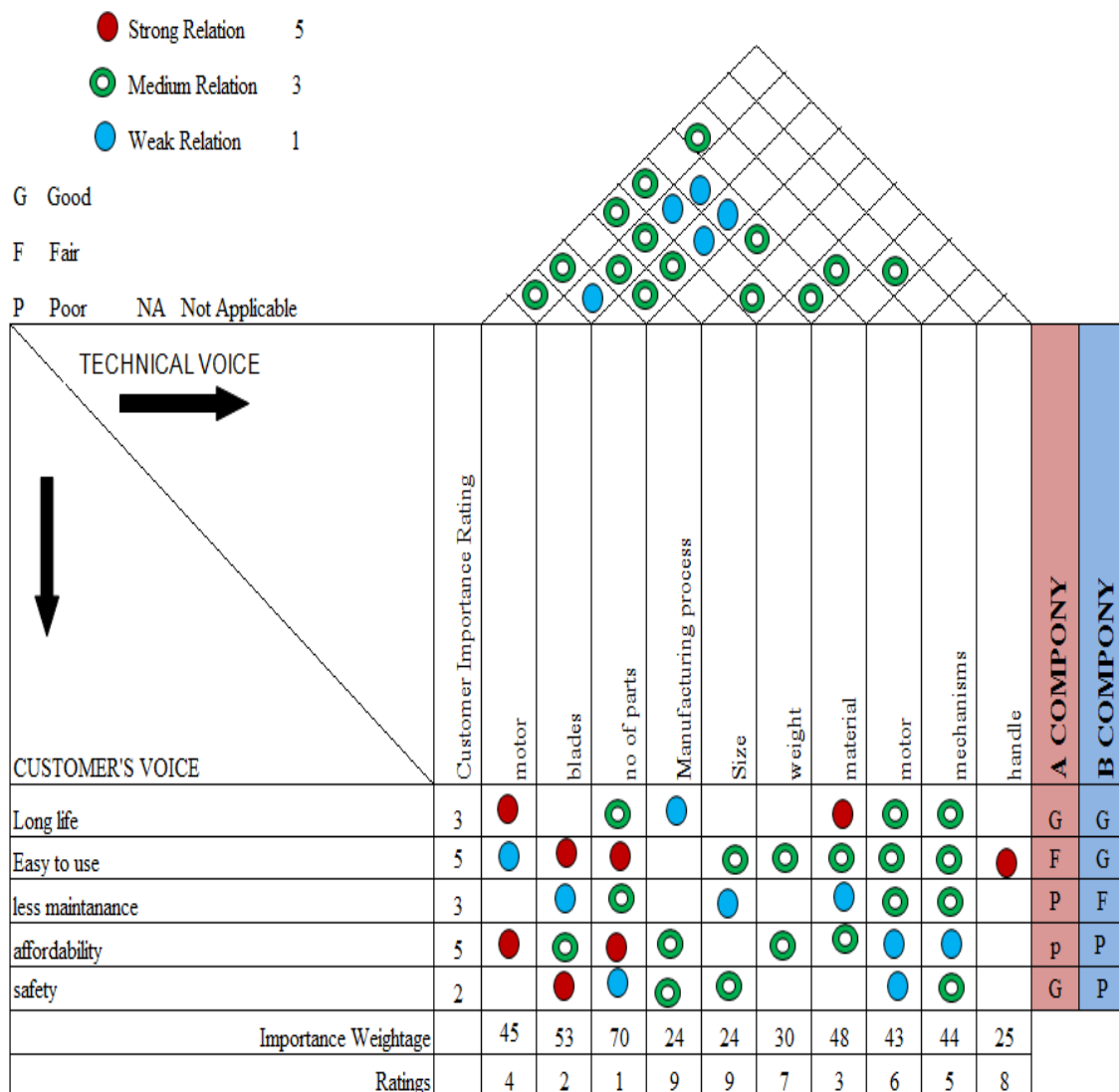


Figure 3.1 QFD - Ragi Harvesting and Threshing

## 3.2 Concept design 1

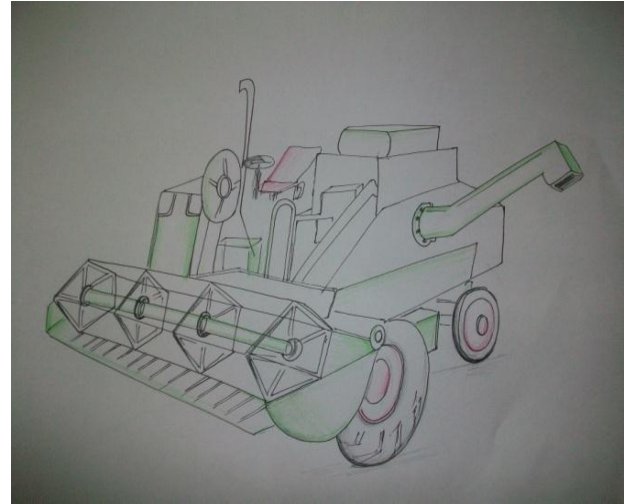
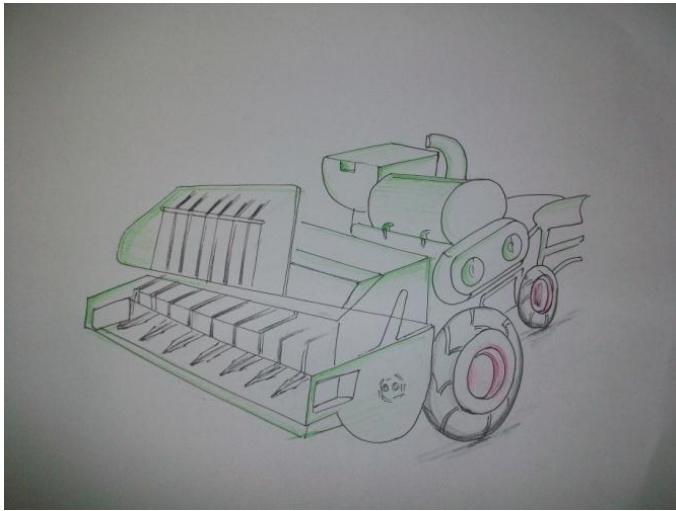


Figure 3.2 Sketch of concept design 1

The first concepts were based on building a moving machine for finger millet threshing and harvesting. A CATIA modeled prototype was designed based on this first concept. The Fig 3.2 below shows the combined harvesting and threshing machine which moves on wheels in the field. The design was completely changed due to some drawbacks which have been mentioned below.

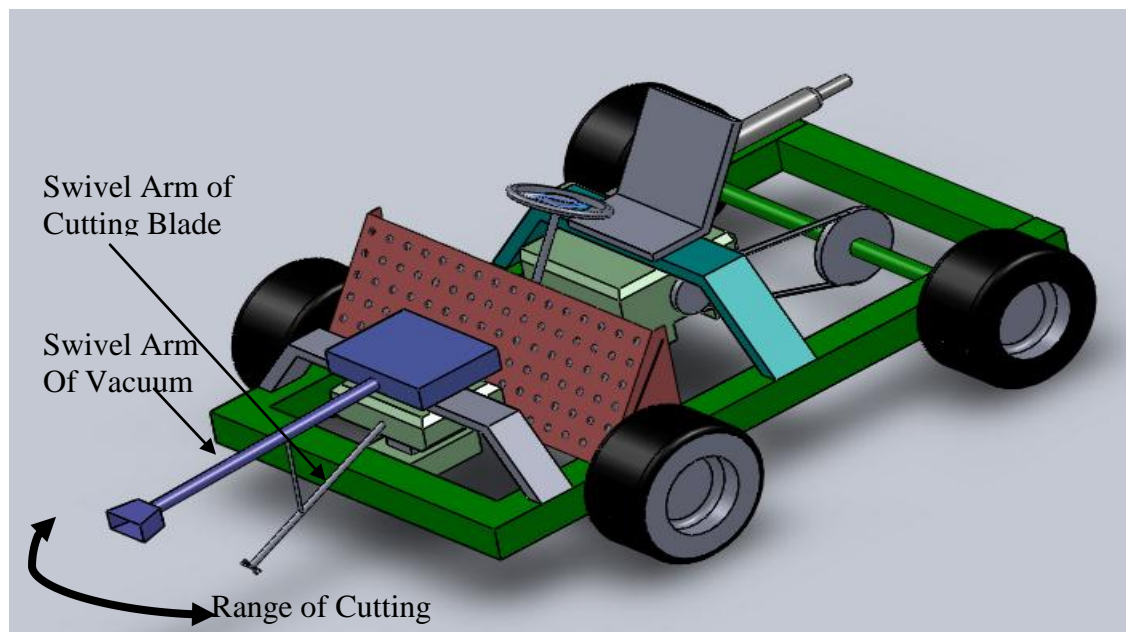


Figure 3.3 CATIA model of concept 1

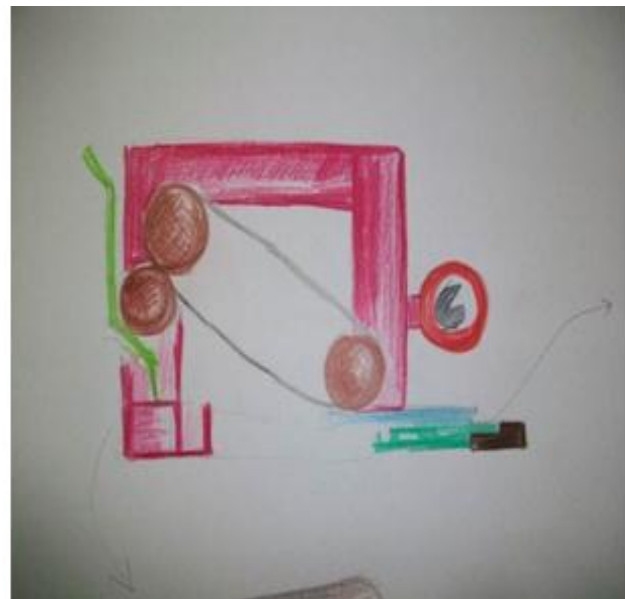
### 3.2.1 Drawbacks of the Prototype

- Motion control of the swivel arm of cutting blade and vacuum not synchronized with vehicle's movement.



- Range of Cutting varies due to swivel mechanism vacuum not synchronized with vehicles movement.
- Skill requirement for handling the swivel operation for straight line cutting of crop.
- Straw collection is not possible as per the design.
- Straw gets completely thrown into the field due to the cutting technique adopted so additional labour required for cleaning the field.
- Possibility of Vacuum pipes getting blocked by foreign particles (Plastics, papers etc.)
- Cost of the Equipment is high.

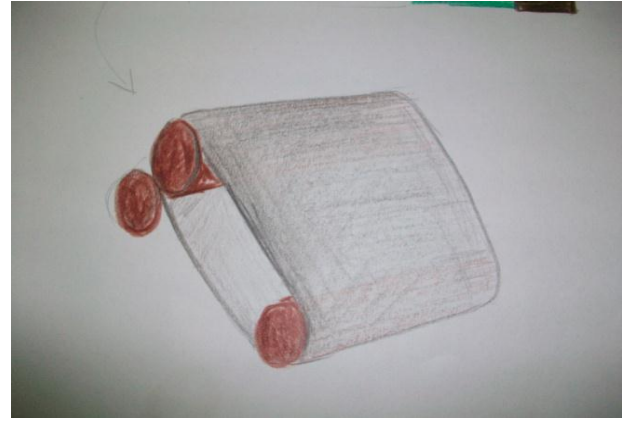
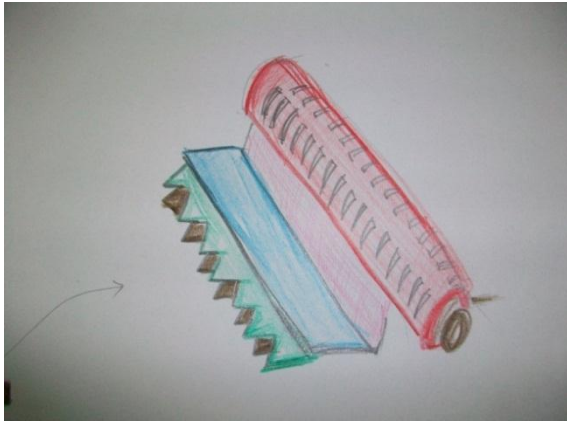
### 3.3 Concept design 2



**Figure 3.4 Sketch of concept design 2**

The second design was based on an idea of an attachment being fixed onto a tractor. This attachment should be capable of drawing the power from the tractor for its operation and should be capable of harvesting and threshing at the same time as shown in fig. 3.4.

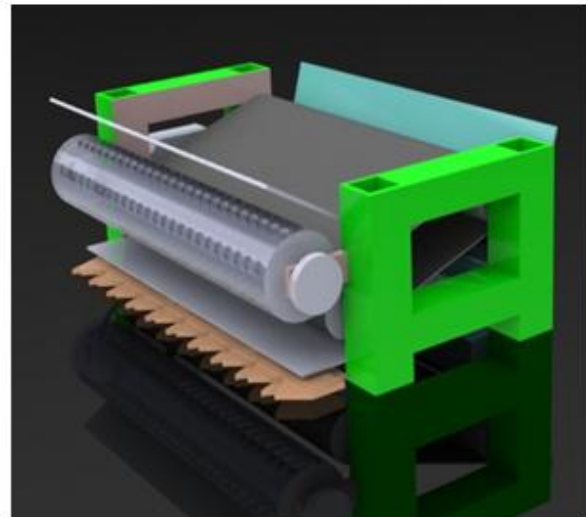
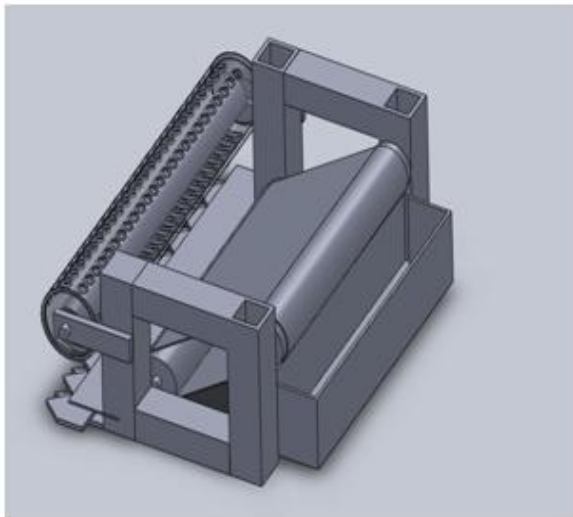
### 3.4 Concept of cutting mechanism with vacuum roller



**Figure 3.5** Sketch of cutting mechanism with vacuum roller concept

This concept design 2 consists of vacuum roller for carrying the cut crop and cutting blades at the bottom having to and fro motion for cutting of the crop. The second image shows conveyer used for carrying of the crop and a secondary roller at the bottom for threshing as shown in 3.5 and 3.6.

### 3.5 Final Concept Modeled in Solid Works



**Figure 3.6** Final concept



## Chapter-4

### Design and Modeling

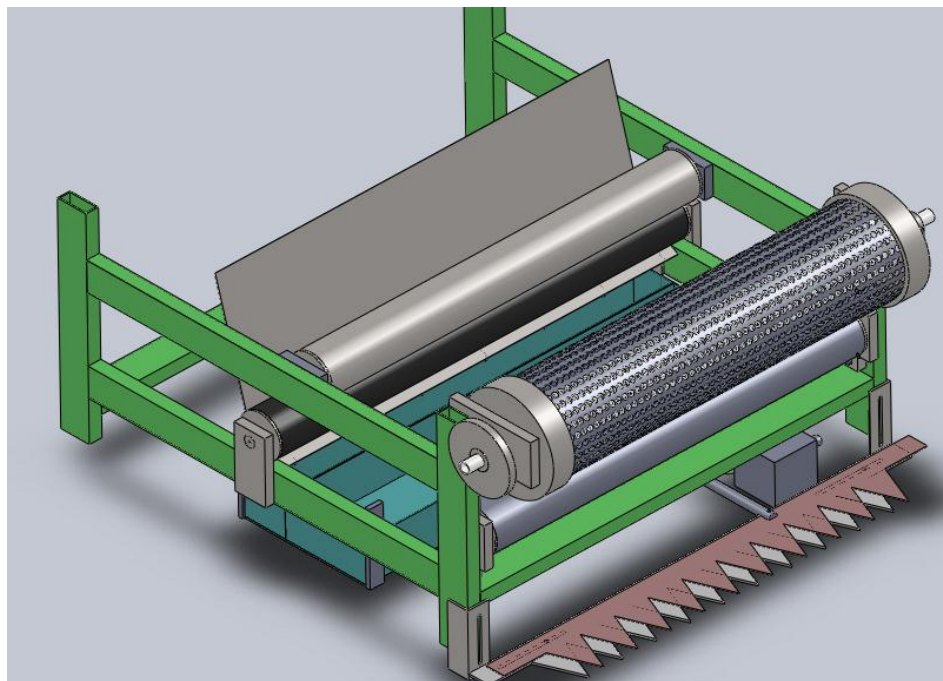
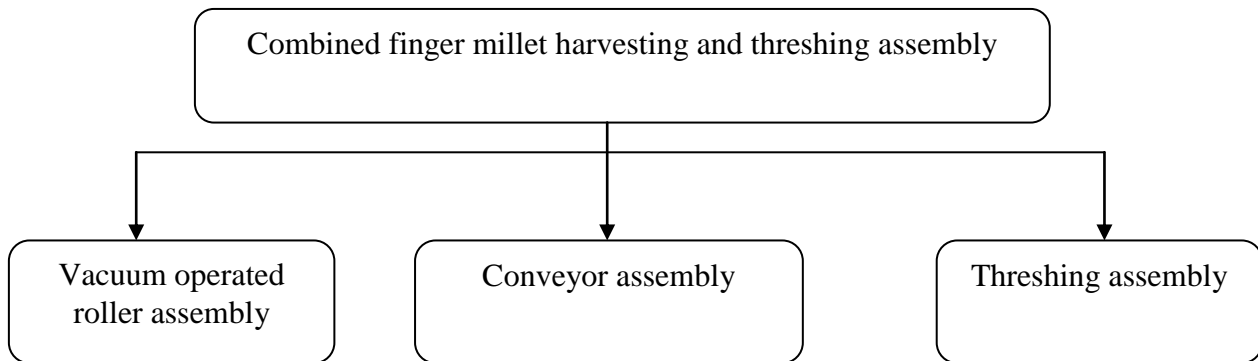
#### 4.1 Design Details

For manufacturing of combined finger millet harvesting and threshing attachment, after arriving to the final concept design the 3D assembly design along with the individual part drawing with dimensioning and bill of materials are generated in first angle projection using Solid Works-V12 and AutoCAD - V10 software. While designing the following considerations are made:

- The height, width and length of the attachment are fixed to (500 x 700 x 990) mm as the attachment is to be compact and of less weight.
- Wherever it's possible standard elements are used in the design in order to reduce the cost and to make the assembly as simple.
- The frame is made of rectangular cross section standard tube selected from IS series having a width of 70mm, with a height of 30 mm and thickness of 2.6mm.
- For the conveyor roller and the threshing roller the standard seamless steel tube of diameter 100mm is used.
- Mostly fasteners (screws, bolts and nuts) are used for assembling wherever it's possible for easy dismantling, maintenance and to carry out correction works.
- For conveyor belt food grade PVC standard belt is selected.
- For vacuum roller AC/DC 230v standard motor with a vacuum pressure of 1000mmHg is selected and fixed in the attachment.
- In order to transmit power to the various mechanisms like conveyor roller, threshing roller, cutting mechanism etc, the shaft is keyed and pulleys are fixed.
- For transmission of power “B2” type pulley and belts are used in the attachment.
- A gear box with bevel gears is used to transmit the power for cutter blades along with a slider crank mechanism to convert rotary motion from the input to reciprocating motion of the cutter.
- The containers for grain collection and the straw collection designed in such a way that can be easily detached from the attachment whenever it is filled.
- Provision for adjusting height of the cutting mechanism is given. Also easy remove and installing of cutting mechanism and also to adjust the height of ground clearance as per the field condition.

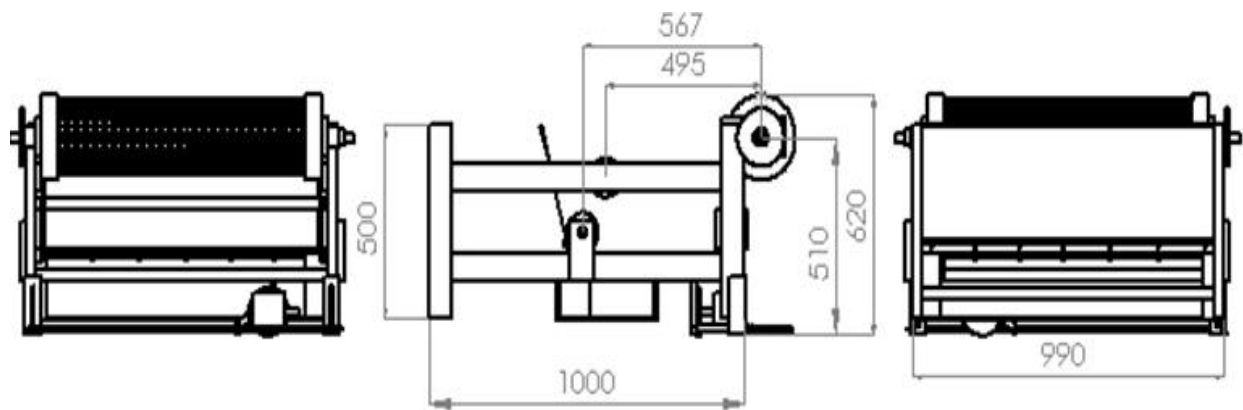
## 4.2 Modeling

The entire modelling of the finger millet harvesting and threshing mechanism is carried out using Solid Works-V12 work bench as it is also possible in the software to convert modelling file into a Para-solid file for transferring the model to ADAMS for kinematic analysis. And the detail manufacturing drawing with dimensions and bill of material is generated using AutoCAD - V10 software. The model consists of the three sub assemblies shown below.

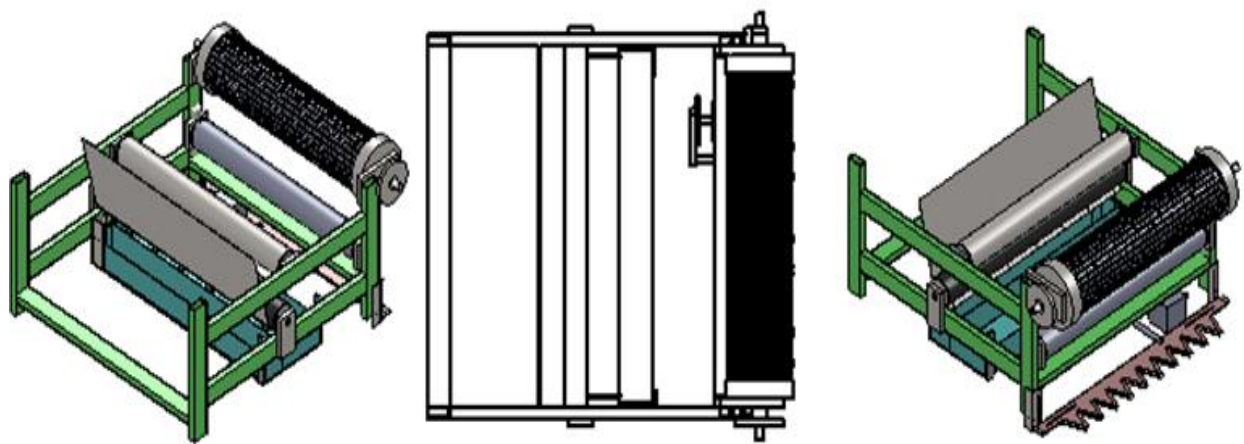


**Figure 4.1 Final assembly**

The image of the finger millet harvesting and threshing attachment after rendering is shown in the Fig4.1.



All dimensions are in mm



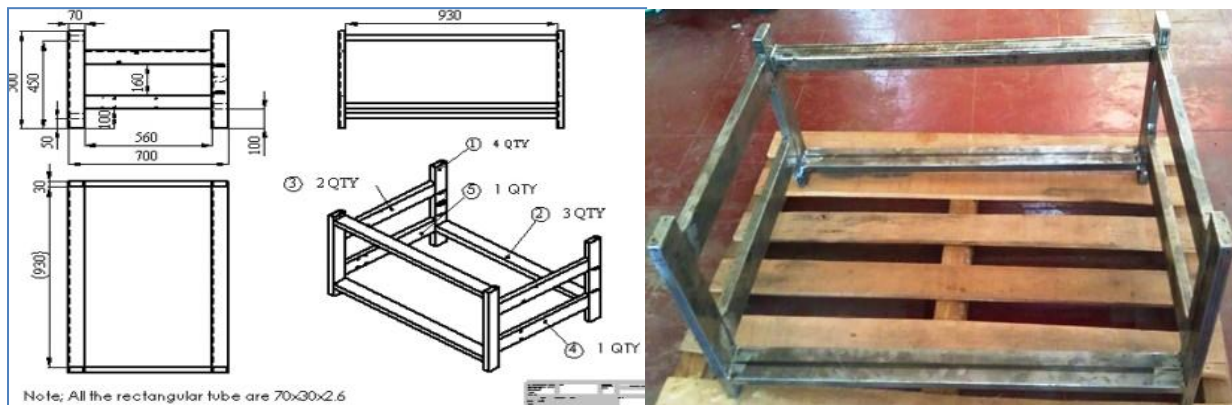
**Figure4. 2**Overall dimensions of assembly

### 4.3 Frame

The frame is the element in which all the sub assemblies i) vaccum operated roller and ii) conveyor iii) threshing unit is assembled. The frame is made up of mild steel tube having a rectangular cross section with dimensions of (70 x 30 x 2.6)mm selected from IS series. While selecting the section, the following considerations are made:

- Less weight to high stiffness.
- Easy weld ability.
- Easy machinability
- Low cost

The various manufacturing process involved in the frame is cutting the rectangular section tube to the required length using metal slitting saw, drilling holes to provide relief holes for the bolts and the major operation is welding to fix the various parts together regidly. The Fig 4.3 shows the the manufacturing drawing and the frame after manufacturing.



**Figure4.3 Frame**

#### 4.4 Vacuum and roller assembly

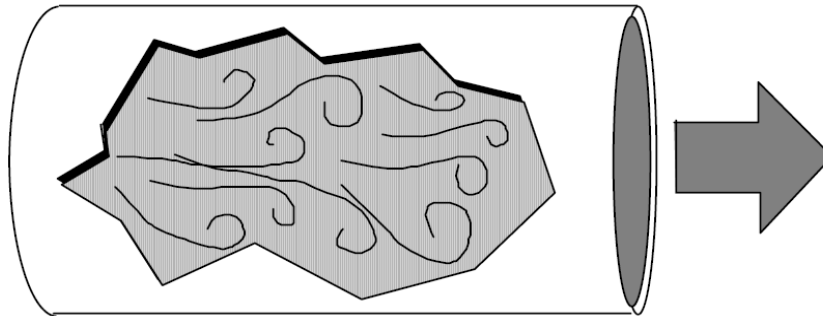
The vacuum roller consist of internal stationary vacuum suction pipe which is inclined to the angle of  $45^\circ$  so as the vacuum pressure will be generated within the angle. The vacuum suction stationary pipe is covered by the pierced sheet rolled on it a rotating drum , which is allowed to rotate freely so that when the cutting takes place due to the vacuum pressure the straws will be carried by holding on the rotating drum and the rotating drum rotates the straws are held by vacuum pressure and carried finally when the drum rotation angle reaches the extreme limit of the vacuum pressure the straws are dropped on to the conveyor as indicated in the arrow in the Fig4.4. The manufacturing processes includes i) vacuum stationary pipe – PVC pipe cutting and joined with adhesive ii) pierced sheet- rolled and welded to the end caps iii) end caps – turned and bored to the dimension.



**Figure 4.4 Vacuum roller**

## Chapter-5 Mechanisms, Calculations and Manufacturing

### 5.1 Vacuum mechanism



**Figure 5.1 Vacuum mechanism**

Vacuum Technology is based on the mechanism in which air is removed from a system to sub atmospheric pressure. Particles move from high atmospheric pressure to low atmospheric pressure. In the current system vacuum motor is used to generate the vacuum so that air is removed from the perforated drum causing pressure difference within the drum resulting in crop sticking onto drum.

**Table 3 Vacuum description and range**

Vacuum Description	Range
Low vacuum	25 to 760 Torr
Medium vacuum	$10^{-3}$ to 25 Torr
High vacuum	$10^{-6}$ to $10^{-3}$ Torr
Very high vacuum	$10^{-9}$ to $10^{-6}$ Torr
Ultrahigh vacuum	$10^{-12}$ to $10^{-9}$ Torr
Extreme Ultrahigh vacuum	below $10^{-12}$ Torr

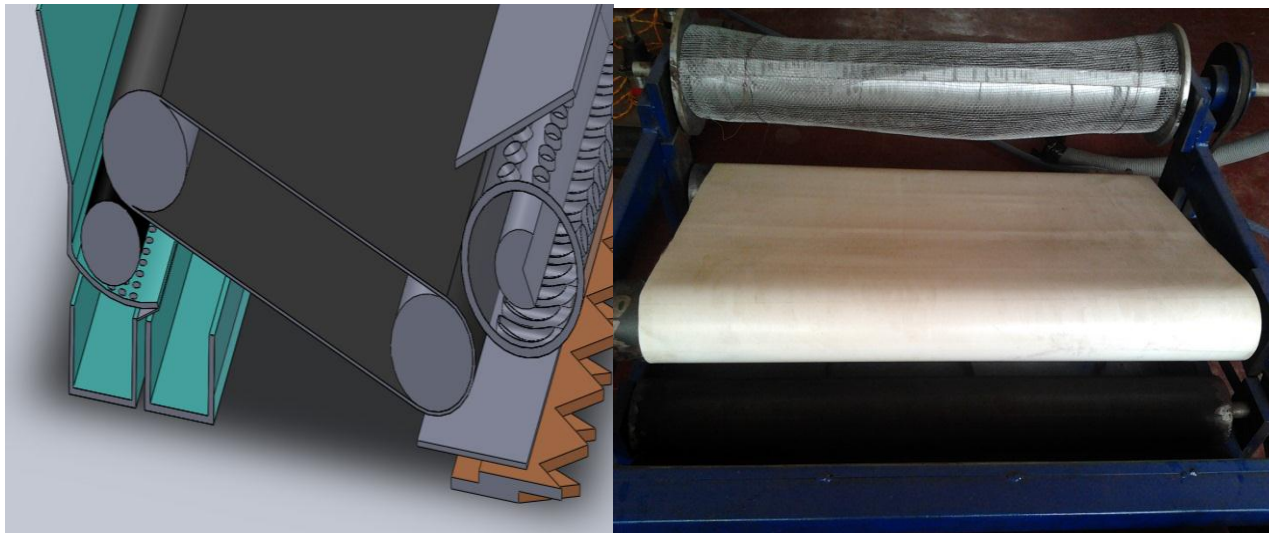
A universal Motor is selected so it can be connected to AC current or DC Current (230 V- Single Phase). A medium pressure vacuum motor having a vacuum pressure of 1.3 torr (1 Torr = 760 mmHg) is used for the current system. The basic selection of a vacuum motor is based on the suction force rating of the motor. The suction force should be more than the total force exerted by the crops downwards, when the crop is held by the perforated sheet of the vacuum assembly.

### 5.2 Conveyor mechanism

The conveyor is the other mechanism which is provided to carry the straws to the threshing mechanism after cutting. The rollers are placed at the angle of  $15^\circ$  so as the effective transfer of the straws takes place and also to provide the threshing mechanism and to place the collecting bins for straws and grains are placed below the conveyor which in turn reduces the length of the attachment. For this mechanism two rollers are used, one roller acts as driver which is connected to



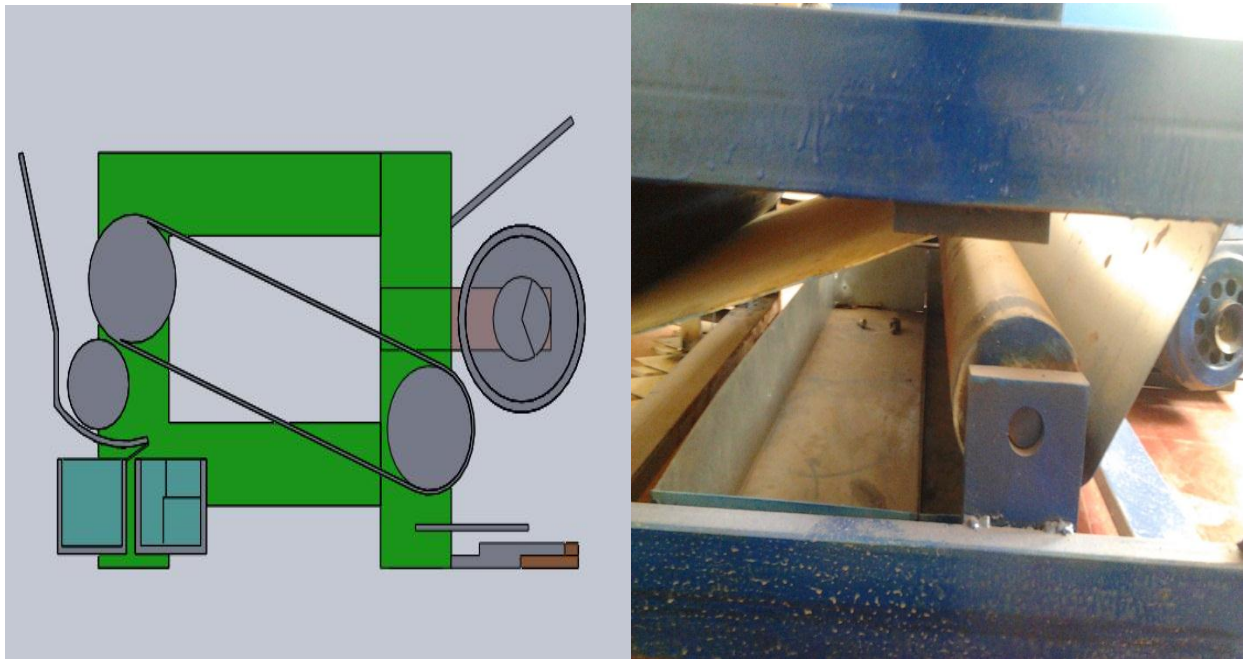
the pulley and the other roller is driven by the driver using conveyor belt. In this assembly for conveyor rollers seamless steel tubes of standard diameter 100mm is used and the standard conveyor belt PVC food grade conveyor belt is selected and used. The manufacturing processes includes i) end caps – turned and welded to the conveyor roller ii) bearing support plates – hole is bored to fix the bearing and holes are drilled to fix the plate in the frame using bolts. The Fig5.2 shows the conveyor assembly.



**Figure 5.2 Roller and conveyor mechanism**

### **5.3 Threshing mechanism**

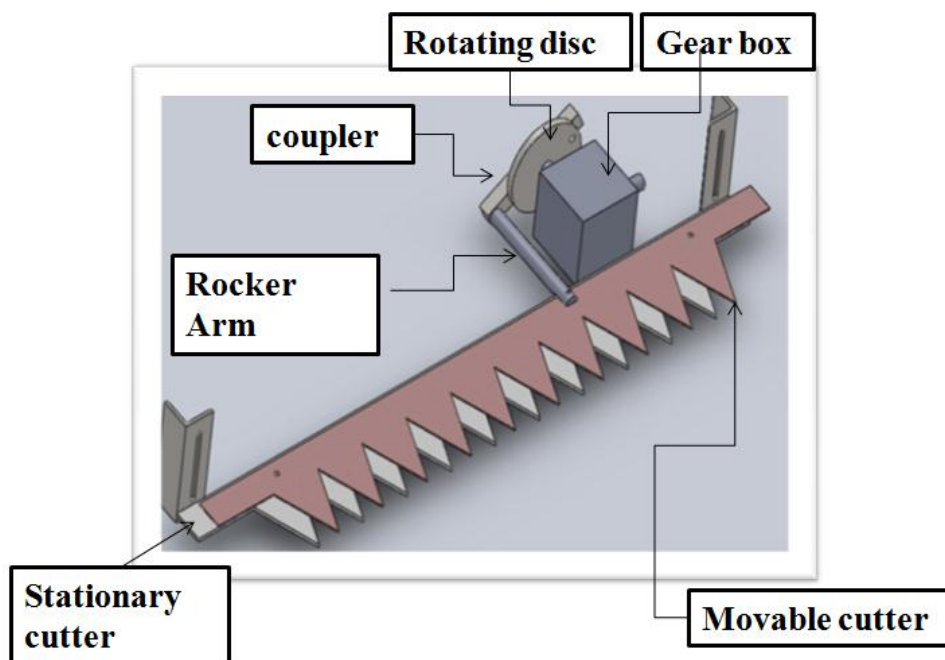
Threshing mechanism is provided to separate the grains from the straws the mechanism consists of threshing roller which is covered by the rubber material to avoid damaging of the grains and by friction to transfer the straws to the collecting bin threshing mechanism consist of threshing plate, the clearance between the threshing plate and the threshing roller is gradually reduced to 1.5 mm as the finger millet diameter is around 1.5mm. The series of holes are provided in the threshing plate below the holes the grain collecting bin are provided through the holes the grains gets collected into the bin. In order to strengthen the threshing plate the stiffeners are provided to the threshing plate. For the threshing roller a standard seamless steel tube of diameter 100mm is used. The end cups are turned and welded to the roller, the bearing support plates are bored and bearings are fixed and relief holes are drilled to clamp the support plate to the frame. The Fig5.3 shows the threshing attachment.



**Figure 5.3 Threshing mechanism**

#### **5.4 Harvesting mechanism**

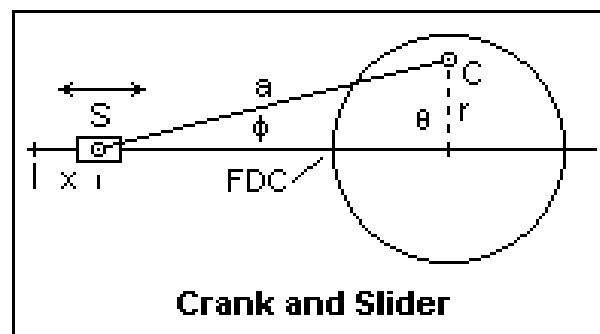
The harvesting (cutting) mechanism consists of two cutting blades the fixed blade and moving blade. The fixed blade is the stationary blade which remains stationary while cutting takes place and the moving blade slides on the fixed blade by the slider crank mechanism and cuts the straws a bevel gear box is used to transmit the power to 90°



**Figure 5.4 Cutting blade mechanism**

### 5.4.1 Mechanism of harvesting

For the motion of cutting mechanism for blades a simple ‘Slider-Crank Mechanism’ is employed which has fixed blade, movable blade, rotating disk, rocker arm and coupler in which the fixed blade and moving blade has prismatic joint, coupler and rocker arm has revolute joint, the coupler and rotating disk has revolute joint and the rocker and moving blade has fixed joint. This mechanism is used to convert rotary motion into the reciprocatory motion. This can be achieved by mounting the coupler off set from the center of rotating disk as shown in the Fig5.5.



**Figure 5.5 Slider Crank Mechanism**

In the Fig5.5 the circle represents a rotating disk of thickness ‘t’ and radius ‘R’. CS represents the length of the coupler positioned offset in rotating disk at a distance ‘r’. When the coupler and the dotted line indicating distance ‘r’ gets collinear at one end the minimum stroke and in the other end maximum stroke is achieved and thus the displacement ‘S’ takes place.

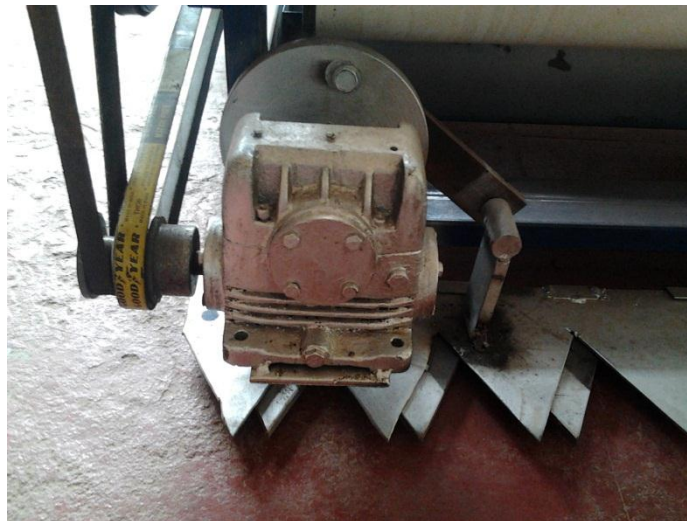
For this mechanism, the power for driving the cutting mechanism is transmitted from the engine with the help of the pulley mounted on the external shaft and a bevel gear box is used to power obtained from the pulley in 90° and the suitable diameters of the pulley is used in the cutting mechanism to ensure the velocity of blades in cutting mechanism. The belt used in this mechanism is the V-Belt of type ‘B’ for the pulleys.

### 5.4.2 Slider Crank Mechanism for cutting

The pulley mounted at the cutting mechanism is rotating about the horizontal axis parallel to the engine axis, in order to transmit power rotating disk the power has to be transmitted to the perpendicular axes for which the bevel gear box is used. In the cutting mechanism, the standard bevel gears box which are present in the machine tools is used.

For the above bevel gear arrangement, one bevel gear is coupled to the shaft of the pulley placed at the cutting mechanism and the other bevel gear (having the axis of rotation intersecting the previous one at 90°) was coupled to the center of the circular plate as shown in Fig5.6.



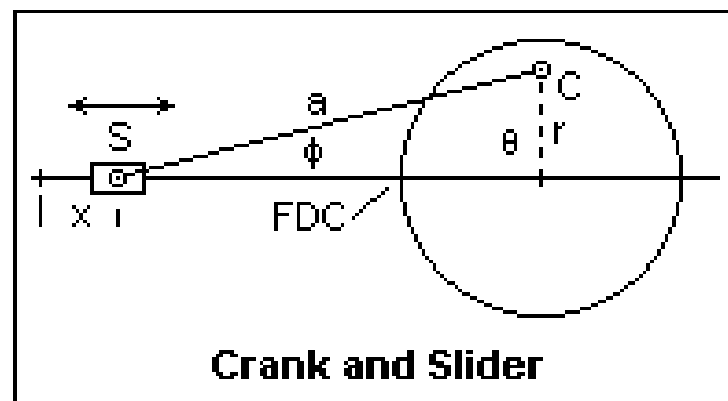


**Figure 5.6 Bevel Gears box of machine tool**

## 5.5 Calculations

The maximum displacement of the cutting blades and the velocity of the blades are calculated. The distance by which the slider moves per stroke is given by the following relation.

$$x = a(1 - \cos \phi) + r(1 - \cos \theta)$$



**Figure 5.7 Slider Crank Mechanism**

Where,  $x$  is the linear displacement

$a$  is the length of the connecting rod

$r$  is the length of the crank

$\phi$  is the angle subtended by the connecting rod with the horizontal.

$\theta$  is the angle subtended by the crank with the horizontal.

The above mentioned relation was used to determine the distance as shown below:

$$\begin{aligned}
 x &= a(1 - \cos \phi) + r(1 - \cos \theta) \\
 &= 0.304(1 - \cos 30) + 0.0762(1 - \cos 30) \\
 &= 0.0407 + 0.01020 \\
 &= \mathbf{0.0509 \text{ m or } 50.9 \text{ mm}}
 \end{aligned}$$

From this, it can be seen that the upper blades will move by a distance of 50.9 mm for one full rotation of the disc. The speed of the cutter is determined using the following procedure:

$$V = r \cdot \omega$$

Where,  $r$  is the radius of the crank

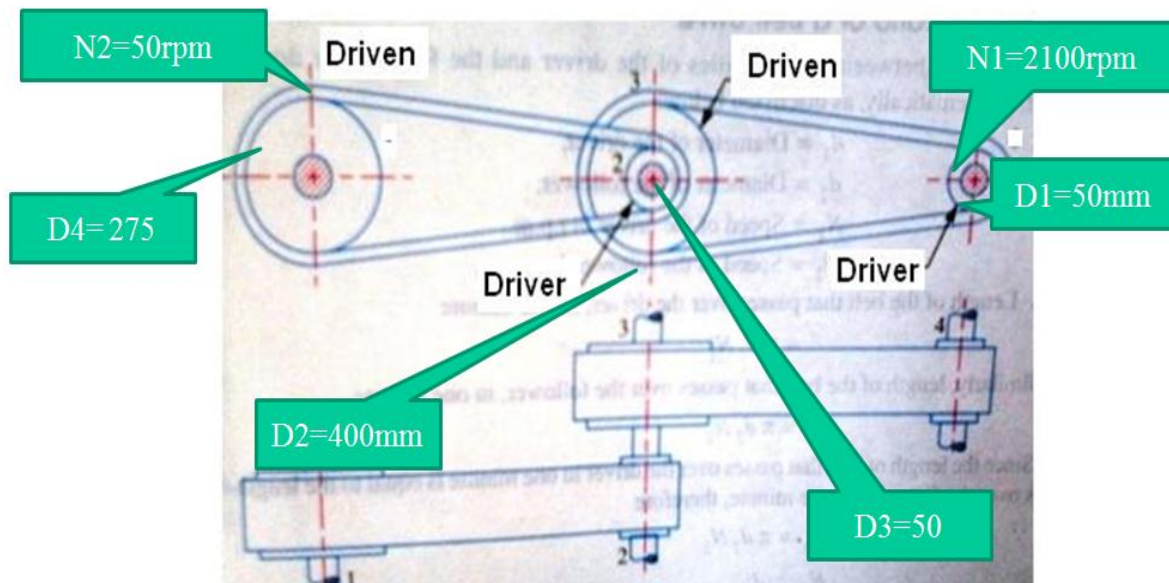
$\omega$  is the angular velocity in rps.

$$\begin{aligned}
 V &= 0.1524 \cdot 0.0762 \\
 &= \mathbf{0.0116 \text{ m/s.}}
 \end{aligned}$$

From this, the speed of the cutter is deduced to be 0.0116 m/s or 11.6 mm/s.

## 5.6 Calculations of belt drive

As the rpm of the engine is 2100 in order to obtain various rpm at the various mechanism like vacuum roller, threshing roller, conveyor roller, etc it is required to select the proper diameter pulley and also in between intermediate pulleys are used to reduce the diameter of pulley and to obtain the rpm as shown in the Fig().



**Figure 5.8 Combined belt drive**

The diameter and the rpm of pulley are found using the velocity ratio formula:

$$\frac{N_1}{N_2} = \frac{D_2}{D_1}$$

Were,

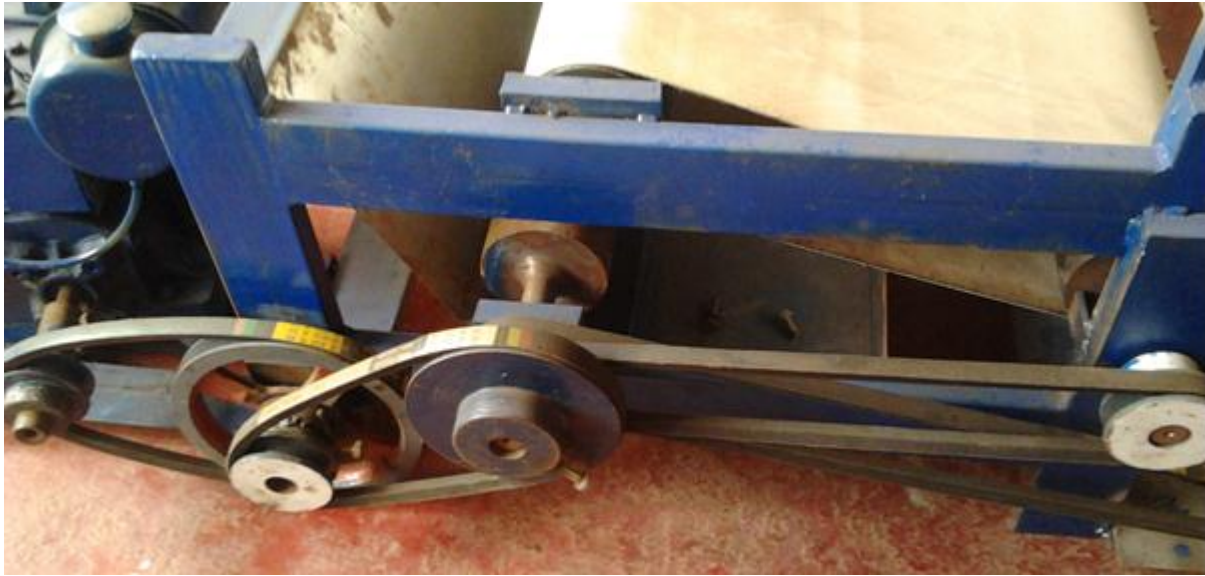
$N_1$  = rpm of driving pulley.

$N_2$  = rpm of driven pulley.

$D_1$  = diameter of driver pulley.

$D_2$  = diameter of driven pulley.

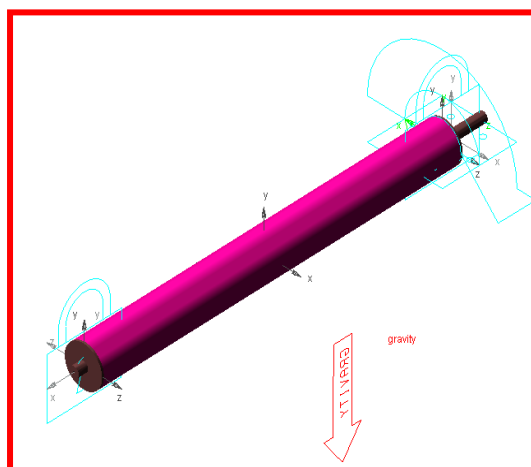
The various diameter of pulleys are found and fixed in the attachment as shown in the Fig5.8.



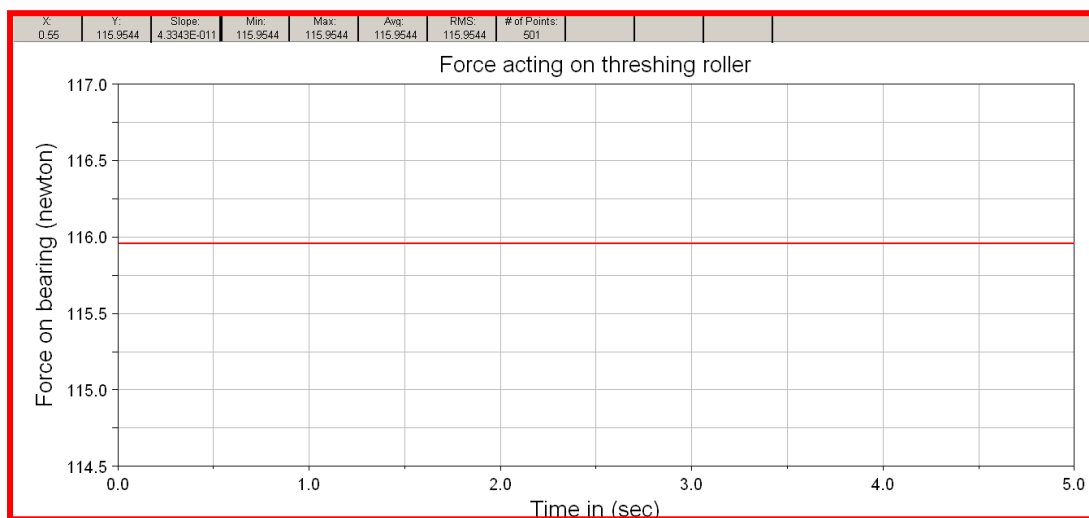
**Figure 5.9 Power transmission using belt drive**

## 5.7 Kinematics analysis

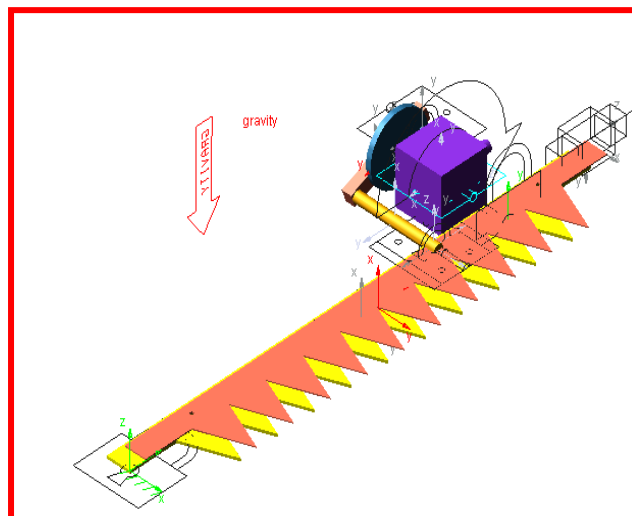
The kinematics analysis is carried out using the ADAMS software through which the motion of the blades in the cutting mechanism is verified and also the forces acting on the bearing due to the rotation of the rollers are found and the bearings are selected based on the result obtained. The Fig5.11 shows the graph of the force acting on the bearing in Newton and the Fig5.13 shows the graph of displacement length of the blade in mm.



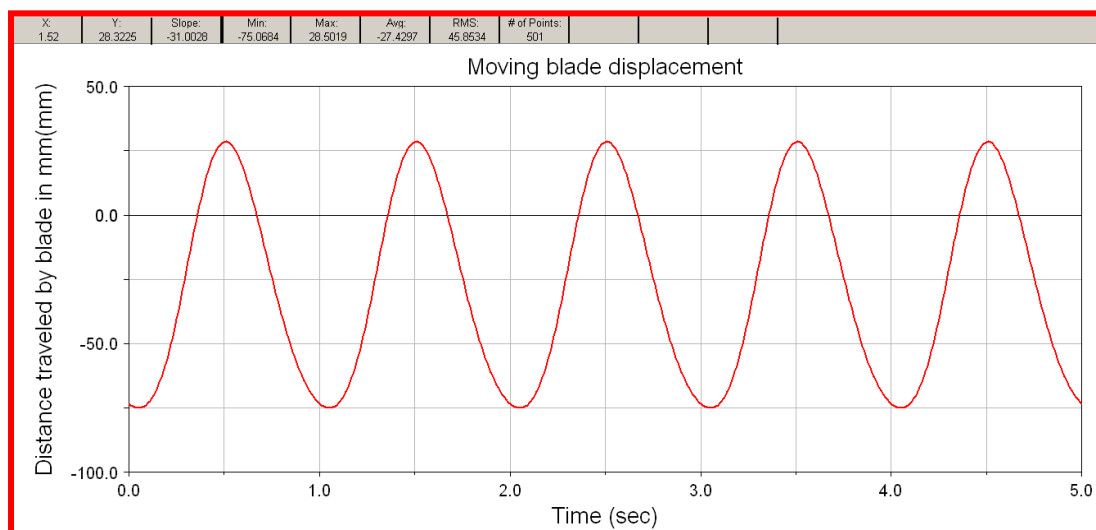
**Figure 5.10 Model of roller to obtain forces acting on roller**



**Figure 5.11 Forces acting on roller bearings**



**Figure 5.12 Model of cutting mechanism to obtain blade velocity**



**Figure 5.13 Displacement of cutting blade**



## 5.8 Various steps in manufacturing





## Chapter-6

### Fabricated Combined Harvesting and Threshing Attachment

#### 6.1 Final finished project of combined harvesting and threshing attachment

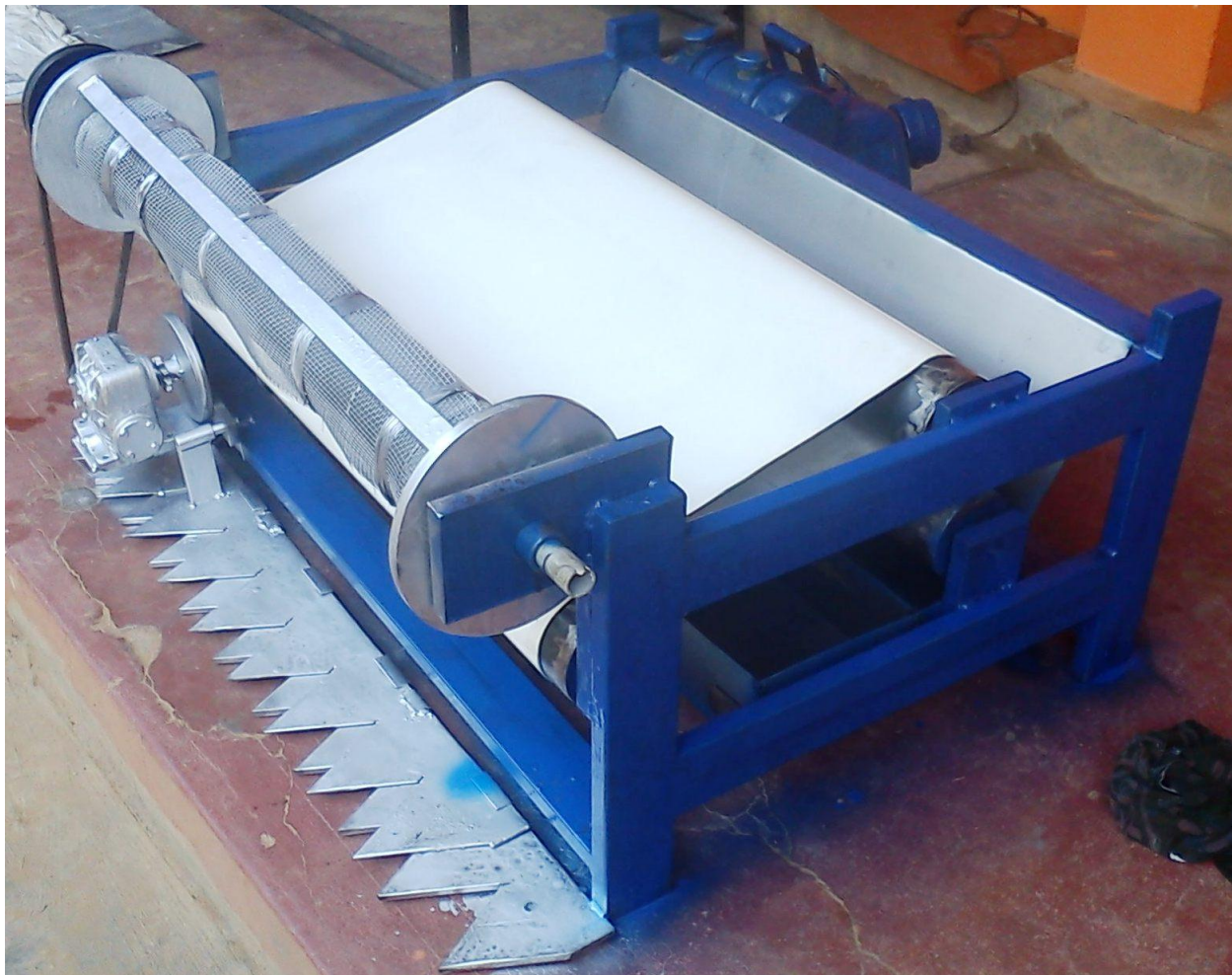


Figure 6.1 Finished combined harvesting and threshing attachment

#### 6.2 Specifications of the vehicle

- Weight--- 140 kg (Approx)
- Overall length---1000 mm
- Overall width---1000 mm
- Height ---500 mm
- Cutting width---1000 mm
- Engine type--- Needle vibrator engine
- Engine fuel---regular petrol
- Maximum power – 1.2kw at 2100 rpm

### 6.3 Advantages

The finger millet harvesting and threshing has following advantages:

- The attachment is compact and can be easily attached to the agricultural farm machineries.
- Range of Cutting is designed for the bed width of finger millet plantation.
- Straw collection and the grain collection is possible by the attachment.
- Possibility of Vacuum to use as blower for cleaning the vacuum roller while it gets blocked
- Finger Millet crop height is not the problem for this attachment it is possible to harvest different crop heights.
- Ground Clearance of the blades can be varied by the height adjuster.
- Cutting force on the blade is reduced by the vacuum pressure as the vacuum roller pulls the crop and in tension cutting takes place.

### 6.4 Scope for Future work

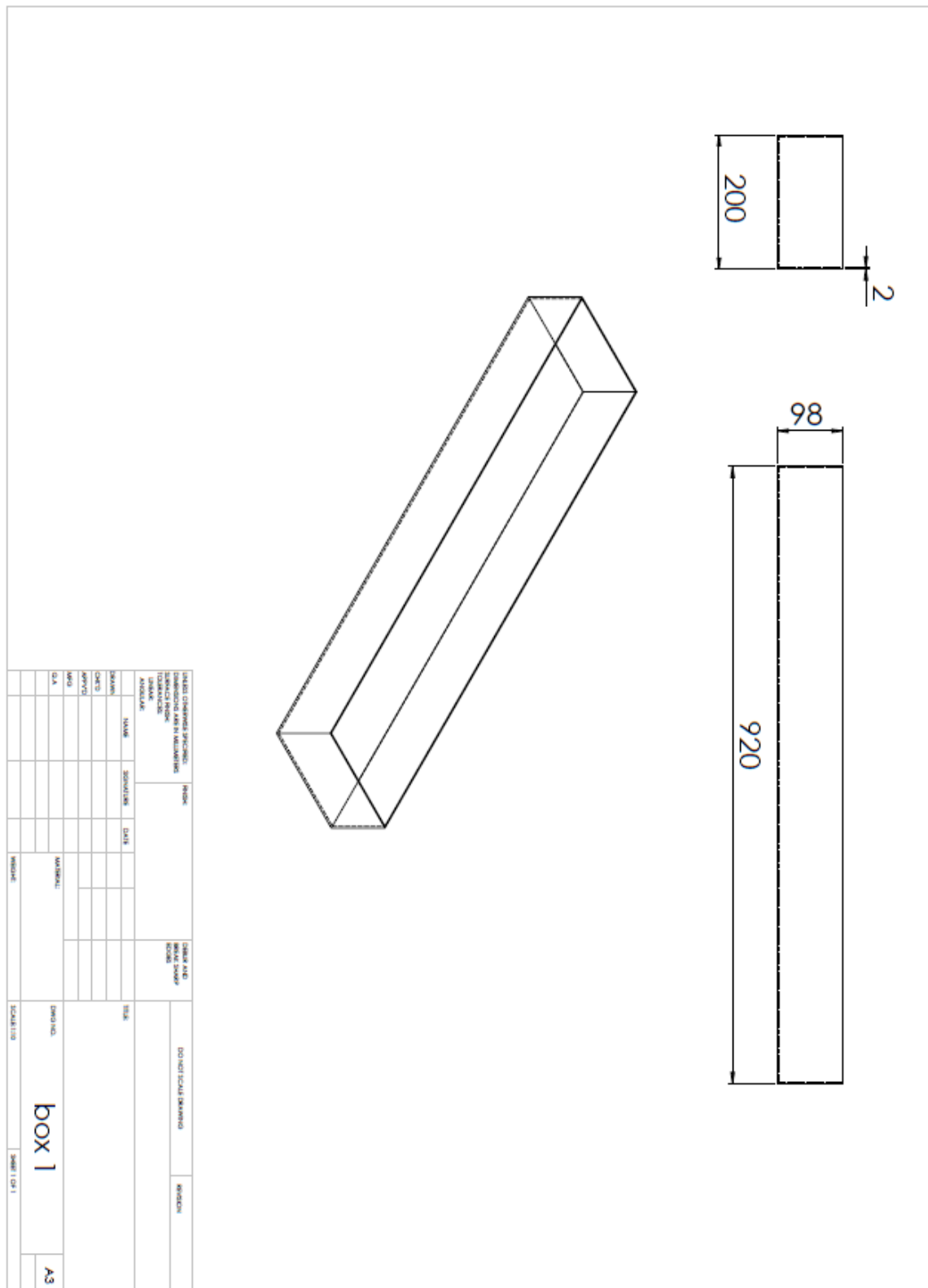
- Power transmission to the attachment from the tractor to be incorporated.
- The storage capacity of grains and straws to be increased
- The size and the weight of the attachment has to be reduced
- The number of pulleys used for the power transmission has to be reduced
- Intermittent heaters can be incorporated before threshing.

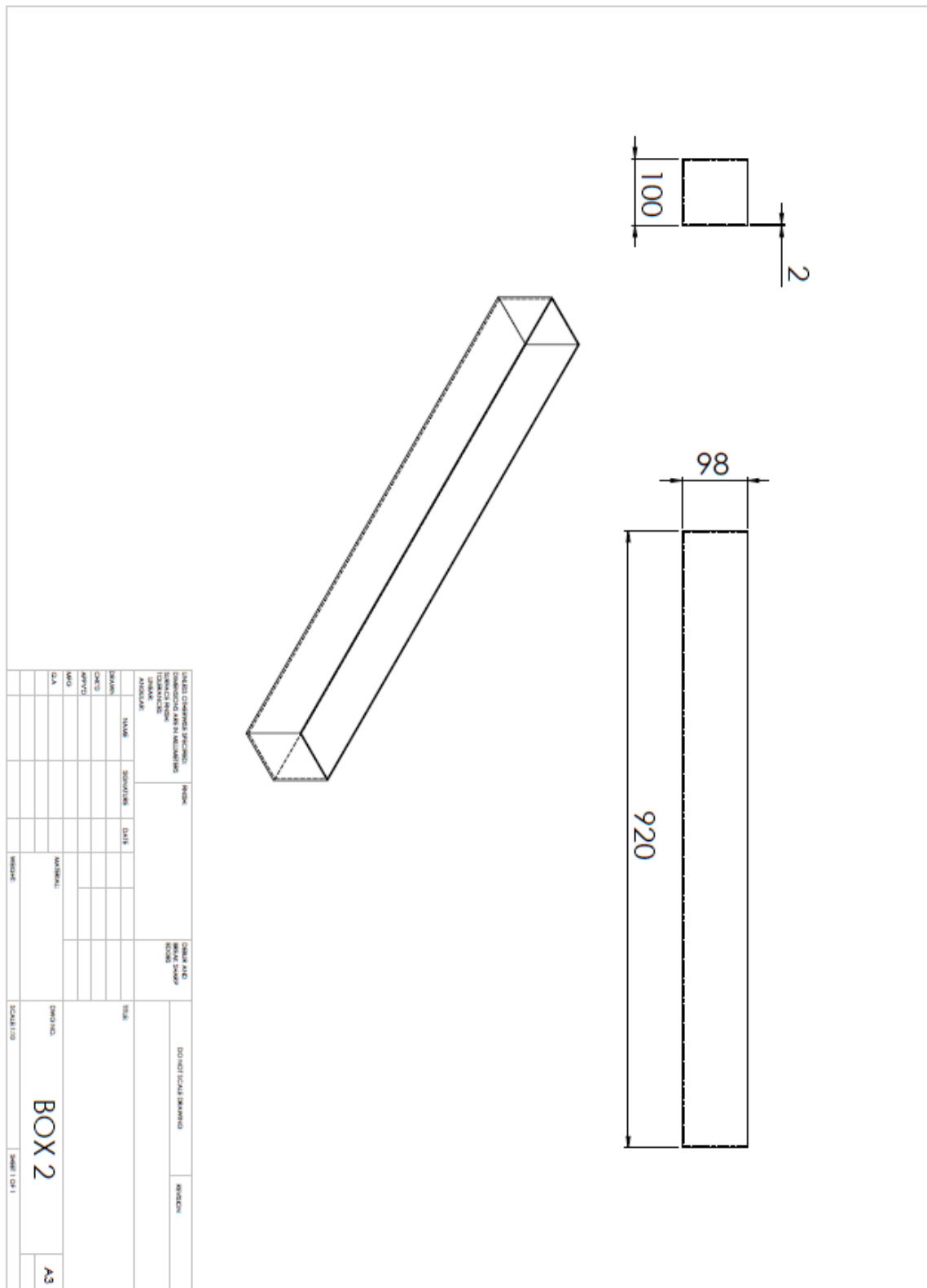
## References

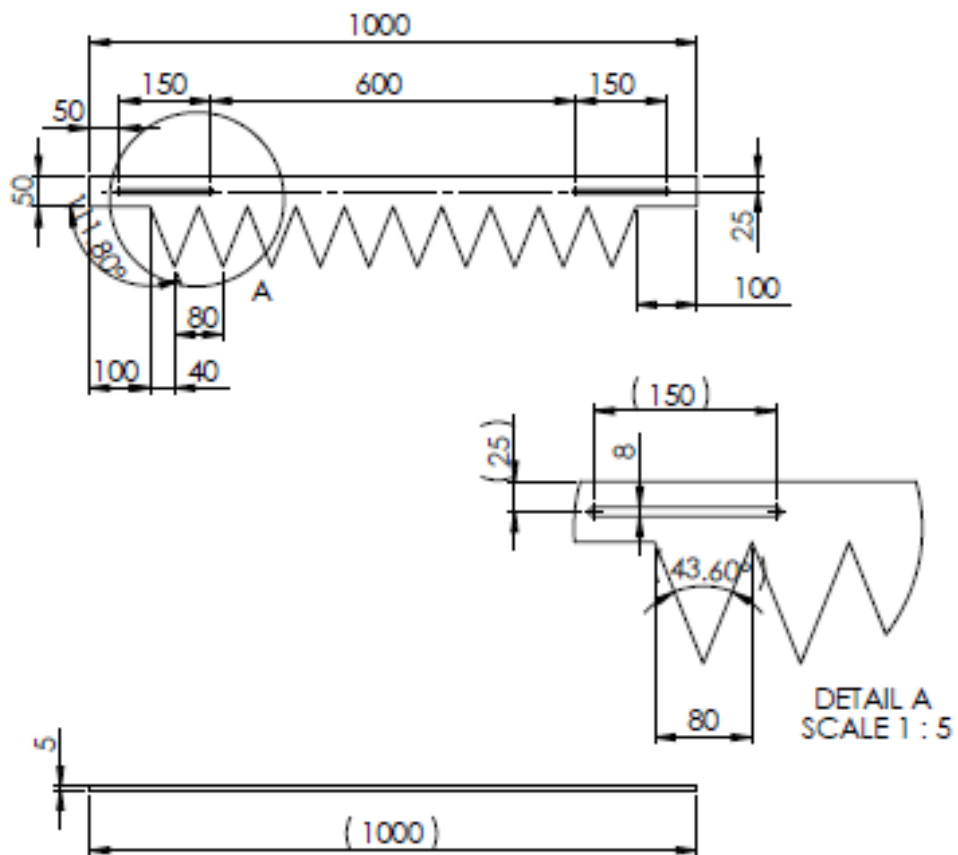
- [1]Dr. ShailajaHittalmani, "*Developmentof high yielding, disease resistant, drought tolerant Finger millet*", University of Agricultural sciences,GKVK, Bangalore-560 065, India, shailajah\_maslab@rediffmail.com
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- [9][http://www.qfdi.org/what\\_is\\_qfd/what\\_is\\_qfd.htm](http://www.qfdi.org/what_is_qfd/what_is_qfd.htm)
- [10]"*Millet*s", Millet Network of India - Deccan Development Society - FIAN, India



## **Appendix – Part Drawings**



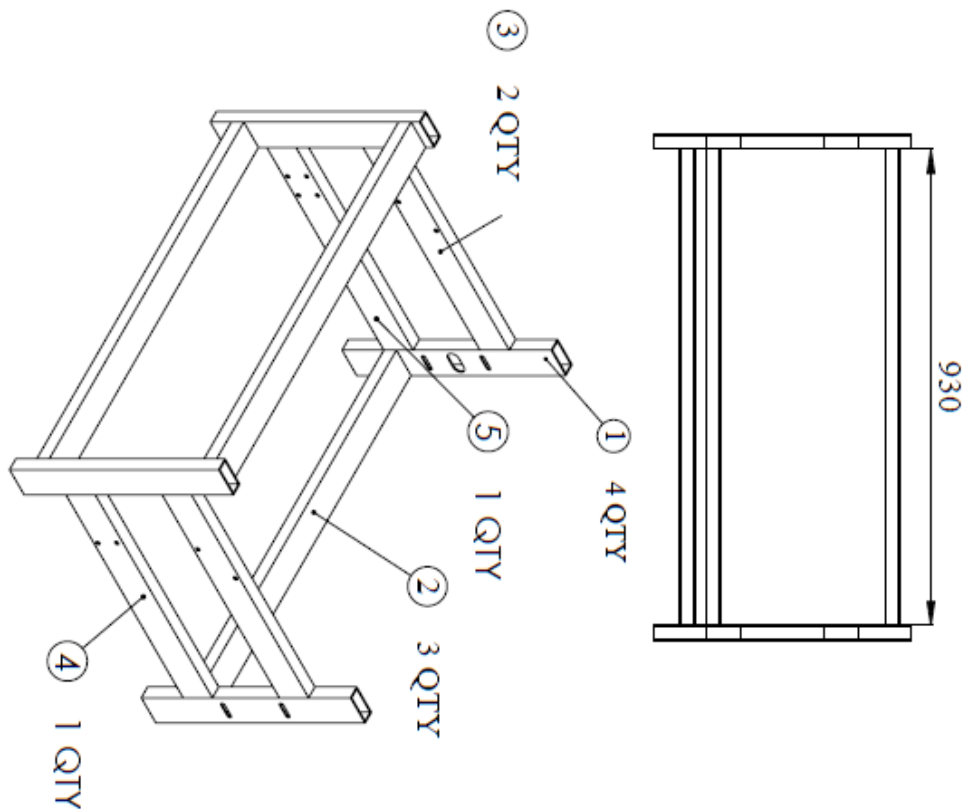
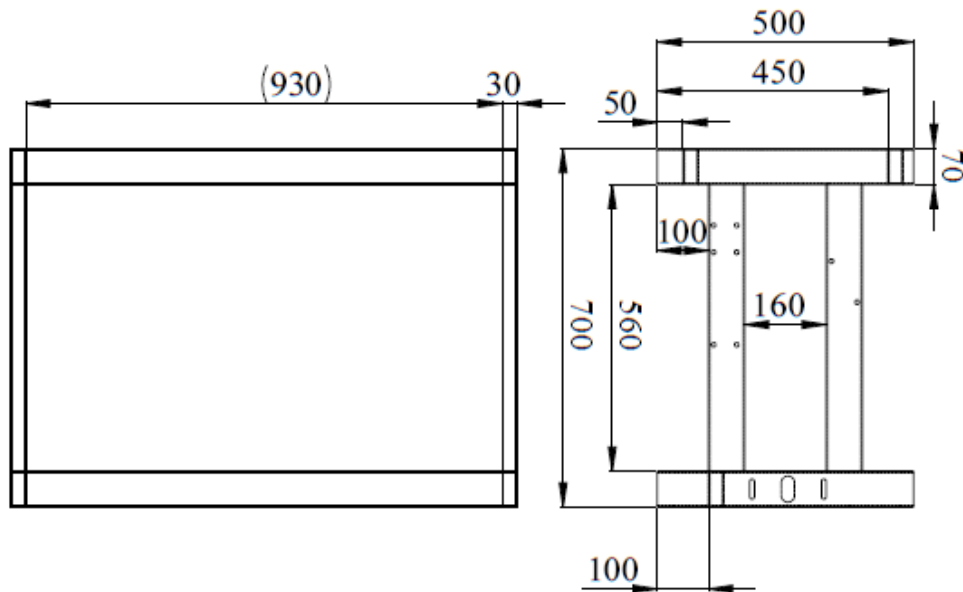




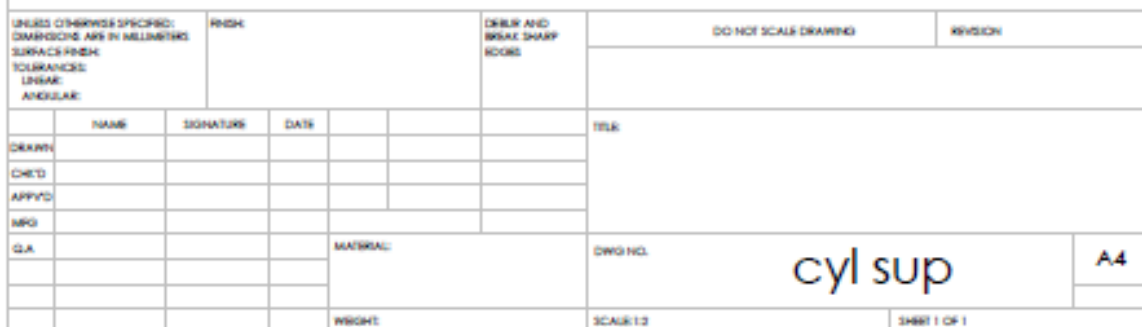
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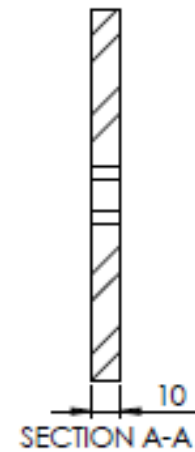
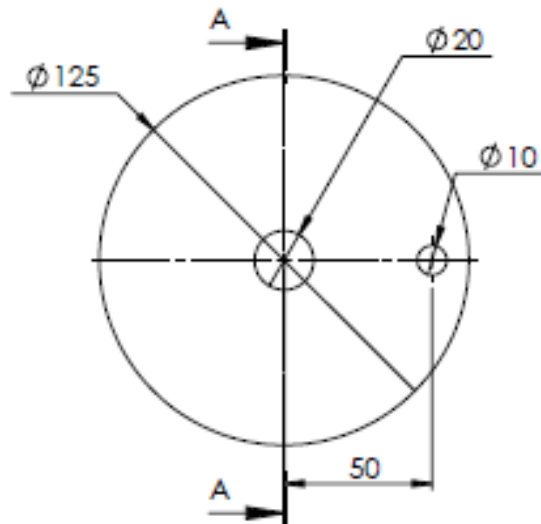
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DESIGN									
CHECKED									
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G.A.			MATERIAL:			A4			
			WEIGHT:						

Note: All the rectangular tube are 70x30x2.6

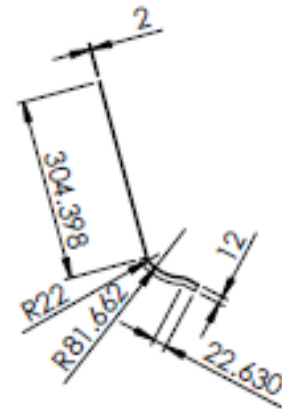
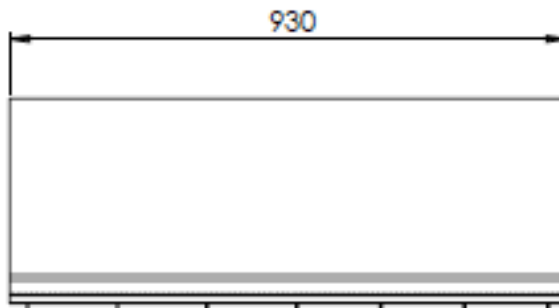


Sl. No.	Part Name	Qty	Remarks
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4	Rectangular Tube	1	
5	Rectangular Tube	1	
Total Qty			
10			

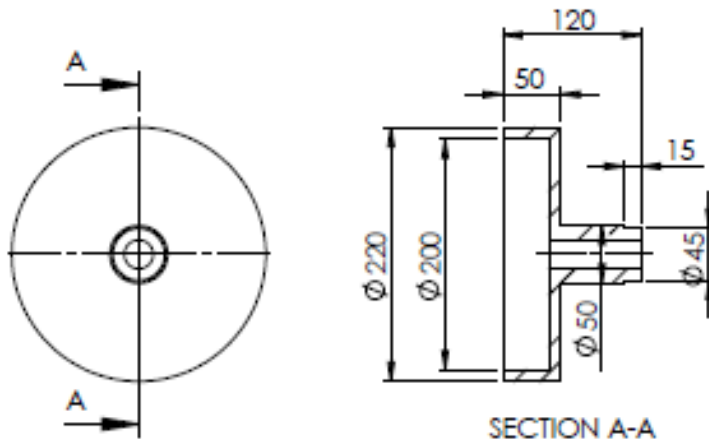




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W

Note :STD. L angle 50x50x5  
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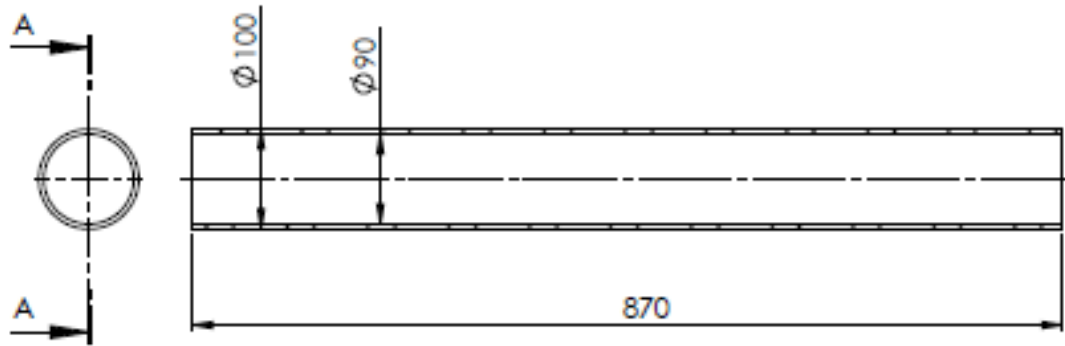
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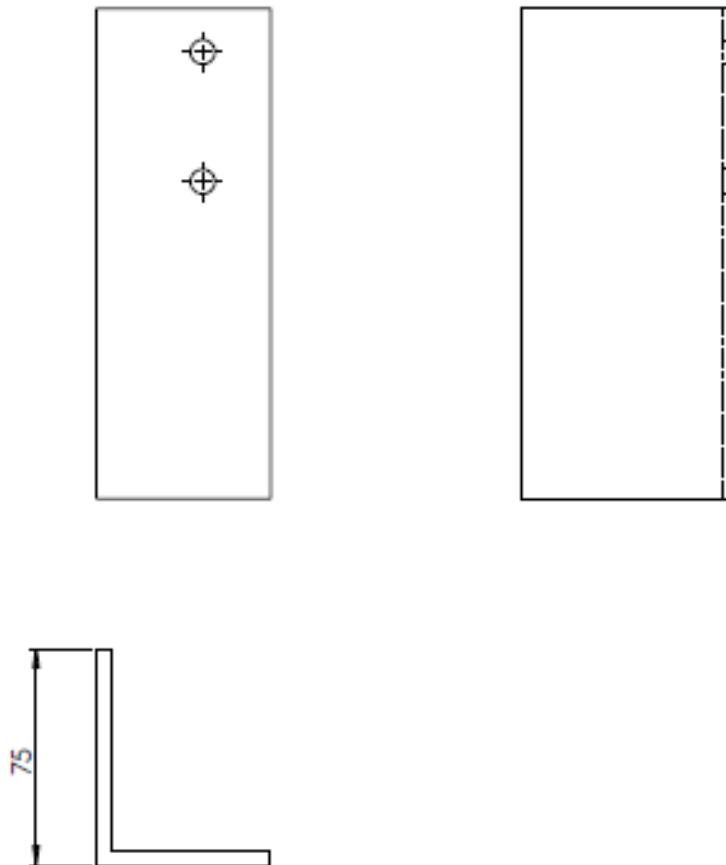
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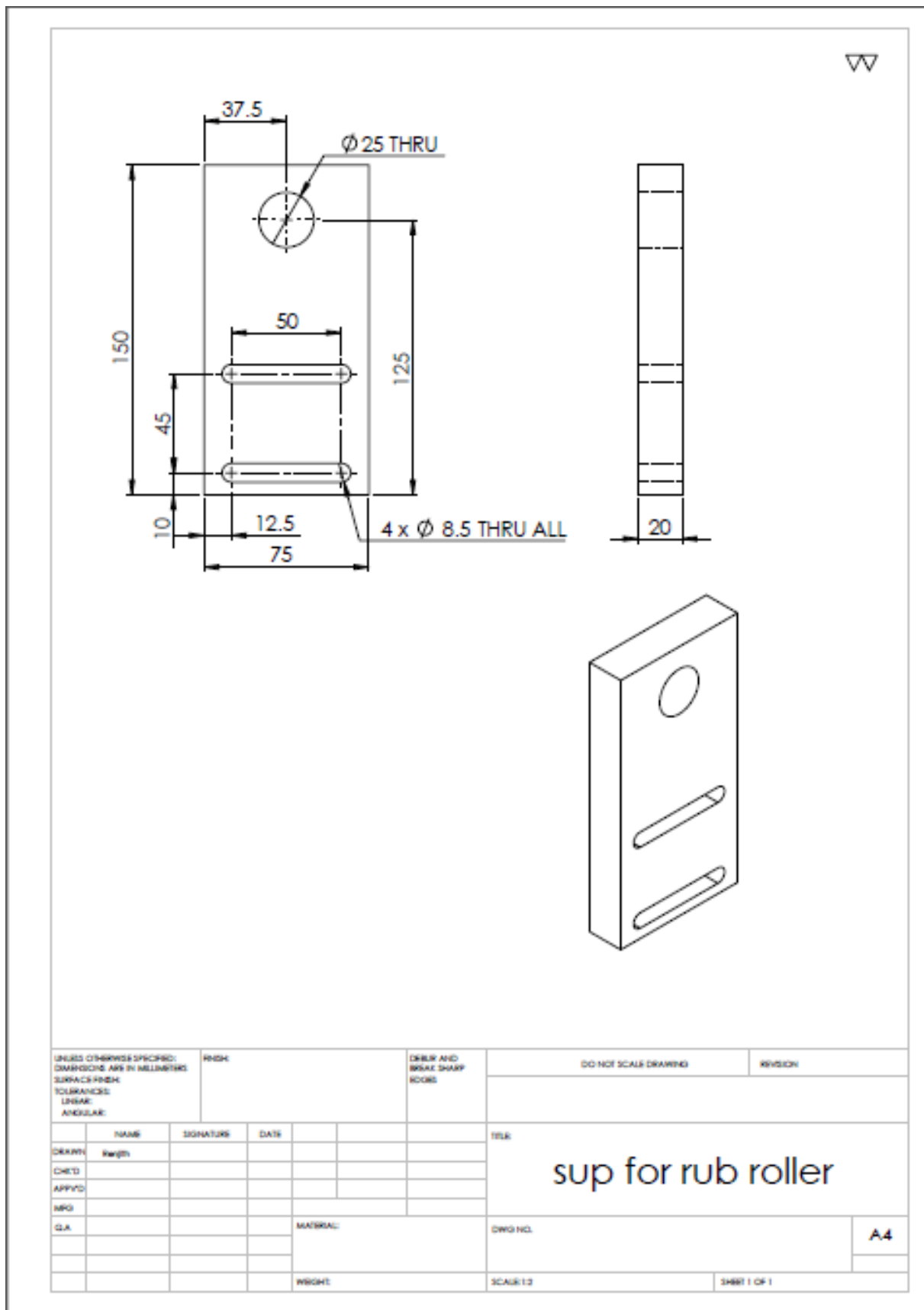


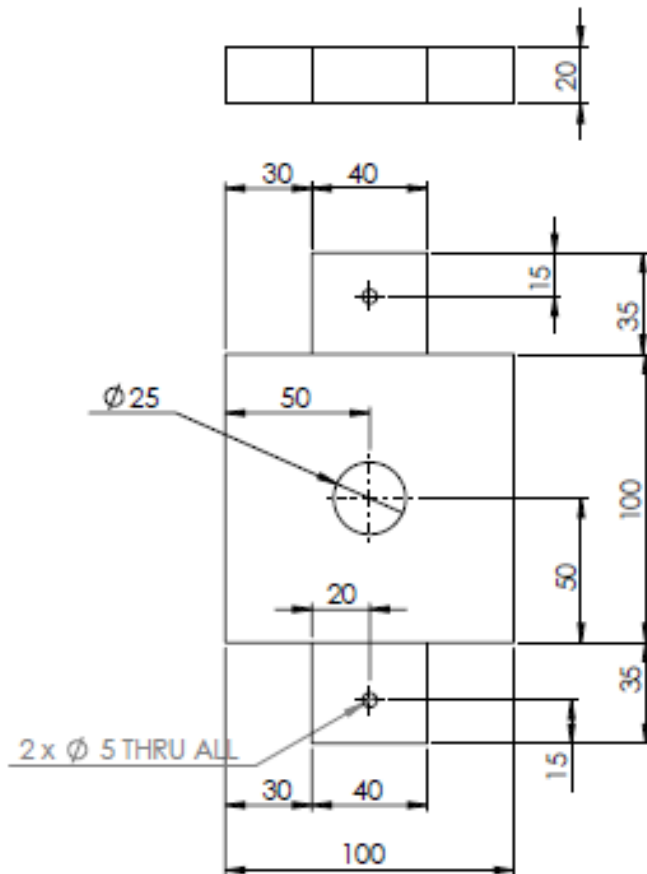
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MFG											
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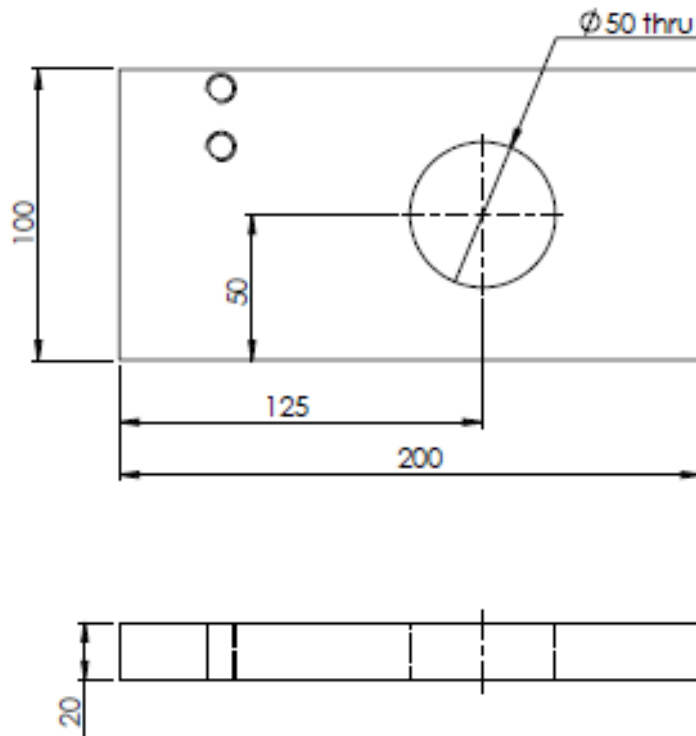
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