ADDIS ABEBA UNIVERSITY

ADDIS ABEBA INSTITUTE OF TECHNOLOGY

SCHOOL OF MECHANICAL AND INDUSTRIAL ENGINEERING

DESIGN OF TEFF SEED DRILL MACHINE

BY:

Habtamu Mulatu Alemu

A thesis is submitted to the School of Graduate Studies of Addis Ababa University in partial fulfilment of the Requirement for the Masters of Science in Mechanical Engineering. (Mechanical Design stream)

Advisor: Dr Daniel Tilahun

Co Advisor: Mr Geta K/Mariyam (PhD candidate)

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DECELERATION

Here I'm declare this work, which is being presented the thesis report for the completion of Partial Fulfilment of the Requirements masters of Science in Mechanical Design Engineering, under the supervision of Dr Ing Daniel Tilahun instructor in School of Mechanical and Industrial Engineering, and Mr Geta K/Mariyam (PhD candidate in Addis Ababa university) whose is the researcher on teff, Mechanical Design Engineering program in Addis Ababa University/Institute of Technology, Ethiopia.

The contents of this report reflect my ideas except for quotations and summaries which have been duly acknowledged and I'm responsible for the facts and the accuracy of the information presented in this document. All relevant resources of information used in this paper have been duly acknowledged.

Habtamu Mulatu Alemu _____ _____

Name of student Signature Date

This is to certify that the above statement made by the candidate is correct to the best of my knowledge and belief. This report has been submitted for presentation with my approval and this project is adequate in terms of scope and quality for the award of the degree of Masters Science of Mechanical Engineering (Mechanical Design stream).

Dr Daniel Tilahun _____ _____

Advisor Signature Date

Mr Geta K/Mariyam (PhD candidate) _____ _____..

Co-advisor signature Date

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Habtamu Mulatu

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ABSTRACT

The main objective of this project is to design teff seed drill machine which use for improve the cultivation technology. Since the teff is most well-known and widely consumed grain in Ethiopia for a long period of time. Due to the importance of this cereal crops the consumption were increase time to time. But in recently the provision of extension service to improve teff product in order to satisfy the demand, use seed drilling with the application of technology have been introduce by Ministry of agriculture and its partner. For thus different research Center were been in trying to do the technology as per the specification i.e. Ethiopian Institution of agricultural research beside ministry of agriculture, minister of agricultural mechanization and agricultural transformation agency (ATA), Oromia agricultural mechanization sector at Melkasa agricultural centre, Bahir Dar agricultural mechanization and food science research Center, and RASSELAS research and engineering development were doing on the way. Some projects have public to evaluate but standing from this almost all system has functional in limited soil resistance (low and probably medium moist soil conditions). The adoption of this technology improvement was take in serious by combining different system, evaluating, comparing and contrasting as per the agricultural requirement criteria which will the best ideas for fits to teff seed drilling application. The critical point of system is to design based on the physical properties of teff seed and fertilizers which are vary according to moisture condition. It requires single person to operate which placed on his shoulder to work continuous two –four hours without tiredness, it has 5.67kg full loaded weight, it can drill three row at a time both teff seed and fertilizer with in 20cm row gaps, the theoretical field capacity has eight hours required for one hectare. It's applicable for almost all soil conditions.

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GDP: - growth domestic production

ATA: - agricultural transformation agency

PLC: - privet limited company

EIAR: -Ethiopian Institution of agricultural research

MSDARDB: - MINJAR SHENKORA District Agriculture and Rural Development Bureau

MOA: - Ministry of Agriculture

FTC: - Farmer Training Centres

SNNP: - south nation and nationality of people

DAP: - Di-ammonium Phosphate

HP = horse power

T= torque

T_e = equivalent torque

V_2 = velocity

MPa = mega-Pascal

N= number of rotation

D= diameter

L=length

μ= coefficient of friction

t= thickness

b= width

Y = deflection

E = modules of elasticity

F = load

Z = shear modules

M =bending moment

M_e = equivalent bending moment

N = factor of safety

PEEK = polyether-ether ketone

TC = total cost

LC = labour cost

σ_{max}= maximum tress

σ_b = bending stress

τ =shear stress

DAP= Di-ammonium Phosphate

CHAPTER - ONE

1. INTRODUCTION

1.1. Background Of The Study

Ethiopian government has designed and implemented several economic development plans, notably the sustainable development and poverty reduction plan, which covered the year 2002/03E.c to 2004/05E.c and a plan for accelerated and sustainable development to end poverty that ran from 2005/06 to 2009/10E.c. Available data shows the country has registered a real GDP growth rate of more than 11 % over the period 2002-2008. Over these years, agricultural remained the main sector of the economic accounting for about 45% of the GDP of the country on average whereas the average contributions of the industry and service sectors were about 13% and 42% respectively [1].

According to the plan, the Ethiopian government aims to double agricultural production in the future by increasing the capacity and extensive use of labour, increasing agricultural land utilization linking specialization with diversification, strengthening the agricultural marketing system and scaling up best practices in the sector [1]. To achieve the above objectives the government has establish the Ethiopian agricultural transformation agency (ATA). The agency achieves the target by identify the bottlenecks that limits the achievement of the desired levels of food security and growth and creating the solution for those problems. Doing a lot of researches which creates a solution and mechanized the agricultural sector are also the main aim of the sector [1].

From those agriculture products the one which is broadly use both in terms of production and consumption throughout the country is teff. In a country of over 80 million people, it accounts for about 15% of all calories consumed in Ethiopian. Further, approximation 6 million households grow teff and it is the dominant cereal crop in over 30% out of 83% high-potential agricultural. In terms of production, it's the first dominant cereal by area planted in production and consumption. However, yields are relatively low (around 1.2t/ha) and high loss rates (25-30%befor and after harvest) reduce the quantity of grain available to consumer by up to 50% [2]. As Ethiopian agricultural transformation Agency was display the crop product transition season 2003/2004E.c from all over the land 2.78million hectare land were covered, the crop had produce 1355 kg, from farmer participate on crop production

development it had covered in 1999- 2003/4E.c 28.4%, 28.5% and 28.4% respectively from all crop kind which have a great quantity [10].

Many researchers were argued about teff and rise different ideas in the previous time. From those manly they are focuses on about important manner of teff and the reason why not agricultural industry be developed were the researcher had believes on the farmer strongly relation with teff production. But also, according to some research tells us about food oil mineral content and other food nutrients of tef which have high relative to other crops. Amino Acid is an important mineral for healthy life which present in teff, thereof in traditional measurement a person who eat one Enjera with stew they get a good amino acid according to researcher[11].

It's gluten free crop which makes it suitable for peoples with celiac diseases *[3, 4]* and a best chosen for a person who is allergy patient [10].It contains important nutrients and from total aggregate of chemicals 60% is starch with 20% of it is rapidly digestible that convert in to blood glucose within about half an hour. Whereas the remaining 50% of the starch is slowly digestible that changes into blood glucose within 3 to 5 hours while 30% is resistant starch that cannot be converted in to glucose, but use as substrate for the bacterial flora in the colon [5]. The hull/bran/Chid also use animal dry food and house building preparation with local mud. Doe to those reasons through time to time teff has become highly demands in international market. Even now a day foreign company looking for this to invest on teff agroindustry in Ethiopia, but it has domestic production of Ethiopian crops. So we should develop our agricultural industry to satisfy our teff demanded and increase export production.

Most of the Ethiopian crops adopted in cold areas (Dega), semi-cold area (weyna Dega) and hot area (kola). As it gets from farmer discussion (questionnaires) teff were been grown in hot area for a long period of time in selective soil type. But, now a day due to global climatic change teff were adapted the semi-cold area climate. It had the first rank which has 30% from all agriculture crops in the main production season [12]. Teff grain is found widely in most part of the country mainly in the altitude ranging from 1800 to 2100 meters above sea level due to this reason teff can be grown under diverse agro-ecological conditions. The major teff producing areas are Amhara, Oromia, Tigray and SNNP regions [18]. In some area beyond main season north shewa (around shewa Robit), south and north Wello and other please, it becomes the best production beside other fruit plantation in Ethiopian Autumn season which is so called Bunign teff. For instance in 2002E.c from the main autumn agricultural

production 1.24 million hectare land coverage crop had took 81% which is teff had get 10.24% value. [13]. Now a day the demand and supply of teff is not much stable. Therefore in study of extending land coverage we develop the best quality mechanism as per presence land usage. In some area from pre-extending program many farmers participate on using relative exchange technic to increase their product. They had got 2400-2500kg increase to 5000kg in one hectare *[10]*.

The behaviour of teff according to agronomic properties are fits to most conditions, i.e. it has resistant to extreme water conditions, as it is able to grow under both drought and waterlogged conditions in different soil type [2,31], It could grow faster which is use full for double cropping, Its reliable catch crop when there is some disaster happen, It couldn't attack by any plant disease and insects,*[2, 32]*, It can preserve for a long time,

It is self-pollinated annual grass, 40–80cm tall (Dejene et al., 2012) amongst the factors that contributing to low productivity of the crop are lodging poor crop management practices, low soil fertility, insect pests and weeds are some of the major once (Ermias et al., 2007). Product development of teff in appropriate agronomic practices (seeding rate, seeding methods, seedbed preparation, fertilizer rate and time of application) would greatly contribute for higher productivity of the crop Tarekegne (2010). From those factors the one which takes resolve relatively most factors by seed distribution mechanisms with in the required rates. The ministry of agriculture of Ethiopian had been prepared a plan to achieve program.

Seed drilling

Tangibly the most common way of teff planting, farmers was been use broadcast method in high seed rate of between 25 - 50 kg per hectare (ATA 2013c report). they argued this practice (Figure 1.2) reduces yield because the un-even distribution of seed increases competition between teff plants for water, light, and nutrients, and makes weeding more difficult once the plants have matured (Fufa et al. 2011).

Line sowing in current situation as a recommended to reduce the seed rate which is 3–5 kg per hectare and to drilling in rows (Figure 1.2) to reduce competition between seedlings and allows for optimal branching out of the plants. By seed drilling method land management and especially weeding prevent can be done more easily. The incidence of lodging is also found to be reduced, as the stem of seed row space is better able to support the weight of the filled head of grain (Berhe et al. 2011, Chanyalew and Assefa 2013).

Figure: 1-1: Labor requirement of tef row planting technology Source: MSDARDB (2013) secondary source from [18]

But this Line sowing requires involvement of large human power and sowing is not exactly on required place. Households with large family size were able to provide more number of labour assistance from the family members.it uses for demonstration purpose (See the figure 1.1.).

Figure: 1-2 Teff sowing practice using traditional broadcasting (left) versus row (right) source [14] *[15]*

The belief in the potential of reduced seed rate technologies to increase teff productivity is the outcome of on-station agronomic research to achieve higher productivity in food staple crops for our countries, farmer's needs to scale up the adoption of improved technologies. However, there is a lack of empirical knowledge on the potential and impact of promotion programs that aim to scale up the adoption of such new technologies [14] [15].

Many researchers had been investigating this method is used to drilling limited seed rate by appropriate fertilizer rate which is the best technics for good production system of teff cereal crop product. According to Ethiopian agricultural transformation agency showed us on its report since in 2005e.c the production change between broadcasting and seed drilling mechanism (see Fig. 1.2), the new technology has good result as compared previous method

of cultivation, From the base of Agricultural transformation agency experimental investigation seed drilling mechanism is the highest variation of product development [ATA, 2005e.c report table 7, page 32]. In the main planting season of 2011, the Ministry of Agriculture (MoA), ATA, and the Regional Bureaus and extension system initiated a large scale trial of these new technologies. Demonstrations were made with 1,430 farmers participate in Farmer Training Centres (FTCs), which resulted in 50-80% yield improvement compared to the national averages [18]. They had been concludes the teff seed drilling is the Best method of crop productivity. So in order to increase the productivity, mechanized sowing system is important by having drilling machine which is designed and manufactured based on agronomic properties of teff.

The machine were been designed and modelling in different agricultural research and development centre, minister of agriculture develop in Melkassa and Debrezet centres leading by Ethiopian agriculture transformation agency, RASSLAS engineering research PLC, and one team leads in Bahir Dar Agricultural Mechanization and food science Research Center have been doing a continuous work. But as it shown where in data collecting time they have less awareness and collaborative work between other researches centre. Promotion of their working stage should have been done continuously.

1.2. Statement of problem

Teff were been adopted in different soil and climatic condition. As usual observation soil may have low clay soil, medium clay soil, very wet and sticky soil. From those soil types Low and medium moist soil type relatively easy rather than very wet sticky soil, but the existing projects were a little bit functional in low and a little bit in medium clay soil condition. Actually there were been on going. But, as they shown almost all types of teff seed drilling machine have rotational driven system which have directly contact with soil except highland type drill(use vibration system). The soil has a potential to resist the motion in vertisol area under very wet sticky soil. So the existing machines are not precisely seed dropping because of the sticking properties of teff and soil resistance. Still now in our farmer hand, No one of existing machine could use for give service for such soil condition. So taking the serous effort to solve this problem by which system is fit to very wet soil condition.

1.3. Objective

1.3.1. Main Objective

The aim of the project is to design the system teff seed drill for relative high moisture, wet soil condition.

1.3.2. Specific Objective

a. Problem citation in existing work
b. System development
c. Design analysis
d. Weight determination
e. Preparing fabrication method
f. Estimating investing cost
g. Draw by solid work

1.4. Research Questions

- What is the factor effect to teff drilling?
- In which soil conditions previously were trying to develop system?
- Why the existing project is not functional?
- What system could be resolving the problem?

1.5. Significance of the research

These growth factors affect decisions on seed row spacing and seeding rates. Since teff drilling will result:-

- It minimizes shading and regulates the utilization of solar radiation for photosynthesis.
- Strengthen seedling
- Increasing teff product
- fertile seedling and prevents mutual shading in soil fertility
- avoiding seed extravagancy
- easy weeding and reduce competition with weeds
- Easy harvesting,
- access to available moisture
- seedling could access the nutrients
- Achieve optimal plant spacing.

Based on the above points we have to understood what the farmers need for developing teff products Therefore this mechanized line sowing machine will benefit for Ethiopian farmers by increasing the productivity of teff improving cultivation system.

1.6. Delimitation and limitation of the study

This technology of seed drilling of teff with a reduced seed rate was recently being introduced to the farmers. This technology mechanism has been on progress to development. I have encountered to show a number of problems while doing this project. During data collection there are shortages of literatures, some existing project have been modelled as I talk to my adviser and other different person I have been attend directly to those different area which are participating on this project, but it's difficult to get necessary data for evaluating and showing what is the problem in those previous technology. Even there are not voluntary to tell what needs the requirement rather than asking mechanism of my modelling system. A few activities have done for systems checking test in trial and error through observation which is difficult to achieve. This project is dealing up to design and developing of new system for working on moist soil which has relative soil resistance in a certain limit.

1.7. Material and Methodology

The objective of this project will achieve by taking the following materials and methodologies

a. Literature survey

Information about this issue gathered from our country background was the problem had been obviously known for our people. The necessary data have been collected from different document, research centre report and agricultural expert. Those data are like existing project performance, seed properties, and the specification what the project is achieved.

Through different methods as follow: -

- Using interviewees
- Evaluating existing project (secondary data)
- Through observation agricultural areas.
- Assessing the logical idea
- Studying what it needs the tef seed

b. Methodology

Concept methodology

The ideas were generate in different aspect of problem definition using the comparison method. Using the MS-excel to organize the variant and ranking in its criteria from the expecting value add.

Analytical methodology

The next thing is the detail design of system which is for better strength, efficiency and durability of the product the parts will design in analysis procedure analytically. Defining the dimension and components based on the requirement point and Load analysis also proceeds in this stage. Some parts have development using trial and error methods i.e. in order to find out the space between seed-seed, and seed-fertilizer by setting the tool and test it. Those tools are different size pipe, and other experimental tools are used on this section (appendixes II). Modelling the 2D and 3D views of machine were using solid work.

1.8. Project Organization

This project was organised in to seven sections. The first chapter deals the background of the Study and defining the gap from what I have discussed in literature and existing project evaluation.

The second chapter has deal on the literature Review which provides with an overview of the current situation which attempts to address. By accessing the detail background of the agricultural system of tef production system and follow the evaluation of pre-existing project.

The third chapter is the methodology of thesis task which stats the clear idea of data gathering, what material to be used, dimension, and method of analysis will be cover in this chapter.

The fourth chapter will assess the result and discussion of project from the analysis in chapter three. This could be elaborating the end result of the project.

Fifth chapter has cover the last section of project which would conclude what it get from the result, and recommended to further study of remaining works. Conclude the system operation advantage, limitation work based on the result and recommended what I have got.

CHAPTER TWO

2. LITERATURE REVIEW

The idea about this issue gathered from our country agricultural background and it have been obviously known for our people. The necessary data were been collected from different document, research centre report i.e. existing project performance, seed properties, and the specification what the project is achieved.

2.1.Row spacing

Row spacing is the distance from the centre of one seed tube outlet to the centre of the next outlet. Row spacing is related to nutrient placement, weed competition and sunlight. Seeding rate is primarily related to weed competition and available moisture. As a result, row spacing and seeding rates sometimes will change dependent on variety, season, and soil fertility. Sill we have one specification which declared by ATA, we haven't get any data about the variation factor which affect the critical dimension, but now in this project it follow the design by average optimum dimension which approved by ATA 20cm gap between the rows [16]. So far, we should recommend further study in the above factor and specific Optimum row spacing.

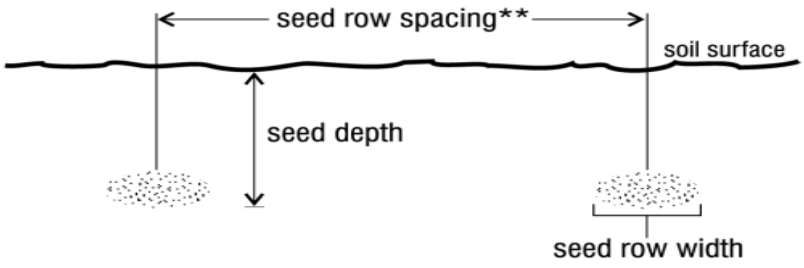


Figure 2-1 Seed rows from two rows drill

When another question delivers to farmers in order to know how they look the technology, the question is which methods best for teff sowing from broadcasting and line seeding? They defend it line sowing couldn't cover the whole area of cultivation land and traditional broad casting is an easy and quick method. Actually we have come up to agree it's quick but another point which couldn't get good result. Finally we had reach to agreement by setting out promotion of technology will show to farmer continuously with real output. This work is

should be plan to be carried out during the time when farmers are relatively free to be willing to invest their time on interviews and discussions.

2.2. Depth of seed placement and Directions of Rows

Depth of seed has assumed considerable importance after the introduction of high yielding varieties. Aberra (1992) discussed the significance of sowing depth as an important factor in grain management practices. Drilling at about 6 cm into moist soil offers a better opportunity for the grains to tolerate a short drought period and to increase grain yield because of better establishment compared with seed planted shallow (2-3 cm)[18]. However as Tareke (2008) explained, sowing depth is an important point which we considered us. Although seeding depth an important, in order to achieve this limit the crop land should be highly levelled however it's impossible to do this. In most parts of the country, soil compaction of Teff field is done using cattle, sheep, goats and/or donkeys and sometimes humans. Teff needs moderate soil compaction to make the seedbed firm, prevent the soil surface from drying quickly which causes seed desiccation and enhance germination [18]. The other point which it get the Teff properties from asking farmer and through observation (my parent were farmer and I have some experience on this) the Teff could produce branches at the point of seed germinating area. When the seed has under the surface will have less probability of getting number of branch. So it possible to should conclude that where this project is used good for teff sowing on the upper surface. Direction of drill is implement based on the wither condition and land elevation.

2.3.Seeding rate:

Seed rate is the factor which affects the yield because the un-even distribution of seed increases competition between teff plants for water, light, and nutrients, and makes weeding more difficult once the plants have matured (Fufa et al. 2011). The rate was in the previous seed broadcast system use high rate of between 25 - 50 kg/ha (ATA 2013G.c). As a researcher investigation seed rate is change due to some factor i.e. varieties, soil fertility. But as per agriculture expert recommendation and ATA document, seed drilling/ha needs 3-5kg while keeping the gap as discussed before to reduce competition between seedlings and allows for optimal branching out of the plants. Sometime it will change as per soil type and season conditions refer to further study [10]. Seed rate has critical point of view to deal this project.

2.4. Physical properties of Teff seed: -

The physical property of teff could change in different moisture conditions. Abdul hakim Shukurea reported in its design and development of Teff seed broadcaster, According to Zewdu and Solomon (2007) experimental investigation The size and weight of teff has change due to moisture content; 5.6-29.6% moisture content the length has change 1.01 to1.27mm, width =0.59 to 0.68mm and equivalent-sphere=0.71 to 0.87mm. While they had conducted further experiment on the variation of moisture content 5.6%, 11.03%, 14.96%, 21.43%, 25%, and 29.6%, the sphericity decrease from 0.70 to 0.63 with 6.6% - 21.43% moisture content and increase to 0.69 with further increasing to 29.6% moisture content[19, 33].

Mass of the thousands of teff seeds have between 0.257g to 0.421g with corresponding moisture increase. Other parameter which they had observed from increasing moisture, the bulk density decrease from 840 to 696 Kgm^{-3} and true density is decrease from 1361 to1207 $Kgm^{-3.}$ [33].

Zewdu and Solomon (2007) they conducted experiment on the angle of repose change as the moisture content increase from 5.6% to 29.6%. They had get a resulted the angle of response increased 23.74^0 to 51.6^0. Angle of repose is the maximum slop at which stack of any losses or fragmented bulk material will stand without sliding (Chelecho, 2003).

The coefficients of friction of teff seed was changed from 0.29 to 0.53 on mild steel, 0.36 to 0.51on wood, and 0.18 to 0.48 on glass as moisture content increase from 5.6% to 29.6% respectively [33].

2.5. Fertilizer rate

Natural fertilizer and Nora Fertilizers are used depends on soil type as per experimental researching study. Those experimental study from the previous up to now we have been used 200 kuntal traditional measurement (20000kg) for natural fertilizer and 40kuntal traditional measurement (4000kg) for Nora use per hectare. But in this drilling system chemical fertilizer is banded. Only two types of fertilizer urea (46:0:0) and Di-ammonium Phosphate (DAP – 18:46:0) are used in Ethiopia. Before use the Soil fertility should be assure in laboratory expert because soil have different from place to place, major factors affecting teff fertilizer application rates are water logging, seasons of planting, graining history, and weed growth

[18] use as the expert recommendation and as usual they have been use the recommended rates of fertilizer application100kg DAP and 50kg urea/ha (after germination) but where urea is use after germination of seed [10].

2.6. Physical Property of fertilizer

The application of granular fertilizers in distribution terms of metering is impacted by physical properties. It is commonly understood that particle size followed by particle density is the most impactful factors influencing the deposition of granular fertilizers. The operator should understand how these properties influence the feeding system.

- Particle size (referred to as granule size in the fertilizer industry): - Particle size and size distribution both have a direct influence on spread width and uniformity. Fertilizer with a wide range of particle sizes, including very small particles, Particle size of fertilizers can be impacted by many factors including transportation, conveyance, handling and metering. These processes can reduce the size of some particles which can increase the particle size variability within a load. But DAP particle size is use *3 – 3.2mm*[36]
- Particle shape: - Particle Shape can vary among fertilizers. Shapes can be classified as round (spherical or egg-shaped), cubic, rectangular and irregular. DAP are examples of *spherically shaped* fertilizers, particle size and shape difference have much more impact on segregation of fertilizer.[36]
- Particle density: the particle within unit volume ---- $1600kg/m^3$[36]
- Bulk density: - it represents the mass to volume ratio of a bulk sample, including the space between individual particles,
- Crushing Strength: - Granule crushed between thumb and forefinger is “soft”; spinner disc speed usually <700 rpm. 3-5 kg/granule[36]
- Flow ability: - it refers to a material’s ability to flow under humid conditions, so it’s an important property to consider during metering and drilling of fertilizers. Flow-ability in blended fertilizers can impact the product segregation and spread width.
- The coefficient of friction and particle shape are directly related to how and when a granular fertilizer particle will exit the spreader.0.5[36]

2.7.Available power

Here there are different alternative power source uses in agricultural areas i.e. Motor, animal and human power, the existing on-going were use two types of power source in different ways. The machines design by rasselas research and engineering development and Minstery of Agricultural agency at melkasa agriculture Center were use pair animal and single man. Sometime they recommend pair man use for accurate [6]. Another machine was design by EIRA which is use single man operator by pushing, but it difficult to push the machine which has more weight relative to operator [7, 8]. According to campiel (1990) the operator could produce a useful work when it works for 3-4 hour continuously 0.-0.13hp [24].

2.8.Field efficiency

The field efficiency of drilling machine was shown in working area/day. For tiff drilling system the efficiency is determine by number of drilling row and speed of machine. Rasselas engineering machine was use for two row drilling method, and EIRA machine have to use four row drills, the drilling system of those machines have direct contact with soil, due to soil condition which have high soil resistance, which cause to reduce the field efficiency by slow down the speed of drilling.

When we see the teff seed drilling machine were design in some research Centres defined in general (not clearly stated) which have to use one ha/day.

2.9. Existing project evaluation

The teff crops were been doing in traditional ways for a long period of time, tangibly still now there were not having an exact foundation of teff line seed machine in farmer hand. But there are some unfinished modelling and relatively on going researching and designing process in different research centre. Some of those are mention and evaluating as follow.

a. ZERITU Seed Drilling Machine

In the RASSELAS research and engineering development; one teff drilling machine have been modelling and designing. This company had works in collaborative with TECHTRA Engineering and SINTEC Ethiopia plc. Its main objective is research conducting on agricultural machinery and implemented industrial and construction machineries. The

seeding machine which names is called ZERITU given from her jobs as the RASSELAS general manager Mr Melese Terassa told me[6]. The specification is display in pamphlet, I couldn't get the actual object operation and mechanisms in their working area because it is unfinished project, so it have get the data simply from there reporting pamphlet and asking the general manager and designer Mr Melese Terassa. He said "this machine works relatively effective for medium soli type.

Figure: 2-2 RASSELASE research engineering PLC Teff drilling machine

Specification:-

- *She has work in single, pair animal or human drawn row drilling*
- *Its empty weight is 19kg.*
- *It can drill 5-10kg of tef seeds per hectare*
- *both fertilizer and seeds simultaneously*
- *It is simple to operate, transport and assemble*
- *It can drill two row at a time*
- *Furrow opener and closers are adjustable and can be removed*
- *Depth and stability is controlled by skidding plate.*

Problem

- The tube is closest to mud, so it have high chance to blockage
- It couldn't able to work in heavy soil.
- Required more power,
- Two farmers with a pair of oxen can plant one hectare with in the one day
- Seed rate is relatively above limiting range

b. Rotary fertilizer and seed drill machine

Another two models teff drilling machine were done by Ethiopian Institution of agricultural research (EIAR) beside ministry of agriculture in MELKASSA Agricultural centre which is display own published research catalogue in 2015Gc]. The machine has to work drilling tef seed and fertilizer in row. It can pull by single or pair of oxen/donkey since the draft requirement is low. The planter is also available pushed by human power. The drill has discs with tangentially drilled seed picking holes (cup) provided on its periphery to pick seed from the hopper and drop them in the seed funnel. The size and number of cells on the disc can vary according to desired seed rate [7].

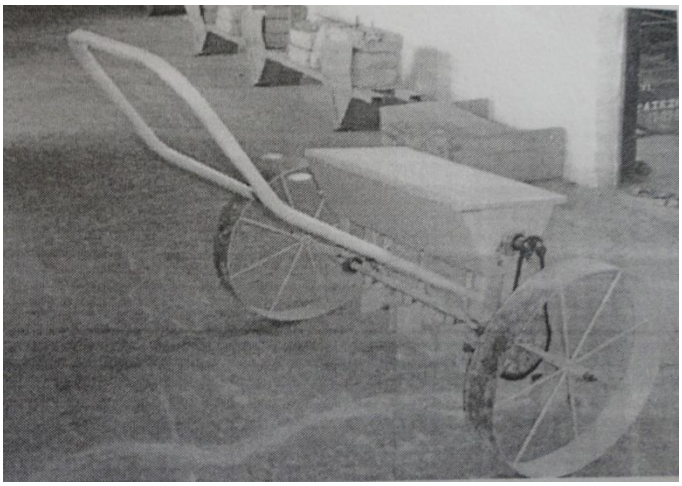


Figure: 2-3 Model one teff drilling machine by Ethiopian institute of agricultural research

Specification:-

- *Overall dimension: length 1200mm, width 459mm, height 680mm*
- *Working depth :- adjustable*
- *Working width:- 1200mm*
- *Seeding rate: 5-10kg/ha*
- *Average seeding space:* ----–
- *Weight:* ----------

Problem

- As it shown in the figure the machine wheel future is designed to low and medium soil. So sometime slippage will happened,
- The seeds are probably blocked at passage due to teff property and tube shapes.

- It difficult to transport because it have uncomfortable structure,
- Required more power
- Weight is not exact specified bet it is difficult.
- The chain system may affected by sands and strong mud

c. **Rotary seed drill machine**

The second models is as following figure which have a four row seed drill and the designed to be operated by single farmer/human without fertilizer option. The drill has disc with tangential drilled seed picking hole (cups) provided on its periphery to pick seeds from the hopper and drops them in the seed funnel. The size and number of cells on the disc can vary according to desired seed rate [8].

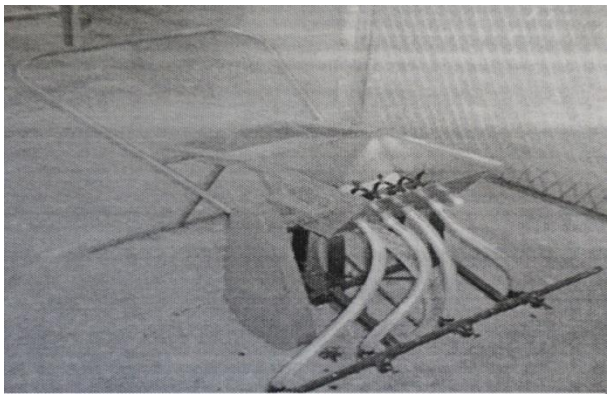


Figure: 2-4 Model two teff seeding machine by Ethiopian institute of agricultural research

Specification:-

- *Overall dimension: length 1200mm, width 460mm, height 550mm*
- *Working depth :- adjustable*
- *Working width:- 800mm*
- *Seeding rate: 5-10kg/ha*
- *Average seeding space: -----–*
- *Weight: ----------*

Problem

- Drill only seeds
- The feeding tube structure are somehow irregular curve which is difficult to pass the seed
- The chain system has affected by the sand and mud
- Also it couldn't implement in heavy soil.
- The tubes as a result tef can't pass through it.
- It use more than recommended seed rate

d. Rotary seed and fertilizer drill machine by MOF

This machine has developed by minister of agricultural mechanization and agricultural transformation agency (ATA) at Melkasa agricultural centre. This machine is the third version of teff drill which has seed metering plate, fertilizer metering bucket, seed furrow opener seed tube, fertilizer furrow opener and tube, furrow closer, ground wheel, frame, handle, beam attachment and chain are the main part.

Figure: 2-5 Teff drilling machine modeling by misters of agricultural agency at Melkass agricultural center.

Specification:-

- It can drill in four rows both seed and fertilizer
- It can managed 5kg tef seed per hectare
- Use 100kg fertilizer per hectare
- It can be drawn in 20cm space between rows

Problem

- The machine have complex system,
- Difficult to transport
- Soil disturbance could affect the dill system
- It can dill 10g in one bucket which have a number of seeds drill in one point, For fertilizer 8-12g per drawer, so it not acceptable rating mechanism.
- It uses for low and medium clay soil types.
- The seed probably couldn't pass through the tube.

e. Bahir Dar teff drill machine evaluator team

Great agricultural expert team members were dealing in evaluation of teff drilling machine from BDU. They took eight different types which are three of them design by ATA and remaining are prepared by Bahir Dar agricultural mechanization and food science research Center i.e. Highland type, Drum type, Rotor With Fertilizer, rotor without out fertilizer, Machine Cup type, Animal drawn Teff seed-cum- Fertilizer drill, Agerawit Animal drawn Teff seed drill, Animal drawn Teff seed drill with no wheels. They had Evaluate the machine by different criteria in detail and suggested which one is the best from all. But as they recommended selected types of drilling machine also have not sufficient for very wet, sticky soil. My co-advisor Mr Geta K/Mariyam (PhD candidate) were been participate on this team work. As he told me the drum type seed drilling is the best from all but when it performs in heavy soil the mud will stick on the wheel and disturb the system operation. The machines were use in medium clay soil.

CHAPTER - THREE

3. METHODOLOGY

3.1. Data Collection

Information about this issue gathered from our country background was the problem had been obviously known for our people. The necessary data have been collected from different document, agricultural research report, through observation, and by asking agricultural expert. Those data are like existing project performance, seed properties, and the specification what the project needs to achieve.

Through different methods as follow: -

- Using interviewees
- Ideally evaluating existing project
- Through observation agricultural areas.
- Assessing the logical idea
- Studying what it needs the teff cultivation

3.2. Conceptual Design

On this stage the designing process of teff line seeding machine starts from the principle solution to design new system development in accordance with technical criteria's. Since in Ethiopia the teff production still as it, so as it mention in literature one of the technology transformations of teff product development is seed drilling machines will develop as per requirement.

3.2.1. Requirement List

The system is more probably chosen what it's seeking by fulfilling the following general requirement.

- Small in size to transport from place to place
- Less Number of component
- More accurate system as possible
- Safe and Easy to operation
- Manual power source
- Less initial cost
- Easy to assemble and Maintainability

3.2.2. Problem Definition

From the plan which agricultural technology transformation will develop in order to satisfy the people needed in teff products, drilling machine will help to improve the existing methods? So, we must have to define the problem to supply the best machine design by evaluating the pre-existing drilling system as follow:-

- The existing project were probably work for low moisture soil condition
- Still there is nothing line seeding equipment in farmer hand
- It makes disturbed teff drilling mechanism
- Complex structure to maintaining
- They have relative more weight
- Use above the required seed rate

So we committed to start this project for improving were the Ethiopian farmer been the traditional broadcasting method up to now. The machine could build inside our country as possible.

3.2.3. Abstraction

This part is used to identify the general criteria of the tef drilling machine specially

- ✓ Develop best drilling system (accurate line spacing as possible)
- ✓ To decrease energy consumption
- ✓ To reduce weight or space required
- ✓ To significantly lower initial cost as possible
- ✓ To improve production methods

3.2.4. Problem Formulation

- ➢ Add the teff seed and fertilizer in its own bucket
- ➢ Start the operation
- ➢ Counting amount of teff seeds and fertilizer
- ➢ Avoiding stick property of drilling material
- ➢ Metring space between row
- ➢ Starting drill both Seed and fertilizer

3.2.5. Idea Generation

3.2.5.1.Functional structure

Based on the problem definition and evaluation of existing project which we should develop the new system. So let's construct the functional structure as follow:

3.2.5.1.1. Over all function

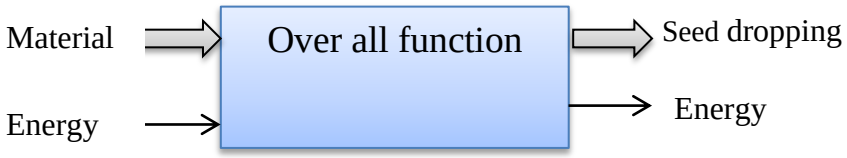


Figure: 3-1 Overall functional structure

3.2.5.1.2. Sub-function

Splitting the overall function in to four simple functions based on the problem formulation:

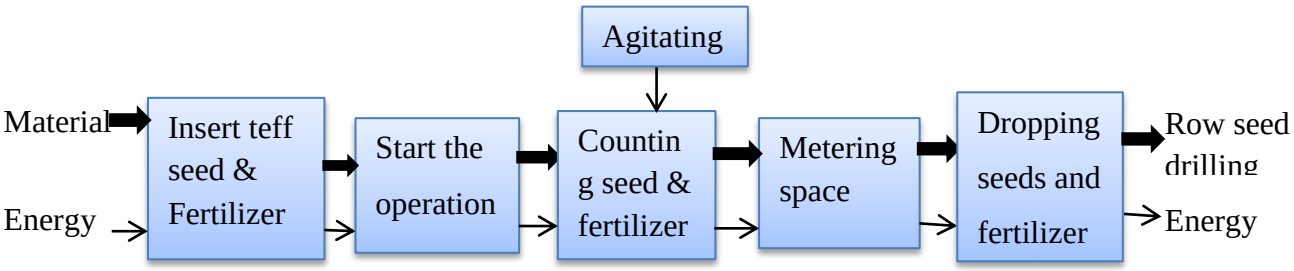


Figure: 3-2 Sub functional structure

3.2.5.2. Option Selection

The following possible alternative options will have deal in the variant evaluation. we have neglect another machinery power source due to the soil condition were we deal this project is focus on relative wet soil condition After constructing the decision tree the system may follow the shaded region as follow. The selection is based on the availability source and simple system.

Table: 3-1. Selective system option

Required power	Man		Man & animal	
	Single	Pair	Single	Pair
Sowing material	Seed only	Seed & fertilizer		
Driven type	Sliding	Rotating	Rolling	Reciprocating
Feeder method	Gravity	Gravity, bucket vibration pneumatic		Gravity & vibration
Hopper shape	Cylindrical	Merged shape		Rectangular
Weight	Low	Medium	Heavy	
No of wheel	0	1	2	

3.2.5.3. Decision Tree

Standing from the above possible alternative option system, we do have construct the following decision tree.

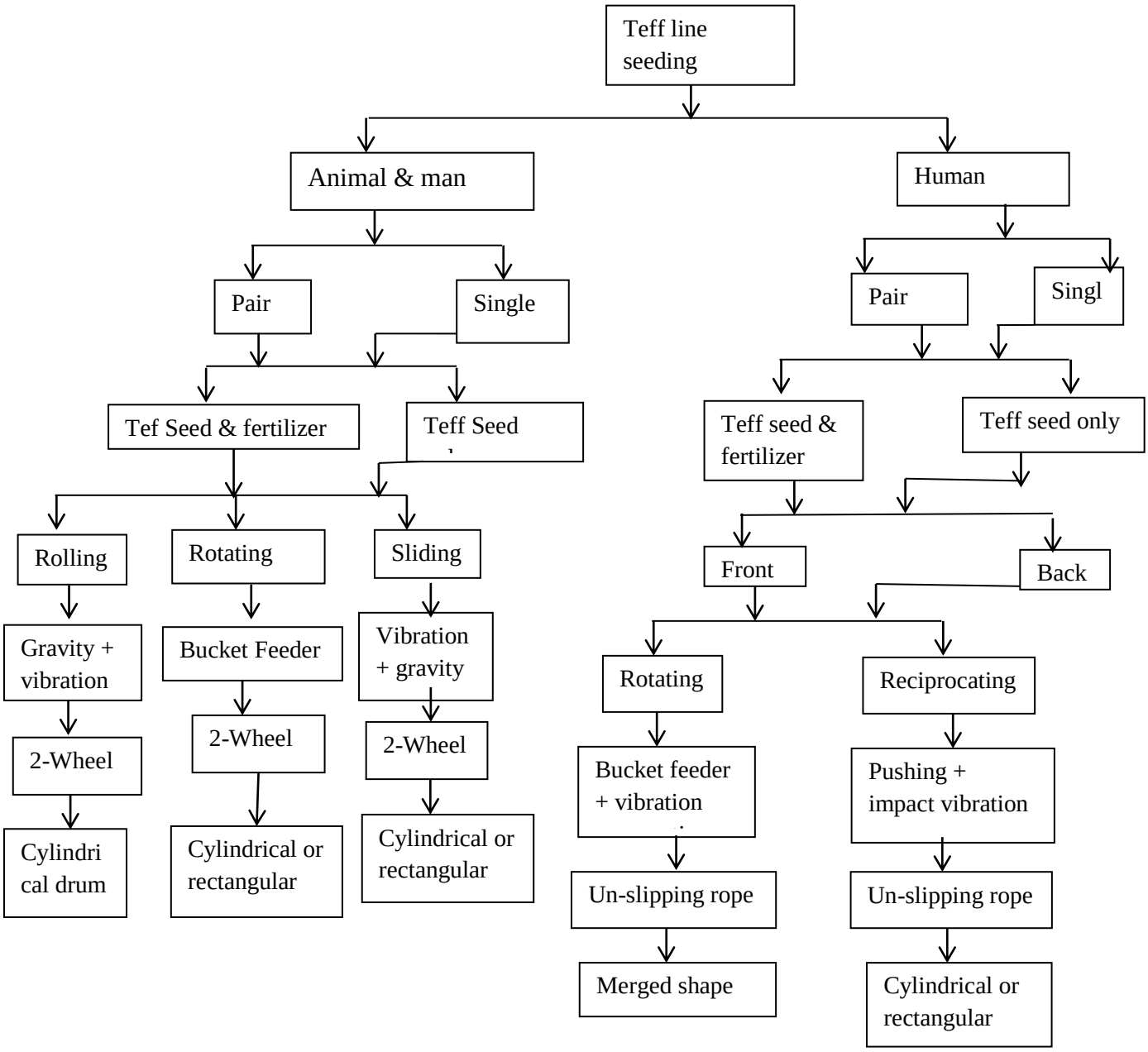


Figure: 3-3 Decision tree

3.2.6. Screening Ideas

3.2.6.1. First Round Screened Of Working Principal Variant

From the decision making tree it have get twenty different possible system combination (seen appendixes), based on the system operation simplicity and it have screen out reduce to ten major concepts as follow.

Table 3-2 some of working principal variant

Variants	Energy source	Required power	owing material	Driven type	Feeder method	hopper	Transport system	No of wheel
1	Animal & man	Pair	seed	I have neglect to listed the criteria because of single material sowing				
2	Animal & man	Single	Seed					
3	Animal & man	Single	Seed & fertilizer	Sliding	Gravity & vibration	Cylindrical or rectangular	Medium	2
4	Animal & man	Single	Seed & fertilizer	Rotating	Bucket feeder	Cylindrical or rectangular	Complex	2
5	Animal & man	Single	Seed & fertilizer	Rolling	Gravity & vibration	Cylindrical drum	Relatively difficult	2
6	Man	single		I have neglect to listed the criteria because of single material sowing				
7	Man	Pair	Seed					
8	Man	Pair	Seed & fertilizer	Back	back system is uncomfortable			
9	Man	Pair	Seed & fertilizer	Front reciprocating	Pushing &impact vibration	Cylindrical or rectangular	Easy	-
10	Man	Pair	Seed & fertilizer	Front/back rotating	Bucket feeder, vibration &	Merged shape	Easy	-

3.2.6.2. Selected working Principal Variants

We have to select the best system from the above decision tree which is those ten possible combinations of seeding system. Then based on the following criteria just they have reduced to five variants.

- System complexity
- Easy during operation ,
- Probability of seed drawn
- Required number of power
- Simplest mechanism
- Probability of manufacturing in Ethiopia

Table 3-3 Select from principal variants

Variants	Energy source	Required power	Sowing material	Driven type	Feeder method	hopper	Transport system	Wheel material	No of wheel
3	Animal & man	Single	Seed & fertilizer	Sliding	Gravity & vibration	Cylindrical or rectangular	Medium	steel	2
4	Animal & man	Single	Seed & fertilizer	Rotating	Bucket feeder	Cylindrical or rectangular	Complex	Steel	2
5	Animal & man	Single	Seed & fertilizer	Rolling	Gravity & vibration	Cylindrical drum	Relatively difficult	Steel	2
9	Man	Pair	Seed & fertilizer	Front/back reciprocating	Pushing &impact vibration	Cylindrical or rectangular	Easy	-	-
10	Man	Pair	Seed & fertilizer	Front/back rotating	Bucket and pneumatic	Merged shape	Easy	-	-

3.2.6.3. Modelling the concept in figure

Those the above five competitive variant then constrict in ideal image and defining the working principle of drill system shown as follow

Variant- three

This machine has operates When the beam pulling by single or pair animal and person, the person has guiding the line using handle and hit the handle by bar continuously . The seed and fertilizer are drop in to soil by gravity and impact vibration. It has four rows.

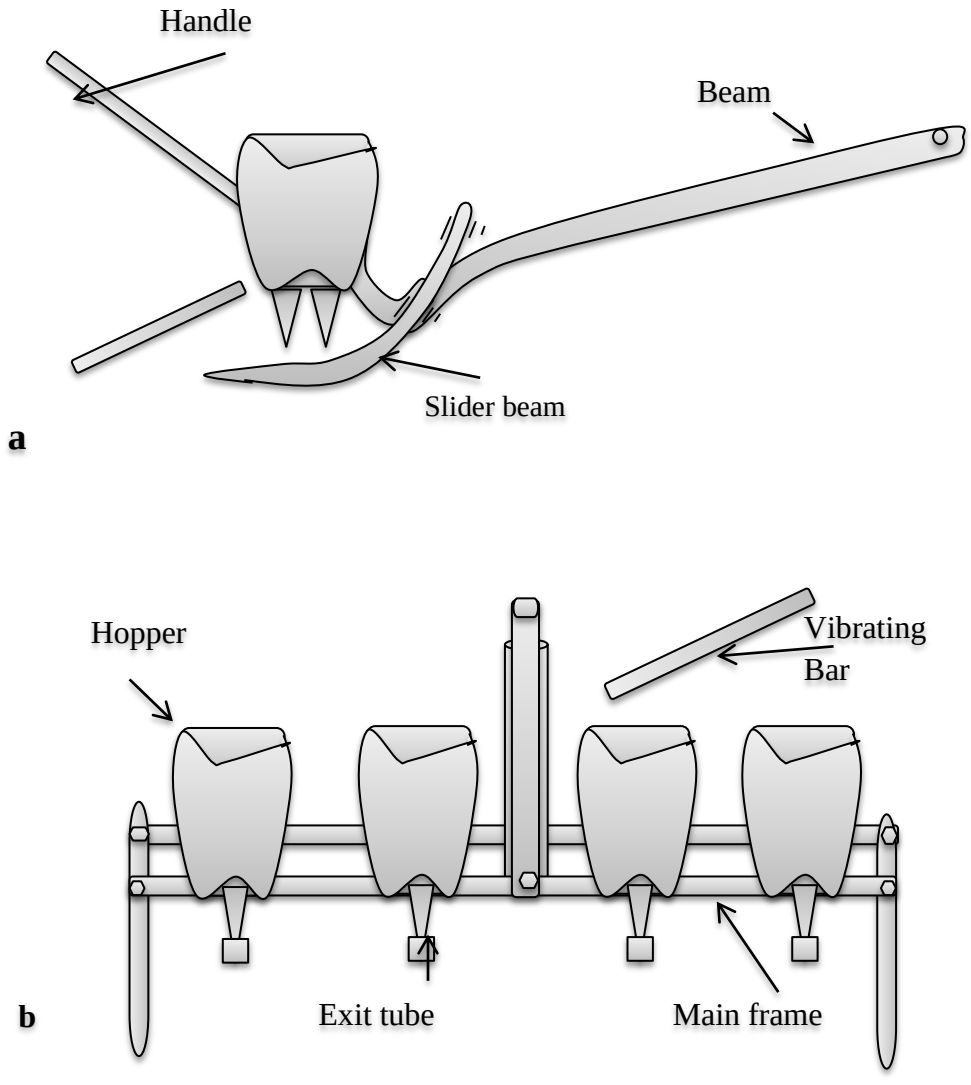


Figure: 3-4 Variant three (a- side view and b- rear view)

Variant -four

This machine has operated by single human power. When pushing a machine forwardly, the tow wheel will rotate and drive the sprocket and crank the pneumatic system, the sprocket has control the seed and fertilizer metering system by gushing and releasing the link. It has four rows in both seed and fertilizer together with separate compartment.

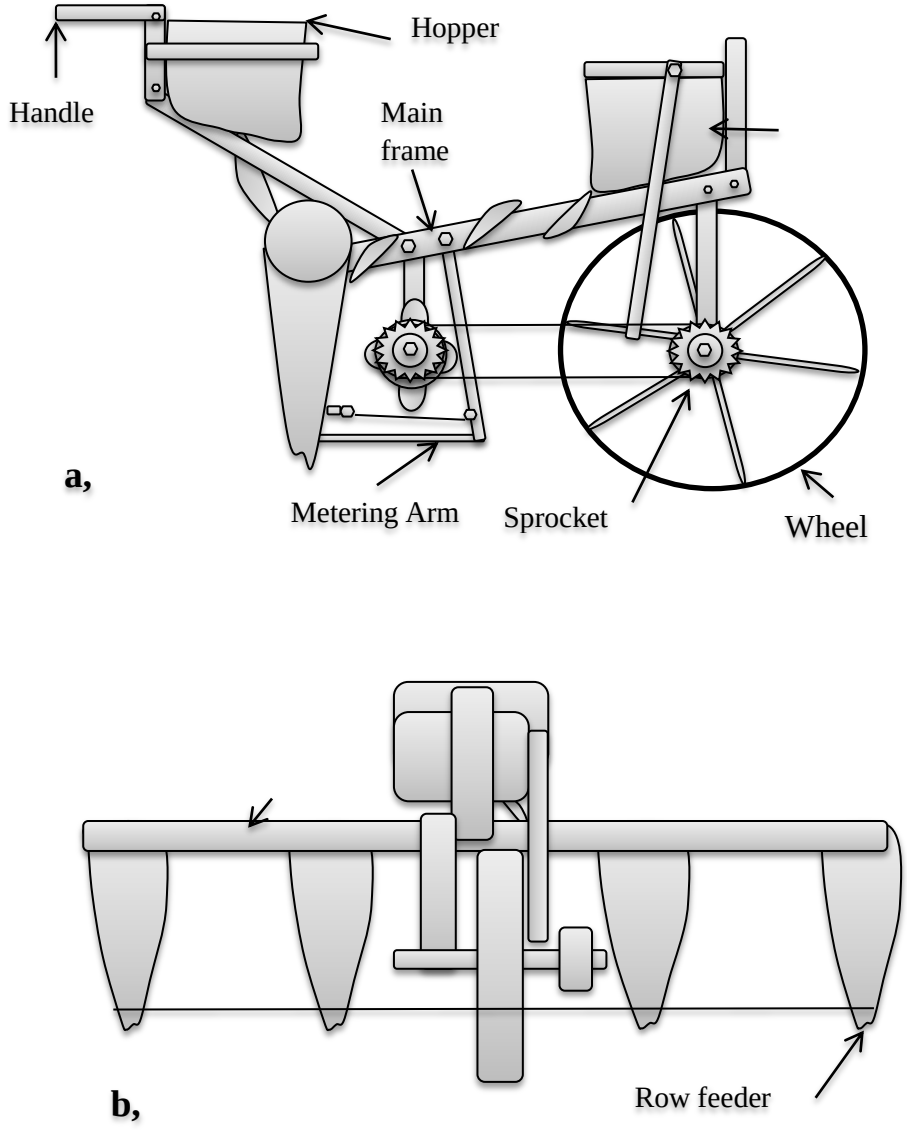


Figure: 3-5 Variant four (a- side view and b- front view)

Variant- five

This machine operated by single or pair human and animal power. When the beam pulling, the wheels could rotating and transmit a motion to the feeder. It has also use for both seed and fertilizer drilling at a time. It has four rows.

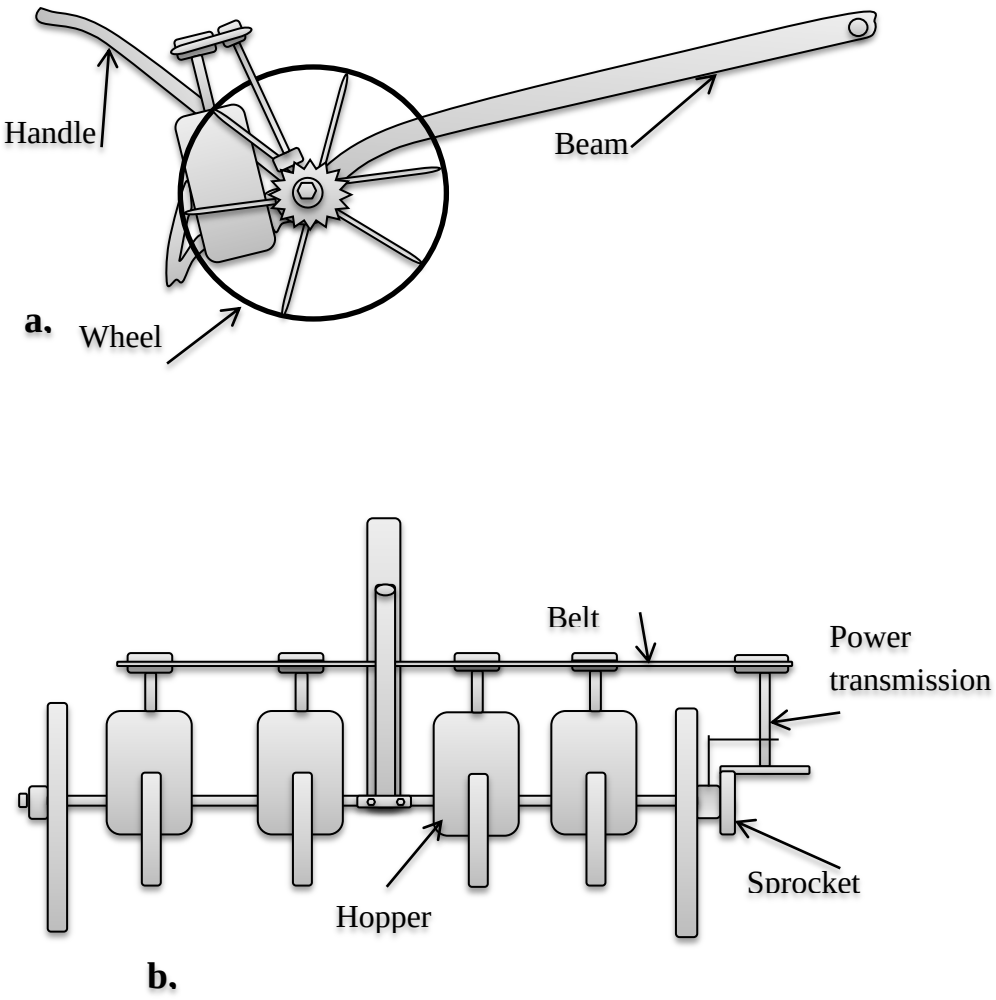


Figure: 3-6 Variant five (a- side view and b- rear view).

Variant- nine

This variant nine has operated by single human power carrying on their shoulder. When the handle moves back and forth the feeder will reciprocate, the feeders measure the amount of Seed and fertilizers. Also it's not any connection with ground. It has three rows.

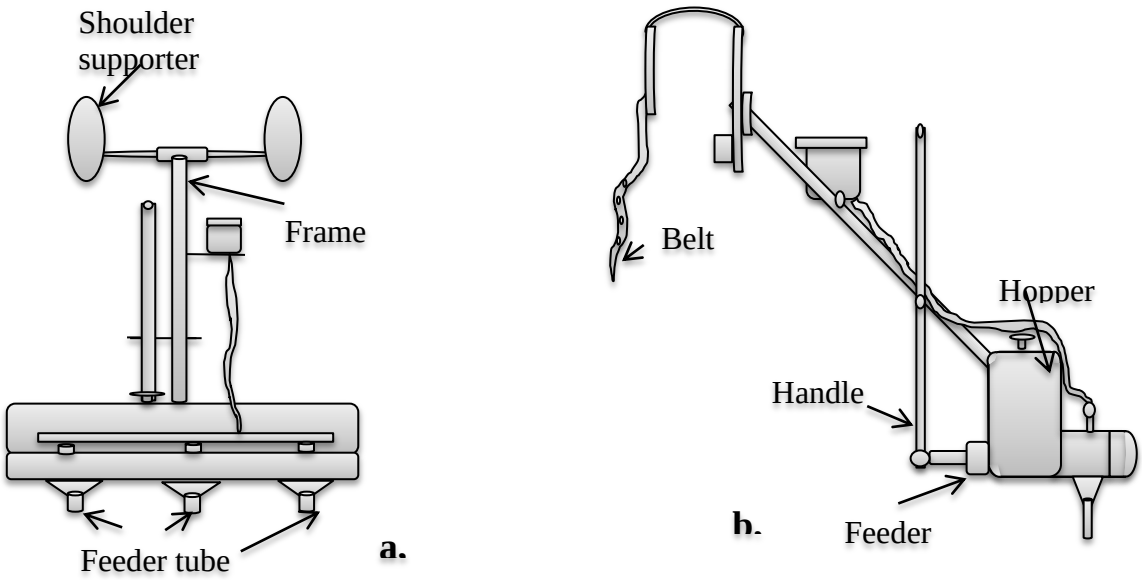


Figure: 3-7 variant nine (a- front view and b- side view)

Variant -ten

Variant ten has work by single or pair human power which is low in weight. When handle (driving arm) rotates motion will transmitted to feeder though tighten rope. Then the seed and fertilizer well draw out. Keeping move the rows in holding guiding the rope by second person. It has three rows.

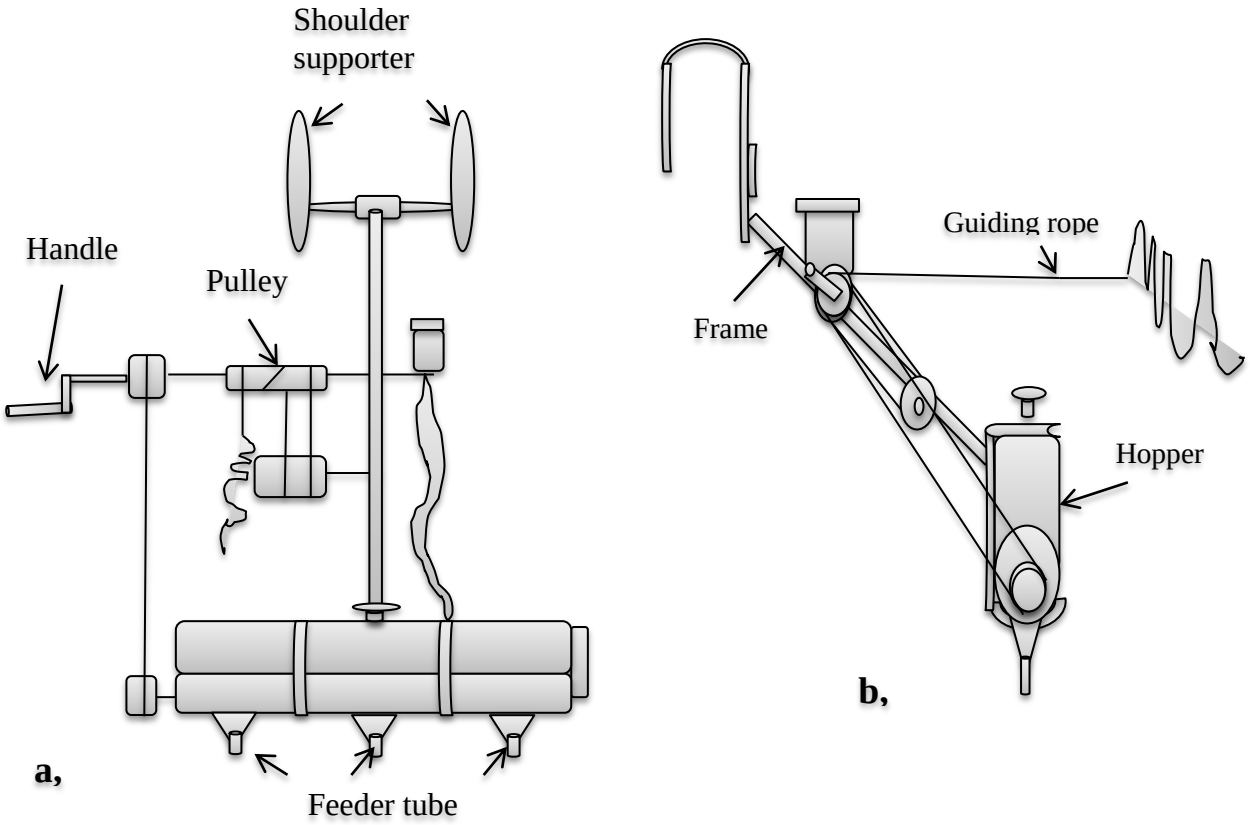


Figure: 3-8 variant ten (a- front view and b- side view)

3.2.7. Feasibility Study Of selected Variant Evaluation

3.2.7.1.Criteria

A. Technical criteria

1. Time
2. Safety
3. Easy to operation
4. Transport
5. Maintenance

B. Economic criteria

1. Assembly cost
2. Material cost
3. Labour cost
4. Production cost
5. Possibility of production

3.2.7.2. Criteria ranking and weighting

Note: criteria levelling: - -2- Greatly inferior, -1-Somewhat inferior, 0-Satisfactory, 2-Greatly Superior, 1-Somewhat superior,

Table 3-4 Criteria screening matrix

criteria	**criteria in detail**	**alternative**				
		variant 4	**variant 3**	**variant 5**	**variant 9**	**variant10**
Time	Preparing time	1	-1	0	2	2
	assembling time	1	-2	-2	1	1
	production time	0	-2	-2	2	2
	seeding time	-2	1	-1	2	2
Safety	Safe in operation	-2	-2	0	2	2
Easy to operation	Simplest mechanism	1	-2	-2	1	2
	metering system	-2	1	1	-2	2
	Manual power source	2	2	2	2	2
	Required power	0	2	0	2	1
	seeding accuracy	-2	-1	1	0	2
	Easy during operation	2	-2	-2	2	2
	soil type	-1	-2	-2	2	2
Transport	required area	-1	-1	-2	2	2
	Weight	0	-1	-2	2	1
Maintenance	System complexity	2	-2	-2	2	1
	Easy maintainable	2	-2	-1	2	1
cost	Less initial cost	-1	-1	0	1	1
possibility of production	probability of manufacturing	2	-1	-1	1	1
total	sum of -2	4	8	8	1	0
	sum of -1	3	6	3	0	0
	sum of 0	3	0	4	1	0
	sum of 1	3	2	2	4	7
	sum of 2	5	2	1	12	11
	Net score	2	-10	-9	15	18
	rank	3	5	4	2	1

Table 3-5 group the criteria in to main heading list

	V4	V3	V5	V9	V10
Time	0	-4	-3	7	7
Safety	-2	-2	0	2	2
Easy to operate	0	-2	-2	7	13
Transport	-1	-2	-4	4	3
Maintainability	4	-4	-3	4	2
Cost	-1	-1	0	1	1
Probability of production	2	-1	-1	1	1

3.2.7.3. Criteria evaluation

From the above system screening I decide variant nine and variant ten are the best system from the whole merge concepts. Next it should divide in to two criteria and weighted the result by set the evaluating

Levelling: - 0 – poor, 1 – Satisfactory, 2 – Good, 3 – Very good, 4 – Excellent

Table 3-6 Technical evaluation of the remaining principle solution variants

		Variant 4		**Variant 3**		**Variant 5**		**Variant 9**		**Variant 10**	
Criteria	**weighted**	**rating**	**weighted score**	**rating**	**weighted score**	**rating**	**weighted score**	**rating**	**weighted score**	**rating**	**weighted score**
1. Time	0.1%	2	0.2	1	0.1	1	0.1	4	0.4	4	0.4
2. safety	0.15%	0	0	0	0	1	0.15	4	0.6	4	0.6
3. Easy to operation	0.45%	0	0	0	0	1	0.45	2	0.9	4	1.8
4.Transport	0.05%	1	0.05	1	0.05	0	0	4	0.2	4	0.2
5. Maintenance	0.25%	4	1	0	0	0	0	4	1	3	0.75
Total score		1.25		0.15		0.7		3.1		3.75	
rank		3		5		4		2		1	
decision	I have to conclude variant ten is the highest chance of choosing in technical criteria										

Table 3-7 Economical evaluation of the remaining principle solution variants

		Variant 4		**Variant 3**		**Variant 5**		**Variant 9**		**Variant 10**	
Criteria	**weighted**	**rating**	**weighted score**	**rating**	**weighted score**	**rating**	**weighted score**	**rating**	**weighted score**	**rating**	**weighted score**
1 assembly cost	0.1%	0	0	2	0.2	1	0.1	4	0.4	4	0.4
2- material cost	0.3%	2	0.6	1	0.3	3	0.9	4	1.2	4	1.2
3-labour cost	0.15%	2	0.3	0	0	2	0.3	3	0.45	4	0.6
4productioncost	0.25%	0	0	0	0	0	0	3	0.75	3	0.75
5-probablity of production	0.2%	4	0.8	1	0.2	1	0.2	3	0.6	3	0.6
Total score		1.7		0.7		1.5		3.4		3.55	
rank		3		5		4		2		1	
decision	The decision will take variant ten which is ranking in lower cost in all aspect										

Percentage evaluation

By giving the variation of evaluation criteria for each technical and economic aspect which is the more and which is the less percentage. Let's see the following and summarize

Table 3-8 variant percentage evaluation

Technical criteria		V4	V3	V5	V9	V10
1. Time	10%	5% / 2	4% / 1	5% / 1	9.5% / 4	10% / 4
2. safety	15%	4% / 0	5% / 0	7% / 1	13.5% / 4	14% / 4
3. Easy to operation	45%	13% / 0	7% / 0	18% / 1	28% / 2	42% / 4
4.Transport	5%	2.5% / 1	3% / 1	1.5% / 0	5% / 4	5% / 4
5. Maintenance	25%	23% / 4	8% / 0	9% / 0	23% / 4	22% / 3
total		47.5%	27%	40.5%	79%	93%

A

Economic criteria		V4	V3	V5	V9	V10
1 – assembly cost	10%	4% / 0	7% / 2	6% / 1	10% / 4	10% / 4
2- material cost	30%	17% / 2	13% / 1	25% / 3	30% / 4	29.5% / 4
3-labour cost	15%	8.5% / 2	5% / 0	8.5% / 2	13% / 3	14.5% / 4
4 –production cost	25%	12.5% / 0	10% / 0	11% / 0	21% / 3	22.5% / 3
5-probablity of production	20%	20% / 4	16% / 1	16% / 1	18% / 3	19% / 3
total		62%	51%	66.5%	92%	95.5%

B

CRITERIA	economic criteria	technical criteria
V4	62%	47.50%
V3	51%	27%
V5	66.50%	40.50%
V9	92%	79%
V10	95.50%	93%

C

So in general we then summarise the comparison of five variants in each other to show which system is the selective as follow using matrix evaluation. More of consider to select the variant by technical evaluation.

	3	4	5	9	10
3	3				
4	4	4			
5	5	4	5		
9	9	9	9	9	
10	10	10	10	10	10

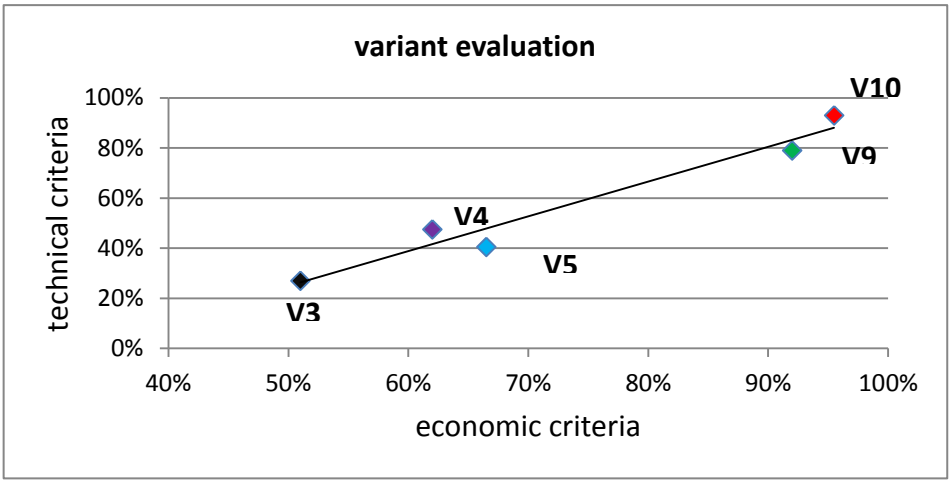


Figure: 3-9 variant percentage evaluations

From the above criteria evaluation one of the variants has shown the best performance of others which should be selected, Variant ten is selected from the above five possible alternatives. **Variant 10:**

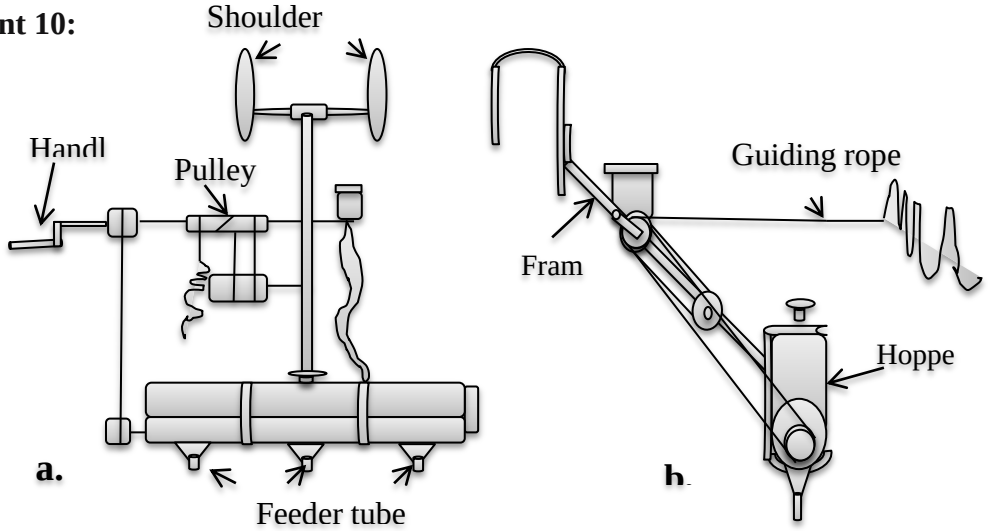


Figure: 3-10 selected variant 10 *(a- front view and b- side view)*

3.3. Dimensions And Load Condition

3.3.1. Working Speed

A few research were literate the speed of human being in dry condition which has no resistance.it is a normal condition. A person who walked From Richad W.Bohannon experimental data normal healthy Adult man speed has averagely 4.32km/hr and more in dry conditions [23, 28, and 29]. But when we came to my design is working in mud areas which have resisting the motion of person. Based on the above data it should be reduce the speed let's assuming one fourth of normal waking speed doe to the sticky property of surface which to set 2.16km/hr.

One hectare (100*100m) has 500 lines with in 20cm apart. The machine has work three rows in one pass. Therefore one hectare should complete in 167 rounds (pass) in this drilling system. But in order to fit with the time requirement, we must see the alternative option by changing the number of row at one time.

$\begin{Bmatrix} 0.6m = 1\ sec \\ 100m = X \end{Bmatrix}$ X = 166.6 sec = 2.77minute, 100m = one pass

Loading time estimation: - Teff hopper has refill after nine pass (900m) which have 56 times fills in one hectare. Let set 10sec use for one time it needs 9.4minut. Fertilizer hopper fills after two pass (200m) which have 250 times fills in one hectare let set 10sec use, 41.4 munities. Therefore the total loading time: t_L = 50.8 minutes.

We then taking the number of row of drilling machine at one time and related the time required to complete one hectare. Also the weight variation of drilling material is the core concept which equal proportion to time.

t/ha = (2.77*No of pass) + (loading time)

	Number of row	1	2	3	4	5
	Number of pass	500	250	167	125	100
	Time(hr)/ha	23.92	12.38	**8.5**	6.6	5.46
	Weight of drill material (kg)	0.45	0.9	1.35	1.8	2.25

3.3.2. Available Power

It was sited according to campiel(1990), the power of usfull work done by human being.

HP = 0.35 - 0.092 log(t) ……..…….(3.1) [24], where t= time in minite

=0.35 – 0.092 log 480

=0.103hp

From this, the requerd power to do is invers relation to working time.the operator invest small power to work for a long time. Let me finde out how mach kg to be carry in this avaliable power.

Hp = $\frac{mass(kg) * speed(\frac{m}{s})}{75}$ ……..(3.2) [24]

Carrying mass (kg) = $\frac{Hp*75}{speed^{m}/_{s}}$ = $\frac{0.103*75}{0.6}$ = 12.875kg , but for getting further potentail to do I have to reduce the mass below the result.

3.3.3. Machine Layout

This machine has operated by one or two person. Those operators may have different height. Therefore this design should be balance the variation it will take the medium person height and make it adjustable. Ethiopian woman were have averagely 157.6 cm height for 25–49 age. The study was done from Self-reported since 1997 [20, 21] the data have only female but not include man, let me assume the variation and take 175cm on this value through observation. Add a system the machine will lift for shorter and lowered for taller person to maintain the preferable range. Set the overall dimension of machine from the following in human anatomy picture. When the soil condition is very wet and sticky the seed and fertilizer will put over depth by human leg which is difficult to keep row walking. So the operator use interchange mechanism from forth to back driven. The back system is use for all soil condition but in moderate low moisture soil seed could need compact to soil. The forth system is preferable for this case. The two machines have different by only two non-critical components.

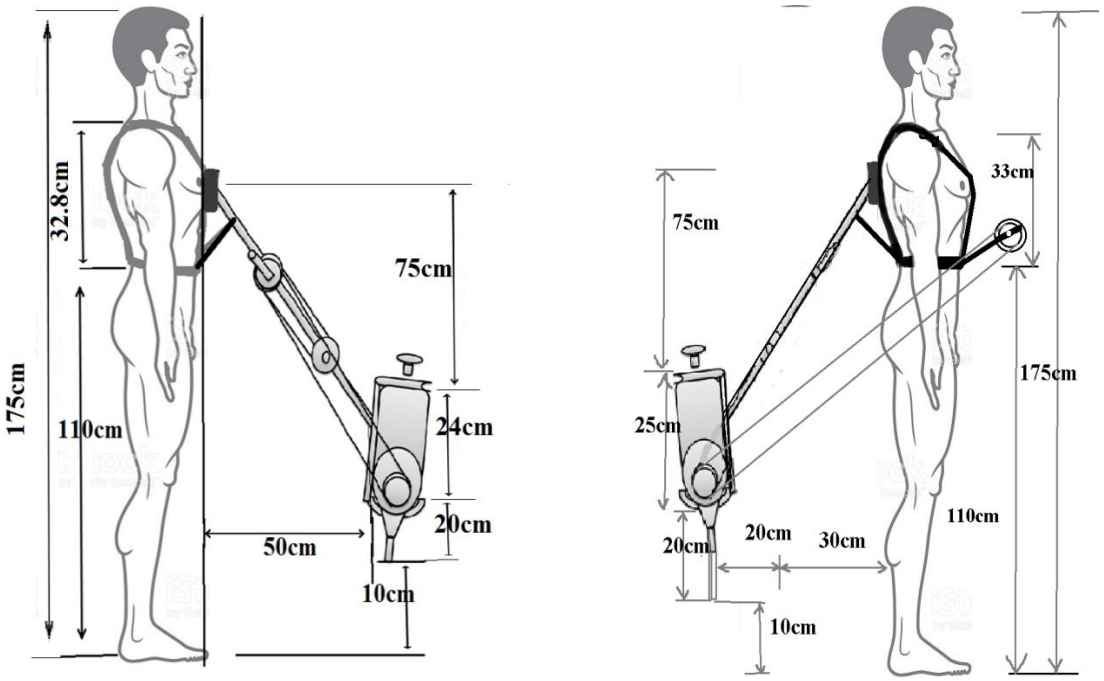


Figure 3-11 Design layout forth and back driven **(**size source from human anatomy Adult mane side view) [22, 30]

3.3.4. Component Description

1. Hopper ,
2. Guiding rope,
3. main Frame,
4. Shoulder supporter,
5. Handle,
6. Lever
7. Feeder tube ,
8. driving Pulley,
9. driven pulley
10. driving shaft
11. driven shaft/metring shaft
12. belt
13. agitator system

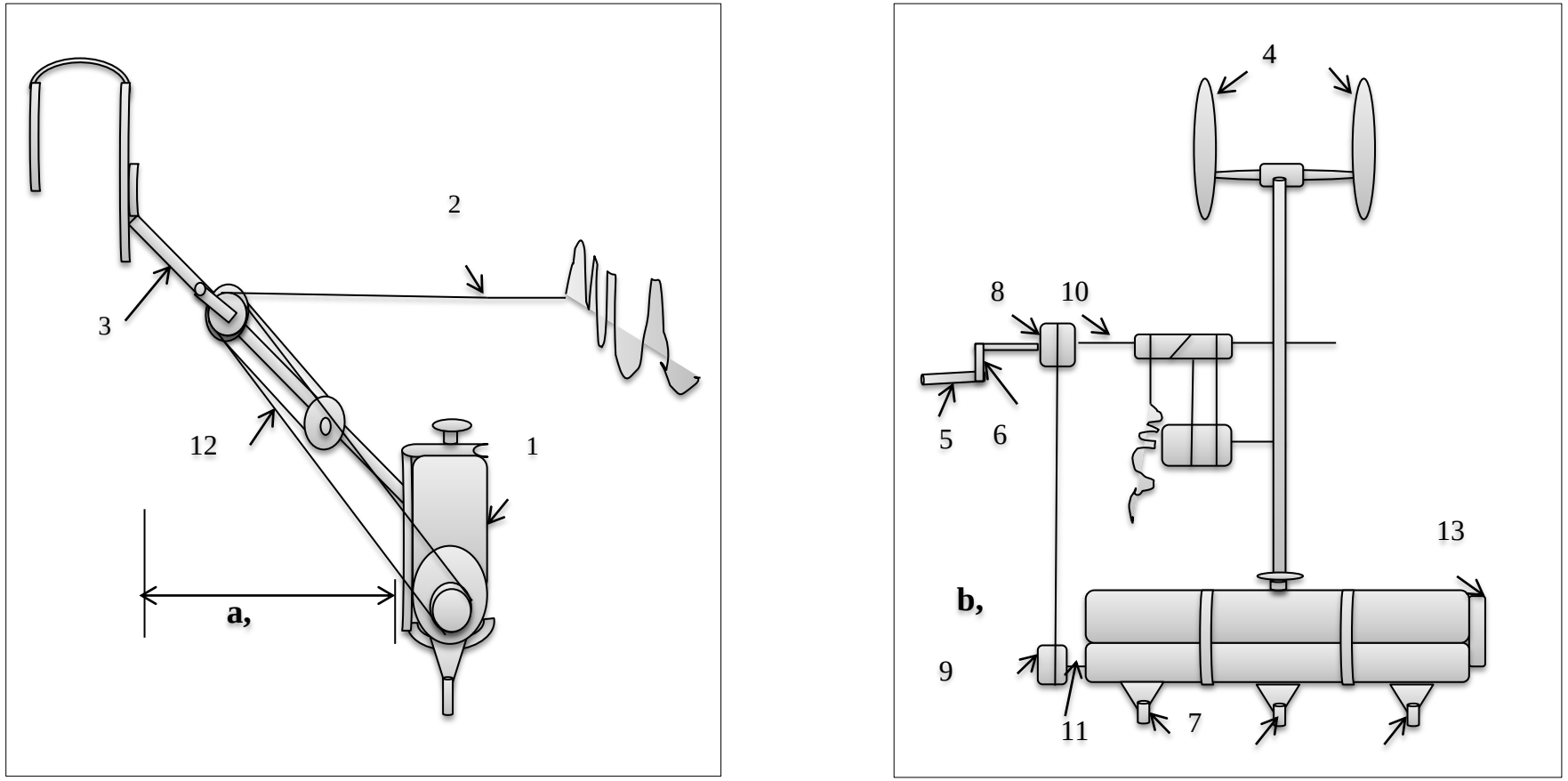


Figure 3-12 component numen-culture (a=side view and b= front view)

Hopper

Hopper part is used for holding drill material. It's made weightless material i.e. plastic is preferable.it has six compartments which are contain drill material seed and fertilizer separately. The size is estimated by comparable weight as a person who can carry for long time during operation.

Guiding rope

Guiding rope: - it is an alternative option; a flexible rope which is used for guide the operator makes straight line. It's made by local material.

Main Frame,

This is another part of the machine that supports the weight of lower part of machine. The material for this machine part should be strong which is made by metal (rectangular or cylindrical bar). The main systems of the machine were hinge on this part.

Shoulder supporter

A frame is placed on the operator shoulder which used to fixe and holed the machine to the operator. It expects to make by wood or metal as per the required dimension and weight consideration.

Handle

Men who perform the operation by rotating the machine handle part. It mad by wood and bundles with steel at the joint.

Lever

Power transmitted to driving shaft from handle using lever. The material assigned in a little bit strong which describe in detail design.

Feeder tube

Tubes which are transferring mediums for drilling materials have to deliver out. It made by thin plastic and fixed with hopper together.

Driving Pulley

This machine part uses powers that transmit to the belt by pulley from driving shaft. It made by wood material. Because of wood have high friction which used to avoid slippage or power loss.

Driven pulley

The second pulley which power or rotational system receive and transmit to metring shaft. It made with metring shaft together by plastic.

Driving shaft

This part is a torque transmitter part using pulley system. It made by steel as considering the size may be small.

Driven shaft (metring shaft)

The second power receiver part is used as a power transmitter and also the main particular function is metring the amount of material which delivers out. It made by two material bundles together.

Belt

Belt is used for power transmitting to the main part of machine. Made by leather or rubber is preferable for this design. Most probably select the flat belt type.

Agitator system

This agitator system is used to disturb the drilling material inside the hopper. Because drilling material have stick properties by its nature.

3.3.5. Expected Working principle

The machine have been assemble in good manner and carried by operator. When the operator rotates the handle, rotational power will transmitted through liver-- driving shaft -- driving pulley sequentially to the driven pulley. Then when the driven pulley receive the power and rotate, the metering shaft will rotate inside the main system under hopper. This part (metering shaft) could meter the amount of drilling material from hopper and deliver out through feeding pipe. Agitator system receive the power from metering shaft, it would have done the operation inside the hopper.

3.4. Analytical Method

In this chapter it has follow the serous step of detail design of drilling machine which is the selected variant in the previous section. By referring the requirement and variant criteria, then proceeds to what it needs before starting the design.

3.4.1.1. Selection Of Pulleys And Belts

According to R.S.khurmi-Gupta [25] for moderate amount of power transmitted in light driving which length of belt is less than 8 meter flat belt is recommended. The flat belt have higher efficiency, hence considerable energy savings have above 90% efficiency [26], Longer service life of belts and pulleys, Clear operation, longer service life of air filters, Longer service life means less down time and higher productivity, Constant tension (no re-tension required), maintenance-free, Smoother operation, lower noise generation, easily made and flexible, Double sided power transmission required

Belt material for flat belt

Made by rubber composite, Friction cover by NBR-Rubber Material, Traction layer by) Polyester Material, Reverse cover by NBR-Rubber Material, Operating temperature admissible (continuous) ---−20 °C/70 °C, Fabrication/ joining system---Flex proof (adhesive-free), High abrasion resistance, Density= 1140Kg/m^3, Modules of elasticity (E) = 100N/mm^2, Specific weight (N/m^2)= 13750, Ultimate tensile strength (MPa)= With layers 37.0, Without layers 44,0, Coefficient of friction = 0.42, The operating speed is slow which refers to no power loss on the system.

Therefore polyester power transmission belt group-TC, belt code-TC-35/30ER, thickness 3mm, pulley diameter minimum – 50mm, tensile force for 1%elongetion per unit of width (ka1after running in) 18N/mm, nominal peripheral force per unit of width 38N/mm [All data are approximate values under standard climatic conditions: 23 °C/73 °F, 50 % relative humidity ISO 554, and are based on the Habasit master joining method catalogue]. As much as we can also use local polyester material

Let set the diameter of driving pulley D_2=70mm and velocity ratio=1.75

$$v_2 = \frac{\pi * D_2}{60} * N_2 \quad = N_2 = \frac{0.33m/s * 60}{\pi * 0.07m}$$

V2=0.33m/s, N_2=90rpm

D_2/D_1=1.75, D1= 40mm

$$\frac{N_2}{N_1} = \frac{t+ D_1}{t+ D_2}\left(1 - \frac{s_1+s_2}{100}\right) \quad \text{..... (3.3)}$$

Where set $s_1 = 0.5\%, s_2 = 0.5\%$ are percentage slip between belt and pulley because belt have high friction, t= 3mm thick ness of belt from standard the lowest limited value.

$$\frac{90rpm}{N_1} = \frac{3+40mm}{3+70mm}\left(1 - \frac{0.5+0.5}{100}\right)$$

The rotational speed of driven pulley (N_1) =154.3rpm

The peripheral velocity of driven pulley $v_1 = \frac{\pi * D_1}{60} * N_1$ $v_2 = \frac{\pi * 0.04m}{60} * 154.3rpm$

$$v_1 = 0.323m/s$$

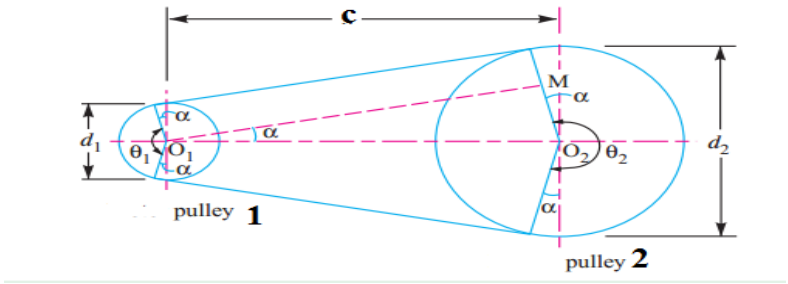


Figure 3-13 Flat belt arrangement

$$arc\ of\ contact\ pulley\ 1\ = 180° - \frac{D_2 - D_1}{c} * 60° = 155°$$

$$arc\ of\ contact\ pulley\ 2\ = 180° + \frac{D_2 - D_1}{c} * 60° = 205°$$

Belt speed: Belt speed is equal to peripheral speed of driving pulley V=0.6m/s

Belt length

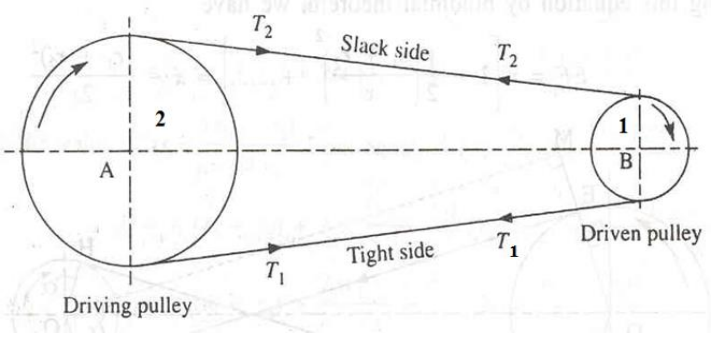
$$length\ of\ belt(L) = 2c + \frac{\pi}{2}(D_2 + D_1) + \frac{(D_2 - D_1)^2}{4c} \quad \text{..... (3.4)}$$

$$L = 2(730) + \frac{\pi}{2}(70 + 40) + \frac{(70-40)^2}{4*730} \text{ In mm}$$

= 1633mm=1.633 metre

Power transmitted by a belt.

First stage belt transmit ion system



Pulley two coefficient of friction μ_2 =0.42…… …..made from wood

Pulley one coefficient of friction μ_1 =0.32 …….. Made from plastic

The effective turning (driving) force at the circumference of the driven pulley or follower is the difference between the two tensions ($T_1 – T_2$), where T_1, T_2 tension in the tight and slack side of the belt respectively.

Work done per second = ($T_1 – T_2$) v N-m/s

Power transmitted (P) = ($T_1 – T_2$) v Watt = 13.05w

($T_1 – T_2$) = 13.05w/ 0.6m/s = 21.5 N

Ratio of driving tensions for flat belt drive: Considering a driven pulley rotating in the clockwise direction as shown above:

$$\frac{T_1}{T_2} = e^{\mu\theta} \quad \text{…… (3.5)}$$

Angle of contact pulley 1 θ_1 =155*3.14/180 = 2.704rad

Angle of contact pulley 2 θ_2 = 205 * 3.14/180 = 3.576 rad

Since both pulleys have different coefficient of friction (μ). Therefore the design will refer to a pulley for which $\mu\theta$ is small?

Pulley two μ_2 =0.32 , Pulley one μ_1=0.42

Pulley 1: μ. θ_1 = 0.42 * 2.704 = 1.135 Pulley 2: μ. θ_2 = 0.32 * 3.576 = 1.144

Since the value of μθ pulley one is less than pulley two. Therefore the design will refer to the smallest value.

$\frac{T_1}{T_2} = e^{1.135} = 3.11$ Therefore $T_1 = 3.11\ T_2$

By substituting the value simultaneously T_1= 58.28N,

T_2= 18.74N,

($T_1 + T_2$) =77.02N

The torque exerted on:

Driving pulley (T) = ($T_1 - T_2$) r_2 …… (3.6)

= (58.28-18.74) * 35 =1383.9Nmm

Driven pulley (T) = ($T_1 - T_2$) r_1 ……..…… (3.7)

= (58.28-18.74) * 20=790.8Nmm

Centrifugal tension could not consider in hear while the system have low speed which is less than 10m/s.

The maximum stress on belt

$\sigma_{max} = \frac{T_{max}}{bt}$ ……..…… (3.8)

$\sigma_{max} = \frac{77.02N}{3*20mm^2}$ =1.286N/mm^2

Where: - T_{max} = maximum torque on belt (T_1 +T_2)

b= width of belt =20mm

T= thickness of belt = 3mm

Initial tension in belts: When the driving pulley starts rotating there will be an increasing in tension in the tight side and a decreased tension in the slack side. These tensions are called initial tension. T_0

Neglecting centrifugal tension $T_0 = \frac{T_1 + T_2}{2}$ …… (3.9)

$= \frac{77.02N}{2} = 38.5N$

Initial effective stress $\sigma_0 = \frac{T_0}{A}$ …… (3.10)

$= \frac{38.5N}{60mm * mm} = 0.642\,\text{Nmm}^{-2}$, A= Area of belt= 60mm^2

Bending stress: This stress appears when the belt goes round the pulley at its value is

$\sigma_b = E\frac{\text{Belt thickness}}{\text{Pulley diameter}}$ …… (3.11)

E = 100N/mm^2

$\sigma_b = \frac{100\text{N}}{mm^2} \times \frac{3mm}{70mm} = \frac{4.285N}{mm^2}$ In driving pulley

$\sigma_b = \frac{100\text{N}}{mm^2} \times \frac{3mm}{40mm} = \frac{7.5N}{mm^2}$ In driven pulley

Belt joints have chosen cemented in shop which has 80 to 90% Efficient.

Pulley diameters are already known, in the above, D_2=70mm, D_1=40mm

Pulley width: The width of pulleys should be at list 1.05 to 1.1 time's belt width

Pulley two width will be =36mm, Pulley one width will be =30mm

Pulley crown

To prevent the flat belts from running off, at least one of the pulleys has to be crowned, preferably the larger pulley, or the pulley with the largest arc of contact. According to ISO22

the recommended crown height of pulley from the table. For pulley diameter 40mm and 70mm- needs 0.3mm [27] corresponding to pulley width. In order to avoid slippage recommended to construct by wood Mass= 77.6g.

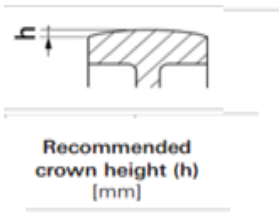
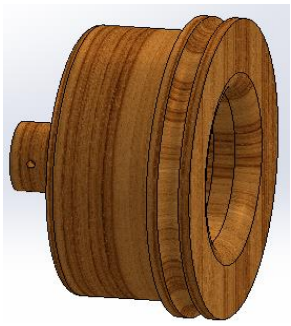


Figure 3-14 pulley crown

Pulley running surface

The running surface of driving pulleys must not be too smooth, due to the risk of stick-slip and noise creation, and not too rough (no knurled surfaces!) as this can cause excessive belt wear and premature belt failure. Habasit's recommendation for the roughness of the running surface: according to ISO 4287 [27] arithmetical mean deviation of the profile (Ra) = 4µm attainable by normal tooling on a lathe.



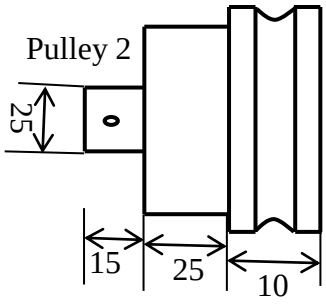


Figure 3-15 Pulleys (all dimension in millimeter)

3.4.1.2. Design Of Handle

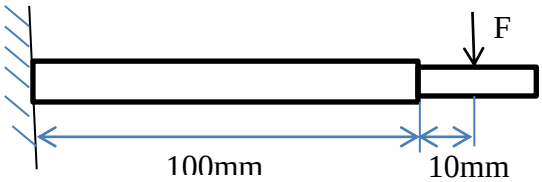


Figure 3-16 Handle structure

F =T/r, F= 1383.9Nmm/100mm = 13.839N

M = F * L = 13.839N *110mm = 1522.29N-mm

Bending stress of handle

The permissible bending stress (σb) is equal to

$M = \sigma b * Z$ …….…… (3.12)

$z = \frac{\pi}{32} * d3$ =50.24, diameter of pedal d=8mm.

$\boldsymbol{\sigma} b$ = (1522.29/50.24)N mm^{-2} =30.3Nmm^{-2}

Let me use factor of safety n=2, $\boldsymbol{\sigma} sy = \boldsymbol{\sigma} b * n = (30.2 * 2) N$$mm^{-2}$ =60.4Nmm^{-2}

Let Choose the material type use polyether-ether ketone (PEEK) have ultimate tensile strength (Suy) 95MPa, elastic modules (E) 3.9GPa, compressive strength=125MPa and 30% elongation at brake. Mass =41g.

3.4.1.3.Lever Design

The cross –section of the lever arm is rectangular & consist width & thickness.

The bending stress $\sigma b = M/Z$ ……. (3.13)
And maximum bending moment (M) is M = F*L

Since, at present time there is in sufficient information on the subject of combined bending & twisting of rectangular sections to enable up to find equivalent bending or twisting, with sufficient accuracy, therefore the indirect procedure is adopted. We shall design the lever arms for 25%more bending moment.

M =1.25* 13.839N * 100mm
M = 1729.9Nmm

And the section modulus (Z) is

$Z = \frac{1}{6} * t * B^2$ ……. (3.14)

Let assuming B =4t and substitute from section modulus formula

$Z = \frac{16}{6} * t^3$

Substitute the value of section modulus & bending moment in the equation of bending stress takes similar material with pedal.

$$\sigma b = M/Z$$

$$60.4\ Mpa = (6 * 1729.9\ Nmm)/(16 * t3)$$

And t = 2.2mm, let me take t = 4 mm

B = 2*t = 4*4mm= 16 mm

Therefore thickness of arm (t) = 4 mm. Width of arm (B) = 16 mm.

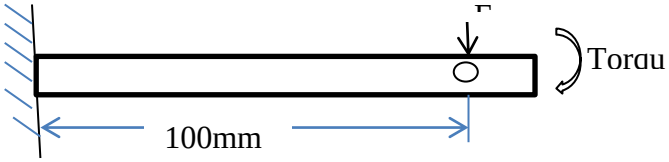


Figure 3-17 lever structure

Let us check the lever arm for induced bending & shear stress.

The induced bending stress (σb) is $\sigma b = M/Z$

Bending moment (M) is M =13.839N * 100mm

M = <u>1383.9Nmm</u>

And section modulus (Z) is $Z = \frac{1}{6} * t * B^2$

$$Z = \frac{1}{6} * 4\ mm * 16^2 mm^2$$

$$Z = 42.67\ mm^3$$

Therefore:- $\sigma_b = \frac{M}{Z} = \frac{1383.9\ Nmm}{42.67\ mm^3}$

$$\sigma_b = 32.4\ {}^{N}/_{mm^2}$$

So the induced bending stress is less than from the allowable bending stress. And the induced shear stress (τ) is

Twisting moment on the arm (T) =1383.9N

$T = \frac{2}{9} * B * t^2 * \tau$ (For rectangular section) …… (3.15)

Substitute all values from the above equation

$$1383.9Nmm = \frac{1}{2} * 16\ mm * 16mm^2 * \tau$$

$$\tau = \frac{1383.9\ Nmm}{2048\ mm^3}$$

$$\tau = 0.67N\ mm^2$$

From the material selection (τ) is $\tau = 0.577\sigma s_y$

$$\tau = 0.577 * 60.4\ Mpa$$

$$\tau = 30.85\ Mpa = 30.85\ {}^{N}/_{mm^2}$$

But the allowable shear stress (τ_{all}) is $\tau_{all} = \frac{\tau}{n}$ …… (3.16)

Where: - n is factor of safety & let assume n = 2

$$\tau_{all} = \frac{30.85\ {}^{N}/_{mm^2}}{2} = 17.4\ {}^{N}/_{mm^2}$$

So the design is in a safe range.

Now let us check the cross section of lever arms for maximum shear or principal stress.

1) Maximum principal bending stress ($\sigma_{b_{max}}$) is

$\sigma_{b_{max}} = \frac{1}{2}[\sigma_b + \sqrt{\sigma_b{}^2 + 4\tau^2}]$ …… (3.17)

$\sigma_{b_{max}} = \frac{1}{2}[32.4 + \sqrt{32.4^2 + 4(0.67^2)}]$

$\sigma_{b_{max}} = 32.4\ Mpa$

2) Maximum shear stress (τ_{max}) is

$\tau_{max} = \frac{1}{2}\sqrt{(\sigma_b{}^2 + 4(\tau^2))}$ …… (3.18)

$\tau_{max} = \frac{1}{2}\sqrt{(32.4^2 + 4(0.67^2))}$

$\tau_{max} = 16.213\ Mpa$

$determine\ the\ diameter\ of\ the\ journal\ (D)$

The equivalent twisting moment (T_e) is

$$T_e = P(\sqrt{\left(\frac{2}{3} * L + X\right)^2 + L^2}) \quad \text{..... (3.19)}$$

$$= 13.85N(\sqrt{\left(\frac{2}{3} * 100 + 10\right)^2 + 100^2}$$

$T_e = 1690.6\ Nmm$

From the other relation (T_e) is $T_e = \frac{\pi}{16} * \tau * D^3$ ..... (3.20)

From the above equation we have the following diameter formula

$$D = \sqrt[3]{(\frac{16T_e}{\pi\tau})} \quad \text{..... (3.21)}$$

$D = \sqrt[3]{(\frac{16*1690.6\ Nmm}{\pi*16.213\ Mpa})}$ = 8 mm D = 10 mm

Let use structural Steel ASTM –A36 is more available and strong. E= 200GPa, ultimate tensile strength (S_u) = 400MPa, yield strength S_y= 250MPa, Mass= 30g.

3.4.1.4. Design of Driving shaft

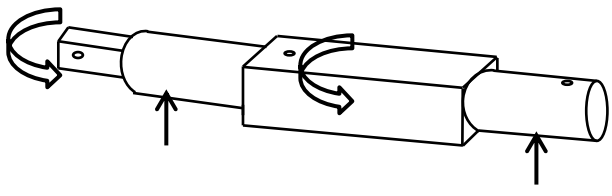


Figure 3-18 driving shaft

The designing is at the critical section. Let's calculate the reaction force at bearing

$$\sum(R_A + R_B - (T_1 + T_2)) = 0\ , \quad \text{..... (3.22)}$$

$T_1 + T_2 = 77.02N$

$R_A + R_B = 77.02N$

$(T_1 + T_2) * 45 + (R_B) * 110 = 0$

$R_A = 45.5N$ $R_B = 31.5N$

Bending moment at the critical section of mid-point

$M = (T_1 + T_2) * over\ hung$

$M = 77.02 * 45Nmm = 3465.9Nmm$

The equivalent torque $T_e = \sqrt{T^2 + M^2}$

$= \sqrt{1383.9^2 + 3465.9^2}$

= 3731.97Nmm

$T_e = \frac{\pi}{16} * \tau * D^3$ ……..……. (3.23)

$3731.97 = \frac{\pi}{16} * \tau * 10^3$

$\tau = 19Nmm^{-2}$

Check for equivalent bending moment:

$M_e = ½(M + \sqrt{M^2 + T^2})$, $T = 1383.9Nmm$

$M_e = ½(3465.9 + \sqrt{3465.9^2 + 1383.9^2}) = 3599Nmm$

$M_e = \frac{\pi}{32} * \sigma_b * D^3$ ……. (3.24)

$\sigma_b = \frac{32}{\pi(10mm)^3} * 3599Nmm = 36.67Nmm^{-2}$

According to maximum shear stress theory, the maximum shear stress in the driving shaft

$\tau_{max} = \frac{1}{2}\sqrt{(\sigma_b{}^2 + 4(\tau^2))}$ ……. (3.25)

$= \frac{1}{2}\sqrt{((36.67^2) + 4(19^2))}$

= 26.4 Nmm^{-2}

According to maximum bending stress:-

$$\sigma_{b\,max} = \frac{1}{2}[\sigma_b + \sqrt{\sigma_b{}^2 + 4\tau^2}] \quad \text{..... (3.26)}$$

$$\sigma_{b\,max} = \frac{1}{2}[36.67 + \sqrt{36.67^2 + 4(19)^2}]$$

$$\sigma_{b\,max} = 44.74\ Nmm^{-2}$$

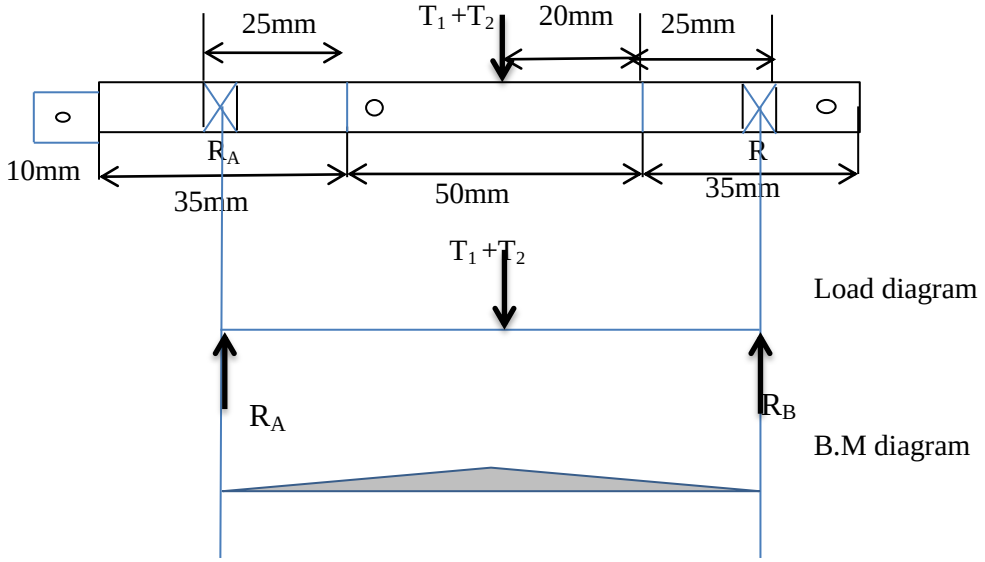


Figure 3-19 load and bending moment diagram of driving shaft

Let use structural Steel ASTM –A36 is more available and strong. E= 200GPa, ultimate tensile strength (S_u) = 400MPa, yield strength S_y= 250MPa, mass=82.3g.

Check the deflection

The deflection of shaft should be minimum, X=55mm, RA =45.5N, Take moment at critical point.

$$EI\ \frac{dy^2}{dx^2} = \mathrm{M}\ , \quad \frac{dy^2}{dx^2} = \frac{R_A X}{EI}\ , \quad \frac{dy}{dx} = \frac{R_A x^2}{2EI}\ , \quad \text{..... (3.27)}$$

$$y = \frac{R_A X^3}{6EI}, \qquad \text{where: } I = \frac{\pi * D^4}{64} = \frac{\pi * 10^4}{64} = 490.6mm^4$$

$$y = \frac{45.5N * (55mm)^3}{6(200 * 490.6) * 10^3 mm^2} = 0.01285mm$$

3.4.1.5. Design of Driven shaft

Driven pulley (T) = ($T_1 - T_2$) r_1 =790.8Nmm, N_2=154.3rpm, D_3=30mm

Pulley one coefficient of friction μ_1 =0.32 …….. Made from plastic

$$\frac{T_3}{T_4} = e^{\mu\theta} \qquad \text{…… (3.28)}$$

$= e^{1.135} = 3.11$

Driven pulley (T) = (T_3 – T4) r_3 = ($T_3 - T_4$) = $\frac{790.8Nmm}{30mm}$=26.36N

T_3=38.85N, T4= 12.5N,

$T_3 + T_4$ = 51.35N

Let resolve T_3, T_4 along the direction of T_1 and T_2

($T_3 + T_4$)/ sin33.3 = 93.53N

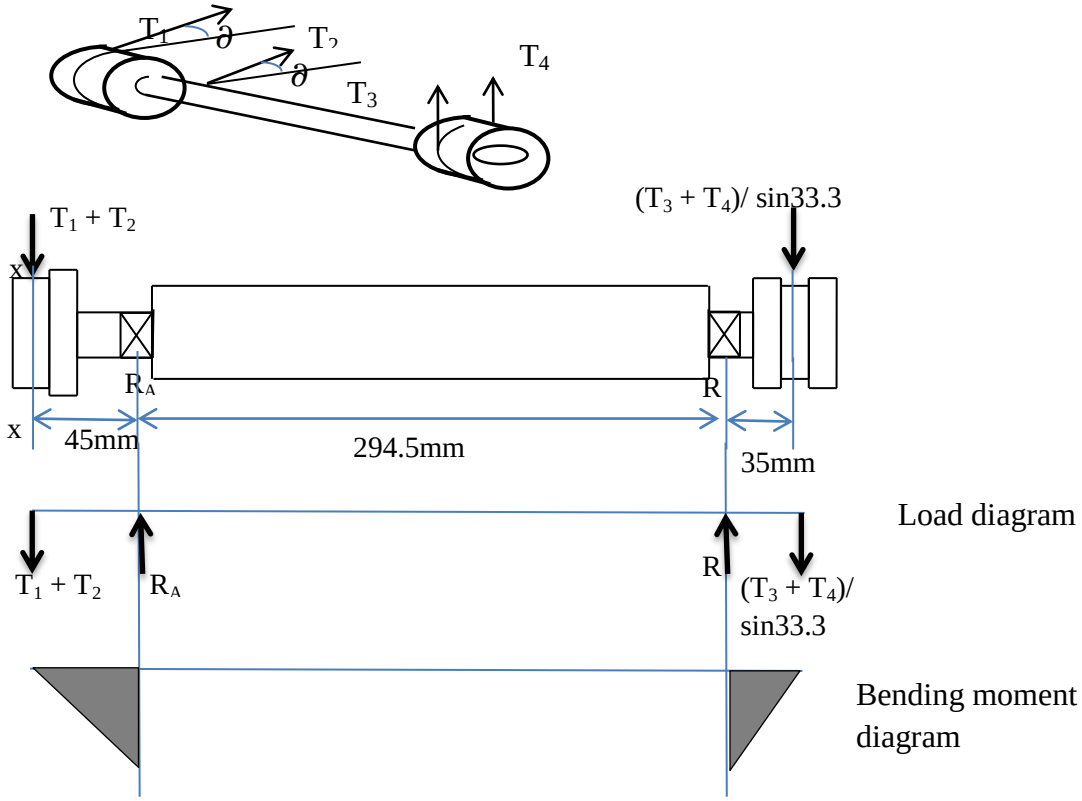


Figure 3-20 load and bending moment diagram

Let's find out the reaction force at supporter

$R_A + R_B - (T_1 + T_2) - ((T_3 + T_4)/ \sin 33.3) = 0$

Moment at point A

$(T_1 + T_2)* 55mm - ((T_3 + T_4)/ \sin 33.3)* 339.5 - R_B *294.5 = 0$

R_A= 77.11N, R_B=93.43N

Maximum bending moment at point A

$M_A = (T_1 + T_2)*$ over hung ……. (3.29)

= 77.02N *45mm = 3466Nmm

The equivalent torque (T_e) $= \sqrt{T^2 + M^2}$ where T=790.8Nmm

T_e = 3555.07Nmm= 3.555Nm

Maximum bending moment at point B

$M_B = ((T_3 + T_4)/ \sin 33.3)*$over hung ……. (3.30)

= (93.53N)*35mm

M_B = 3086.49Nmm= 3.08649Nm

The equivalent torque at point B

$T_e = \sqrt{T^2 + M^2}$ where T=790.8Nmm

T_e =3.18618Nm

Point A is critical section. Let's take this point which factor of safety n= 3

The equivalent torque T_e = 10.665Nm

$T_e = \frac{\pi}{16} * \tau * D^3$ ……. (3.31)

$$10665Nmm = \frac{\pi}{16} * \tau * 20^3$$

$\tau = 6.79 Nmm^2$

Check for equivalent bending moment at point A,

M_e= ½(M +$\sqrt{M^2 + T^2}$), $T = 790Nmm$

M_e= ½(3466 +$\sqrt{3466^2 + 790.8^2}$) =3510.5Nmm

$M_e = \frac{\pi}{32} * \sigma_b * D^3$ …… (3.32)

$\sigma_{b.} = \frac{32}{\pi(20mm)^3} * 3510.5Nmm$ = 4.47Nmm^{-2}

According to maximum shear stress theory, the maximum shear stress in the driving shaft

$\tau_{max} = \frac{1}{2}\sqrt{({\sigma_b}^2 + 4(\tau^2))}$ …… (3.33)

$\tau_{max} = \frac{1}{2}\sqrt{((4.47^2) + 4(6.79^2))}$ = 4.06Nmm^{-2}

According to maximum bending stress:

$$\sigma_{b_{max}} = \frac{1}{2}[\sigma_b + \sqrt{{\sigma_b}^2 + 4\tau^2}] \quad \text{…… …… (3.34)}$$

$$\sigma_{b_{max}} = \frac{1}{2}[4.47 + \sqrt{4.47^2 + 4(6.79)^2}]$$

$$\sigma_{b_{max}} = 9.38 \text{ Nmm}^{-2}$$

Check the deflection

Let use structural Steel ASTM –A36 (use 10mm diameter portion): young's modulus (E) = 200GPa, ultimate tensile strength (S_u) = 400MPa, yield strength S_y= 250MPa, mass=102.10g.

The deflection of shaft is small where at the two ends. R_A= 77.11N, R_B=93.43N

Let me say $T_1 + T_2 = W_1$=77.02N and $(T_3 + T_4)/ \sin 33.3 = W_2$=93.53N,

Moment x-x at right end Mx_{-x}= $-W_2*X + R_B*(X-35) + R_A*(X-329.5)$

$EI\ \frac{dy^2}{dx^2} = M$ ……. (3.35)

$y = \frac{1}{6EI}[W_2x^3 - R_B(x-35)^3 - R_A(x-329.5)^3]$, where: $I = \frac{\pi * D^4}{64} = \frac{\pi * 20^4}{64} = 7850mm^4$

$\underline{y = 0.132mm}$,

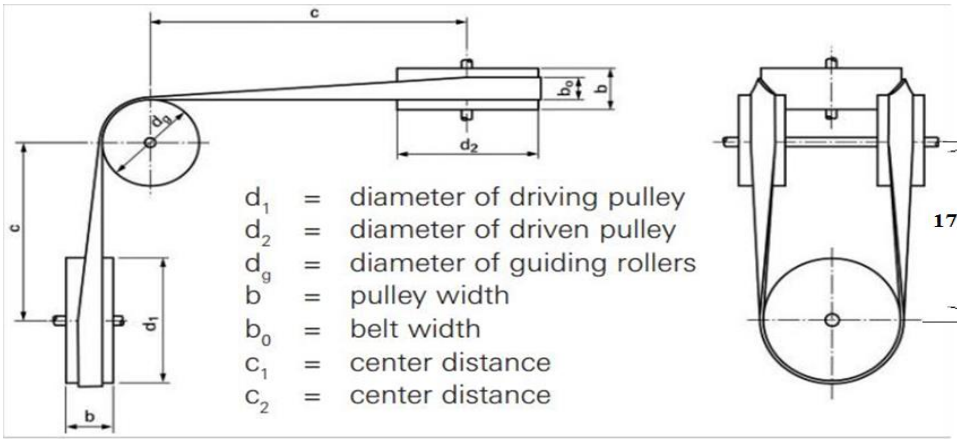
Moment x-x at right end $M_{z-z} = W_1 * X - R_A * (X-45) - R_B * (X-339.5)$

$EI\ \frac{dy^2}{dx^2} = M$ ……. (3.36)

$y = \frac{1}{6EI}[W_1x^3 - R_A(x-45)^3 - R_B(x-339.5)^3]$, Where: $I = \frac{\pi * D^4}{64} = \frac{\pi * 20^4}{64} = 7850mm^4$

$y = 0.136mm$, Therefore the design is safe.

3.4.1.6. Agitator Power Transition Belt



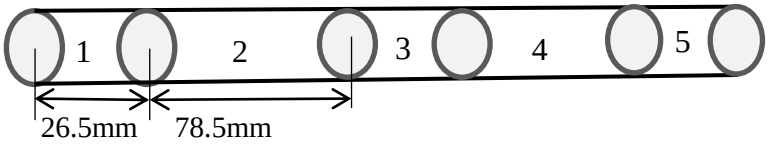
a

d_1=30mm d_2=10mm d_g=15mm

c1=170mm c2= 38mm

$L = 2C_1 + 2C_2 + 1/4(\pi d_g) + (\pi d_2)/2 + (\pi d_1)/2$

L=490.6mm



b

Figure 3-21 : agitating system belt arrangements (a=idler pulley and b=agitating system)

The small pulley have 10mm diameter.

$$length\ of\ belt(L) = 2c + \frac{\pi}{2}(D_2 + D_1) + \frac{(D_2 - D_1)^2}{4c} \quad \text{..... (3.37)}$$

Length of section 1, 3 and 5 transmission belt

$$length\ of\ belt(L) = 2 * 26.5 + \frac{\pi}{2}(10 + 10) + \frac{(10-10)^2}{4*26.5} = 84.4\text{mm}$$

Length of section 2 and 4 transmission belt

$$length\ of\ belt(L) = 2 * 78.5 + \frac{\pi}{2}(10 + 10) + \frac{(10-10)^2}{4*26.5} = 188.4\text{mm}$$

Let use round polyester flexible rope is made by rubber composite (NBR-Rubber) Material or Polyester Material.

- Density= 1140Kg/m^3
- Modules of elasticity (E) = 100N/mm^2
- Specific weight (N/m^2)= 13750
- Ultimate tensile strength = With layers 37MPa
- Coefficient of friction = 0.42

D_3 = 30mm T_3= 38.85N T_4= 12.5N

T_3+T_4 = 51.35N

Let chose the maximum load (T_3) to check the material stress.

$\sigma = \frac{T_3}{A} = \frac{38.53}{3.14}$, A=3.14mm^2

$\sigma d = 11.78 * 3 = 35.3N$mm^{-2}

Idler pulley: Diameter (D) = 15mm, Width (w) = 15mm, mass=4g plastic. Axle made from steel which uses on the frame material, the dimension are given for technical system by 3mm diameter and mass=8.03g.

Other pulleys were made by plastic which have 26mm width and 10 diameters. The axle of each pull are made by steel were us in the structural frame. Diameter= 2mm. complete mass=pulley +spindle=8.44g.

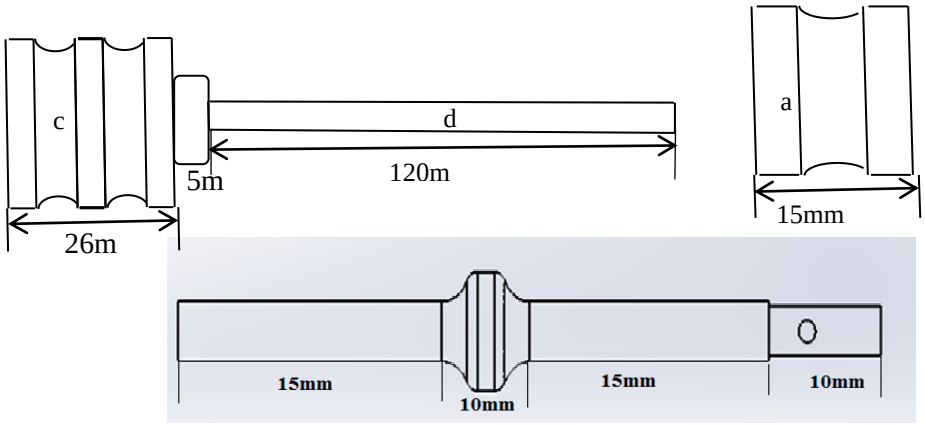


Figure 3-22 (a= idler, c= agitating) pulley and (b=idler, d = agitating) axle

Frame which are support those agitator pulley by Poly-ether-ether-ketone (PEEK): Elastic modulus (E) 3900N/mm^2, tensile strength 95 N/mm^2, compressive strength=125 N/mm^2, Mass= 22g

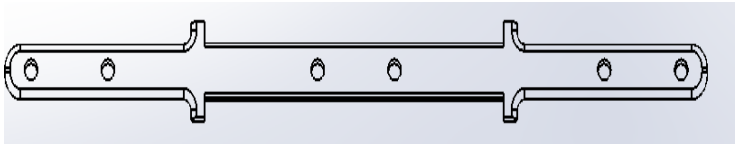


Figure 3-23 Agitating frame

3.4.1.7. Pulley Frame

All dimension are in millimetre

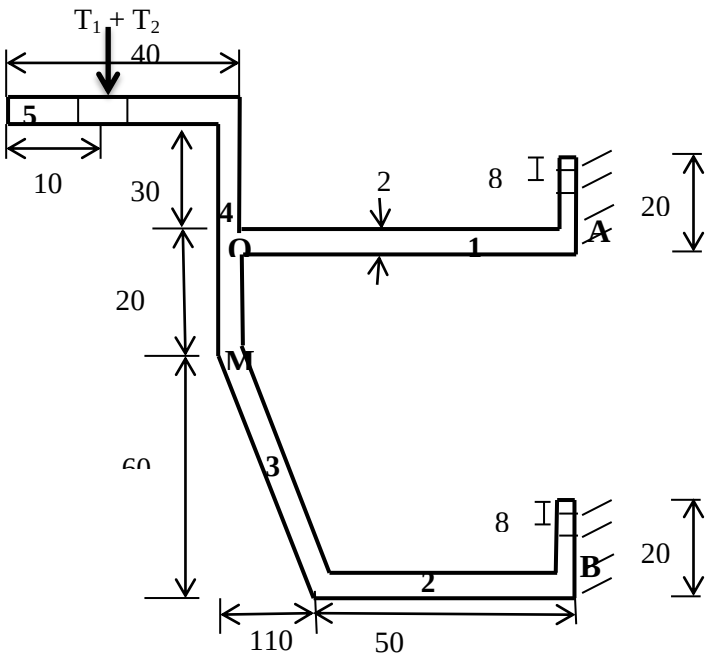


Figure 3-24: pulley frame

Let's see the reaction force

$T - F_{AY} - F_{BY} = 0$

$F_{AX} + F_{BX} = 0$

Moment at point B $T*190 + F_{AX}*80 = 0$

Moment at point O $T*30 + F_{AY}*160 + F_{AX}*80 + F_{BY}*160=0$

F_{BX}=182.9N to right F_{BY} =69.14N UP

F_{AX}= 182.9N to left F_{AY}= 7.87N to down

Let's take the equilibrium equation to determine the elements force (tension).

$\sum F_X = F1 + F2 + 0.478F3 = 0$ …… …… (3.38)

$\sum F_Y = 77.02N - F4 + 0.877F3 = 0$ …… (3.39)

Moment about point O

$\sum M = 2.3106 - 0.00096F3 + 0.08F2 = 0$

Moment about point M

$\sum M = 2.3106 - 0.02F1 + 0.06F2$

F1 (element 1) = 114.22N right F2 (element 2) = 0.436N left

F3 (element 3) =238.04N up F4 (element 4) =131.7N down

Let it be made in structural Steel ASTM –A36: young's modulus (E) = 200GPa, ultimate tensile strength (S_u) = 400MPa, yield strength S_y= 250MPa. Take the Standard structural steel bar thickness of 2mm and 30-40mm width, mass=284.55g. Take the critical element 5 exposed to bending and deflection.

$\sigma_{b.} = \frac{M}{I}$ …… (3.40)

Where $I_{.} = \frac{bh^3}{3} = \frac{30*3^3}{3}$ =270mm^3,

M= $T*30= (T_1+T_2)*30mm= 77.02*30Nmm$

σ_b =8.55Nmm^{-2}

$EI\ \frac{dy^2}{dx^2} = M$, where M = T*x ……. (3.41)

$\frac{dy}{dx} = \frac{Tx^2}{2EI}$ + C let set the boundary $\frac{dy}{dx} = 0$ at x =30mm. then $c = -\frac{MT}{2EI}$

$y = \frac{Tx^3}{6EI} - \frac{TX^2x}{2EI} + c$, y=0, set c=0 and x =0-30mm,

Element 1exposed to elongating let's check

$\sigma = F_{AX}/A = 182.9N/90mm^2 = 2.03Nmm^{-2}$

$\partial = \sigma/E = 2.03Nmm^{-2} / 200*10^3\ Nmm^{-2}$

$\partial = 10^{-5}$. Almost it is negligible the deflection of frame is very small. Add the tin rib on the high stress.

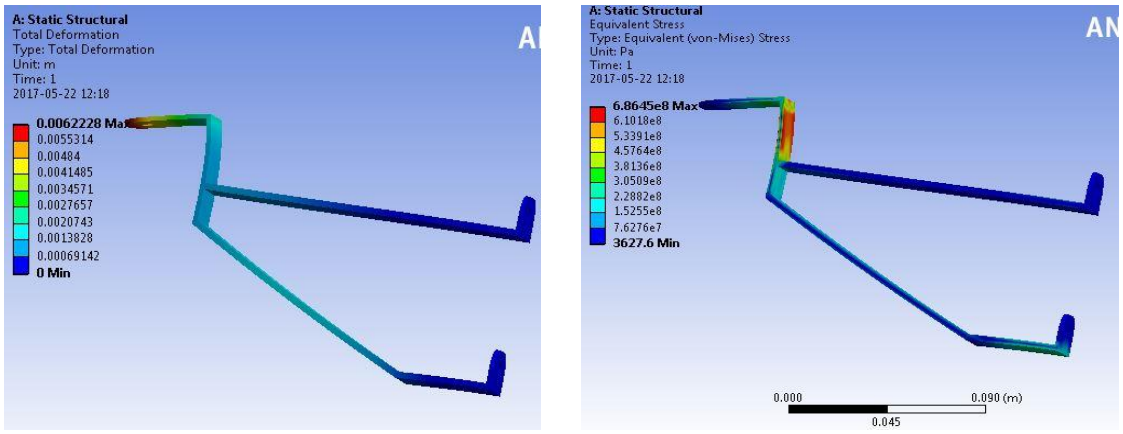


Figure 3-25 pulley supporter frame total deformation and von-mises

3.4.1.8. Buckets Design

3.4.1.8.1. teff bucket size

By using the recommended seed rate range and considering the physical property of tef seed.

One hectare =10000 square meter=100m*100m,

Row space =20cm=0.2m so we have 500line

Let's take the minimum rate (3kg/ha) 6g for one line (100m).

Let's define the space of between the seed (approximating estimate the seedling 20mm) is small in order to determine the bucket size. For design purpose, it should use the maximum limit of number of seeds. In one meter have 34 gaps. Then in one metre needs = 34*8seeds = 272 seeds, for one line (100m) needs 13600 – 27200 seeds

The thousands of teff seed between have 0.257g to 0.421g mass with corresponding moisture increase. [19]. Therefor by taking the maximum limit the amount of teff in one line would use

$$\left\{\begin{matrix} 1000\ seeds = 0.421g \\ 27200\ seeds = \quad X \end{matrix}\right\}$$ X = 8.588g = 9g ……. one line (100m)

Therefor one hectare has 500 lines which should needs *4.5kg* teff seed rate in my project.

Model of the Teff seeds shape was based on the similarities with ellipsoid (see the teff shape Figure) and on that principle the basic assumptions were determined [33, 35].

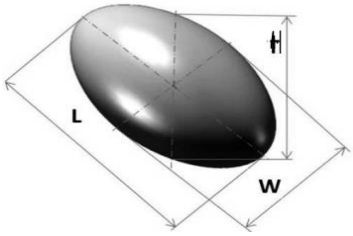


Figure 3-26: Ellipsoid model of Teff seed.

Bucket volume

$$Q = \frac{Rs*W*V}{10000*pb}$$ ……(3.42)[33,35]

Where: - Q= flow rate of seeds from the metering unit (m^3/s)

Rs = seeding rate (kg/ha) 4.5kg/ha

Pb = seed bulk density (kg/) take 700kg/ m^3

W = width of covering of planter (m) =0.4m

V = the peripheral velocity of the machine m/s (rope guider) = 0.6m/s

$$Q = \frac{4.5kg/ha*0.4m*0.6m/s}{10\ 000*\frac{700kg}{m3}} = 1.54*10^{-7}\ m^3/s = 0.000000154m3/s$$

Calculate elliptical con volume (Bucket volume)

$$Vc = \frac{60*109*Q}{Nf*Nr},$$ ……(3.43)

Where: - Vc = cell volume =volume of each cells (mm^3)

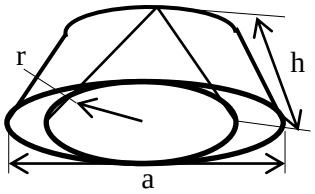
Q= flow rate of seed from the metering unit (m3/s) $1.54 * 10^{-7}$ m^3/s

Nf = number of cell = 5 cell

Nr = rpm of metering shaft = 286.62rpm

$$Vc = \frac{60*109 * 1.54* 10-7\ m3/s}{5* 286.62} = 6.447mm^3$$

$Vc = \frac{\pi*r*h}{3}$, where: r = radius of the con,



h = height of cone

Let take the h = 0.66r

6.447m m^3 = (0.66πr^2) /3

.r = 3.055mm= 3mm

.h = 2.016mm= 2mm

From thus let me give lateral allowance by making the elliptical shape which largest diameter to be increase. In one bucket 4 – 8 numbers of seeds are appropriate for one feeding (see the seed distribution in appendixes'). As the size of seed take the longest side and small number of seeds which are 1.27mm * 4seeds = 5mm.let's choose elliptical bucket profile which gives the result probably achieves the range. When the seed feeds in longitudinal the number of teff would be increase. Set the major axis 5mm & for miner 3mm and 2mm depth.

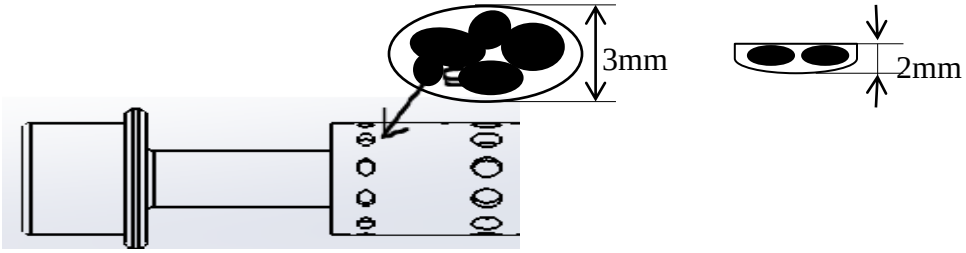


Figure 3-27: Seed bucket size

3.4.1.8.2. fertilizer bucket size

Use the recommended rates of fertilizer application100kg DAP and 50kg urea/ha (after germination) [10].

$100kg/_{500\ lines}$ = 200g for one line and 2g is in one metre space.

The shape of DAP fertilizer is spherical and its size is *3 – 3.2mm* [36] But as the fertilizers have not uniform shapes due to such condition which describes in literature. So it will use the simply estimating by trial observation, let me assigned 7mm diameter and 4mm depth. Which feeds probably minimum two large particle or more as the particle size would reduce. 0.058g fertilizer could deliver by one bucket at a time.

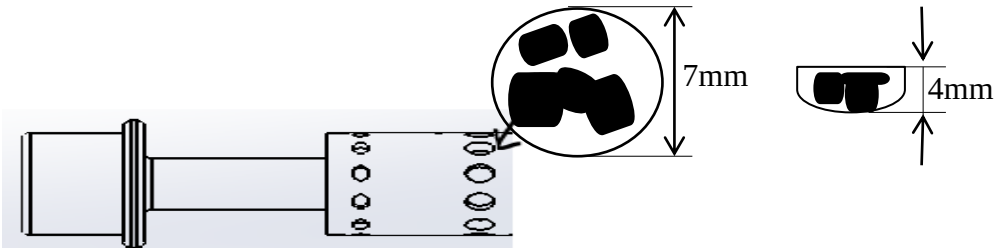


Figure 3-28 : fertilizer bucket size

This bucket made on plastic surface of driven shaft in very smooth.

3.4.1.8.3. Number of bucket

Metring shaft has 40mm diameter and 126mm circumferential dimension. The metering shaft and row guiding rope pulley have similar dimension. By relating the metering shaft with the counter motion of is rotate in 0.6m/s.

$\begin{Bmatrix} 1000\ mm = 34\ gaps \\ 126mm\ =\ X \end{Bmatrix}$ X = 4.58 gaps = 5 gaps, where: - 1 bucket/gap

By taking the longitudinal dimension *five* number of bucket of Teff bucket is desirable on a metering shaft. The centre of both teff and fertilizer buckets are aligns to corresponding each other (see the metring shaft for bucket arrangement).

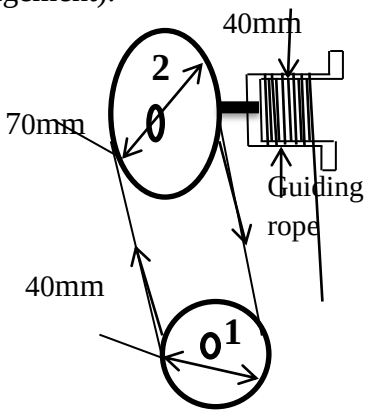


Figure 3-29 metering system

3.4.1.8.4. flow rate

Teff flow rate: -

$\begin{Bmatrix} 1m = 34\ bucket \\ 0.6m\ =\ QX \end{Bmatrix}$, x= 20.4 = 21 bucket, in one bucket feeds 4- 8 seeds averagely 126 seeds/sec. where the mass of thousand seeds are 0.257-0.421g[33]. Therefor by taking the average in one row the flow rate will be

$\begin{Bmatrix} 1000\ seeds = 0.339g \\ 126 seeds \quad QX \end{Bmatrix}$, Qx = 0.042714g/s

Fertilizer flow rate: -

The fertilizer count as in group due to size variation 2g use for one metre which in 34 bucket

Fertilizer low rate = 1.23529g/s use in one row

Therefor T. flow rate = teff flow rate + fertilizer flow rate

= 0.042714g/s + 1.23529g/s = 1.279564g/s

*Flow rate (in three rows/second) = (1.279564*3) g/s= 3.83869g/s*

3.4.1.9.Hopper Design

Hopper is used for holding the drill material. The internal system is smooth material and none flow resistance surface texture.the shape is stable to move the drill material to feeding buket.From the physical property of teff the moisture content 5.6% to 29.6% W.b the angle of response range is 23.75° to 51.16°. In this system relation of angle of response is increase the seed could pass freely so the hopper wall surface could be made in more than limiting range.

It have six compartment those are three compartment could have 50g of seeds each and three compartment could have 400g of fertilizers each. Therefore teff compartment fill after five pass and fertilizer compartment fill after two passs. Where one pass has three line and one line has 100m.

Volume hopper

for single compartment V1

A=((141*100) + $\pi(50^2)/2$) mm^2

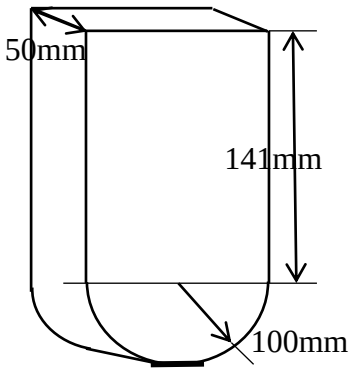
= 18025 mm^2

D= 50mm

V1 =(18025 * 50) mm^3 = 9.0125 * 10^{-4} m^3

The volume of hopper

V = V1 * 6 =54.07 * 10^{-4} m^2



Field capacity

The hopper couldn't have filled full volume. Some space has use for agitating system. For the application of seed rate of 4.5kg/ha

Actual field capacity of drill $=\frac{\text{speed(km/hr.)}*\text{working of drill (m)} * \text{field efficiency}}{10}$... (3.42) [24]

Working width = 3*0.2m = 0.6m

Field efficiency = 90%

Speed = 0.6m/s = 2.16 km/hr.

$= \frac{2.16 *0.6*0.9}{10}$

=0.11664 ha/hr.

the weight of seed to be used in this 0.11664ha will be

= seed rate (kg/ha) × area covered/hr. ×time (hr)

= 4.5kg × 0.11664 ha/hr × 1hr

= 0.524881kg

The volume of seed $=\frac{\text{weight of seed(kg)}}{\text{bulk density kgm}-3}$, where let assume bulk density as 800 kg/m^3 [24]

$= \frac{0.524881\text{kg}}{800} = 0.0006561\text{m}^3 = 6.561 \times 10^{-4}\ \text{m}^3$

Let consider for spillage losses 5%, therefore the total volume of seed drill

Volume of seed box (v) = (6.561 * 10^{-4} + 0.32805) m^3 = 6.88905 m^3

The thickness of seed box is given by (t_s) = $\sqrt[3]{\frac{3 * p * a^2h^2}{4a\ b_s}}$ …..(3.43)[24]

Where: - p= bulk density, 0.008 kg/cm^3

a = bottom width of seed box = 2cm

h = height of seed filled = 9cm

b_s = bending stress = 764.78 kg/cm^2

By substituting the thickness of hopper will be t= 0.233cm = 2.33mm

It have choose 5mm thickness for outer compartment and 2mm for suparation. But, at the lower part have variable thickness as ishow on drawing. The thickness is great advantege for control dryness. Overall size 335 * 390mm which is compact size

It holds 1.35kg mass of drill material. Use polymers Type polyether-ether ketone (PEEK) have ultimate tensile strength (Suy) 95MPa, elastic modules (E) 3.9GPa, compressive strength=125MPa and 30% elongation at brake, mass=1140.99g. PEEK has best material for

resisting friction in the system surface; it has less friction and easy mouldable material to produce a product.

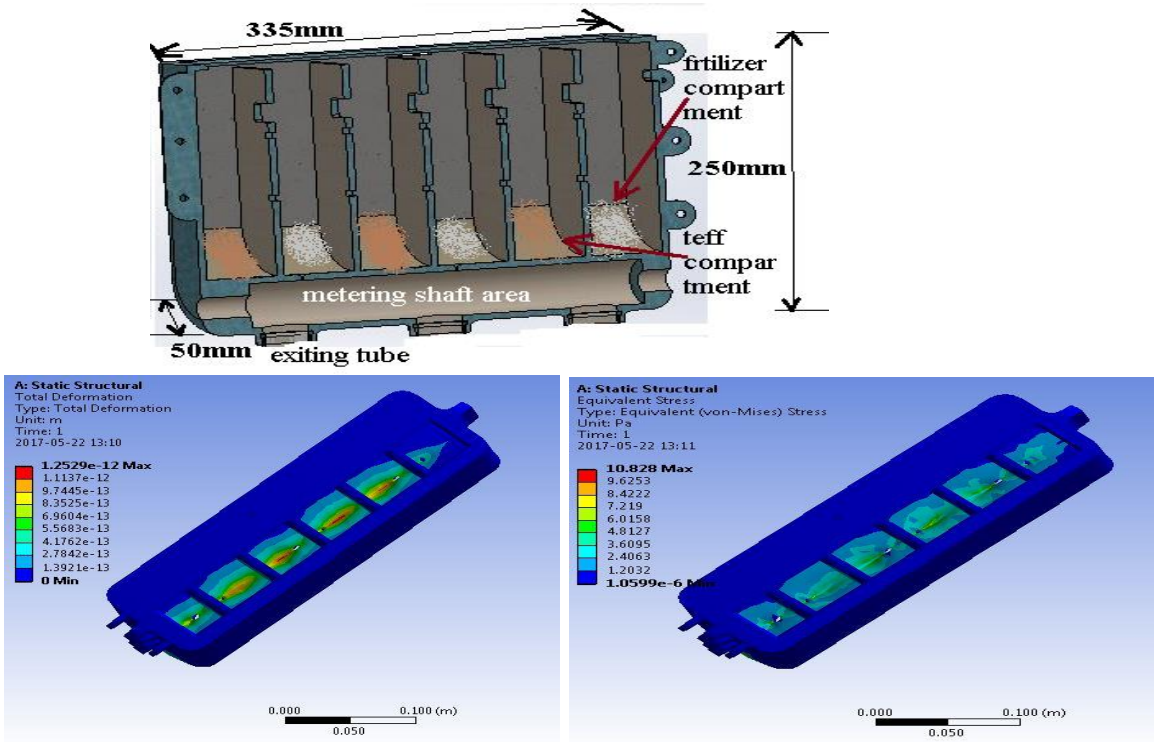


Figure 3-30 front section view of hopper., tatal diformation and von-mises distribution

The deformation of hopper was happen due to the weight of seed and fertilizer which the maximum load is applied when the hopper refilled at the bottom of the hopper. The deformed area is found at the end of seed passage, but the wall is relative tick which resists the load.

3.4.1.10. Metering shaft

The metring shaft has mount at(metering shaft) the bottom part of hopper. It suparet 0.1mm maximum gapfrom compartment which avoids the seed stick between the two surface out of bucket. This component is mad by plastic molding which have hybrid with steel rectangular bar inside. The steel is give strength to metring shaft. The feeding (metering) buckets are made on the outer surface of this shaft. The surface finishing of the bucket and outer surface of metring shaft is very smooth. The load is critically applying the internal steel bare and the plastic type also relative enough to resist the stress as compared the load [see driven shaft design],so no need to manipulate the statically calculation here. It's made by plastic (ABS): young's modulus (E) = 2.3GPa, ultimate tensile strength (S_u) = 40MPa, mass=394.04g.

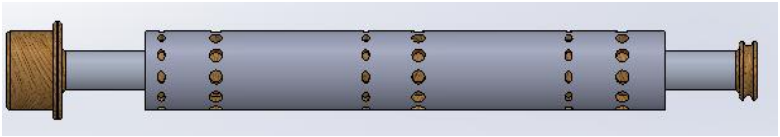


Figure 3-31 metering shaft

Hopper cove made by ABS plastic polymer in 2.5mm thickness plate, mass= 84.26g

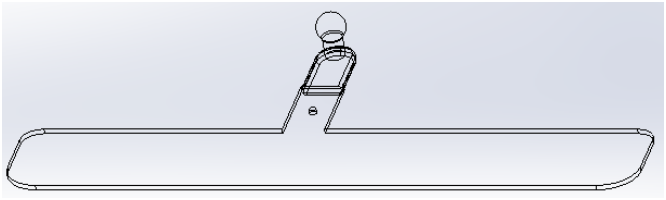


Figure 3-32: hopper cover

3.4.1.11. Hopper holding plate design

It has three in number, which are two plates for fixing to stain the split pattern of hopper together. The two are made by plastic which used for fastening.

The other one is just carrying the lower part of the machine which is different size and thickness and made by structural steel ASTM A36 steel whose mass is 435.5g.

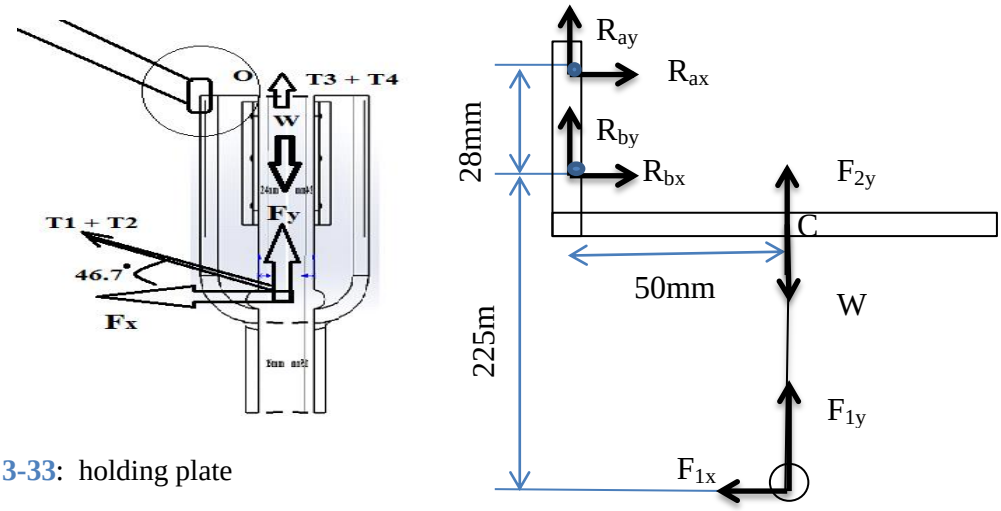


Figure 3-33: holding plate

High stress concentrations were happened at the critical point O. the joint is bolt types which are two in number. Let me calculate the reaction at the joint. Fy, Fx.

Weight (w) =5681.67g (by adding all component and seed with fertilizer) let me change to force = 55.7N

$T_3 + T_4 = F_2 = 51.35N = F_{2y}$

$T_1 + T_2 = F_1 = 77.02N$ 90-33.3

$F_{1X} = F_1 \cos 46.7 = 52.82N$

$F_{1y} = F_1 \sin 46.7 = 56.05N$

$\sum R_{ax} + R_{bx} + F_{1x} = 0$ ……. (3.44)

$R_{ax} + R_{bx} = -52.82N$

$\sum R_{ay} + R_{by} + F_{1y} + F_{2y} - W = 0$ ……. (3.45)

$R_{ay} + R_{by} = -45.75N$

Moment at point b:

$\sum M = -R_{ax} * 28 + F_{2y} * 50 - F_{1x} * 225 + F_{1y} * 50 - W * 50 = 0$ ……. (4.46)

$R_{ax} = -342.83N$ in reverse direction

$R_{bx} = 290N$

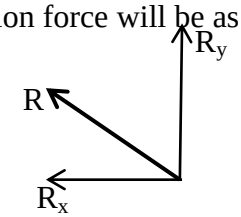
Moment at point c:

$\sum M = -R_{ay} * 50 + R_{ax} * 50 - F_{1x} * 215 = 0$ ……..……. (3.47)

$R_{ay} = -419.1N$ in reverse direction

$R_{by} = 373.4N$

Applied load has distributed equally in both connecting bolt. Reaction force will be as follow.



$R_{ax} + R_{bx} = -52.82N$, Rx=26.41N for each

$R_{ay} + R_{by} = -45.75N$, Ry= 22.8N for each

R (resultant force) = 69.22N

Let's choose M7 bolts made by mild steel are subjected to both tensile and shear load [26]

Direct tensile stress $\sigma t = \frac{R_x}{A}$ …… (3.48)

Where A=$\frac{\pi(D_o-D_i)^2}{4}$, A=1.847mm^2

$\sigma t = \frac{26}{1.847}$ = 14.07Nmm^{-2}, let me take factor of safety 3. σt= 42Nmm^{-2}

Direct shear stress$\tau\frac{R_y}{A}$, where A= $\frac{\pi {D_i}^2}{4}$= 32.8mm^2

$\tau\frac{22.8}{32.8}$ =0.67Nmm^{-2}, let me take factor of safety 3. τ=1.8Nmm^{-2}

The maximum principal tensile stress (σ_{max})

$\sigma_{max} = \frac{1}{2}[\sigma_t + \sqrt{{\sigma_t}^2 + 4\tau^2}]$ …….…… (3.49)

σ_{max}=42.07Nmm^{-2}

Maximum shear stress (τ_{max})

$\tau_{max} = \frac{1}{2}\sqrt{({\sigma_t}^2 + 4(\tau^2))}$ ……..…… (3.50)

τ_{max}=21.077Nmm^{-2} The design has safe.

3.4.1.12. Design of Main frame

The main frame has loaded by the weight of lower part machine. W_1 and W_2

W_1 = 568.67g = 55.7N

W_2 = 825.28g= 8N

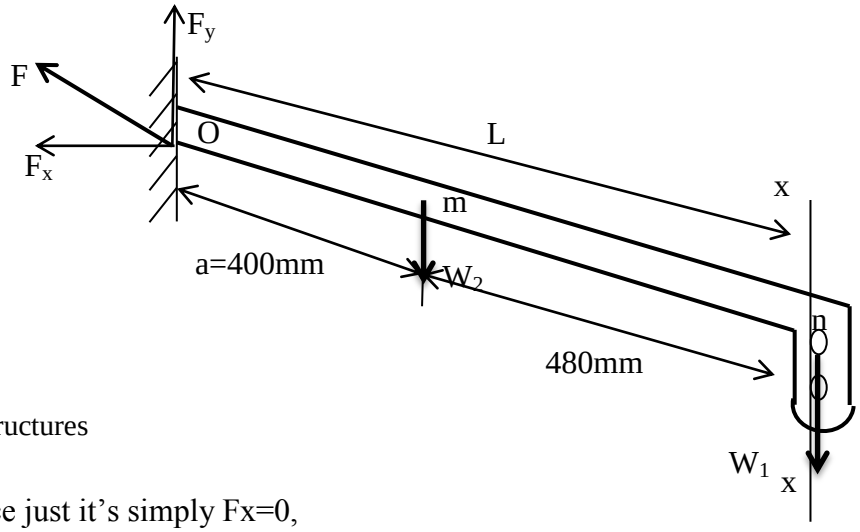


Figure 3-34: main frame structures

Let's find the reaction force just it's simply Fx=0,

Fy = W_1 + W_2 =63.7N

The beam is subjected to bending stress,

Maximum bending moment at point m

M_m=W_2* over hung = 8N *400mm = 3200Nmm

Maximum bending moment at point n

M_n =W_1* over hung = 55.7N *480mm = 26736Nmm

Let's choose the maximum bending moment M_n

$$M_n = A * \sigma_{bn}$$

Where A (hollow rectangular bar) = perimeter * t= 100*1.5=150mm^2

$\sigma_{b.} = \frac{26736}{150mm^2}$ = 178.24Nmm^{-2}

Take factor of safety n=2, σ_b= 334.2 Nmm^{-2}

Check the deflection

Let use a material structural Steel ASTM –A36 (use 10mm diameter portion): young's modulus (E) = 200GPa, ultimate tensile strength (S_u) = 400MPa, yield strength S_y= 250MPa, mass=221.95g.

Moment x-x at right end $M_{z\text{-}z}$= F_y*X – W_A*(X-a)

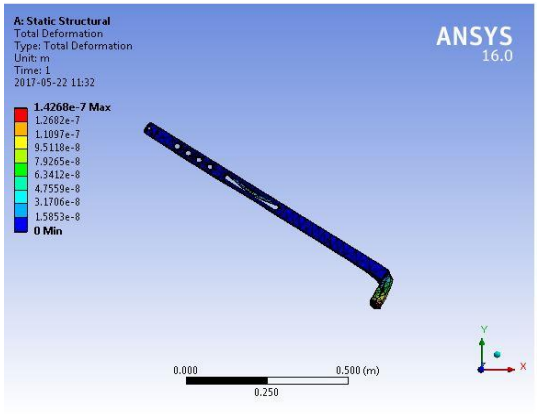
$$EI\ \frac{dy^2}{dx^2} = M \qquad \text{..... (3.51)}$$

Where I=t*h^3/3 = (4*40^3)/3 = 85333.3mm^3

$$y = \frac{1}{EI}\left(\frac{F_y L^3}{4} - \frac{W_1}{4}(L-a)^3 - \frac{W_1}{2}a^2 L - \frac{W_1}{4}a^3\right)$$

$$y = \frac{1}{EI}\left(\frac{63.7(880)^3}{4} - 2(880\text{-}400)^3 - 4(400^2(880)) - 2(400^3)\right)$$

$y = 0.58mm$ Deflection has minimum design will be safe.



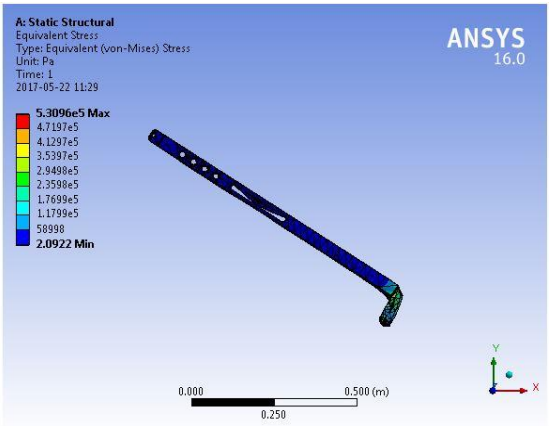


Figure 3-35 main frame total deformation and equivalent stress distribution

From the above values the main frame of drill machine has efficient to support the load.

Bolt Joint at point m

Bolt subjected to only shear stress choose hexagonal bolt M7 made by mild steel

Direct shear stress = $\frac{W_1}{A}$, where A= $\frac{\pi {D_i}^2}{4}$= 32.8mm^2

$\tau = \frac{8}{32.8}$ =0.243Nmm^{-2}, let me take factor of safety 3. τ=0.8Nmm^{-2}

Bolt Joint at point O

Bolt subjected to only shear stress choose hexagonal bolt M7 made by mild steel

Direct shear stress (τ)= $\frac{F_y}{A}$, where A= $\frac{\pi {D_i}^2}{4}$=32.8mm^2

$\tau = \frac{63.7}{32.8}$ =1.42Nmm^{-2}, let me take factor of safety 3. τ=5.826Nmm^{-2} it has safe corresponding the load and material properties.

3.4.1.13. Design of Shoulder Supporter

This is the part which carries the whole part fixed to human body. Let me take similar to main frame structural steel.

W=63.7N

W_x = Wsin33 = 34.69N

W_y = Wcos33 = 53.4N

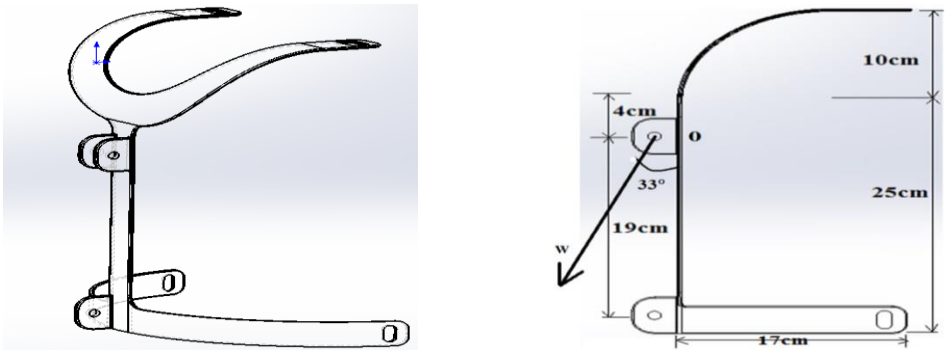
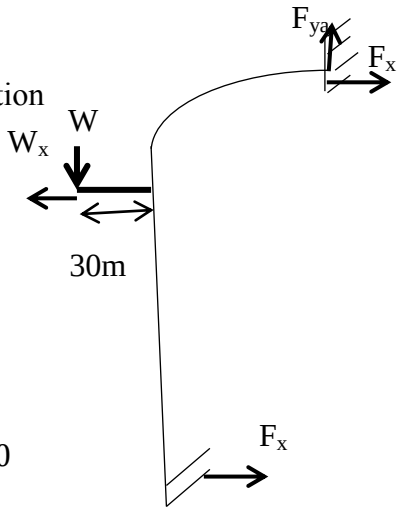


Figure 3-36: shoulder frame

Let's find the reaction at fixed point by taking equilibrium equation



$$\sum W_x - F_{xa} - F_{xb} = 0$$

$$F_{xa} + F_{xb} = 34.69N$$

$$\sum W_y - F_{ya} = 0$$

$$F_{ya} = 53.4N$$

$$\sum M_a = W_y * 18.5cm - W_x * 10cm + F_{xb} * 35cm = 0$$

$$F_{xb} * 35cm = 641Ncm$$

$$F_{xb} = 18.31N$$

$$F_{xa} = 16.37N$$

The part is subjected to bending stress.

The maximum bending moment will be at point o. width=30mm, thickness=3mm

$M_o = F_{ax} * 100mm - F_{ya} * 170mm = 7405Nmm$

$\sigma_b = M_o/A = 82.3Nmm^{-2}$

Use factor of safety n=3,

$\sigma_{nb} = 246.8Nmm^{-2}$ tends to counter clockwise direction which refers to safe condition.

Check the deflection

Let use a material structural Steel ASTM –A36 (use 10mm diameter portion): young's modulus (E) = 200GPa, ultimate tensile strength (S_u) = 400MPa, yield strength S_y= 250MPa,

$EI\ \frac{dy^2}{dx^2} = M$ ……. (3.52)

$y = \frac{1}{EI}(\frac{F_{ay}{x_2}^3}{6} - \frac{F_{xa}}{6}{x_1}^3 + c_1(x_1 + x_2) + 2C_3)$, take c_1=c_3=1

Where $I=t*h^3/3 = (3*30^3)/3=900mm^3$

By substituting the value(x_1= 100mm, x_2=170mm)

y= 0.25mm …. It is a good design

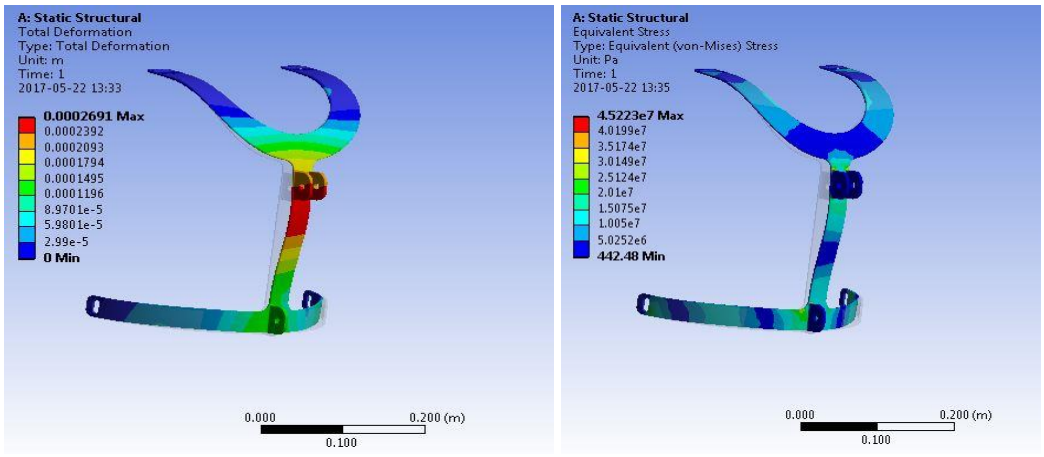


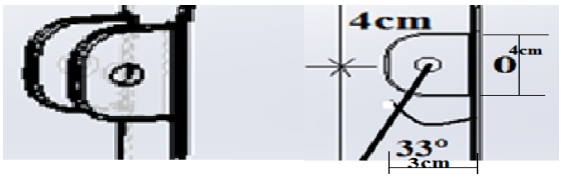
Figure 3-37 shoulder frame total deformation and von-mises distribution

From the above result the shoulder frame have minimum deflection and equivalent stress which satisfy the design.

<u>Shear stress at the point of connection</u>

Direct shear stress (τ) =$\frac{F_y}{A}$ …… …… (3.53)

Where A= $\frac{\pi {D_i}^2}{4}$=32.8mm^2



W=63.7N

A= ((40*5)-(5*8)) mm^2 =160mm^2

$\tau = \frac{63.7}{320}$ = 0.2Nmm^{-2}, let me take factor of safety 10.

τ=2Nmm^{-2} it's safe for the selected material as per the selected material

3.4.1.14. Bearing selection

Plastic bearings cost and weight less than their metal counterparts. And they often run longer in harsh environments and under adverse conditions. Plastic bearings typically consist of a thermoplastic alloy and solid lubricants with a fibre matrix often added for creep resistance and strength. Plastic bushings and plain bearing change to the self-lubricating solution and save up to 40%.20mm internal diameter bush bearing has available [40]. The bearing has subjucted to minimum radial load, the rotational speed also less which have to absorbe the load.

Figure 3-38 bushings and plain bearing

3.4.1.15. Transporting Tube

This tube is used for transporting seed and fertilizer from bucket to soil. From the M. Kroulík (2016) experimental investigation they used different seeds i.e. corn, winter wheat and winter oilseed rape For delivery tubes with internal diameter in different size conclude the result the tube size is recommended above 10mm for seed only. The seeds in vertical delivery tube have shown that the risk of blockage delivery tube increases when delivery tube with inner diameter less than 10 mm was used [34]. Which are larger sizes from teff seed, for this project the seed and fertilizer are pass together? So it has to uses 28mm by 18mm internal major and minor axis.

The geometry design is based on the angle of response of teff physical property which defines as follow:- The angle of tube wall is = $\tan^{-1}(170/71.46)$ = 67.2° therefor the seed could pass easily. By increasing the angle of response we can reduce the motion friction. It made by plastic molding have 1.5mm thickness.

Figure 3-39 transporting tube

3.5. Manufacturing Process

This chapter will cover the detail description of manufacturing process of each machine part of seeding machine. This step of manufacturing process is helps to produce the machine in our county using available material. Required tool and machine are used as per necessity.

3.5.1. Manufacturing process of Component

3.5.1.1. Driving pulley

Required material: - wood

Required tool: - cutting tool, milling tool, measuring tool, drilling tool

Steps: - see part drawing 4 of driving pulley

a. Cut round wood 8cm diameter by 5cm width.
b. Making recessing by 0.5cm diameter and 0.25cm far from edge
c. Turning the round bar in 5mm depth by 4cm length
d. Again turning the bar in 2.6cm depth by 1.5cm length
e. Bore at the centre by 1*1 cm^2 area.
f. Drill pin hole by 2mm diameter.

3.5.1.2.Handle

Required material: - steel bar.

Required tool: - Turning tool, facing tool, boring tool of lathe machine

Steps: - see part drawing of handle

a. Cut the round bar by length 120mm and 1cm diameter,
b. Turning the face by 1mm cutting depth for 20mm length
c. Bore in back side 7mm diameter in 80mm length

d. Drill pine hole at the small diameter by 2mm diameter and 1cm length from edge to centre of pine

3.5.1.3.Liver

Required material: - angle iron length 110mm, 4mm thickness by 16mm width

Required tool: - drilling tool, facing tool of milling tool

Steps: - see part drawing of liver

a. Cutting the plate by required dimension as I show the previous
b. Drill 8mm diameter whose centre of hole is 10mm from one end.
c. Drill 4*4mm^2 area 4mm far from another end
d. Remove any sharp corner in each edge by mille

3.5.1.4.Driving Shaft

Required material; - structural steel

Required tool: turning tool, facing tool, drilling tool, measuring tool (calliper and dial gage), milling tool,

Steps: - see part drawing of driving shaft

a. Cut the rectangular bar by 130mm length and 10*10mm^2 cross-sectional area,
b. Make round by 10mm diameter and 3.5cm length from right end,
c. Make it round bar 4.5cm length by 10mm diameter from other end,
d. Make rectangular 4*4mm^2 cross sectional area in 10mm from left edge,
e. Drill 2mm diameter pin hole as the dimension specify on drawing,

3.5.1.5.Pulley holder

Required material: - steel plate (3mm thickness), 20mm inside Diameter pipe

Required tool: - cutting, measuring, drilling, bending, wielding tool

Steps: see the figure part drawing

A. Cut 240mm structural steel (figure A)
B. Drill 23mm diameter hole in 20mm distance from each edge,
C. Drill at the middle in 9mm diameter hole,
D. Bend in 90° after measuring 70mm length,
E. Again bend in 90° after measuring of 66mm length,
F. Cut two piece 20mm inside diameter pipe in 20mm length,(figure B)
G. Wield those pipe on the 20mm diameter hole at the two end,
H. Cut 20mm diameter circular plat and drill 10±1mmdiametre hole at centre,(figure C)
I. Wield at the centre of pipe hole,

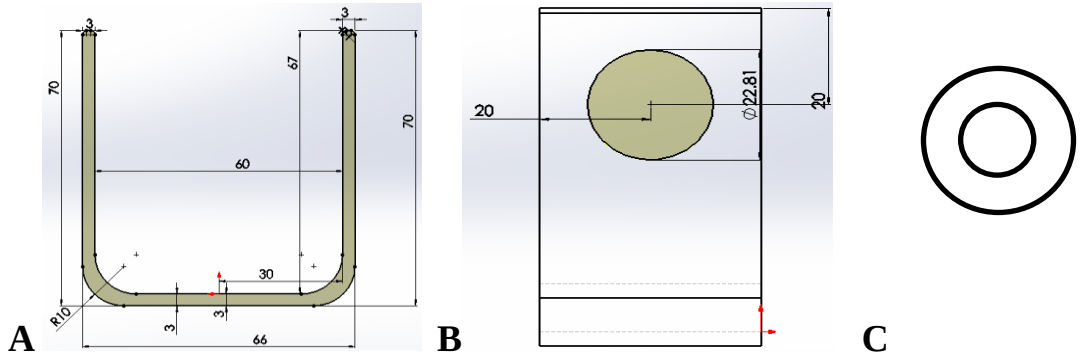


Figure 3-40: pulley holder

3.5.1.6.Driving Pulley Frame

Required material: - structural steel/ angle iron 3mm thickness by 30mm width

Required tool: - cutting tool, bending tool (hammer, bench vice,), drilling tool, welding tool (complete arc welding equipment), measuring tool,

Steps: - see the figure of pulley frame

a. Measuring and cutting the plate,
b. Measuring 40mm and bend by 90°,
c. measure50mm and 61.3° away,
d. Measure 125mm and bend in horizontal level,
e. Measure 50mm and bend 90°,
f. Measure 20mm and cut the plate.
g. Another terminal measure 160mm and bend 90°,
h. Measure 20mm and weld at giving dimension,
i. Welding at every bending point for giving strength

3.5.1.7.Pulley frame for back system

Required material: - steel plate (3mm thickness)

Required tool: - cutting, measuring, drilling, bending, wielding tool

Steps: see the part drawing

A. Cut 190mm structural steel
B. Drill 7mm diameter one hole in 20mm distance from one edge,
C. Bend after 40mm
D. Drill two hole at the beginning other end in 8mm diameter.
E. Weld at the bending section

3.5.1.8.Main frame

Required material: - structural steel (20mm by 40mm with 2mm thickness)

Required tool: - cutting tool, drilling tool, measuring tool, wielding tool,

Steps: see part drawing main frame

a. Measure 880mm cut,
b. Cut another terminal 4thickness, 20mm by 30mm,
c. Weld both at edge by 33° away each other,
d. Drill 8mm diameter hole,
e. Drill the driving pulley frame attachment area by 8mm*182mm at a specific dimension,

3.5.1.9.Frame wedge

Required material: - structural steel (15mm width and 4mm thickness),

Required tool: - cutting tool, drilling tool,

Steps: - see the part drawing of frame wage

1. Cut structural steel by 250mm,
2. Drill three hole by 8mm diameter in 30mm apart from one end,

Figure 3-41: Supporting beam

3.5.1.10. Joint plate

Required material; - structural steel

Required tool: - cutting tool, drilling tool, welding tool...

Steps: see part drawing of joint plat

a. Cut L-cross sectional structural steel frame length 55mm * width 30mm,
b. Drill the hole by 8mm diameter,

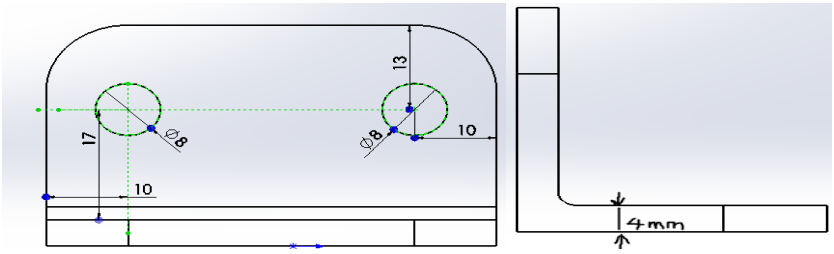


Figure 3-42: connecting component

3.5.1.11. Hopper holding plate

Required material: - structural steel

Required tool: - bending tool' cutting tool, drilling tool, measuring tool, Welding tool.

Steps: - see part drawing holder plate

a. Cut a rectangular frame 622mm length,3mm thickness by 30mm width
b. Measuring 245mm and bend half circle by 50mm diameter,
c. Drill hole 8mm diameter at the required point,
d. Another terminal measure 156 length and drill the hole fit with first frame,
e. Weld at the 90°beanding point,
f. Quantity three

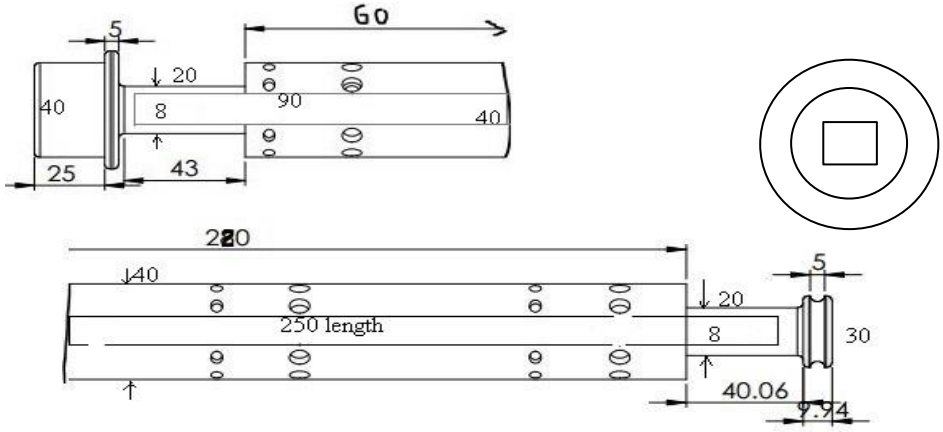
3.5.1.12. Metering shaft

Required material: - structural steel and plastic

Required tool: any necessary moulding tool, lathe tool (turning, facing, boring), milling tool,

Steps:- see part drawing….

1. Preparing mould (inside have rectangular bore)
2. Malting plastic material
3. Pouring molten plastic
4. Cooling and separating part
5. Removing unwanted part and smoothing the outer part
6. Drill the bucket see: 4.5.9.



a) Cut 8*8 mm^2 rectangular hollow bare thickness 2mm and length 350mm

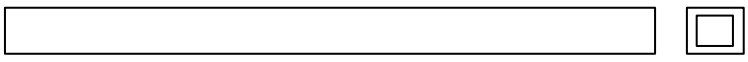


Figure 3-43: metering shaft manufacturing steps

3.5.1.13. Agitator Pulley

Required material: - it use for designing process by ABS plastic, but it possible to use another plastic because it doesn't have strong load is applied, and round steel are used for spindle.

Required tool: - cutting tool (turning, facing, grooving), heat treatment tool,

Steps;- see part drawing of agitator pulley

a. Cut the round plastic bar by 10mm diameter with 30mm length,
b. Removing unwanted part 5mm from edge by 5mm diameter,
c. recessing the belt grove 5mm apart,
d. Make it the groove surface relative fine smooth by heating in visual estimating heat range,
e. By using heat treatment 3mm diameter and 123mm length attached to the pulley,
f. They are six in number,

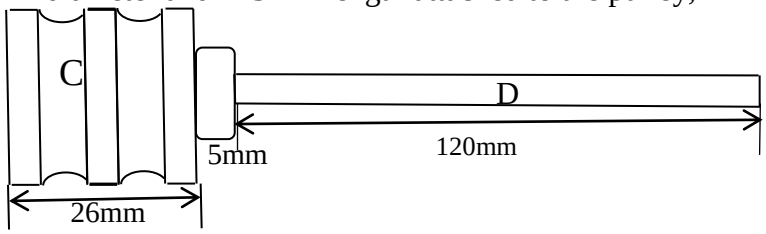


Figure 3-44: agitating pulley manufacturing steps

3.5.1.14. Agitating Frame

Required material: ABS plastic

Required tool: - cutting tool drilling tool

Steps: - see part drawing of agitator frame

a. Cut a rectangular plastic frame 265mm by 25mm width and 4mm thickness,
b. Removing unwanted part by cutting and milling as I shown the dimension as follow
c. Drilling the hole,

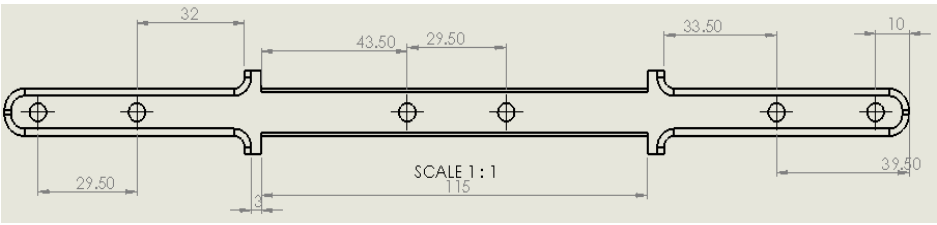


Figure 3-45: agitating frame manufacturing steps

3.5.1.15. Idler Pulley and Shaft

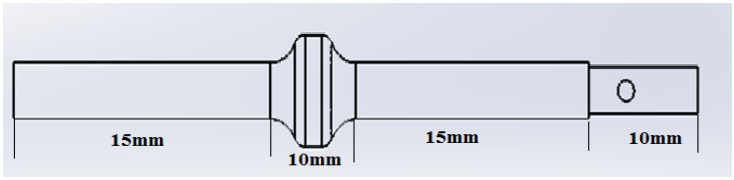
Required material: - It use for designing process by ABS plastic, but it possible to use another plastic because it doesn't have strong load is applied, and round steel are used.

Required tool: - cutting tool (turning, facing, grooving), heat treatment tool,

Steps: - see part drawing of idler pulley and shaft

a. Cut the round plastic bar by 10mm diameter with 15mm length,
b. recessing the belt grove 5mm apart,

c. drill at the centre by 4mm diameter,
d. cut 8mm diameter round bar in 50mm length
e. Turn to reduce the diameter in 2mm cutting depth for 15mm from one edge and 25mm from other side,
f. Make rectangular cross section 3*2mm from long side by 10mm length.
g. Drill pin hole in 1.5mm diameter,



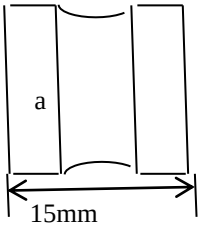


Figure 3-46: idler pulley and shaft manufacturing steps

3.5.1.16. Hopper

Required material: - plastic material

Required tool: - mould, pouring tool, cutting tool, cooling, clamping tool

Steps; - see part drawing of hopper

- Split in two part,
- Preparing mould by cast iron(use for mass production)
- Melting the plastic material in specific temperature
- Pouring the molten plastic in to mould,
- Cooling and separating the part
- Trimming the extra un wanted part and drilling bolt hole

3.5.1.17. Hopper cover plate

Required material: - plastic plate

Required tool: - use simple cutting tool

Steps; - see part drawing of cover plate

a. Cut 2.5mm thickness 135mm* 322mm size,
b. Measure from one corner 170*95mm^2 remove unwanted part,
c. Measure 132mm *95mm remove unwanted part,
d. Drill two 3.5mm diameter pin hole 30mm from right side and 55mm from left side,

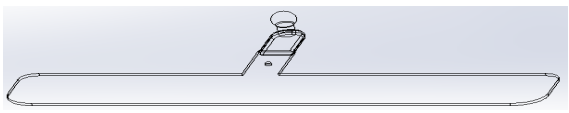


Figure 3-47: hopper cover plate manufacturing steps

3.5.1.18. Feeding tube

Required material: - plastic material (tube)

Required tool: - use a tool as per necessity for plastic molding

Steps: - see the part drawing of feeding tube:

Similar to molding part i.e.

3.5.1.19. Shoulder supporter

Required material: - structural steel (3*30mm^2)

Required tool: - cutting tool, bending tool, welding tool, drilling tool, measuring tool,

Steps;- see the part drawing of shoulder frame

a. Measure and cut twice of 210mm, 250mm, 534mm length separately,
b. Bending after 53mm by 100mm diameter of 210mm length both element,
c. Drill at one end in both element by the given dimension shown on drawing,
d. Both curve element separate by 50° and weld at one end of 250mm element,
e. Cut 4mm thickness, 30*40mm^2 joint, three in number,
f. Drill each joint by 8mm diameter hole,
g. Weld on the 250mm element (two at the upper end and one at lower end),
h. Another element bend in half circle by 170mm diameter of 534mm length steel element,
i. Drill at the two end by the dimension shown in the drawing,
j. Weld with 250mm length element,

The back system manufacturing process is similar to this but it has some ergonomics difference aspect (seen the difference on drawing).

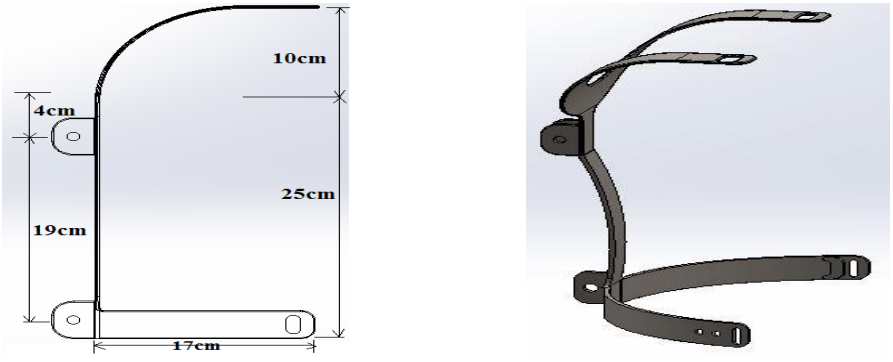


Figure 3-48: forth and back shoulder frame

3.5.1.20. Rope guider

Required material: -structural steel

Required tool: - cutting, drilling, measuring, wielding tool.

Steps: - see the part drawing of rope bar

- Cut 56mm steel rectangular bar,
- Drill 2mm diameter pin hole,
- Drill at the middle 3.5mm diameter hole,
- Cut 65mm length steel round bar,
- Wield the two bar look like as follow

3.5.1.21. Clamper belt

Required material: - leather (20mm width, 2-3mm thickness)

Required tool: - cutting tool, tiring tool, joining tool, measuring tool,

Steps: -

1. Cut 534mm length leather belt.
2. Drill five holes at one end 3mm diameter in 20mm apart.

3. Cutting-out piece one leather in 230mm length, and make it elbow,
4. 200mm length belt two piece,
5. Joining the three piece as display

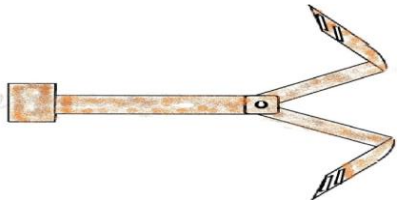


Figure 3-49: shoulder belt manufacturing steps

3.6. Assembly Procedure And Maintenance

3.6.1. Assembly procedure

1. Clear and ready the hopper half part to assemble,
2. Put the bush on the metring shaft place,
3. First the metring shaft to be lock with inside steel element,
4. assemble the metring shaft to hopper at the lower part,
5. Put the agitating pulley to its frame and assemble on one part of hopper,
6. Assemble the agitating pulley belt inside the hopper,
7. Assemble the half part of hopper on the other and tight by fastener,
8. Clamp the hopper by three separate frame,
9. Assemble idler pulley on right side of hopper,

10. Assemble the belt from metering shaft to agitating pulley on aver the idler,
11. Bolted the joint element with the middle hopper holding plate,
12. Assemble main frame on the joint at the middle hopper holding plate,
13. Insert the driving shaft to driving pulley and lock by pine,
14. Insert the bearing on driving pulley supporter,
15. Assemble the driving pulley and shaft on supporter,
16. Connect The handle with liver,
17. Liver lock by pine with driving shaft,
18. The driving system holder frame attached with main frame by bolt,
19. Assemble the flat belt from driving pulley to driven pulley,
20. Main frame bolted with shoulder support,
21. Put the rag on the shoulder frame.
22. The shoulder supporter tightening by belt on operator back,
23. Put the moisture trapper on the hopper cover
24. Cover the hopper,

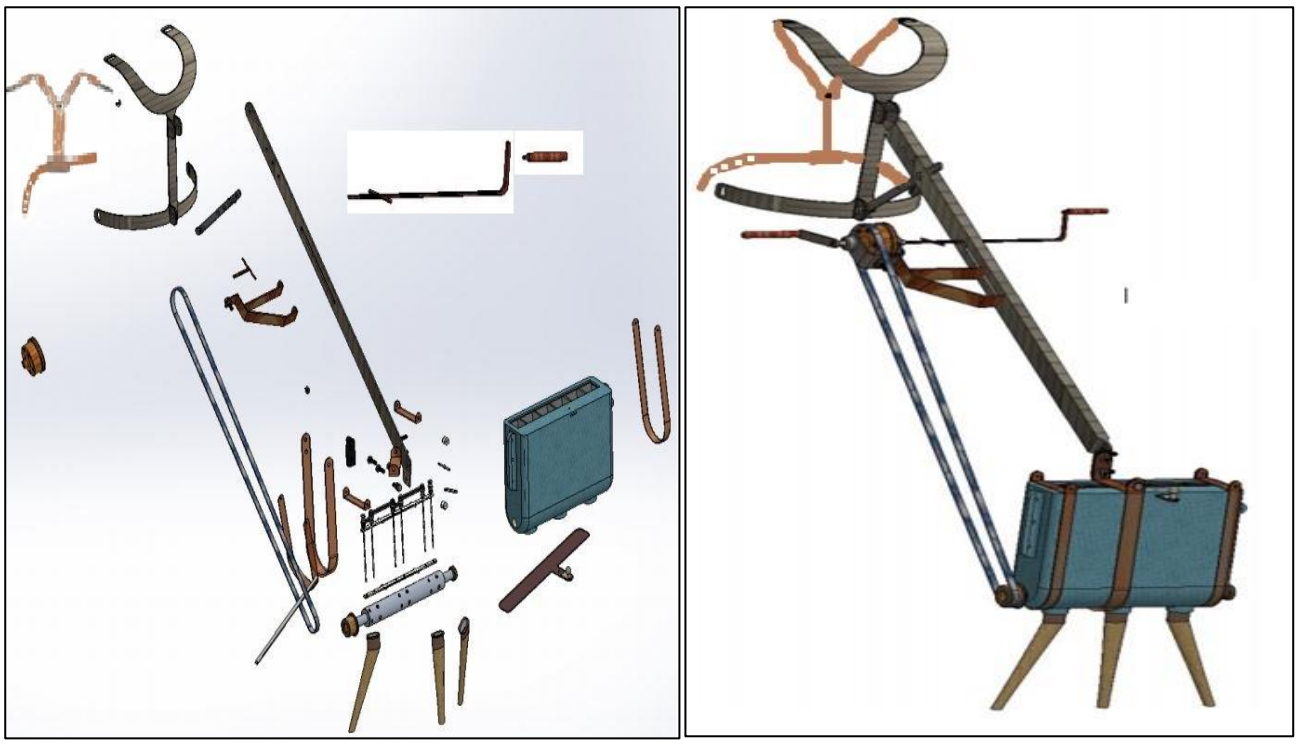


Figure 3-50 disassembling part and assembled part of forth system

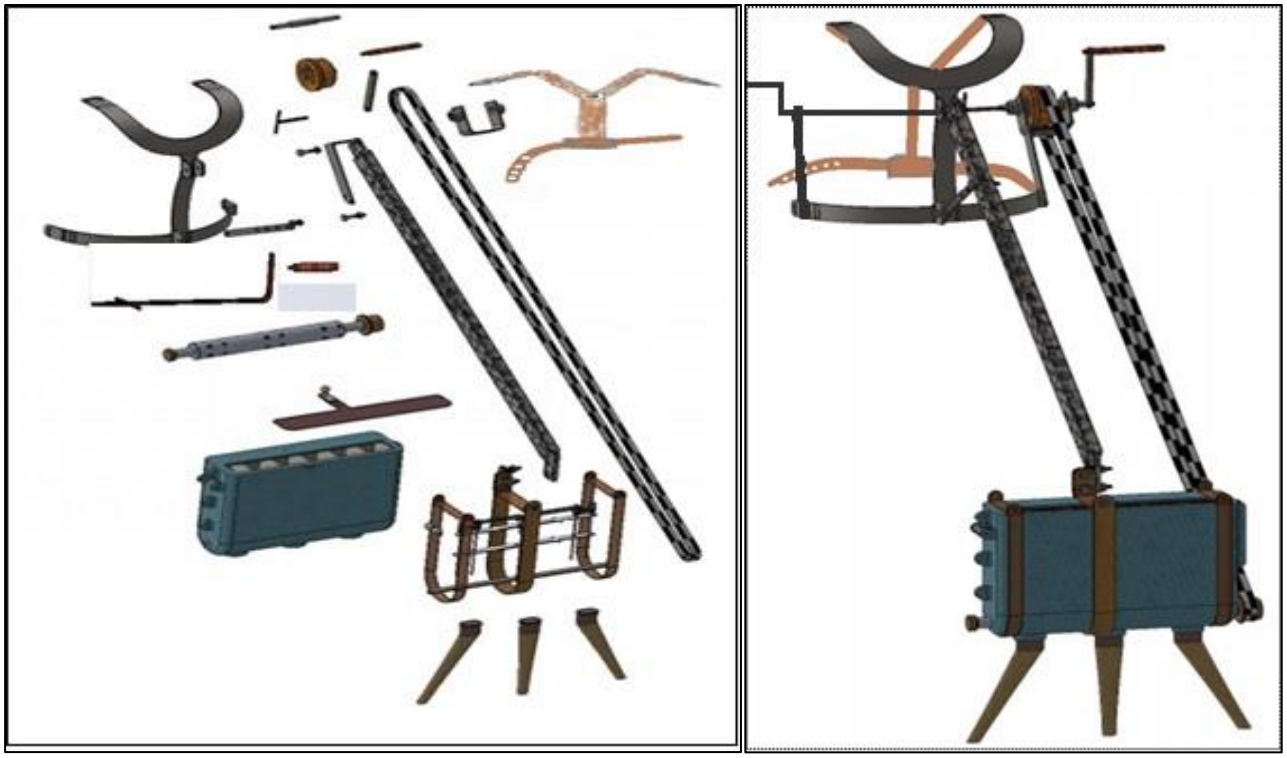


Figure 3-51 Disassembling part and assembled part of back system

3.6.2. Operation, Safety And Maintenance

3.6.2.1.Operation

a. Before starting the machine operation, the operators should inspect the machine condition,
b. Clean, dry the main part of system,
c. Assembled the dismantled part of machine.
d. Put the rag on its shoulder, waste, and chest,
e. Clamp the shoulder frame on the operator shoulder using belt system,
f. Fill sowing material to the hopper,
g. Put the line guiding rope,
h. Start the operation by rotating the handle and walk slowly,
i. When the handle start to rotate, the diving pull could rotate and the motion will transfer to driven pulley,
j. The driven pulley is fixed on the metering shaft,
k. Rotational motion will transfer from metering shaft to agitating pulley inside the hopper by belt system.
l. The agitating system could avoid the sticky property of sowing material when it rotates,

m. When the metering shaft rotates, the buckets are on its which takes the sowing material and drop to the feeding tube.
n. The feeding tube has distributed the sowing material in 20cm apart.
o. The operator should walk in line by following the guide rope

3.6.2.2.Safety and maintenance

- The machine must take maintenance after and before working time.
- The machine will keep it in dry away from moisture. During operation the season is in summer season (raining). So car about moisture contact area.
- Inspection should necessary.
- Feeding buckets are small in size which keeps from dust.
- The belt system of machine should not more tight or loss.
- Keep the feeding tube from blockage.
- During operation the feeding tube are more chance to expose to moisture and mud. Therefore it keeps carful.
- After and before working time the machine main/core system specially hopper inside surface, metering shaft, agitating system, and feeding tube must be clean, dry and put in appropriate place.
- At the time of filling of sowing material, the operator should use umbrella if the weather condition have moisture probably it will affect the system.
- The sowing material should be dry and free from any dust,
- In order to manage ergonomic, the operator should be use a dens rage on the shoulder, waste and chest.
- Keep the leather belt from moisture
- Before and after the working time, oil should apply on leather belt to prevent moisture and dryness, to gaining flexible property.

3.7. Cost Analysis

3.7.1. Standard

Table 3-9 standard cost

No	Commercial component	Quantity	Unit cost	Total cost
	Bolt & nut	22	2.5	55
	bush Bearing type(plain plastic bush bearing)	2	60	120

3.7.2. Manufacturing Cost Analysis (each component individually)

The machine will have made the material which cost of each component merges and manufacturing cost could be summarised in appendix.

Manufacturing cost

$$= \sum(process\ rate\ *\ time\ required) + (\sum(time\ required)) * labour\ cost$$

= 695E.t. birr

Material cost = 468Et. Birr

3.7.3. Assembling cost

This is the last step of line seed drilling machine production. When the machine assembled it needs simple a few tools i.e. three different number spanners and single human power is enough. The machine is very simple, so it's easy to assembled the machine part, Let it be needs 20 (0.33) minutes assembling time.

- Labour cost per hour(LC) = 50 E birr,
- Tool cost per hour(TC) = 33 E birr,
- Total cost = (LC + TC) 0.33 = 27.39 = 30 E birr

***Therefor the total cost could take*: -** Product cost = material cost + manufacturing cost + standard component cost + assembling cost

= (468 +694.8 + 30 + 175) ET birr

= 1367.8 ET birr

CHAPTER FOUR

4. RESULT AND DISCUSSION

System selection;- The ideas were generate in different aspect of problem definition using the comparison method which evaluate in economic and technical criteria's, variant ten was selected we could also use the variant ten in both back and forth interchangeable system (3.2).

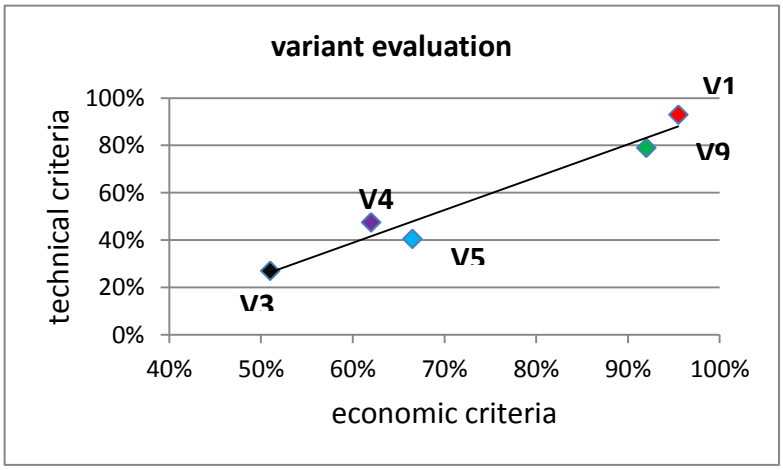


Figure 4-1 variant percentage evaluation

This system has a great advantage to avoid the soil disturbance by isolating the machine from ground. The working principle is leads by the operator carry the machine and drive by handle, power transmitted to the metering shaft to feed the drill material.

The variant has drill three rows as recommended space 200mm apart were the on the surface of the soil which it has been discussed in chapter two in detail. So the machine has compatible to use in most soil condition specifically for the objective has targeted in very wet, sticky soil condition by planning which satisfy this condition. So for those purpose operator was driving the machine in two ways as the soil condition i.e.:-

- When the soil is low moisture condition through observational classification In order to put the seed to soil for stick condition an operator use front drive mechanism, when it moves forwardly he put the seed to soil by his leg.
- When the soil condition medium and relatively moist soil, for avoiding the seeds put over depth it should be use back driven the back

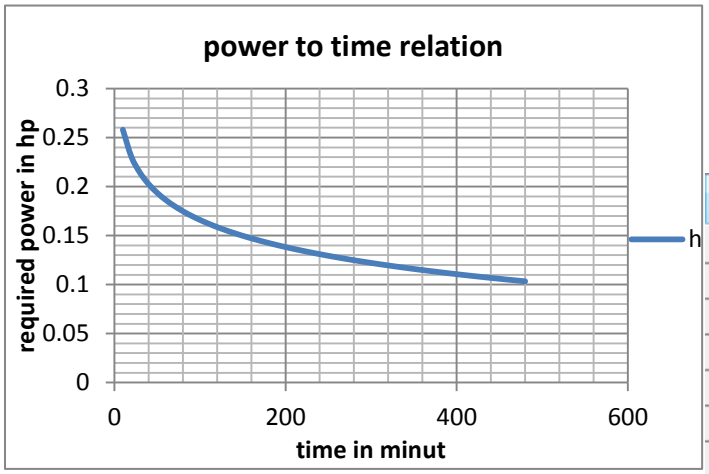
The feeding mechanism is metered by using bucket and gravity is enough to drops. Site some additional pressure to feed by pneumatic system. The pneumatic system was done in trial and error approximation test due to limitation of experiment tools, so it,s put as the future work.

Power available: -The source of power use for teff seed drilling machine were chosen based on the availability, easy to perform the task, minimum power wastage, from the available alternative power option i.e. motor animal and human. In most of the time teff seed were drill in very wet, sticky soil condition, so motor power were not applicable for this purpose. Probably animal power could use but it is difficult to follow the line straight. Therefore human power has the best fit to this application with minimum power to do long time.

According to Campbell (1999), power of useful work done by an average human on the drive machine is given by [38]

$H = 0.35 - 0.092 \log t$ Where, t is the operation time in minutes

Power in hp, mass in kg

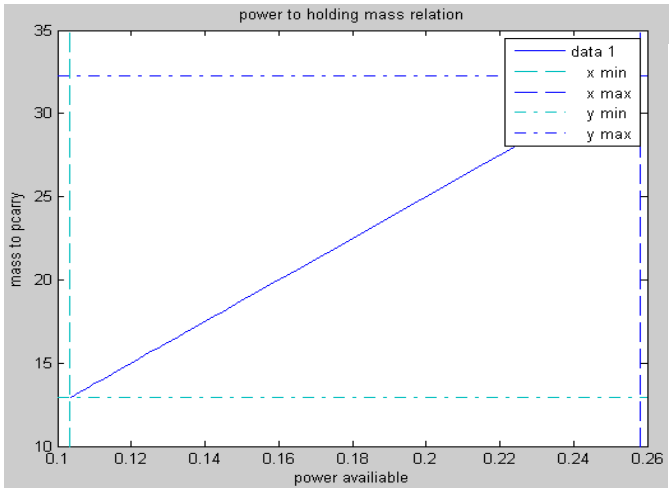


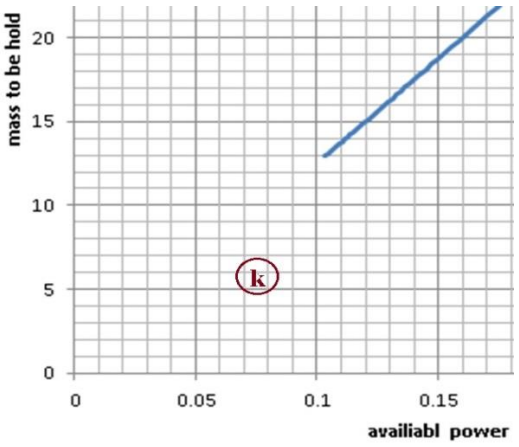
	X	Y
min	10	0.1033
max	480	0.258
mean	245	0.1409
median	245	0.1302
mode	10	0.1033
std	140	0.03542
range	470	0.1547

Figure 4-2 Power to time relation and statical data

As it shows in the above chart the time and power were invers relation in order to do work for a long time the investment power should be low. From the detail design one hectare has taken one day (8hr) to complete. So in this time the required power has 0.1033hp.

Carrying mass (M) = $\frac{Hp*75}{speed^{m}/_{s}}$ kg





	X		Y	
min	0.1033	☑	12.92	☑
max	0.258	☑	32.25	☑
mean	0.1409	☐	17.61	☐
median	0.1302	☐	16.28	☐
mode	0.1033	☐	12.92	☐
std	0.03542	☐	4.427	☐
range	0.1547		19.33	

Figure 4-3 Power to mass of machine relation, enlarged views and statical data

As we see from the result the time required, the mass which carried by the operator were designed in detailed has 5.75kg which refers from the corresponding power requirement as follow. Available power and mass have direct relation. So the power has 0.046hp for carrying the machine. Let's use some factor to be use due to fatigue which added 0.70%. Therefore the operator should use 0.0795hp is best for this machine. Locate the point **k** from the graph

Seed rate: - Seed rate has a range from 3-5kg in official 2005E.c printed document. But it has been corrected up to 10kg. In order to get the seed rate one hectare has 50,000 m

Table 4-1 Seed rate analysis

		Seed rate in kg							
		3	4	5	6	7	8	9	10
	Weight of seeds/m (g)	0.06	0.08	0.1	0.12	0.14	0.16	0.18	0.2
	Min Number of seeds/m	234	311	390	467	545	623	701	779
	Max Number of seeds/m	143	190	238	285	333	380	428	475
	Average No seeds	188	251	313	376	439	501	564	627

By relating to corresponding seed distribution area where the seed could not put together at appoints it covers some area see the appendices as the test from the required height of dropping and

distribution area. The number of seed rate is increase in the same distribution area which will and when reduce the seed rate the distribution is more scatter [3.4.1.9]. Therefore we should use relative minimum range 4.5kg/ha. The seed speed became 126seeds/s and 1.235g/s fertilizer. Based on the physical properties of teff and fertilizer the bucket has designed and Flow rate of both fertilizer and teff seeds (in three rows/second) = (1.279564*3) g/s= 3.83869g/s

Theoretical field efficiency: - The field efficiency of the machine is indicating in the time requirement to complete one hectare. As it shown in the chapter three, five variant took in different alternative number of drill row at a time. The number of row drill at one time to increase, the completion time has reduced and parallels the weights of drill material have increase. So balancing the time and weight to be carry which will decide from the standing point of view the number of row is three and have corrected the conceptual design. Therefore the field efficiency could be 1hactare complete in 8.5hours.

Material:- The manufacturing process and method of material selection were done in the base of system requirement strength, less weight, machinability and availability listed in the table as follow which could made in low level work shop except hopper mad metring shaft. Most of the components are needs light operation that produce in short time i.e. cutting, grinding, welding, drilling, and bending.

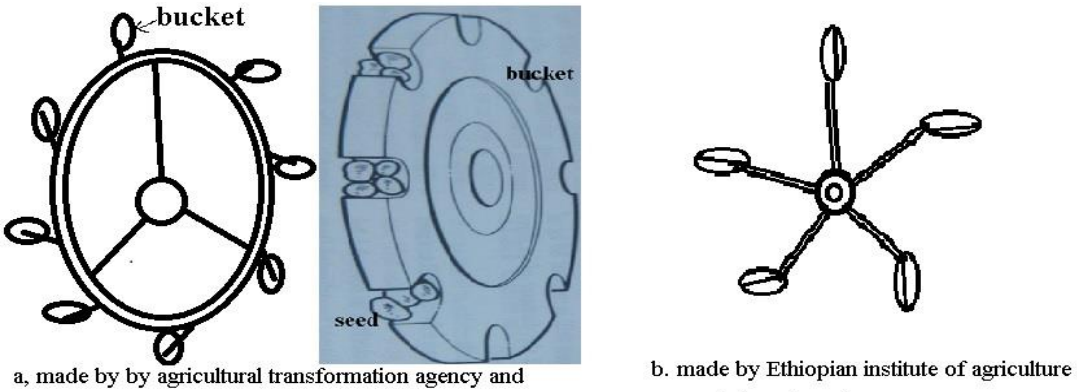
The heart part of machine is metering system which contains the metering shaft and hopper made with high smooth material. The meeting point of metering shaft and lower part of hopper is very smooth surface and should have <0.2mm gape.to avoid seeds cut and transport extra seeds (see appendix II experiment III).

From the pre-existing machine, metering system were been build up by metallic plate and hopper were made by sheet metal. In this project we use a material to build by plastic which have smoothness, mouldable, and should use molding in order to get a desired smoothness. Plastic brackets generated less friction than metal brackets [39].

The hopper shape and structure of existing machine were almost similar trapezoidal shape in a good angle of response which has one teff compartment and one fertilizer compartment for all rows. But in this project we had been dividing the hopper in each row separately in order to manage the metring system. The seed and fertilizer compartment are separate from the metring by the hopper bottom wall while the previous projects have in one system. It has compact shape which overall

dimension is 335 * 390mm. It holds 50g in each three teff seed and 400g in each fertilizer compartment. Totally 1.35kg will hold in this hopper. It has less stress will apply on a body.

The metering component of the previous project had been in plate and bucket type which mad by steel. It perform the action inside the compartment, so it difficult to hold the seed and fertilizer when transport to feeding pipe which have more probability to fall back to the hopper before reach to feeding tube. Where in this new project the metering component (metering shaft) is made by plastic and inside rectangular hollow steel, it has low weight as compared to those existing system. The operation is out of the seed compartment which links through small limited hole (see fig below).



a, made by by agricultural transformation agency and ministry of agriculture at melkasa research centre (see fig 2.5)

b. made by Ethiopian institute of agriculture research (see fig 2.4)

Figure 4-4 metering component of existing project

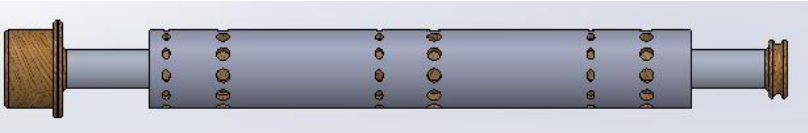


Figure 4-5 the desired metering component

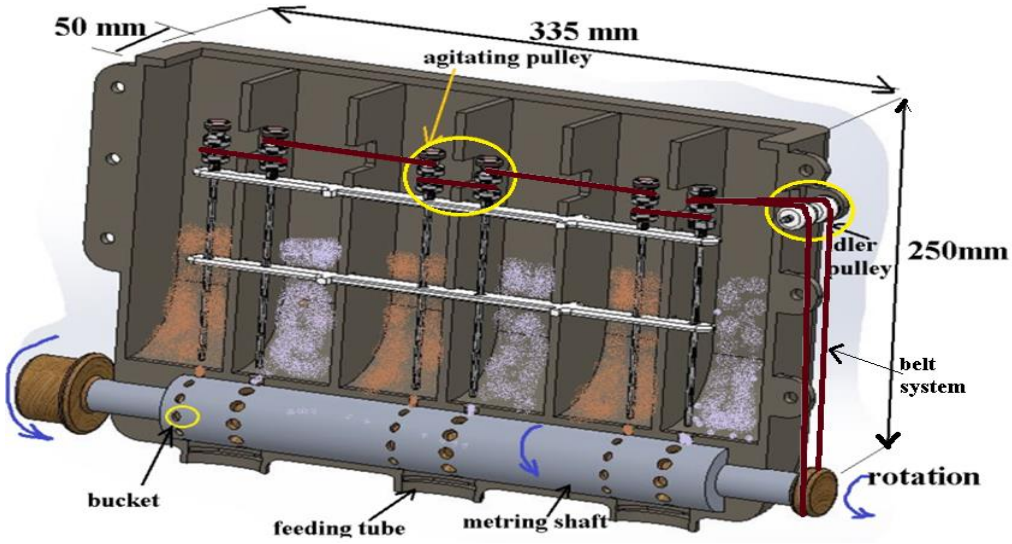


Figure 4-6 Arrangement of metering shaft

Table 4-2 component specification

No	Component name	Material	Required property	Weight(kg)
1	Handle	Wood	Fit to the load	0.041
2	Liver	Structural steel	>>	0.03
3	Driving shaft	Structural steel	>>	0.0823
4	Driven shaft bar	Structural steel	>>	0.104
5	Metering shaft	Fit to the load	>> smoothness	0.52
6	Agitator frame	Plastic(PEEK)	>>	0.03
7	Agitator pulley	Plastic(PEEK)	>>	0.0675
8	Idler system	Plastic(PEEK)	>>	0.012
9	Pulley frame	Structural steel	>>	0.2845
10	Hopper	Plastic(PEEK)	>>	0.876
11	Cover plate	Plastic(PEEK)	>>	0.039
12	Hopper holding plate	Structural steel	>>	0.4355
13	Fastening plate	Plastic(PEEK)	>>	0.062
14	Main frame	Hollow steel	>>,smoothness	0.668
15	Shoulder frame	Structural steel	>>	0.25
16	Wage	Structural steel	>>	0.109
17	tube	Plastic(PEEK)	>>	0.075
18	Seed	Teff seed	Clean good seeds	0.15
19	Fertilizer	DAP	Unreformed size	1.2

The machine has 3.685kg dead weight and 5.03kg in full loaded drill material. It has light weight as compared to other existing project which has more than 19kg. They did not that much considerable the weight as the basic criteria that the machine stands on the soil. The 2D, 3D modelling and assembled view have done in right way by solid work which shows the system. The cost of the machine had to calculate as the methods which are listed in the appendix it takes 1370ET birr.

Machine specification:-

Table 4-3 Machine specification

	Specification	Measurement
	Length- Width -Height	0.7m - 0.38m -1.4m
	Operating speed	0.6m/s
	Working width	40cm
	Required power	0.0795hp
	Metering shaft diameter	4cm
	Labour requirement	two people
	Seed rate	4.5kg
	Drilling material	both teff seed and fertilizer
	Number of row	3 row
	Field efficiency	8hr/ha
	Operating system	back

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

- This machine could improve teff cultivation system as the appropriate row space and seed rate for the most soil condition and it designed based on the available material and it could build by in simple light operation except molding process.
- The machine has operation in two deriving system
    - Forth system arrangement: when the soil condition is low moisture content which the seed to stick on the mud and it would not put under the soil surface by the operator leg.
    - Back system arrangement;- use this system arrangement when the soil condition have medium moisture very wet soil condition in order to avoid the seed put under the soil surface
- The machine hasn't direct contact with soil which to separate the system operation from soil disturbance. So it can give a service for most soil condition i.e. very wet, sticky, low clay or medium soil conditions. But there is a restriction where the soil condition is up to operator could walk with not much soil resistance
- The machine has 3.685kg dead weight and 5.03kg in full loaded drill material. It is light weights which use minimum power consumption i.e. one man could enough to operate and follow the row by needs another person. So it needs two persons in maximum safe operation.
- The machine has used in three row drilling for both seed and fertilizer which has complete one hectare in 8.5 hours. Its working width has compromise the system complexity and weight reduction.
- The seed rate could use in 4.5kg/ha which is an acceptable rate as the researcher's investigation and the fertilizer rate also as usual 100kg/ha.
- The machine hopper has compact shape which overall dimension is 335 * 390mm it holds 1.35kg at full load. It has less stress will apply on a body. The critical component of this machine is metring system which has shown the surface condition on manufacturing step. It should be produce in very accuracy molding system by plastic material. The hopper will refill teff seed after five pass of drill and fertilizer will refill after two pass of drill. The flow rate is = 3.83869g/s for both seed and fertilizer in three tube.

- The system is easy as it shows the maintenance and operating sequences clearly in the maintenance section which everybody could dismantle, reassemble and maintain; no need further skill to familiarize the operation. It's a portable which have light weight to transport from place to place.
- The machine investment cost is small which takes 1370 ET birr. According to the cost it needs low price and made in simple ways, also we can troubleshoot easily.so it's an expectable machine which can give good service.
- This machine has a very comfortable system to work in most soil condition is recommended. This portable seed drill machine could complete one hectare within eight hours in which the base of time saving it's a preferable to use it.

Future work

Some of task couldn't be done due to limitation of material, scientific data and needs further study to develop the technology more.

- Increasing the number of row by System optimizing,
- Reduction the weight of component by further material and size change
- Analysing the soil resistance and standardized in scientific way
- Friction analysis between teff seed and plastic material
- Specify the number of teff which is vary according to variety

Reference

1. Bekabil fufa, Befkadu Behute, Rupert Simon, and Tareke Berhe, Strengthening the tef value chain in Ethiopia, Ethiopia agricultural transformation agency, November 2011.
2. Journal of Biology, Agriculture and Healthcare ,ISSN 2224-3208 (Paper) ISSN 2225-093X (Online) Vol.5, No.5, 2015 Determination of Row Spacing and Fertilizer Rate for Transplant Planting Methods on the Growth and Yield of Teff in Eastern Amhara Region, Ethiopia by Amare Aleminew, Adane Legas ,Sirinka Agricultural Research Center
3. Laca M (2009) Biomass Production of 15 Tef Varieties Grown in Churchill County, Jay Davison, Area Forage and Alternative Crops Specialist University of Nevada Cooperative Fact Sheet.
4. Dekking L, Kooy-Winkelaar Y, Koning F (2005) The Ethiopian cereal tef in celiac disease. New England Journal of Medicine 353: 1748-1749
5. Abraham R (2015) Achieving Food Security in Ethiopia by Promoting Productivity of Future World Food Tef: A Review. Adv Plants Agric Res 2(2): 00045. DOI: 10.15406/apar.2015.02.00045
6. Rasselas research and engineering development PLC Adiss Abeba printed promotion pamphlet in science and technology day. Email rasselasresearch.eng@gmail.com
7. catalogue published by Ethiopian institute of agricultural research(EIAR), Melkassa agricultural centre, complied by Girma moges,bisrat getnet, and Teshome Bullo
8. Catalogue published by Ethiopian institute of agricultural research(EIAR), Melkassa agricultural centre, complied by Girma moges,bisrat getnet, and Teshome Bullo
9. Ethiopian agricultural transformation Agency (ATA) in 2005e.c report page14
10. Ethiopian agricultural transformation Agency report pamphlet , 2005e.c
11. Ethiopian agricultural transformation Agency (ATA) in 2005e.c report See the table 1
12. Ethiopian agricultural transformation Agency report pamphlet in 2005e.c,Table1: teff production rate 1998/99-2004/5 page 8
13. Agricultural sample survey 2009/10 volume V
14. LICOS Discussion Paper Series350/2014, Perceptions, impacts and rewards of row planting of teff, JoachimVandercasteelen, Mekdim Dereje, Bart Minten, and Alemayehu Seyoum Taffesse http://www.econ.kuleuven.be/licos]
15. Journal of Biology, Agriculture and Healthcare ISSN 2224-3208 (Paper) ISSN 2225-093X (Online) Vol.5, No.5, 2015, Determination of Row Spacing and Fertilizer Rate for

Transplant Planting Methods on the Growth and Yield of Teff in Eastern Amhara Region, Ethiopia, Amare Aleminew* Adane Legas, Sirinka Agricultural Research Center,

16. Ethiopian agricultural transformation Agency (ATA) in 2005e.c page15
17. Journal of Biology, Agriculture and Healthcare ISSN 2224-3208 (Paper) ISSN 2225-093X (Online) Vol.5, No.5, 2015, Determination of Row Spacing and Fertilizer Rate for Transplant Planting Methods on the Growth and Yield of Teff in Eastern Amhara Region, Ethiopia Amare Aleminew* Adane Legas, Sirinka Agricultural Research Center
18. Assessment of Factors Affecting Farmers' Adoption level of Row Planting Technology and Yield Improvement on the Production of Eragrostis Teff [ZUCC.] Behailu Getu Desta, Addis Ababa University, JUNE 2014
19. Design and Development of teff seed broadcaster by Abdulhakim Shukurea Addis Ababa, 2012
20. Subramanian, S. V.; Özaltin, Emre; Finlay, Jocelyn E. (2011). "Height of Nations: A Socioeconomic Analysis of Cohort Differences and Patterns among Women in 54 Low- to Middle-Income Countries". Public Library of Science. 6 (4): e18962. doi: 10.1371/journal.
21. Average height of men and women (National Geographic dead link
22. For the 50 percentile Adult Man, average height is 69.1" (175 cm). human anatomy report
23. Richad W.Bohannon, EdD, MS, BSA. Williams Andrews, MS, BS Michael W. Thomas, BS] ,Walking speed reference values and correlates for older adults
24. D.nsharma,agricultural farm machine design design principles and problems, chaudhary charan singh Harayana agriculture university, Hisar -125004,New delhin.
25. machine design text book by R.S. khurmi and J.K. Gupta page 678
26. Shigley's Mechanical Engineering Design, Eighth Edition Page 863
27. HABASIT PARTNER catalogue.service media No 6026,
28. Reference values for standardized tests of walking speed and distance: Nancy M. Salbach, PhD, Kelly K. O'Brien, PhD, Dina Brooks, PhD, Emma Irvin, BA, Rosemary Martino, PhD, Pam Takhar, MSc, Sylvia Chan, BScPT, Jo-Anne Howe, BScPT
29. RICHARD W. BOHANNON: speed of adults aged 20-79 years: reference values and determinants: School of Allied Hearth, U-101, University of Connecticut Storrs, CT 06269, USA and Department of Rehabilitation, Hartford Hospital, Hartford, CT USA
30. Testing and evaluation of agricultural machinery and equipment: Human body size, D.W. smith, B.G. sims, D.H. o'Neill: 1994Gc, page 67
31. Teklu and Tefera 2005; Minten et al., 2013

32. Fufa et al., 2011; Minten et al., 2013
33. Zewdu A.D and Solomon W.K(2007), moisture dependant physical properties of Teff seed, biosystems Engineering.96(1).59-63
34. Seed passage speed through short vertical delivery tubes at precise seeding, M. Kroulík*, J. Hla, A. Rybka and I. Honzík. Czech University of Life Sciences Prague, Faculty of Engineering *Agronomy Research* 14(2), 442–449, 2016.
35. Image analysis of the shapes and dimensions of Teff seeds (*Eragrostis tef*) by D. Herak, Czech University of Life Sciences Prague, Faculty of Engineering, Department of Mechanical Engineering, Kamycka 129, CZ 16521 Prague, Czech Republic, e-mail: herak@tf.czu.cz,, *Agronomy Research* 14(S2), 1299–1305, 2016
36. Physical Properties Of Granular Fertilizers And Impact On Spreading, John Fulton, PhD, The Ohio State University, Kaylee Port, Project Coordinator, The Ohio State University, Jul 28, 2016
37. PNR CTG SH 07 EU, Spray engineering hand book, www.pnr-nozzles.com, 03-2014.
38. A. Gbabo, Design and construction of a two-row cowpea and maize planter. Maintenance and Repair Unit, Agricultural Engineering Section, National Cereals Research Institute, Badeggi 1988.
39. Frictional forces in stainless steel and plastic brackets using four types of wire ligation*, Vanessa Nínia Correia Lima**, Maria Elisa Rodrigues Coimbra***, Carla D'Agostini Derech****, Antônio Carlos de Oliveira Ruellas.
40. igus® inc Plastic bearings producer and supplier industry

APPENDIXES

Appendixes **I**

Variants	Energy source	Required power	Sowing material	Driven type	Feeder method	hopper	Transport system	No of wheel
1	Animal & man	Double	Seed	Sliding	Gravity & vibration	Cylindrical or rectangular	Medium	2
2	Animal & man	Double	Seed	Rotating	Bucket feeder	Cylindrical or rectangular	Complex	2
3	Animal & man	Double	Seed	Rolling	Gravity & vibration	Cylindrical drum	Relatively difficult	2
4	Animal & man	Double	Seed & fertilizer	Sliding	Gravity & vibration	Cylindrical or rectangular	Medium	2
5	Animal & man	Double	Seed & fertilizer	Rotating	Bucket feeder	Cylindrical or rectangular	Complex	2
6	Animal & man	Double	Seed & fertilizer	Rolling	Gravity & vibration	Cylindrical drum	Relatively difficult	2
7	Animal & man	Single	Seed	Sliding	Gravity & vibration	Cylindrical or rectangular	Medium	2
8	Animal & man	Single	Seed	Rotating	Bucket feeder	Cylindrical or rectangular	Complex	2
9	Animal & man	Single	Seed	Rolling	Gravity & vibration	Cylindrical drum	Relatively difficult	2
10	Animal & man	Single	Seed & fertilizer	Sliding	Gravity & vibration	Cylindrical or rectangular	Medium	2
11	Animal & man	Single	Seed & fertilizer	Rotating	Bucket feeder	Cylindrical or rectangular	Complex	2
12	Animal & man	Single	Seed & fertilizer	Rolling	Gravity & vibration	Cylindrical drum	Relatively difficult	2
13	Man	single	Seed	reciprocating	Pushing &impact vibration	Cylindrical or rectangular	Easy	-
14	Man	Single	Seed	rotating	Bucket feeder, vibration & pneumatic	Merged shape	Easy	-
15	Man	Single	Seed & fertilizer	reciprocating	Pushing &impact vibration	Cylindrical or rectangular	Easy	-
16	Man	single	Seed & fertilizer	rotating	Bucket feeder, vibration & pneumatic	Merged shape	Easy	-
17	Man	Pair	Seed	reciprocating	Pushing &impact vibration	Cylindrical or rectangular	Easy	-
18	Man	Pair	Seed & fertilizer	rotating	Bucket feeder, vibration & pneumatic	Merged shape	Easy	-
19	Man	Pair	Seed & fertilizer	reciprocating	Pushing &impact vibration	Cylindrical or rectangular	Easy	-
20	Man	Pair	Seed & fertilizer	rotating	Bucket feeder, vibration & pneumatic	Merged shape	Easy	-

I: Some of working principal variant

Appendixes II

Experiment 1

***Aim*:** To measure what would be the gap between the tube outlet and moist soil (wet rough soil 1-3 cm roughness from field observation) for the space between the seed-seed and seed-fertilizer approximately 30mm and 50mm respectively?

Material and methodology

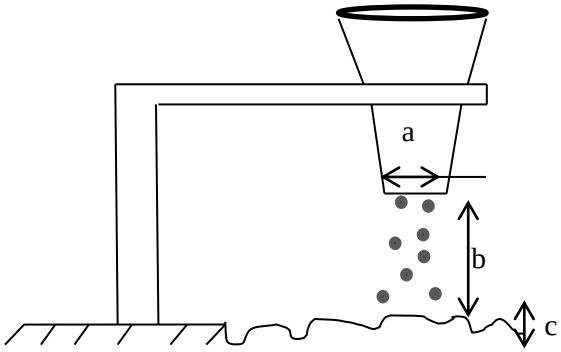
Put rough surface black close in horizontal to avoiding the rolling(bouncing) and it uses to clearly visible the teff and fertilizer which have used white teff and fertilizers, put the tube holder frame and known dimension tube where it defined in the size determination in vertically. Feed the sowing material through the tube (4-8 seeds at once and two grain fertilizer) and measure the space between seed-seed and seed-fertilizer using distance measurement.

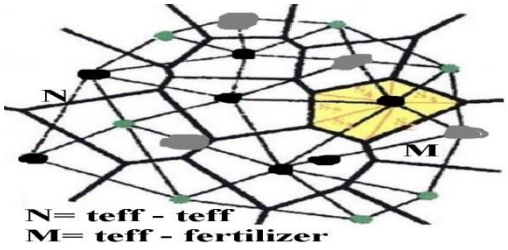
Where: -

a= out let elliptical tube 28mm by 20mm
Major and minor axis,

b = gap between pipe and rough ground
(Height of dropping) = variable,

c = estimating soil roughness = 10-30mm

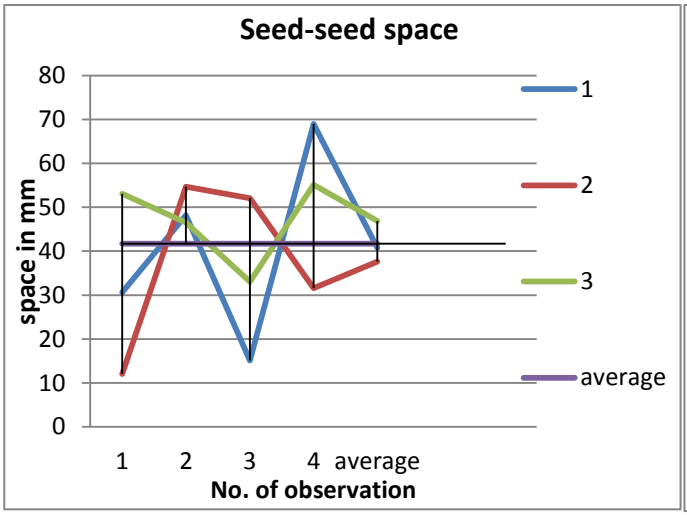


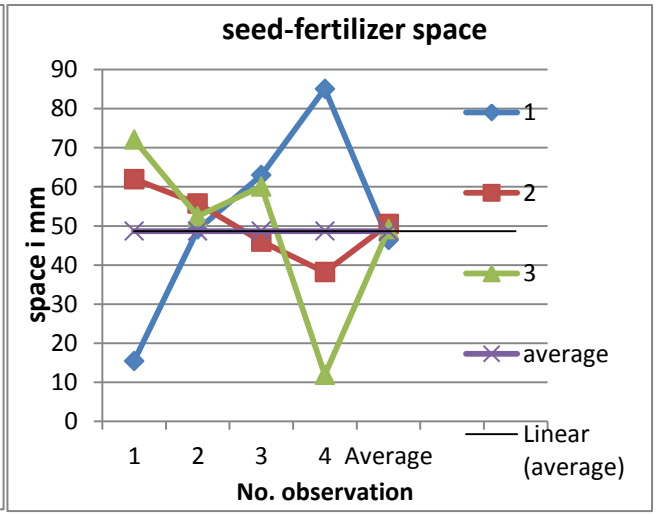


Result and Conclusion:

Table space experiment result in 15cm pipe outlet height

No of observation	Seed-seed space (mm)					Seed-fertilizer space(mm)				
	1	2	3	4	average	1	2	3	4	Average
1	30.6	48.2	15.1	69	40.725	15.4	49.1	63.0	85.1	46.4
2	12.0	54.7	52.1	31.6	37.6	62.0	55.7	46.0	38.2	50.475
3	53.1	46.5	33.0	55.1	46.9	72.1	52.5	60.1	11.9	49.15
Average					***41.74***					***48.675***





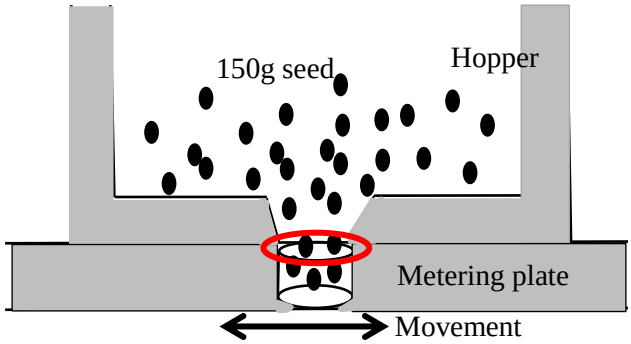
The experiment were continues to recorded up to three number of observation. By varying the gap between the pipe and soil (30cm, 20cm, 10cm) I have to choose 15cm the nearest approximation to the space limit (up to 5cm). The dropping height and distribution are having direct relation. The seed space used to avoid some impact of seedling development from the above experiment the average space between seed-seed is averagely 41.74mm which is good as an expert Mr Bereket Forsido oral discussion in minster of agricultural research Center. Seed-fertilizer average space is 48.675mm the recommended is at list it could be 50mm but it doesn't show the impact in scientifically. Therefor 15cm was the best gap between

Experiment III

Ami: - check number of crashed seeds when in metering system

Material and methodology

The method was use a fixed hoper mounted with sliding plate which have three bucket in 0.5μm surface finishing for ABS plastic material which product made by injection thermoplastics molding process adjust on the table. Assemble the tool arrangement, Feed the seed in appropriate amount 4-8seeds in each bucket, move the sliding plate in forth and back push and pull through hands in non-defined load, using magnifying glass observe the crashed no of seed.



Assemble the tool arrangement

Result and Conclusion

No. observation	No. of crash seeds in each bucket		
	B1	B2	B3
1	0	0	0
2	0	0	0
3(relative fast)	2	0	0

The metring component have three bucket. It slides slowly forth and back. The seeds are transported inside the bucket to drops down. But at a point of fixed hopper and sliding component meeting section shown as the figure above the seed probably crashed. The surface of bucket is very smooth, the gape also small, the seed could have a properties has less friction, it has a chance to back to hopper without crashing by the testing load of 150g weight couldn't have an impact on seed which has been on the bottom part of hopper when in two serous observation.

From the experiment, 4-8(averagely 6 in some bucket) seeds are feeding at one bucket; seed have a property to back because of the grain is small. The last observation which makes relative fast from other two seeds has crashed laterally.

Appendixes III

Cost breakdown

The machine will have made the material which cost of each component merges and manufacturing cost could be summarised as follow in the table.

Main frame cost

Manufacturing cost

$$= \sum(process\ rate\ * time\ required) + (\sum(time\ required)) * labour\ cost$$

$$= [(\text{cutting} * \text{Ct}) + (\text{drilling} * \text{dt}) + (\text{grinding} * \text{gt}) + (\text{wielding} * \text{wt})] + [(\text{Ct} + \text{dt} + \text{gt} + \text{wt}) * \text{labour cost}]$$ ET birr

= [(20*0.1) + (40*0.05) + (20*0.017) + (27*0.03)] +[(0.1+0.05 + 0.017 +0.03) * 50]

= 15ET birr

Material cost = 88ETbirr.

Total cost = manufacturing cost + material cost

= 15+88= 103ET birr

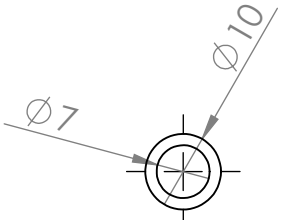
Table 0-1 material and manufacturing cost of drill machine

	material cost				manufacturing cost					total p. cost
part name	**material**	**quantity**	**cost/ unit**	**total Mt cost EB**	**manufacturing steps**	**required hour**	**machine cost ET birr**	**labour cost ET birr**	**total Mf. cost**	
Hopper	plastic	1145g	66/kg	75.57	molding, trimming, drilling, heat treatment	No need time count as fixed	150		150	225.57
metring shaft	plastic	105g	66/kg	6.93	molding, trimming, drilling, heat treatment	No need time count as fixed	185.75		185.75	192.68
main frame	structural steel	880*20mm* 40mm rectangular cylinder 2mm thickness	100/m	88	cutting	0.1	2	5	15	103
					drilling	0.05	2	2.5		
					grinding	0.017	0.34	0.85		
					wielding	0.03	0.81	1.5		
shoulder frame	structural steel	1000*30*3 in mm	67/m	67	cutting	0.25	5	12.5	53.34	120.34
					drilling	0.16	6.4	8		
					grinding	0.09	1.8	4.5		
					bending, wielding	0.17	7.14	8.5		
handle	wood	120mmlength * 10mm	7/m	2	cutting	0.066	1.32	3.3	19.095	21.095
					facing	0.075	2.625	3.75		

		diameter			drilling	0.09	3.6	4.5		
liver	structural steel	110mm*4m mthickness	67/m	7.37	cutting	0.066	1.32	3.3	13.62	
					drilling	0.1	4	5		29.98
pulley holder	structural steel	240mm *30* 3mm	67/m	16.08	cutting	0.05	1	2.5	14.63	
					bending, wielding	0.033	1.386	1.65		
					drilling	0.09	3.6	4.5		30.71
pulley frame	structural steel	355mm * 30*3 mm	67/m	23.785	cutting	0.25	5	12.5	40	
					drilling	0.083	3.32	4.15		
					bending, wielding	0.166	6.97	8.3		63.785
Driving shaft	rectangular steel bar	130* 10* 10 in mm	88/m	11.44	cutting	0.066	1.32	3.3	22.12	
					facing	0.1	3.5	5		
					drilling	0.1	4	5		33.56
Driving pulley	round wood	80mm* 50mm	1.5	1.5	cutting	0.05	1	2.5	6.4	
					facing	0.0166	0.581	0.83		
					drilling	0.0166	0.664	0.83		7.9
hopper clamper	structural steel	622mm*30mm*3mm	67/m	41.674	cutting	0.033	0.66	1.65	11.037	
					bending, wielding	0.0166	0.697	0.83		
					drilling	0.08	3.2	4		52.7
joint	structural steel	55mm*30*4	112/m	6.16	cutting	0.166	3.32	8.3	16.24	
					drilling	0.03	1.2	1.5		
					wielding	0.025	0.675	1.25		22.4
frame wedge	structural steel	250*15*4 mm	112/m	28	cutting	0.008	0.25	0.4	1.37	
					drilling	0.008	0.32	0.4		29.37

fastening and agitating frame	plastic plate	265*25 mm	66/kg	7.7	cutting	0.33	6.6	16.5	26.13	33.8
					drilling, bending	0.033	1.32	1.65		
agitating pulley	width round plastic	10mmdia *30mm	66/kg	4.5	cutting	0.05	1	2.5	12.85	17.35
					recessing	0.11	3.85	5.5		
idler pulley	plastic	10mm dia*15 mm width	66/kg	1	cutting, drilling	0.08	4.8	4	8.8	9.8
lesser belt	leather in mm	117 *20* 2	____	40	cutting	0.03	0.6	1.5	31.15	71.15
					joining	0.35	11.55	17.5		
feeding tube	ABS plastic	80g	66/kg	5.3	molding, trimming,		60		60	65.3
air bag & pipe	bag	1	9	9	fastening	0.008	_____	0.4	0.4	9.4
belt	polyester	160*20*2mm	25	25	cutting, joining	0.0833	2.7489	4.165	6.914	32
total				468.009					694.846	1162.86

	process	cost/hr
Machining cost	cutting	20
	drilling	40
	Boring, facing	35
	Bending	15
	Welding, grinding	47
labour cost	_____	50
hand tool	_____	33



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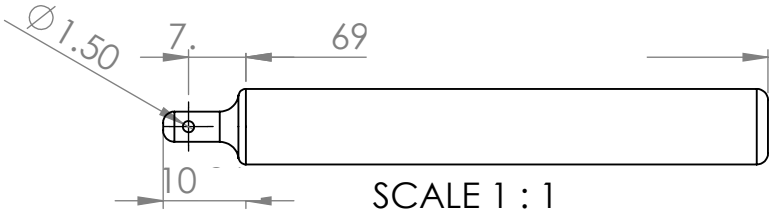

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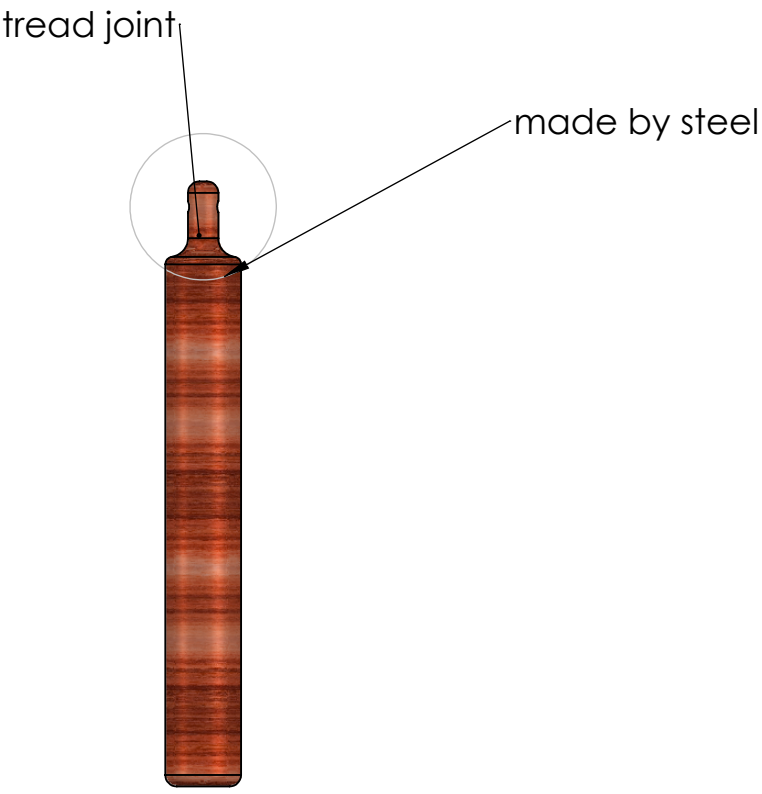

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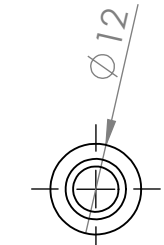
All dimension in mm

	NAME	SIGNATURE	DATE	TITLE:	
DRAWN	**Habtamu Mulatu**			handle	Addis Ababa Univeresity institute of technology school of industrial and mechanical Engineering
CHK'D					
APPV'D				MATERIAL: wood	DWG NO. 1 A4
Q.A	1			WEIGHT:	SCALE:1:1



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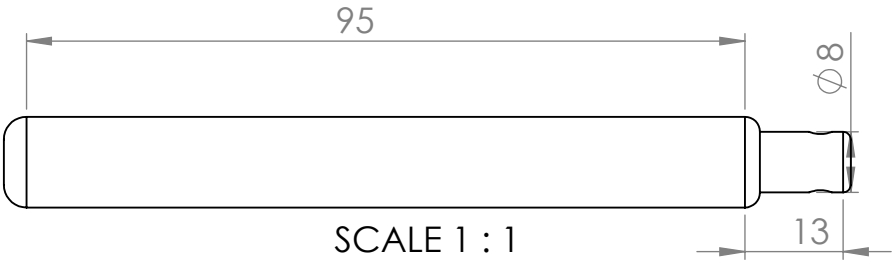

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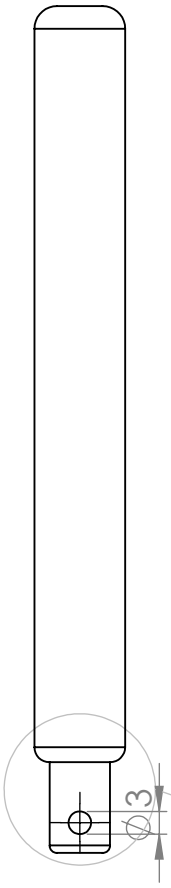

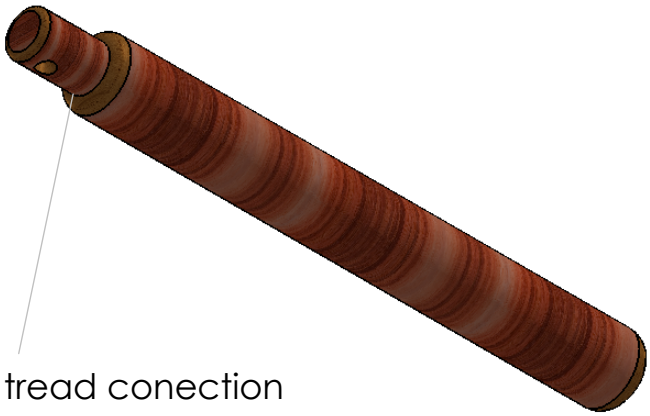

tread conection

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made by steel

SCALE 1 : 1

All dimension in mm

	NAME	SIGNATURE	DATE	TITLE:	Addis Ababa Univeresity institute of technology school of industrial and mechanical Engineering	
DRAWN	**Habtamu Mulatu**			handle		
CHK'D						
APPV'D				MATERIAL: wood	DWG NO. 1	A4
Q.A	1			WEIGHT:	SCALE:1:1	

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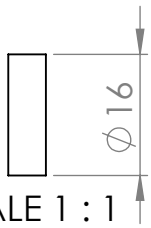

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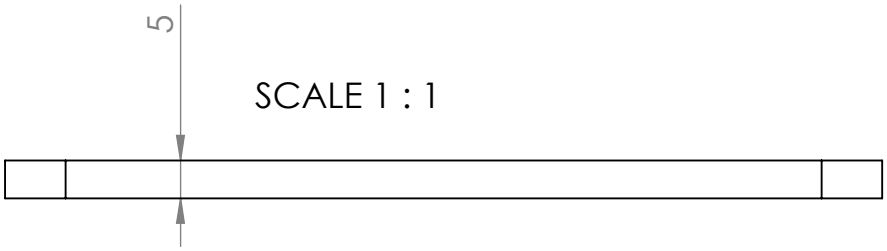

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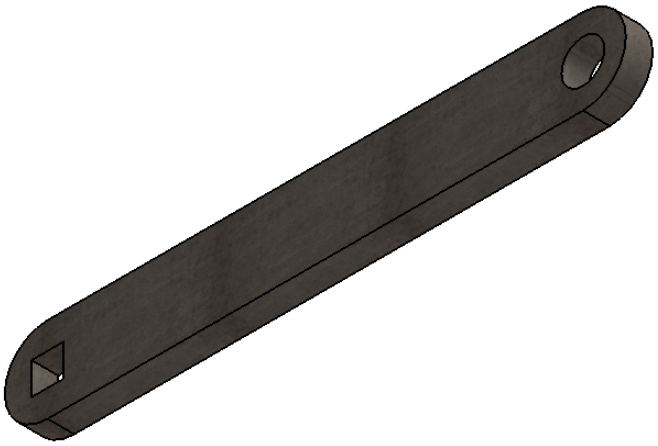

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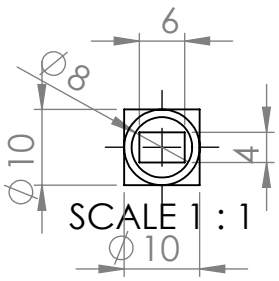
All dimension in mm

	NAME	SIGNATURE	DATE	TITLE:	
DRAWN	**Habtamu Mulatu**			Lever	Addis Ababa univeresity institute of technology school of industrial and mechanical engineering
CHK'D					
APPV'D				MATERIAL: steel	DWG NO. 3 — A4
Q.A	1			WEIGHT:	SCALE:1:1 — SHEET 1 OF 1



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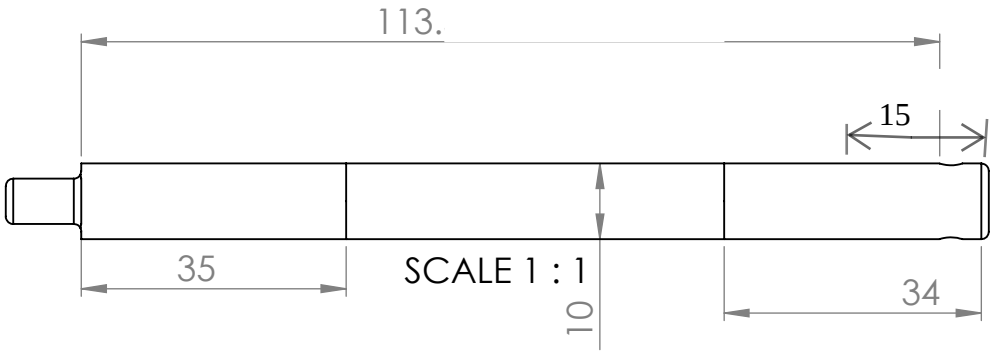

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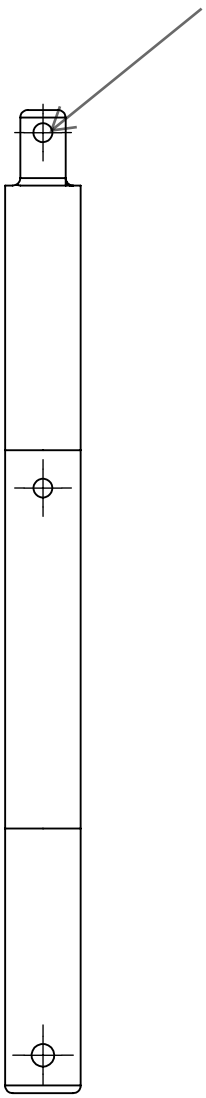

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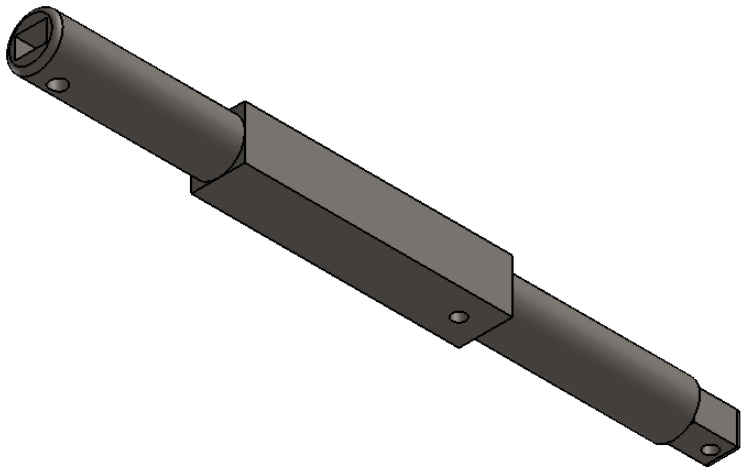

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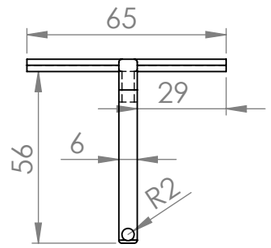
All dimension in mm

	NAME	SIGNATURE	DATE	TITLE: driving shaft	Addis Ababa university institute of technology school of industrial and mechanical engineering	
DRAWN	**Habtamu Mulatu**					
CHK'D						
APPV'D				MATERIAL: steel	DWG NO. 2c	A4
Q.A	1			WEIGHT:	SCALE:1:1	SHEET 1 OF 1



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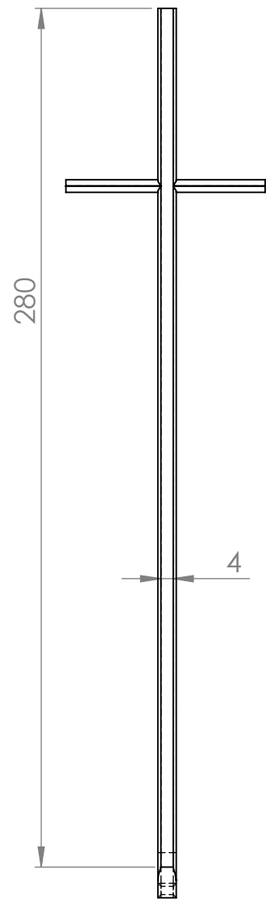
SCALE 1 : 2



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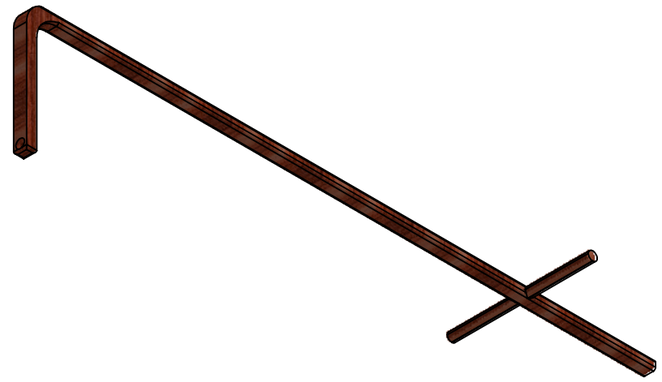

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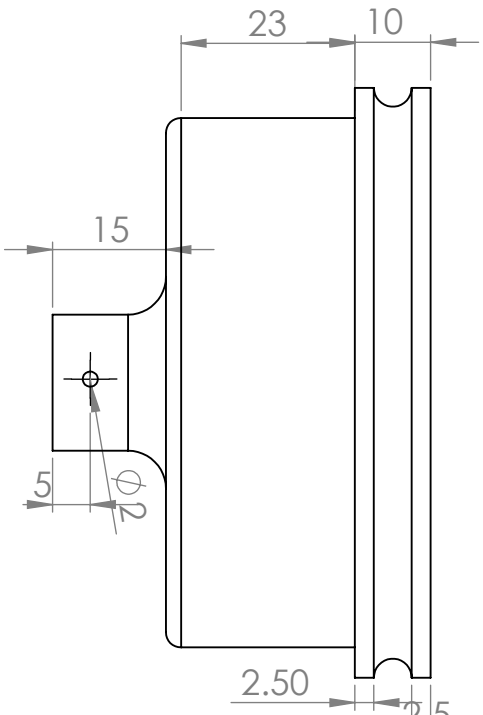
All dimension in mm

	NAME	SIGNATURE	DATE		
DRAWN	habtamu mulatu			guiding rop holder	addis abeba university institute of technology school of industrial and mechanical engineering
APPV'D					
MFG					
Q.A				MATERIAL: steel	DWG NO. •• A3
				WEIGHT:	SCALE:1:1 SHEET 1 OF 1



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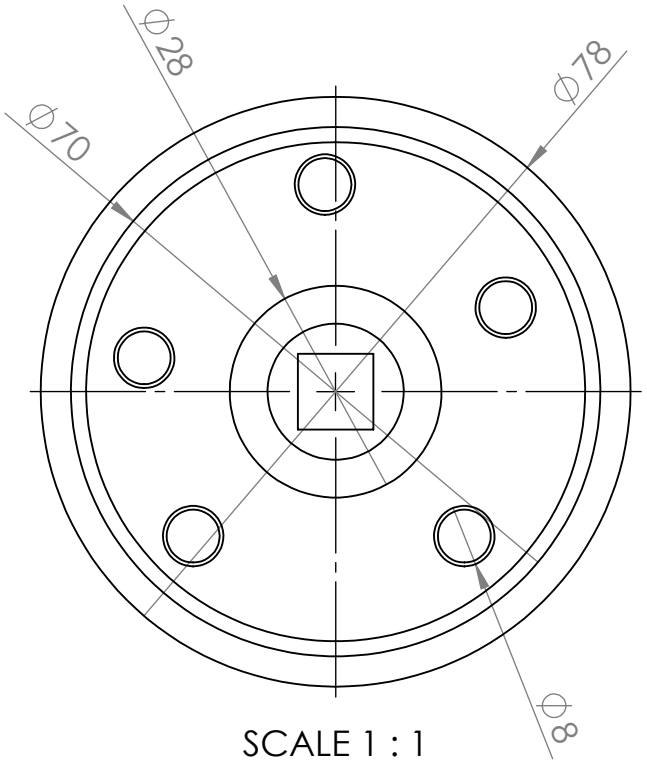

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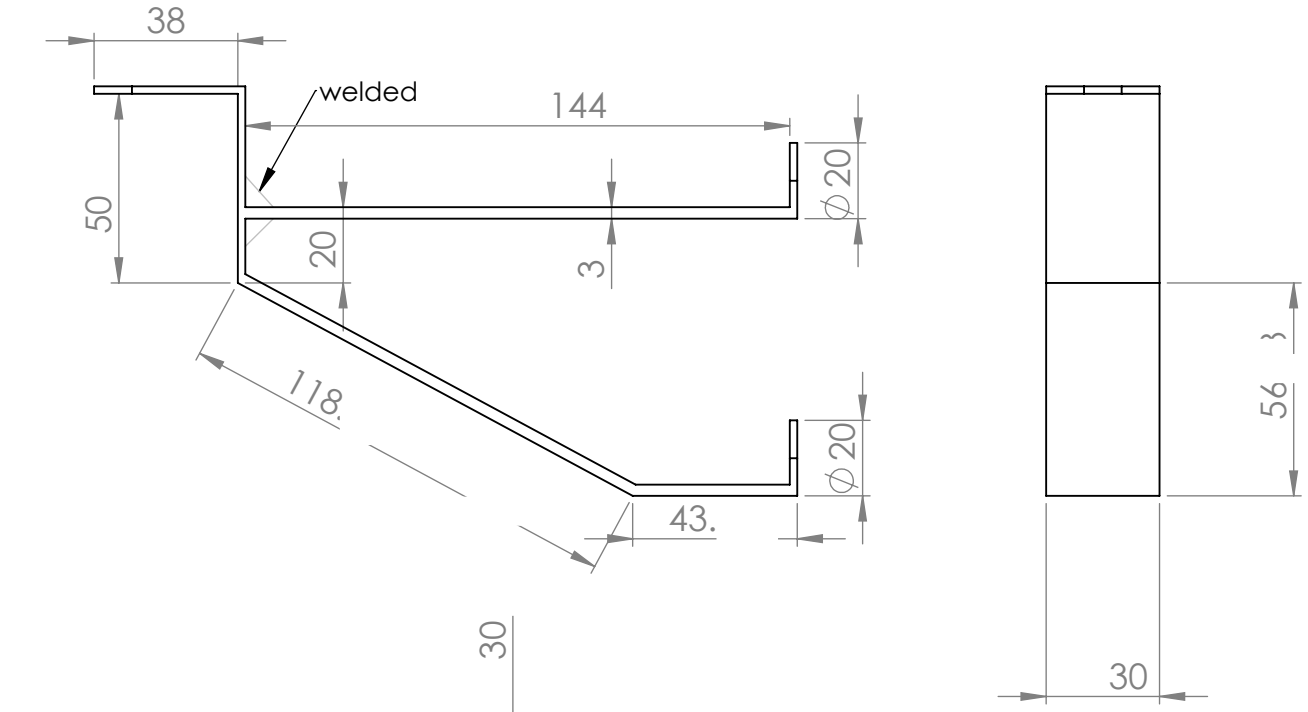
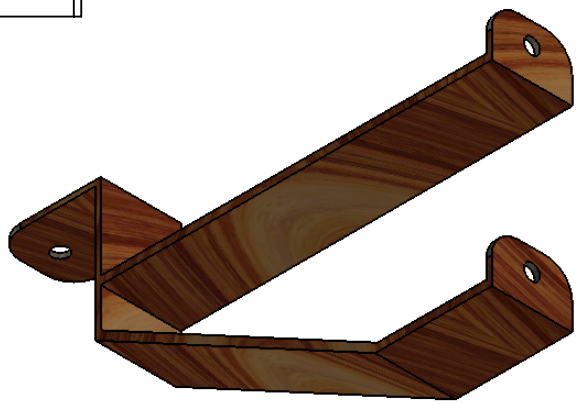
SCALE 1 : 1

All dimension in mm

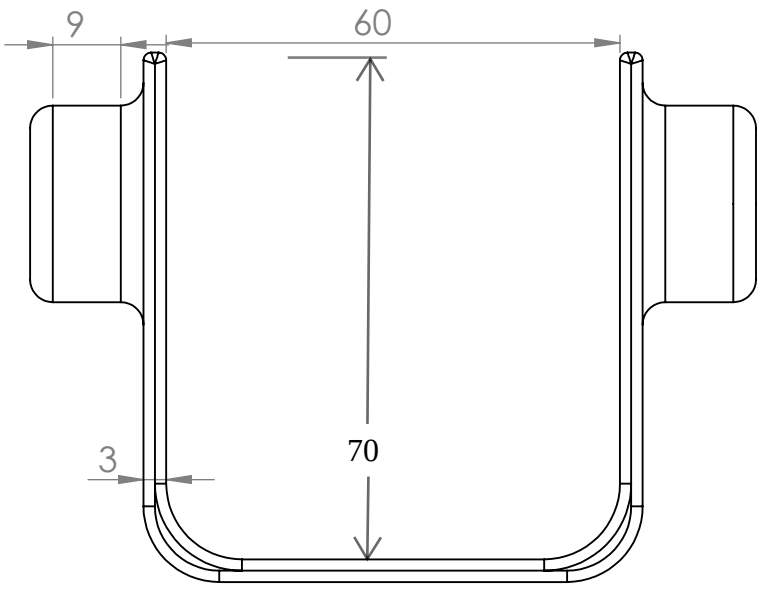
	NAME	SIGNATURE	DATE	TITLE:	
DRAWN	**Habtamu Mulatu**			driving pulley	Addis Ababa univeresity institute of technology school of industrial and mechanical engineering
CHK'D					
APPV'D				MATERIAL: wood	DWG NO. ... A4
Q.A	1			WEIGHT:	SCALE:1:1 SHEET 1 OF 1





All dimension in mm

	NAME	SIGNATURE	DATE	TITLE: pulley support frame	Addis Ababa univeresity institute of technology school of industrial and mechanical engineering	
DRAWN	**Habtamu Mulatu**					
CHK'D						
APPV'D				MATERIAL: structural steel	DWG NO.	A4
Q.A	1			WEIGHT:	SCALE:1:2	SHEET 1 OF 1



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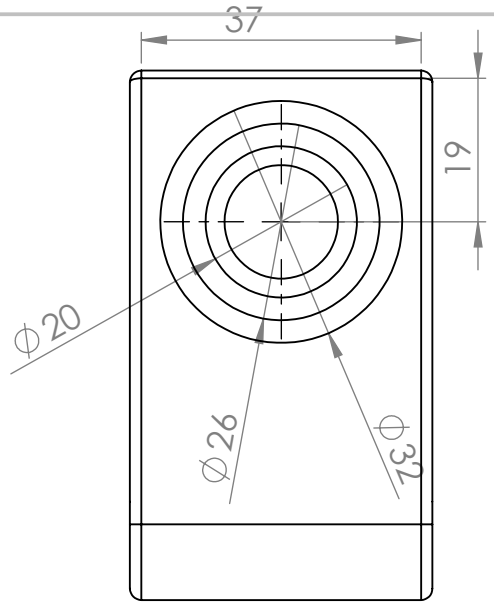

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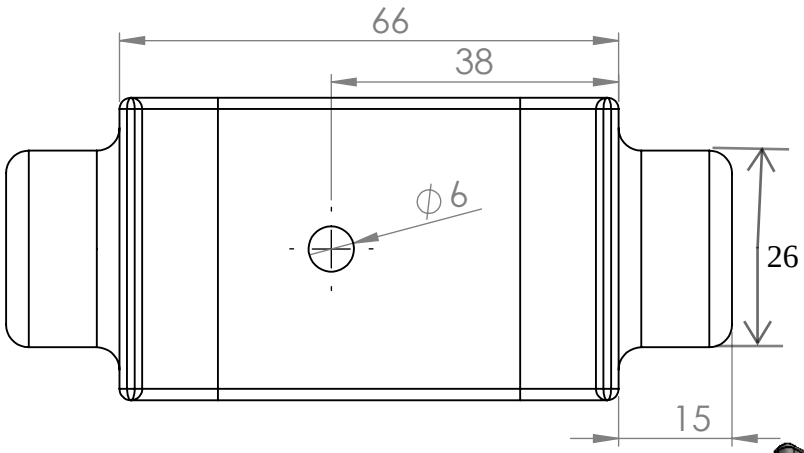

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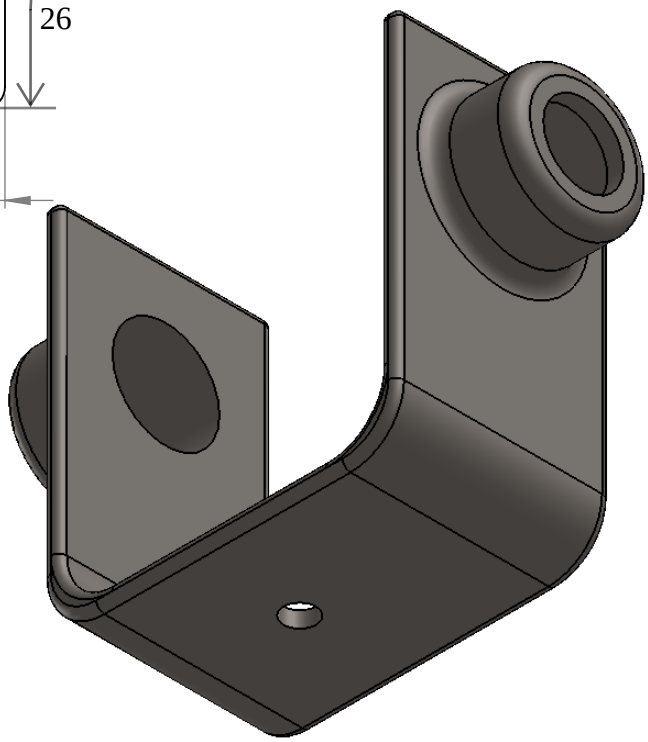
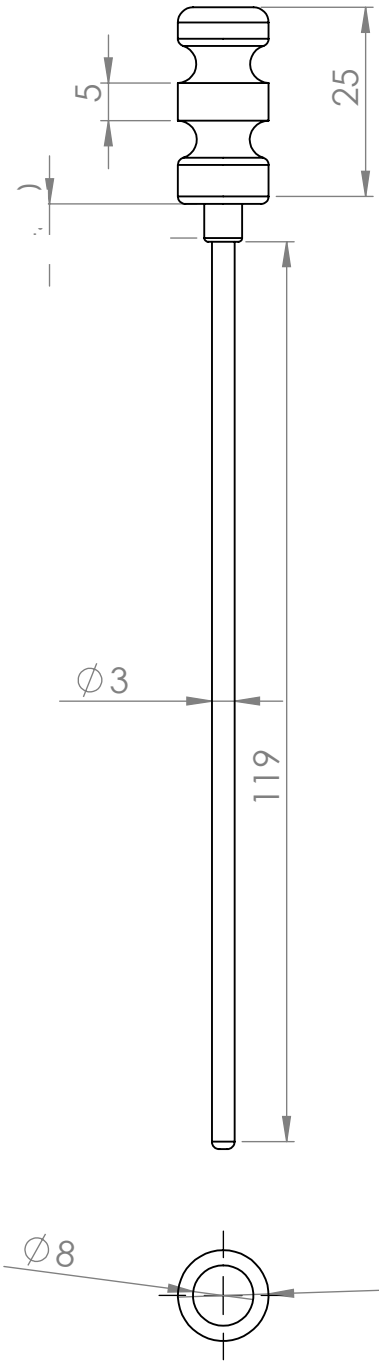
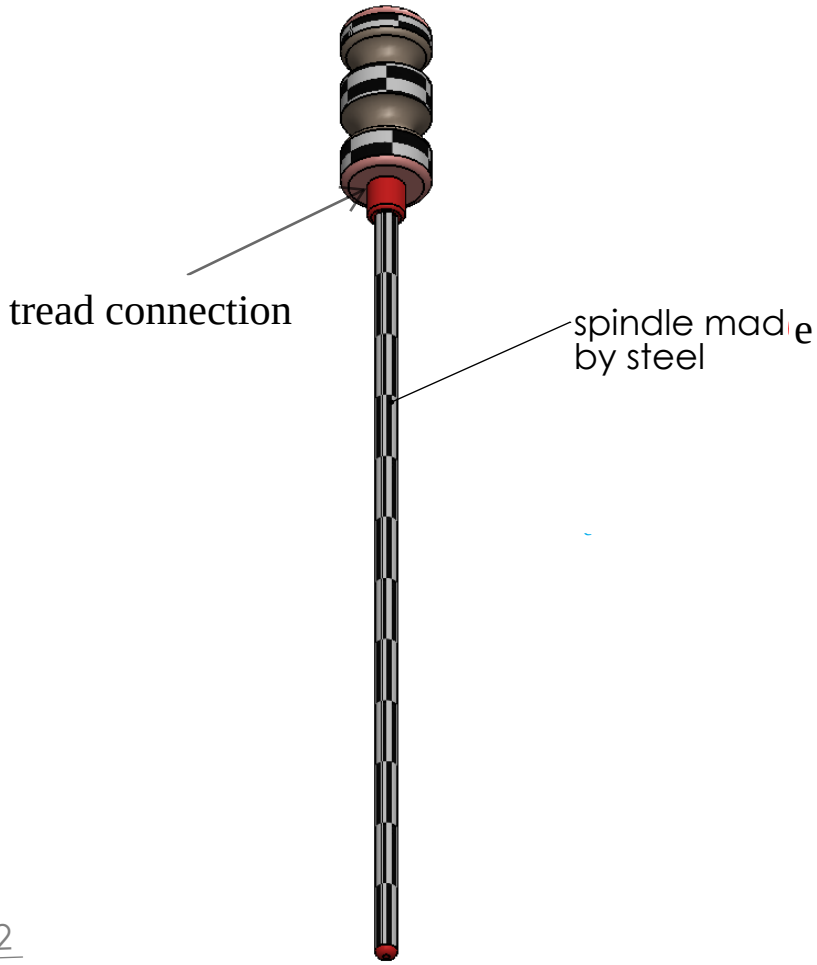


SCALE 1 : 1

All dimension in mm

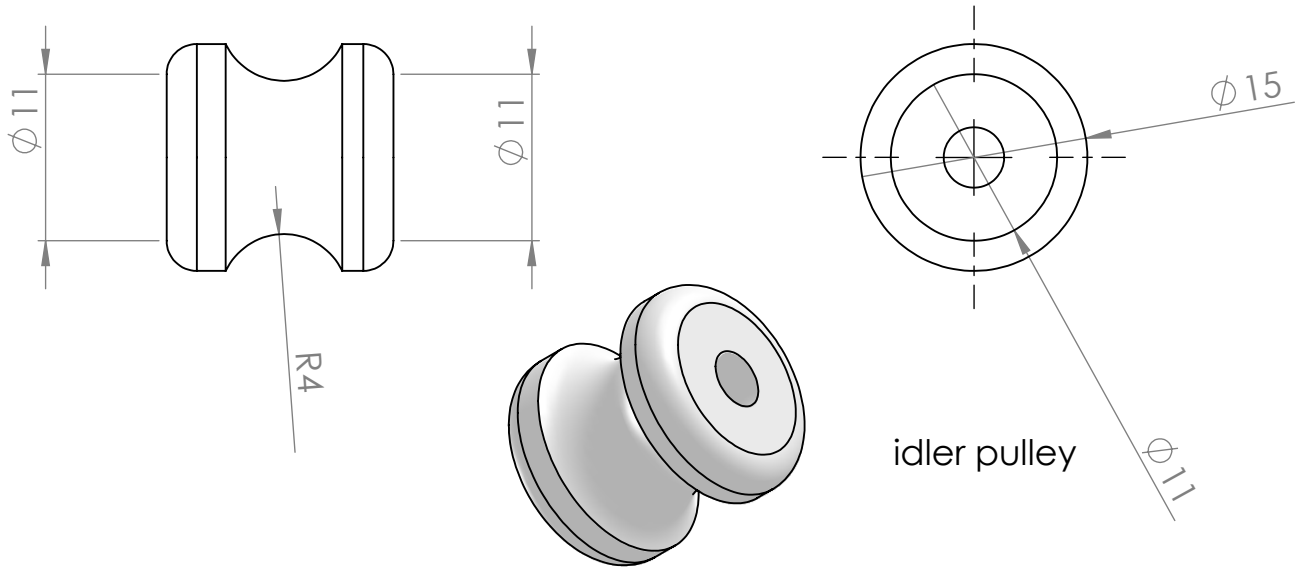
	NAME	SIGNATURE	DATE	TITLE:	
DRAWN	**Habtamu Mulatu**			pulley holder	Addis Ababa univeresity institute of technology school of industrial and mechanical engineering
CHK'D					
APPV'D				MATERIAL: structural steel	DWG NO. .. A4
Q.A	1			WEIGHT:	SCALE:1:2 SHEET 1 OF 1



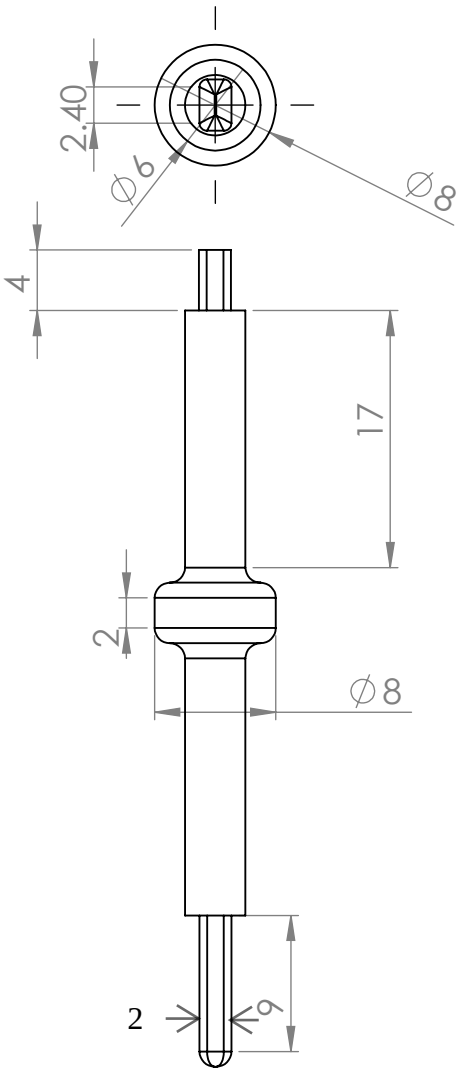


All dimension in mm

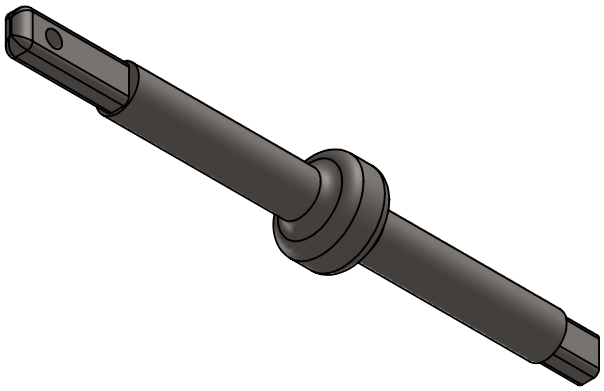
	NAME	SIGNATURE	DATE	TITLE: agitating pulley	Addis Ababa univeresity institute of technology school of industrial and mechanical engineering	
DRAWN	**Habtamu Mulatu**					
CHK'D						
APPV'D				MATERIAL: plastic	DWG NO. ..	A4
Q.A	6			WEIGHT:	SCALE:1:1	SHEET 1 OF 1



idler pulley

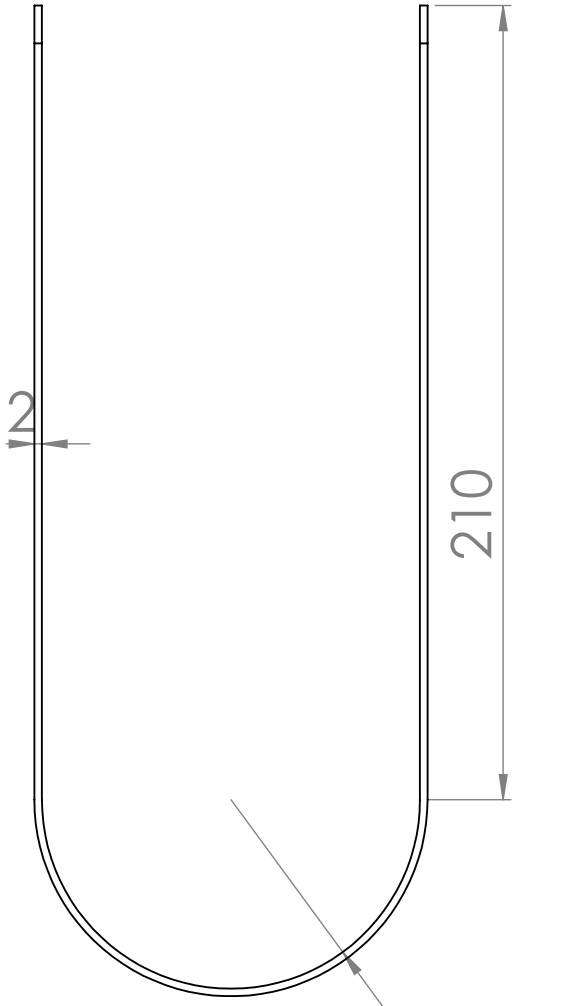


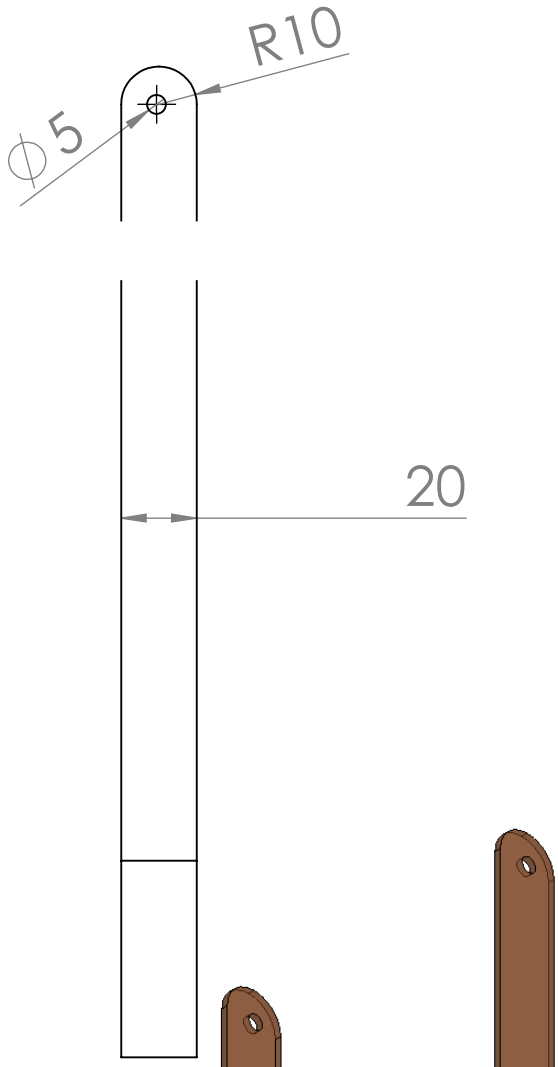
idler pulley shaft

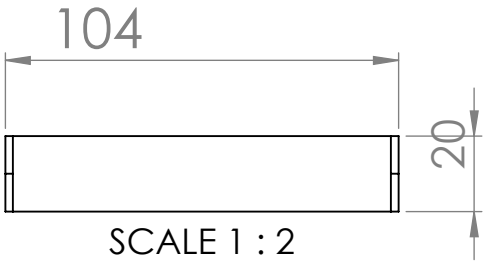


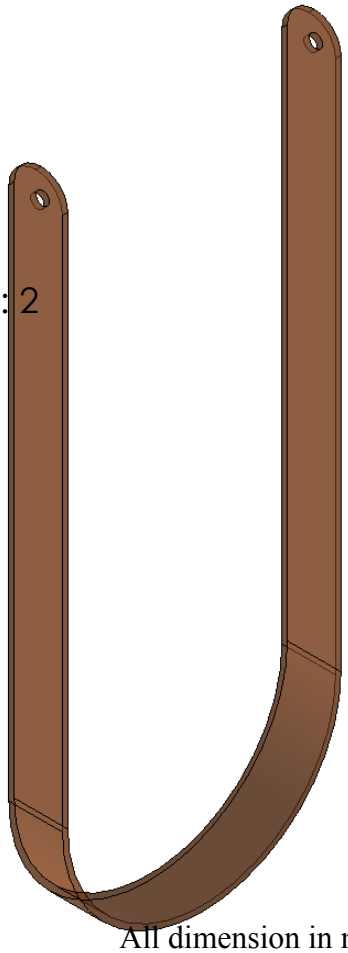
All dimension in mm

	NAME	SIGNATURE	DATE	TITLE: idler pulley and shaft	Addis Ababa university institute of technology school of industrial and mechanical engineering	
DRAWN	Habtamu Mulatu					
CHK'D						
APPV'D				MATERIAL: plastic	DWG NO. ..	A4
Q.A	1			WEIGHT:	SCALE:2:1	SHEET 1 OF 1



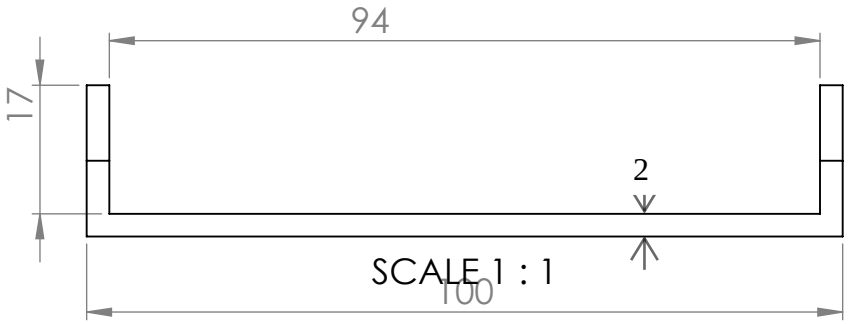




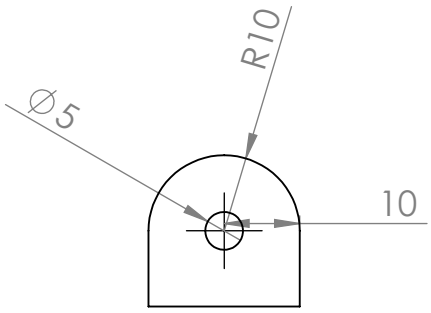


All dimension in mm

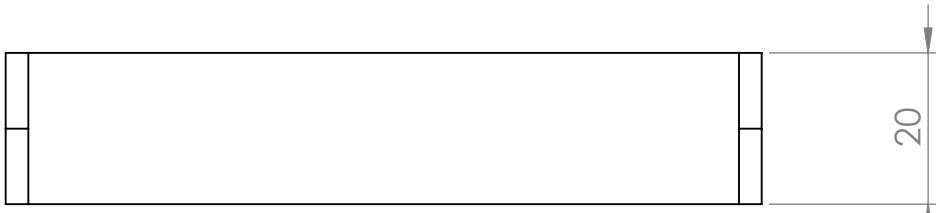
	NAME	SIGNATURE	DATE	TITLE:	Addis Ababa Univeresity institute of technology school of industrial and mechanical Engineering
DRAWN	**Habtamu Mulatu**			clamper	SCALE 1 : 2
CHK'D					
APPV'D				MATERIAL: plastic	DWG NO. A4
Q.A	2			WEIGHT:	1:2



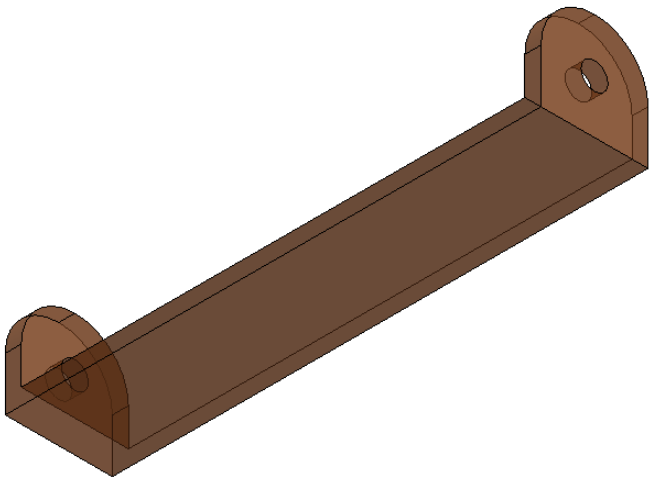
SCALE 1 : 1



SCALE 1 : 1

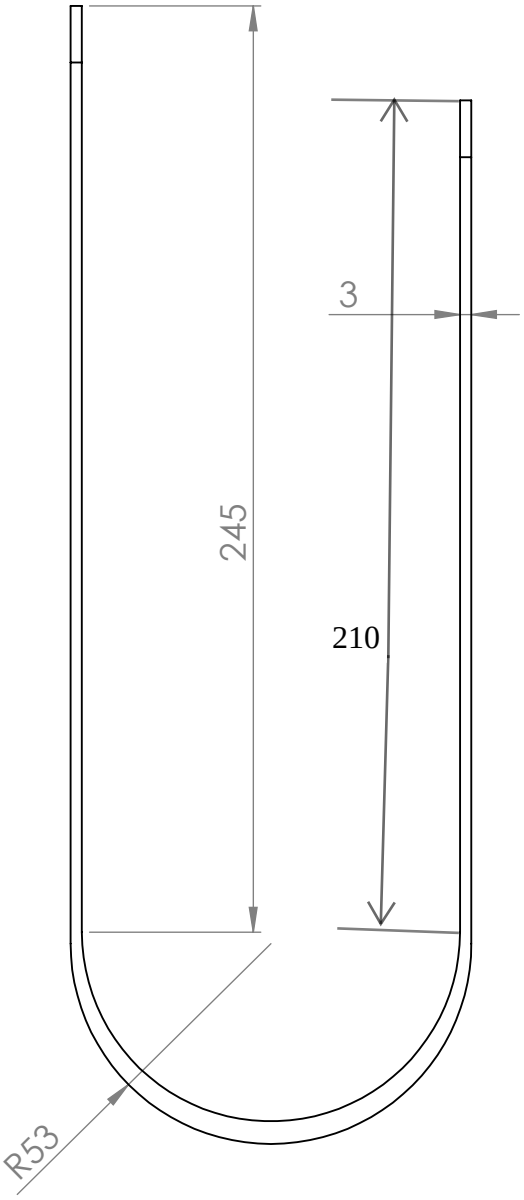


SCALE 1 : 1

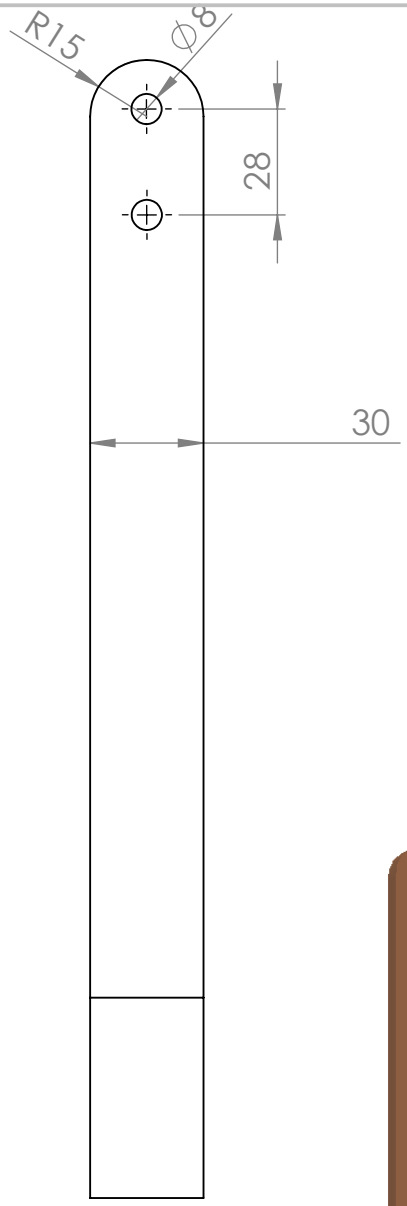


All dimension in mm

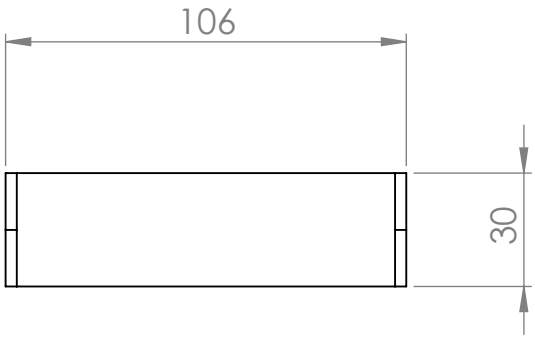
	NAME	SIGNATURE	DATE	TITLE:	Addis Ababa Univeresity institute of technology school of industrial and mechanical Engineering	
DRAWN	**Habtamu Mulatu**			clamper		
CHK'D						
APPV'D				MATERIAL: plastic	DWG NO.	A4
Q.A	3			WEIGHT:	1:2	



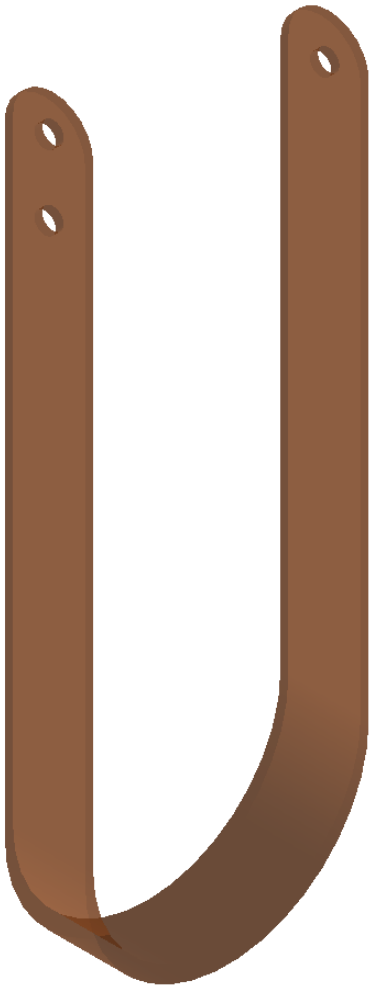
SCALE 1 : 2



SCALE 1 : 2

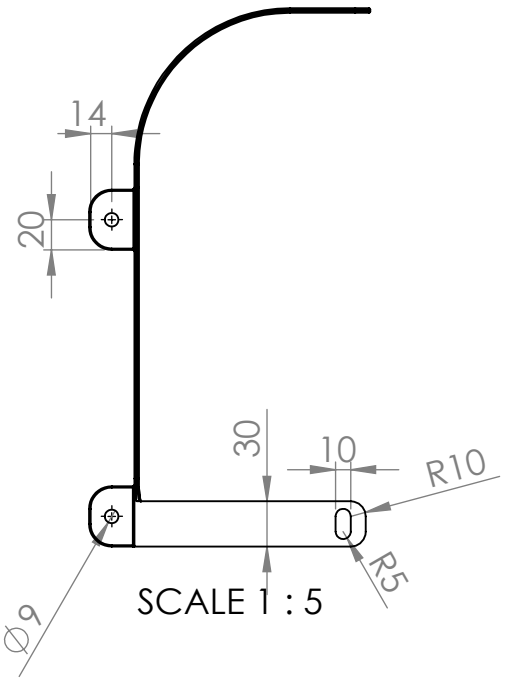


SCALE 1 : 2

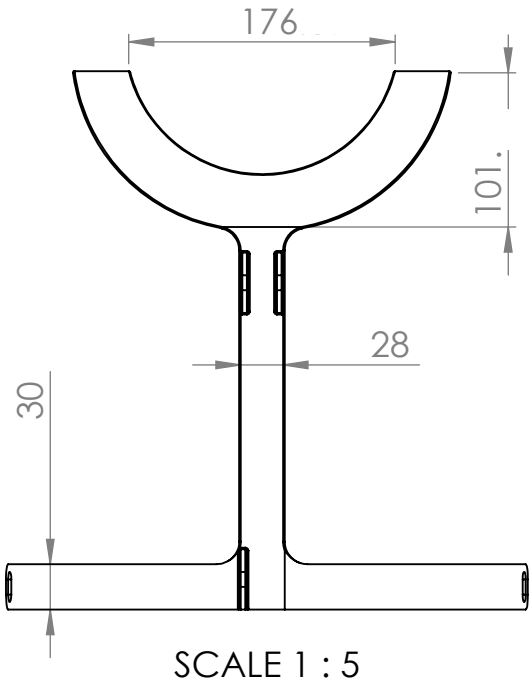


All dimension in mm

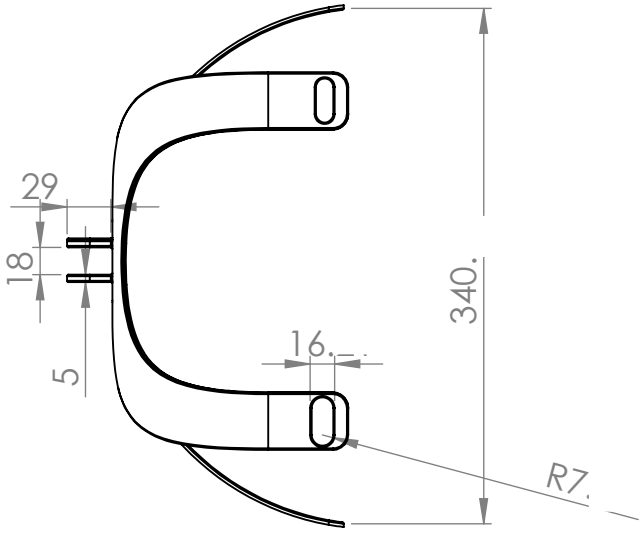
	NAME	SIGNATURE	DATE	TITLE:	Addis Ababa Univeresity institute of technology school of industrial and mechanical Engineering	
DRAWN	**Habtamu Mulatu**			clamper		
CHK'D						
APPV'D				MATERIAL: plastic	DWG NO.	A4
Q.A	1			WEIGHT:	1:2	



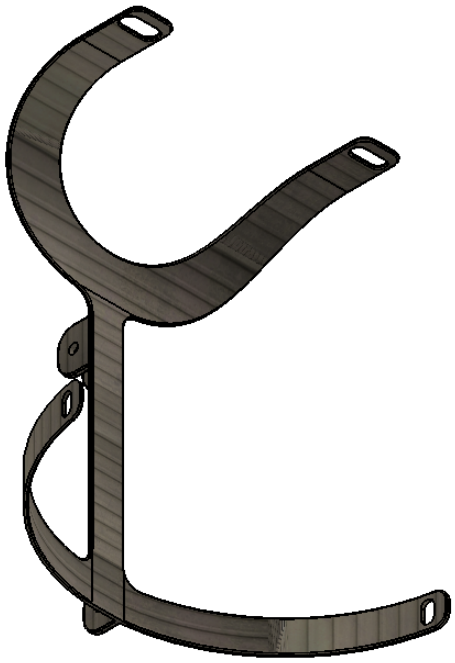
SCALE 1 : 5



SCALE 1 : 5



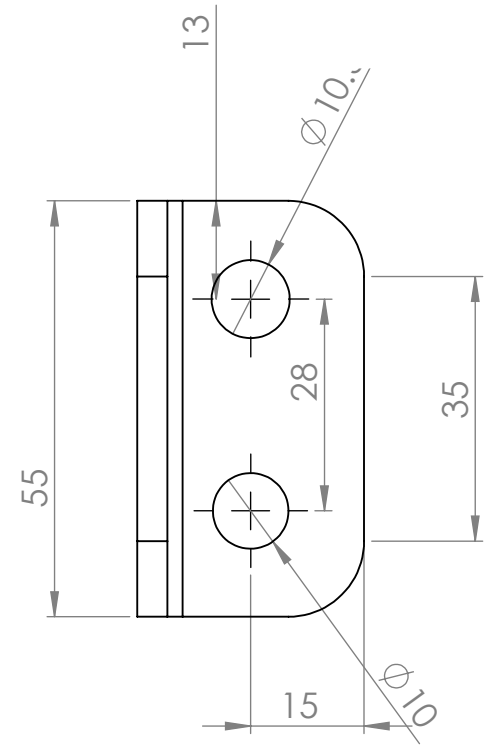
SCALE 1 : 5

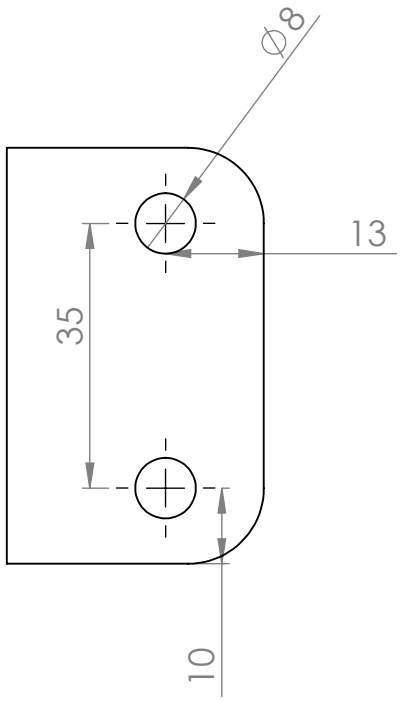


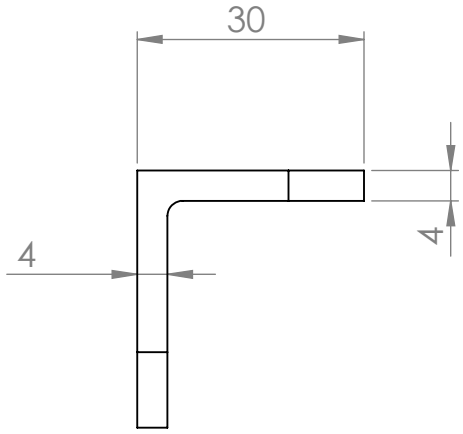
* each joint by weld

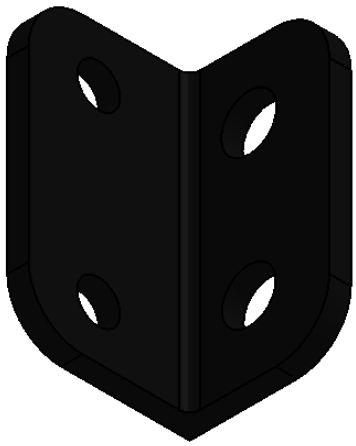
All dimension in mm

	NAME	SIGNATURE	DATE	TITLE:	
DRAWN	**Habtamu Mulatu**			shoulder frame	Addis Ababa Univeresity institute of technology school of industrial and mechanical Engineering
CHK'D					
APPV'D				MATERIAL: structural steel	DWG NO. A4
Q.A	1			WEIGHT:	1:2



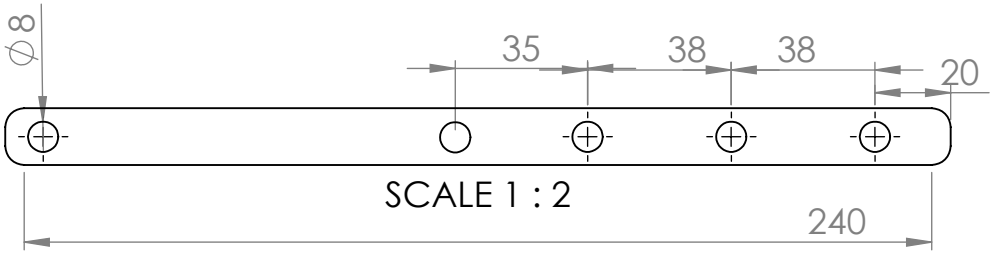




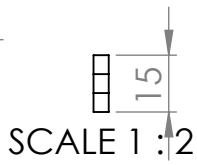


All dimension in mm

	NAME	SIGNATURE	DATE	TITLE:	
DRAWN	**Habtamu Mulatu**			joint plat	Addis Ababa university institute of technology school of industrial and mechanical ingineering
CHK'D					
APPV'D				MATERIAL: structural steel	DWG NO. .. A4
Q.A	1			WEIGHT:	SCALE:1:1 SHEET 1 OF 1

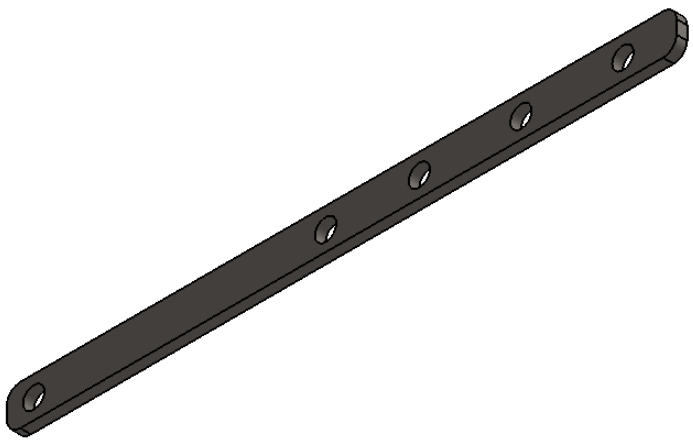


SCALE 1 : 2



SCALE 1 : 2

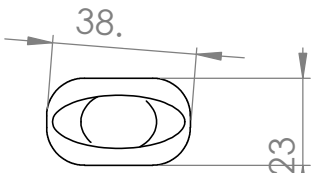
SCALE 1 : 2



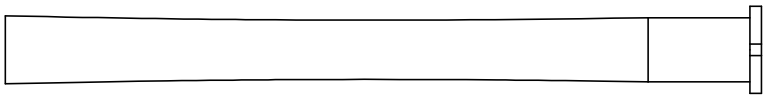
SCALE 1 : 2

All dimension in mm

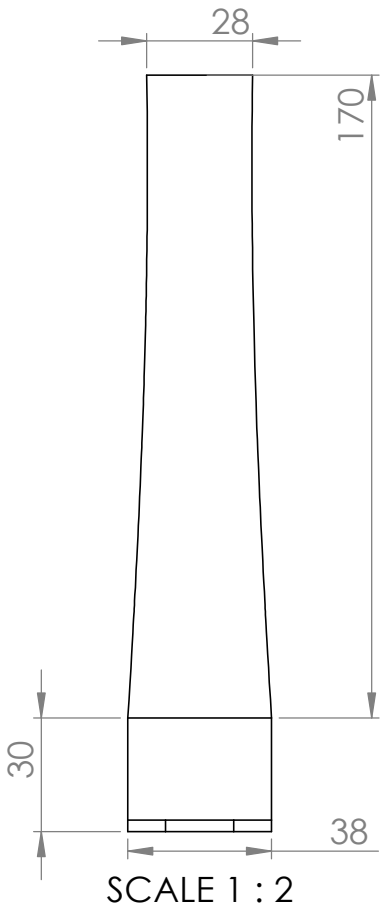
	NAME	SIGNATURE	DATE	TITLE: wage	Addis Ababa university institute of technology school of industrial and mechanical engineering	
DRAWN	**Habtamu Mulatu**					
CHK'D						
APPV'D				MATERIAL: structural steel	DWG NO. ..	A4
Q.A	1			WEIGHT:	SCALE:1:2	SHEET 1 OF 1



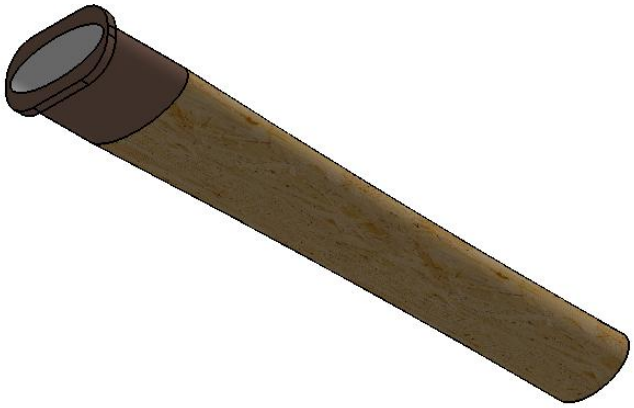
SCALE 1 : 2



SCALE 1 : 2



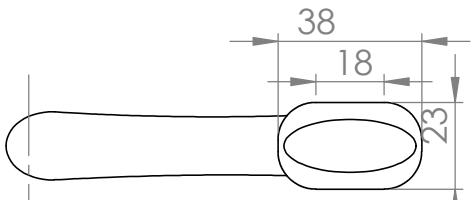
SCALE 1 : 2



SCALE 1 : 2

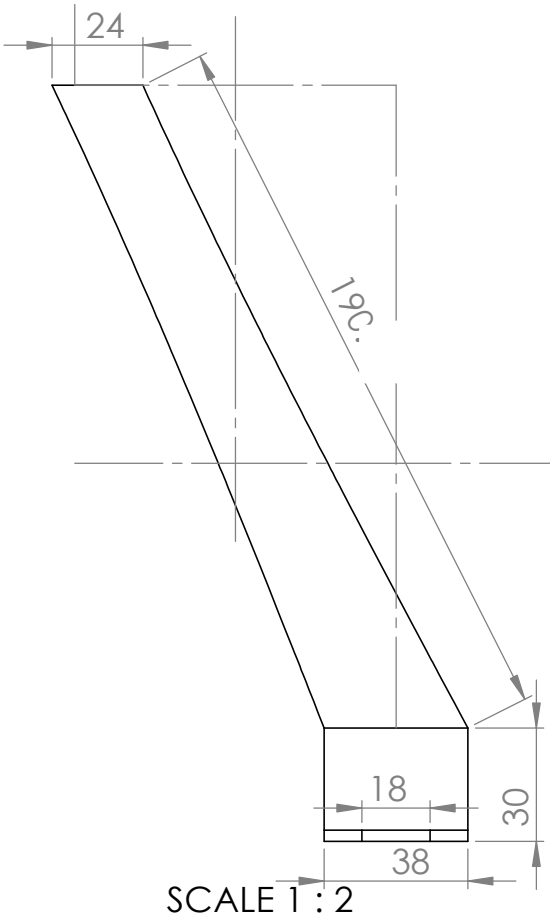
All dimension in mm

	NAME	SIGNATURE	DATE	TITLE: middiletube	Addis Ababa univeresty institute of technology school of industrial and mechanical engineering	
DRAWN	**Habtamu Mulatu**					
CHK'D						
APPV'D				MATERIAL: plastic	DWG NO. .	A4
Q.A	1			WEIGHT:	SCALE:1:2	SHEET 1 OF 1

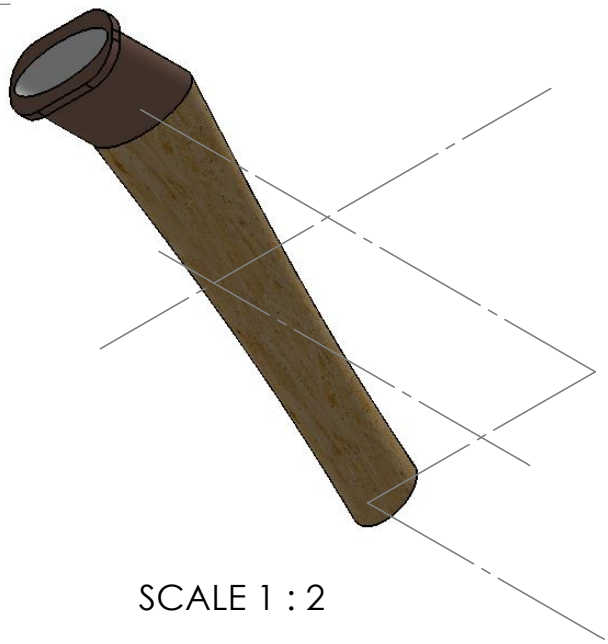


SCALE 1 : 2

SCALE 1 : 2



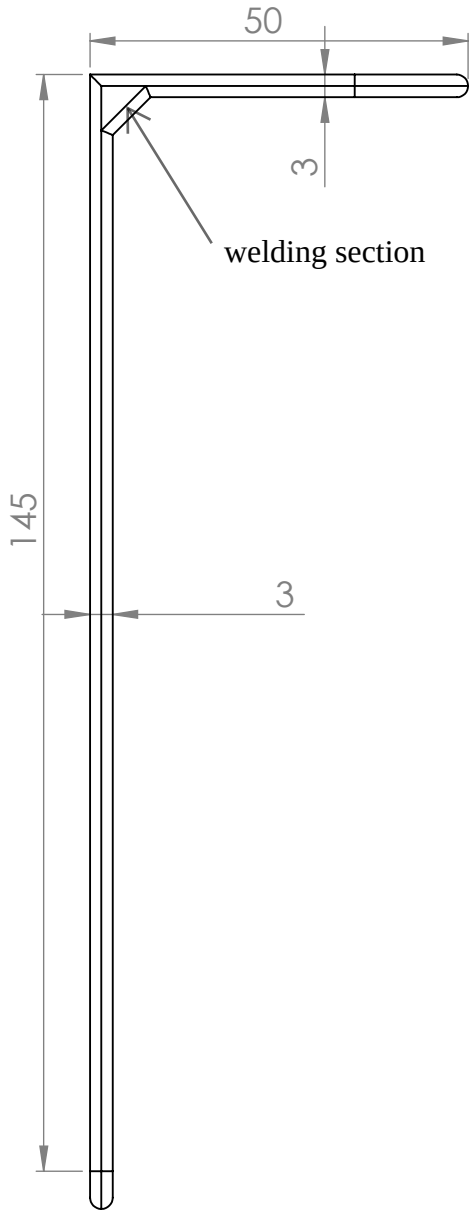
SCALE 1 : 2



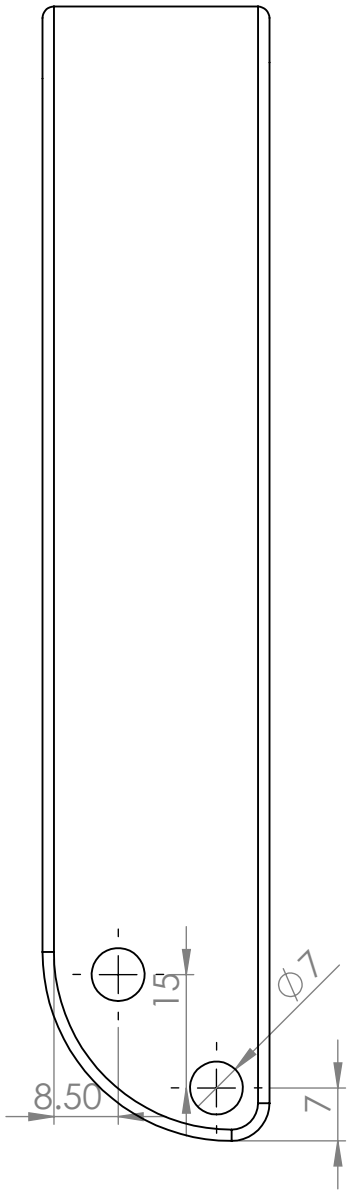
SCALE 1 : 2

All dimension in mm

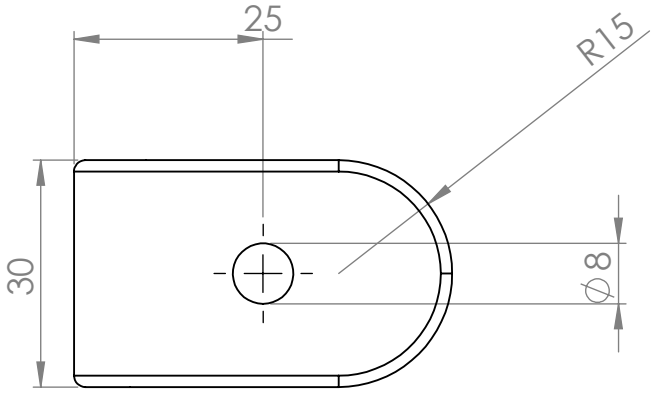
	NAME	SIGNATURE	DATE	TITLE:	
DRAWN	**Habtamu Mulatu**			side tube	Addis Ababa university institute of technology school of industrial and mechanical engineering
CHK'D					
APPV'D				MATERIAL: plastic	DWG NO. .. A4
Q.A	2			WEIGHT:	SCALE:1:2 SHEET 1 OF 1



SCALE 1 : 1



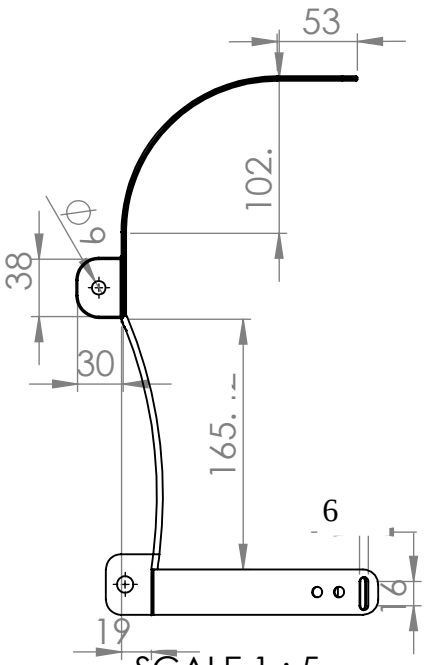
SCALE 1 : 1



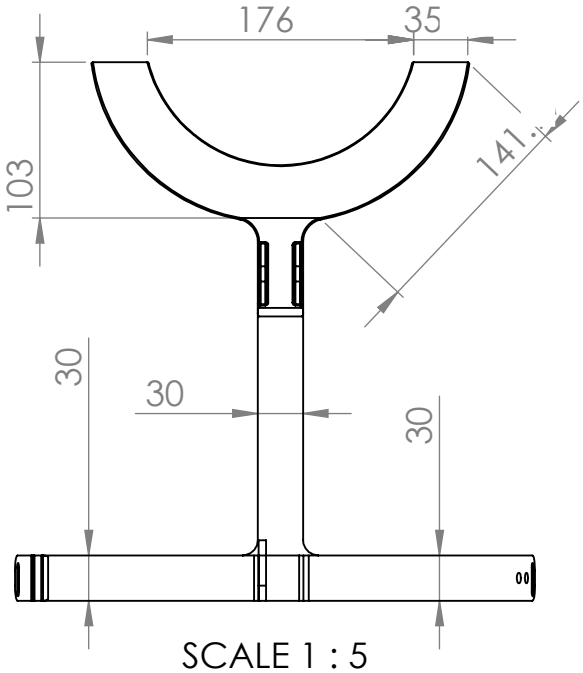
SCALE 1 : 1

All dimension in mm

	NAME	SIGNATURE	DATE	TITLE:	Addis Ababa University
DRAWN	**Habtamu Mulatu**			back pulley suport frame	institute of technology school of industrial and mechanical Engineering
CHK'D					
APPV'D				MATERIAL: structural steel	DWG NO. A4
Q.A	1			WEIGHT:	1:1

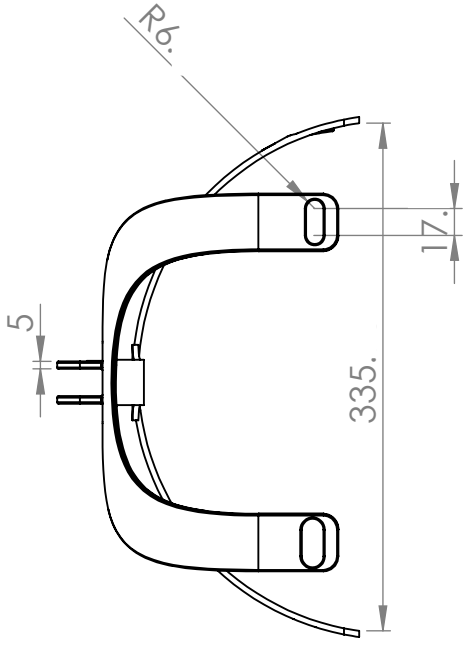


SCALE 1 : 5

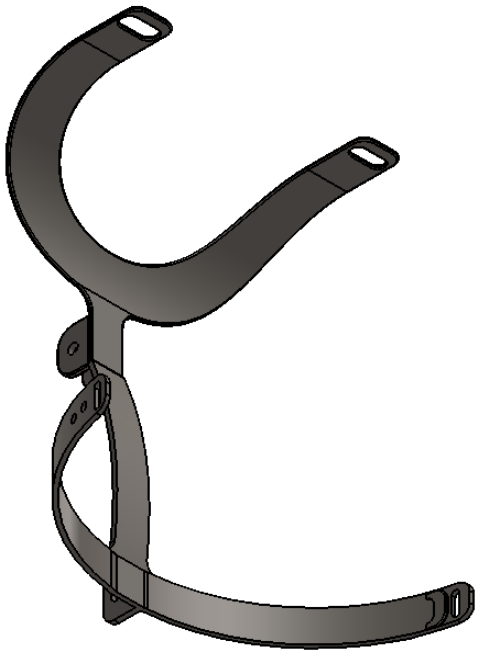


SCALE 1 : 5

* each joint by weld



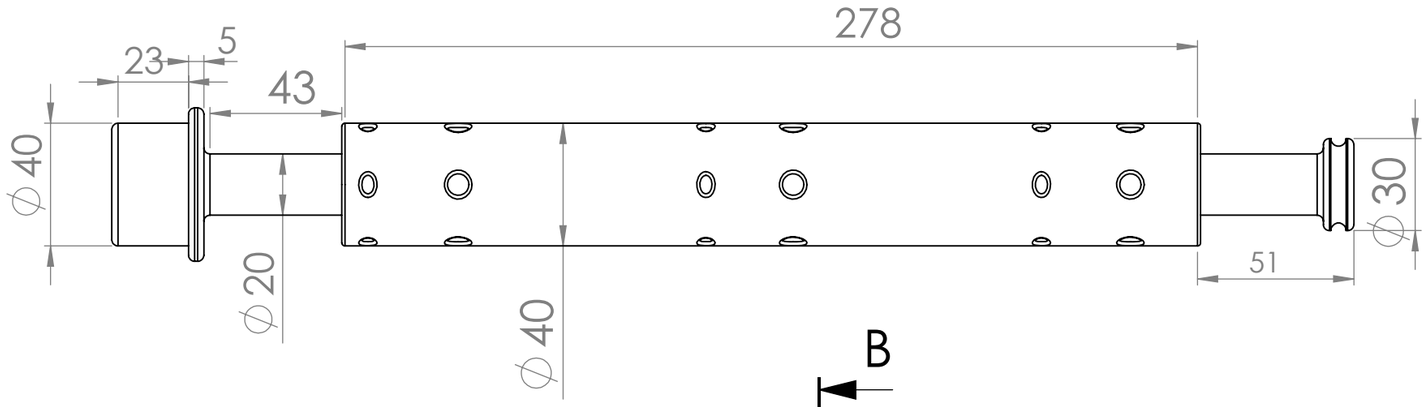
SCALE 1 : 5

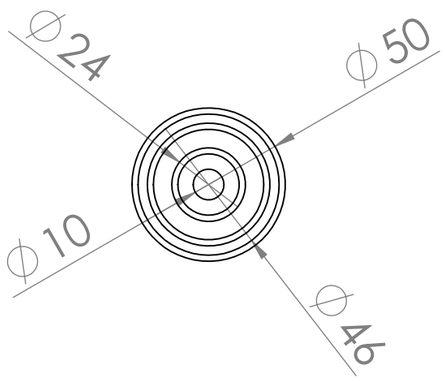


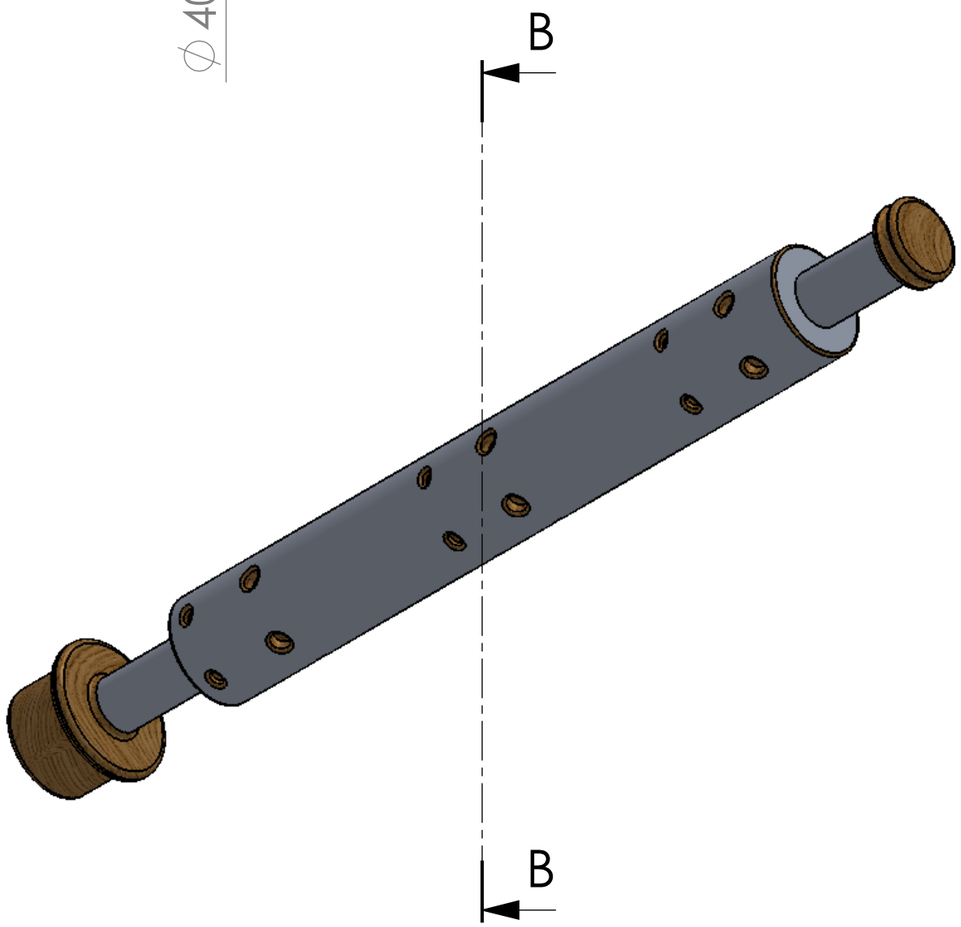
SCALE 1 : 5

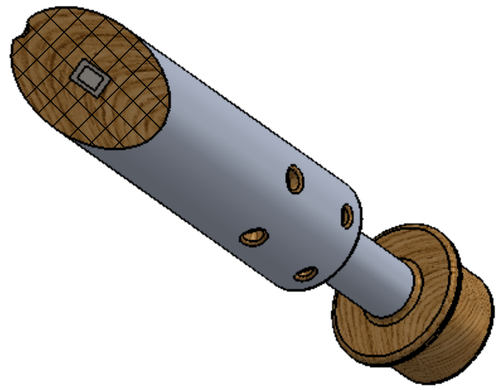
All dimension in mm

	NAME	SIGNATURE	DATE	TITLE:	Addis Ababa Univeresity institute of technology school of industrial and mechanical Engineering	
DRAWN	**Habtamu Mulatu**			shoulder frame back sy		
CHK'D						
APPV'D				MATERIAL: structural steel	DWG NO.	A4
Q.A	1			WEIGHT:	1:5	





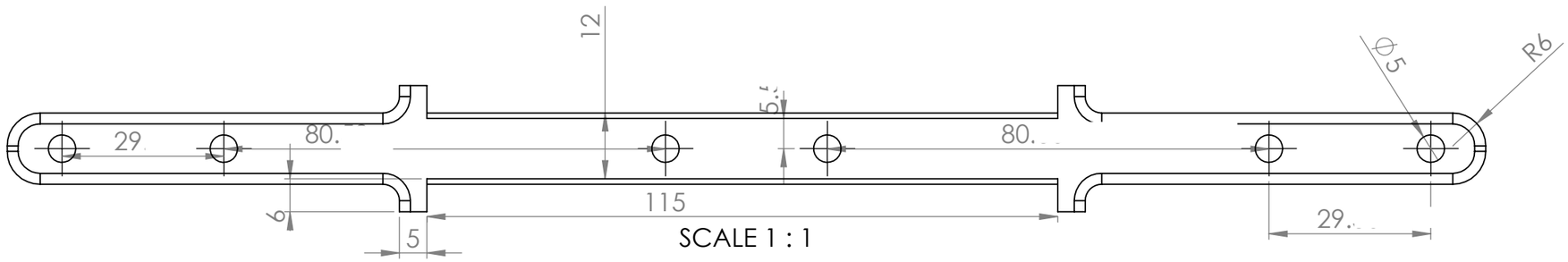




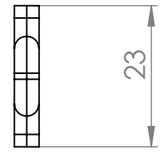
SECTION B-B

All dimension in mm

	NAME	SIGNATURE	DATE		
DRAWN	Habtamu Mulatu			metering shaft	addis ababa univeresity instituet of technology school of industrial and mechanica l engineering
APPV'D					
MFG					
Q.A				MATERIAL: plastic	DWG NO. A3
				WEIGHT:	SCALE:1:2

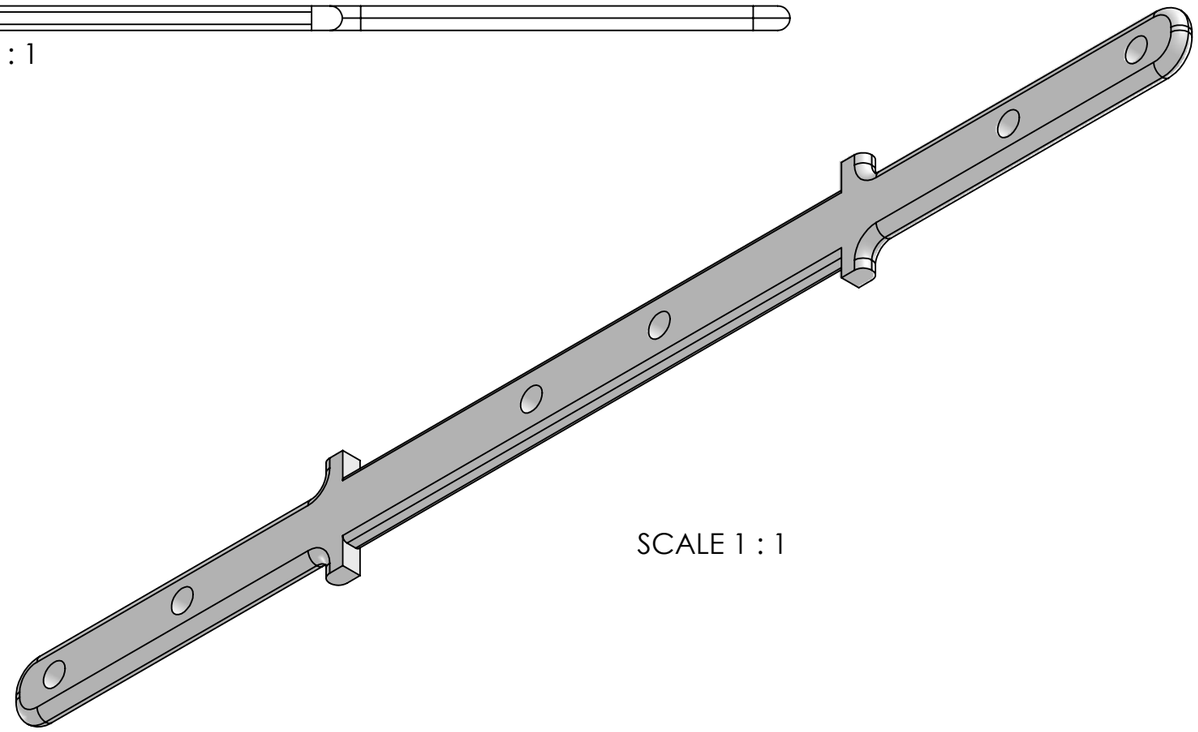


SCALE 1 : 1



SCALE 1 : 1

SCALE 1 : 1

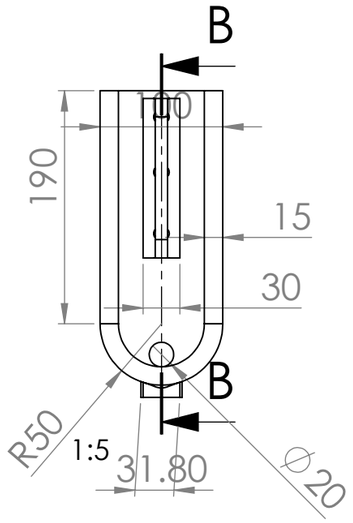


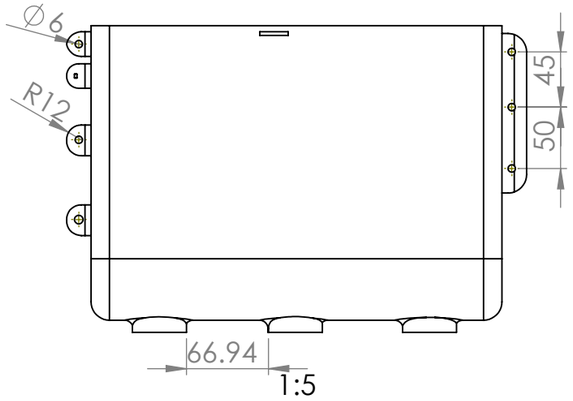
SCALE 1 : 1

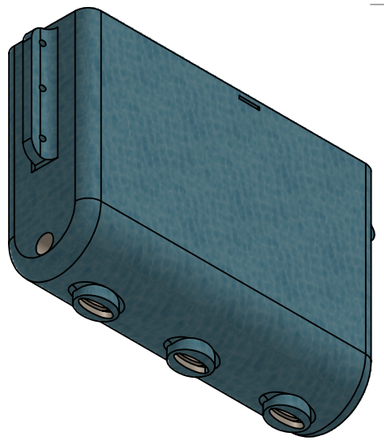
* produce in simple
plastic plate trim

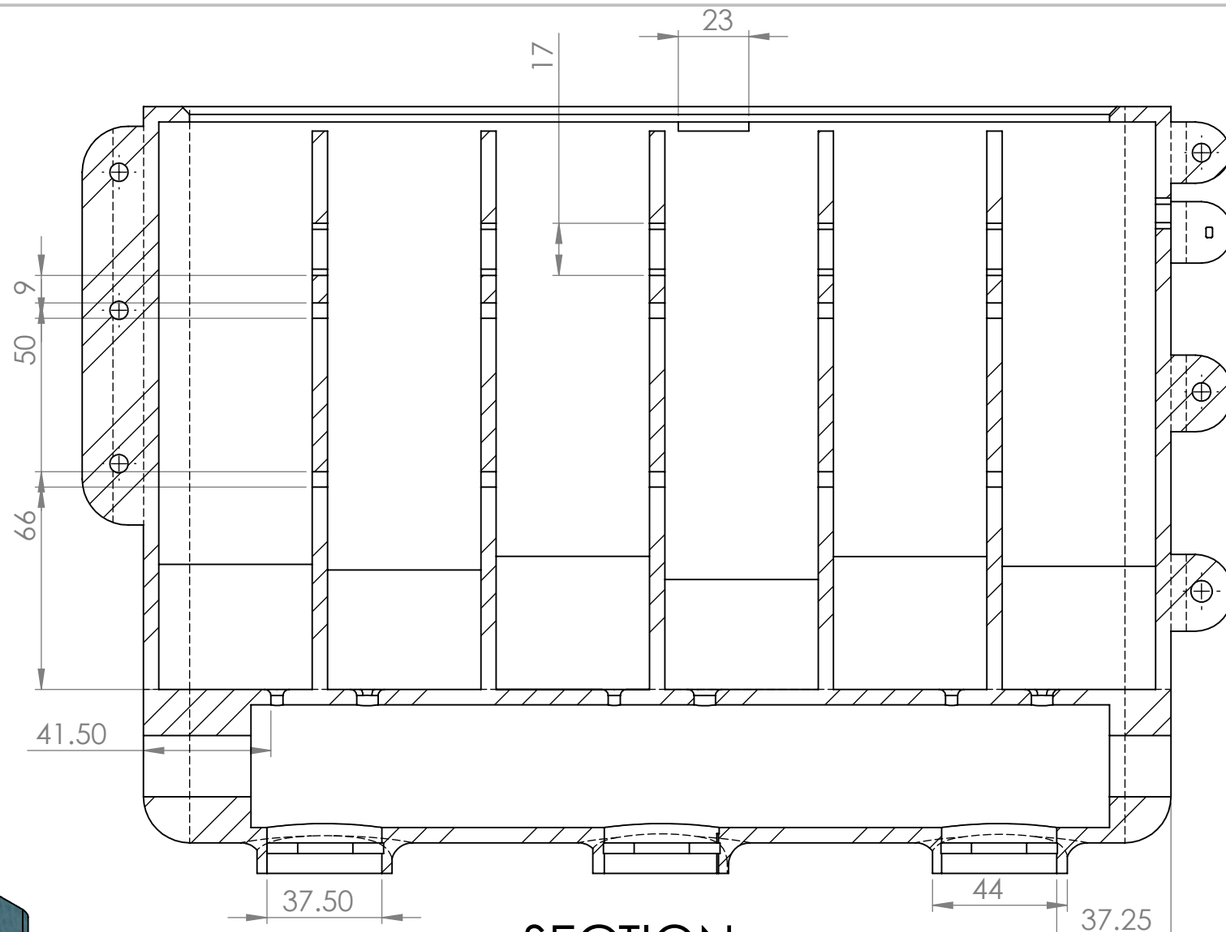
All dimension in mm

	NAME	SIGNATURE	DATE		
DRAWN	habtamu mulatu			agitating frame	addis abeba university institute of technology school of industrial and mechanical engineering
APPV'D					
MFG					
Q.A				MATERIAL: plastic	DWG NO. •• A3
				WEIGHT:	SCALE:1:1 SHEET 1 OF 1



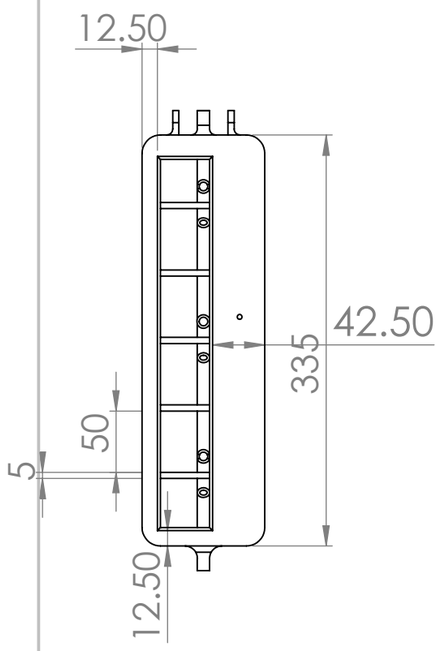






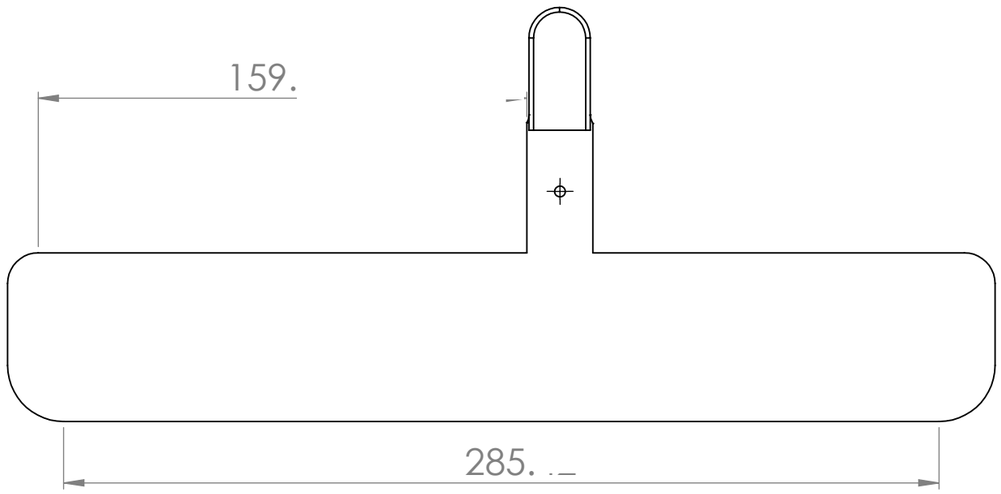
SECTION B-B

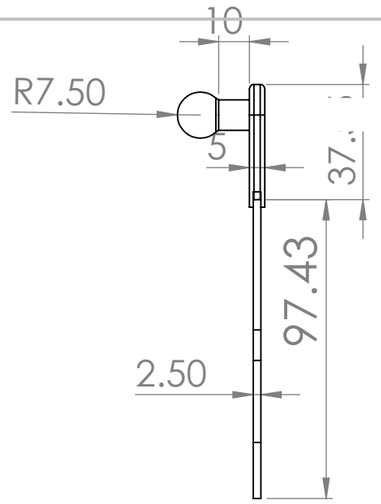
SCALE 1 : 2

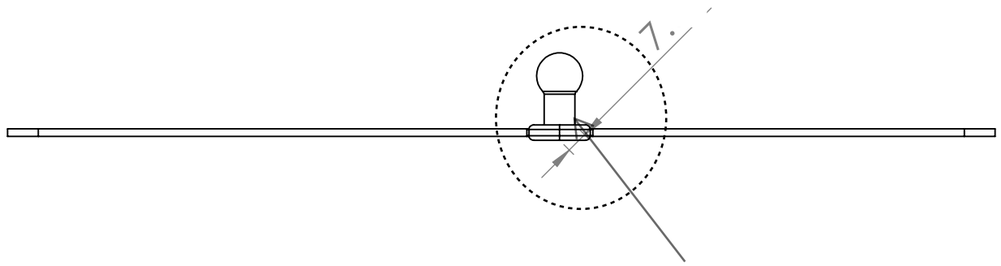


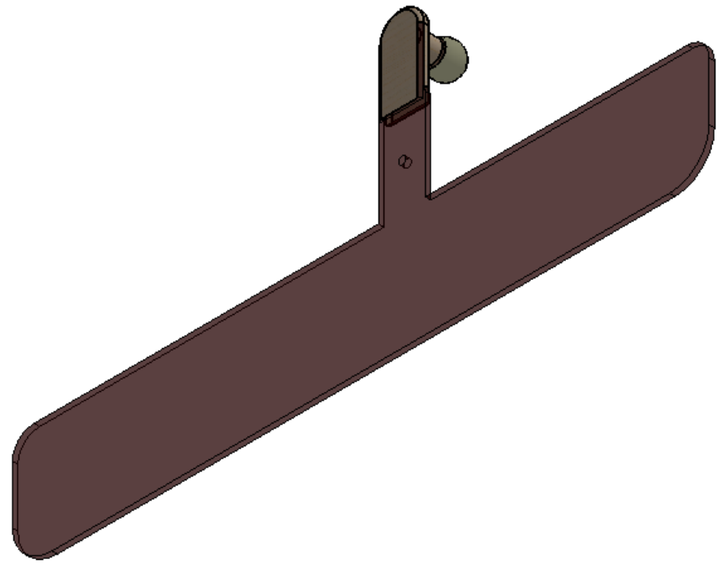
All dimension in mm

	NAME	SIGNATURE	DATE		
DRAWN	habtamu mulatu			hopper	addis ababa university institute of technology school of industrial and mechanical engineering
CHK'D				MATERIAL: plastic ASC	DWG NO. • A3
APPV'D					
MFG					
Q.A				WEIGHT:	SCALE:1:5 SHEET 1 OF 1



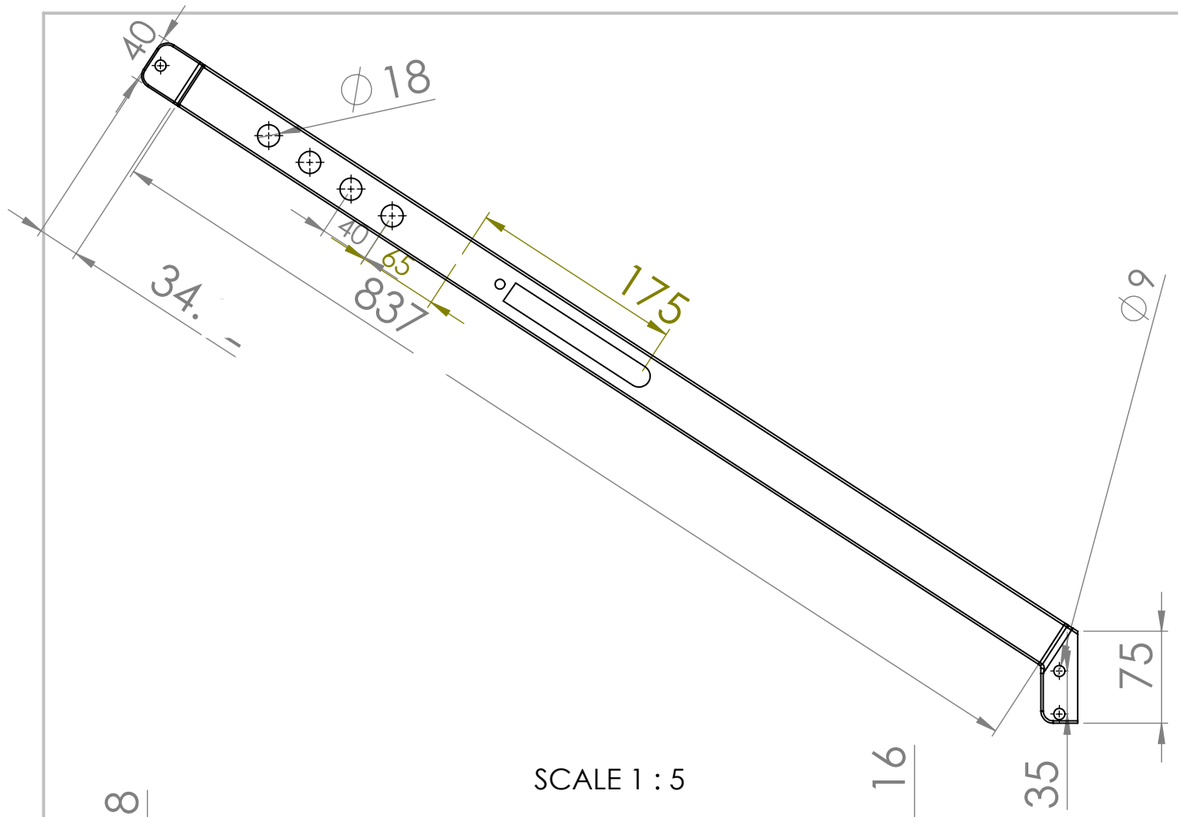






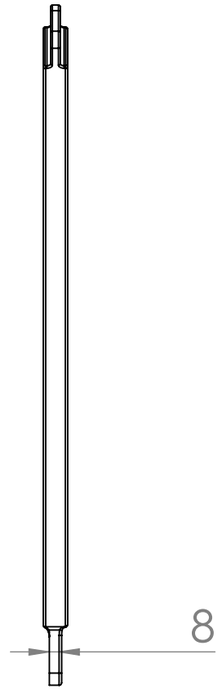
All dimension in mm

	NAME	SIGNATURE	DATE		
DRAWN	habtamu mulatu			hoppr cover	addis ababa university institute of technology school of industrial and mechanical engineering
CHK'D					
APPV'D					
MFG					
Q.A				MATERIAL: transparent plastic	DWG NO. .. A3
				WEIGHT:	SCALE:1:2 SHEET 1 OF 1

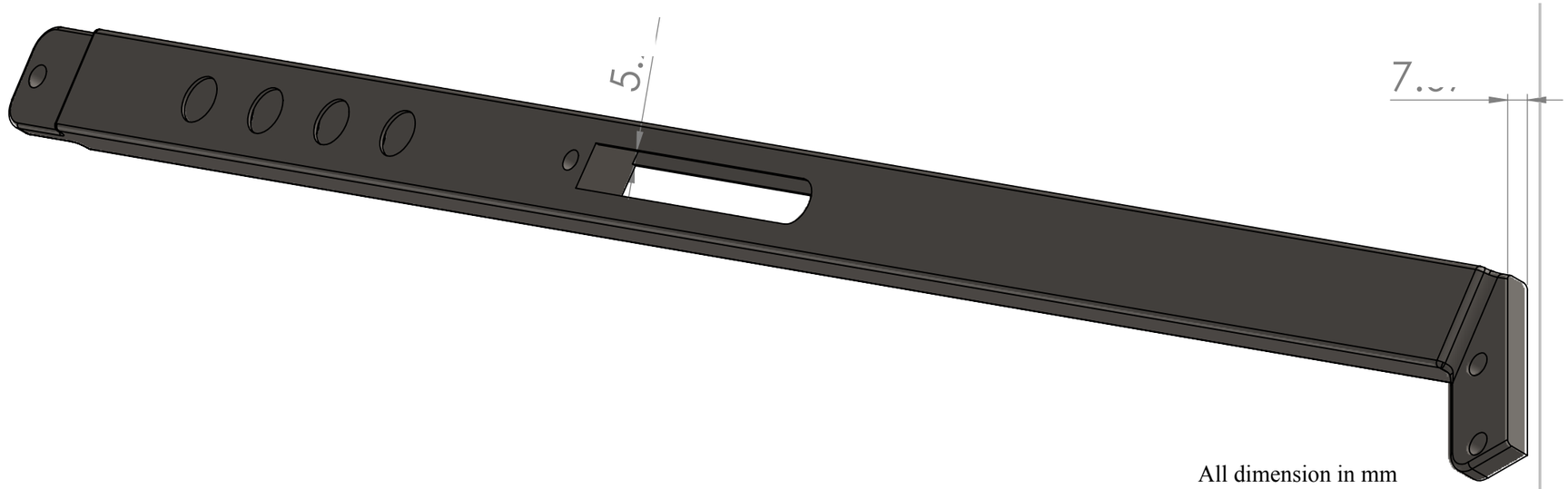


SCALE 1 : 5

SCALE 1 : 5

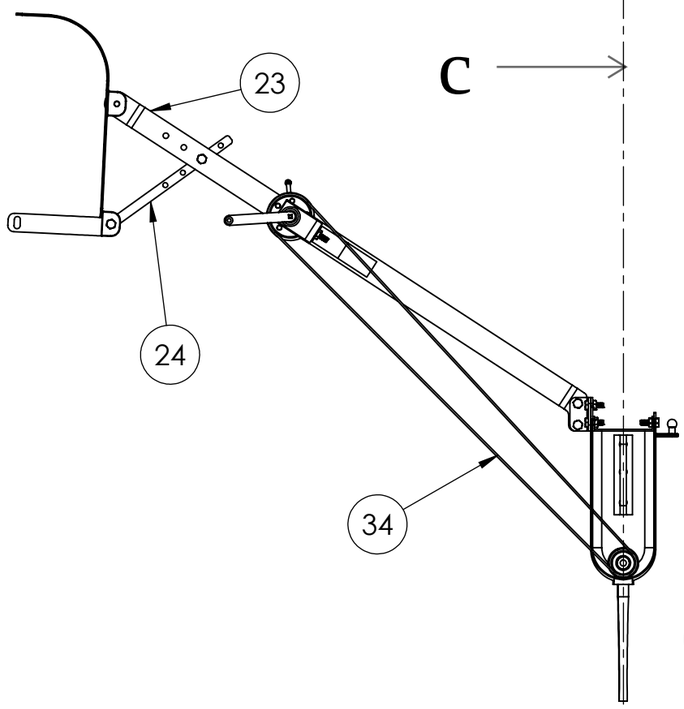


SCALE 1 : 5

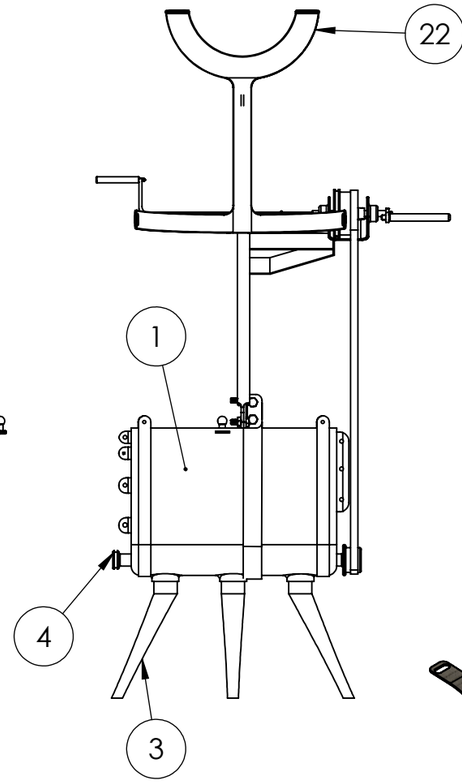


All dimension in mm

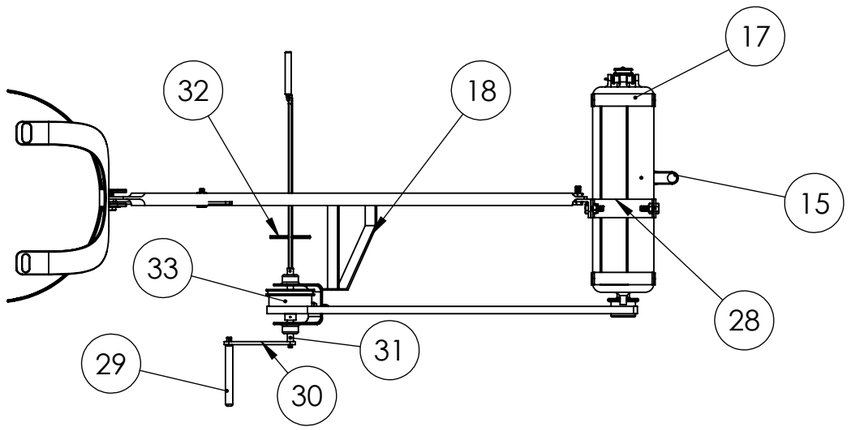
	NAME	SIGNATURE	DATE		
DRAWN	habtamu mulatu			main frame	addis abeba university institute of technology school of industrial and mechanical engineering
APPV'D					
MFG					
Q.A				MATERIAL: structural steel	DWG NO. .. A3
				WEIGHT:	SCALE:1:1 SHEET 1 OF 1



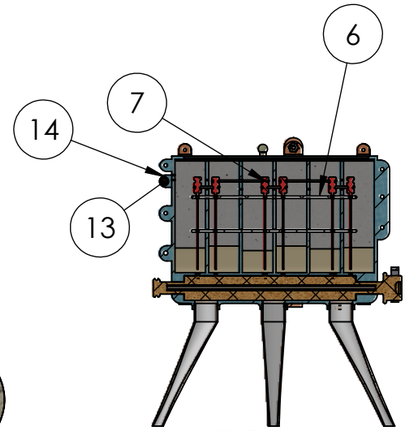
SCALE 1 : 10



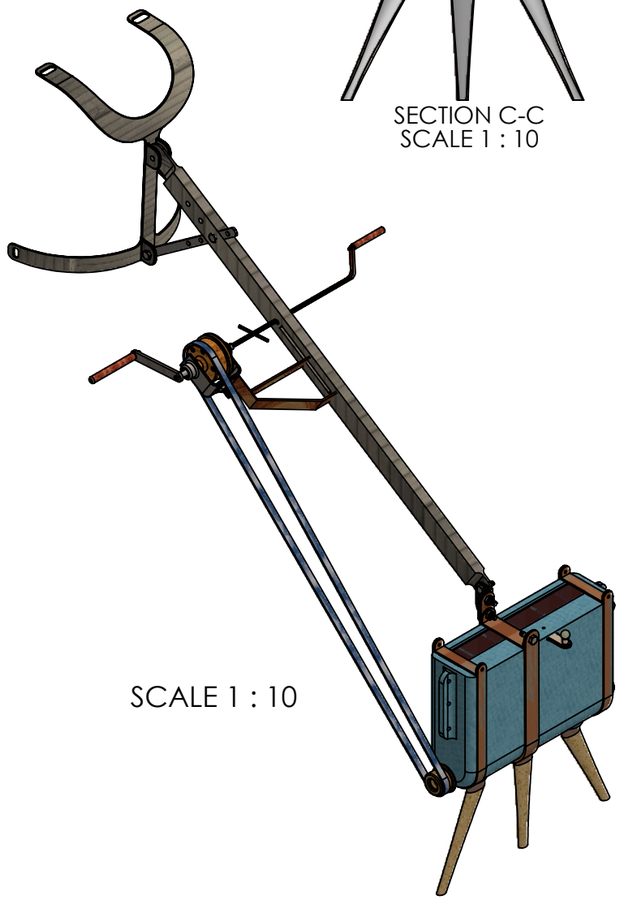
SCALE 1 : 10



SCALE 1 : 10



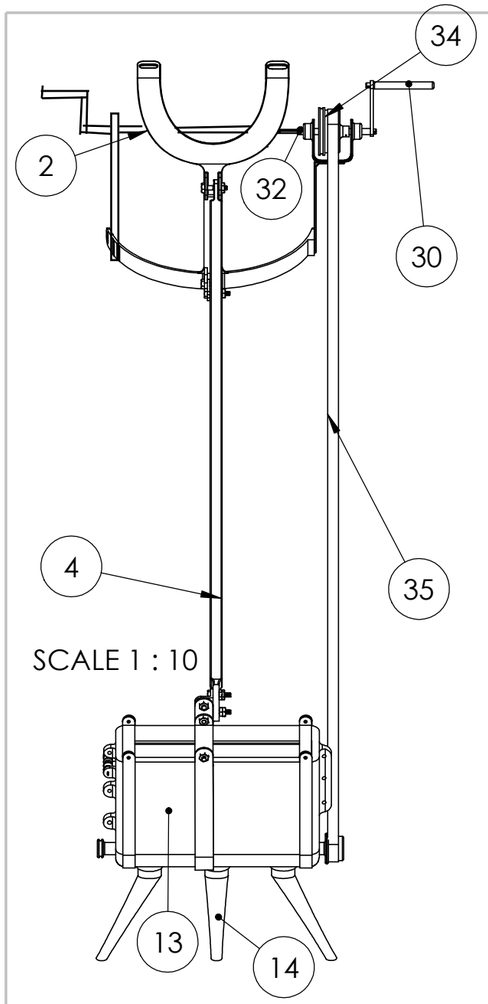
SECTION C-C
SCALE 1 : 10



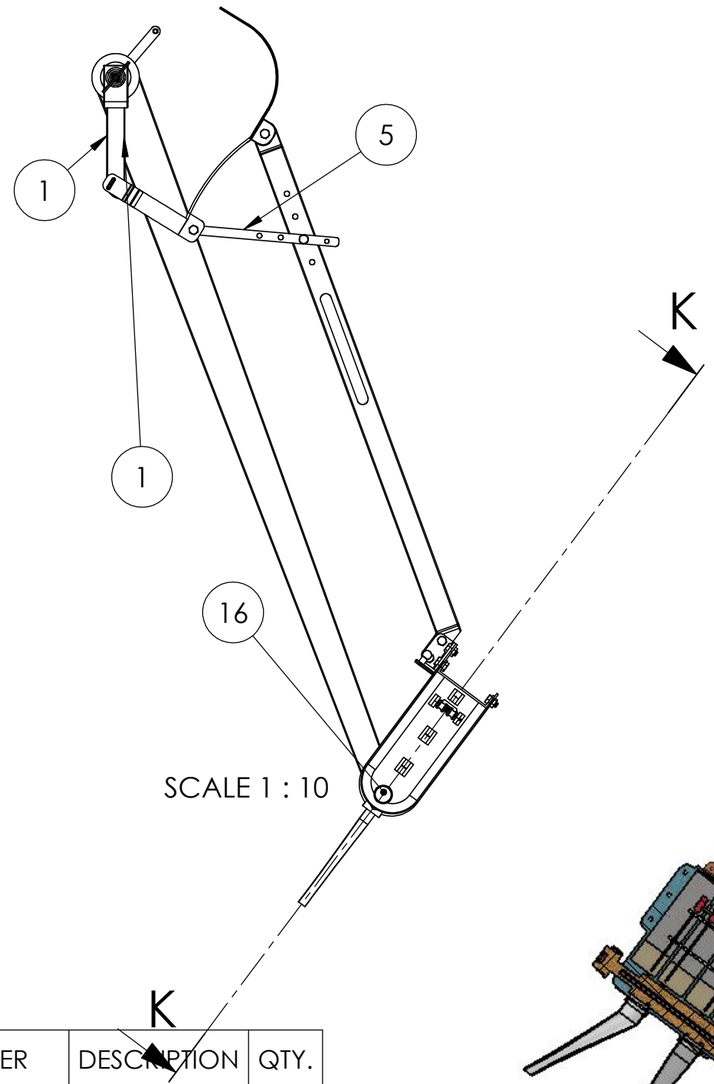
SCALE 1 : 10

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	hopper		1
2	pipe		1
4	metering shaft		1
6	agitating frame		2
7	agitetting pulley		6
13	idler pulley shaft		1
14	idler pulley		2
15	hopper cover		1
16	clamper		2
18	pulley frame		1
22	shoulder support		1
23	main frame		1
24	frame wadge		1
26	Part19 conector1		1
27	hopper supporter		1
29	handle		1
30	liver		1
31	driving shaft		1
32	guiding rope holder		1
33	driving pulley		1
34	Belt		1
35	handle two		1

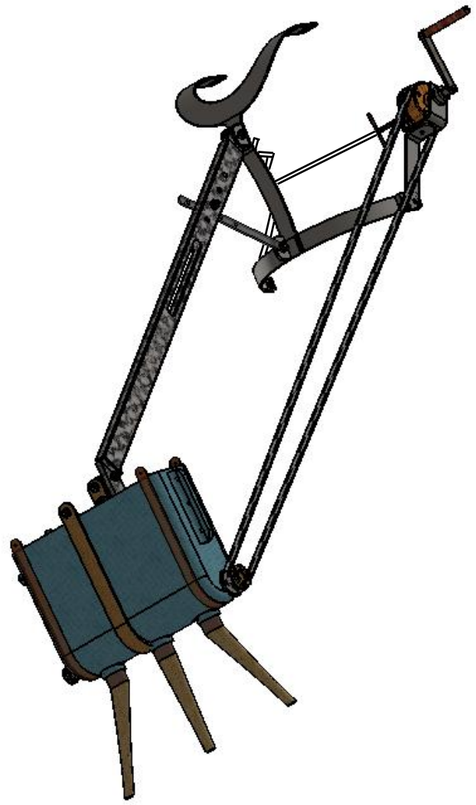
	NAME	SIGNATURE	DATE		
DRAWN	Habtamu mulatu Alemu			MATERIAL:	title: forth driven drill machin Assembly — A3
CHK'D					
APPV'D				WEIGHT:	SCALE:1:10 — SHEET 1 OF 1



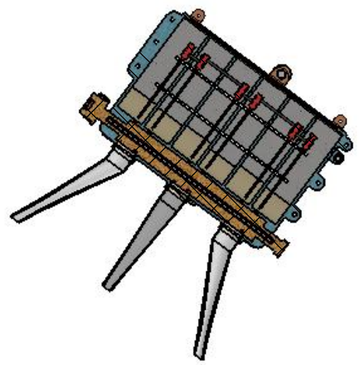
SCALE 1 : 10



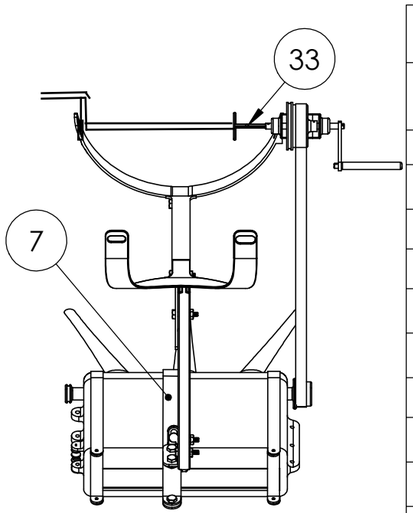
SCALE 1 : 10



SCALE 1 : 10



SECTION K-K
SCALE 1 : 10



SCALE 1 : 10

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	pulley supporter frame		1
2	shoulder frame		1
4	main frame		1
5	frame wadge		1
7	hopper supporter		1
13	hopper		1
14	true pipe		1
16	metering shaft		1
30	handle		1
32	driving shaft		1
33	guiding rope holder		1
34	driving pulley		1

Addis Ababa Univeresity
institute of technology
school of industrial and mechanical Engineering

	NAME	SIGNATURE	DATE
DRAWN	Habtamu mulatu		
CHK'D			
APPV'D			
Q.A			

TITLE: assembling

DWG NO. 28 | A3

SCALE:1:10 | DO NOT SCALE DRAWING