IDC School of Design
अभिकल्प विद्यालय
IIT Bombay

DESIGN PROJECT 2

AGRICULTURAL TOOL REDESIGN, THOOMBA

GUIDE: PROF. P KUMARESAN

DESIGN PROJECT 2 - 17U130007

APPROVAL SHEET

The design project entitled “Agricultural Tool Redesign, Thoomba” by Jake V Abraham, roll no. 17U130007 is approved in partial fulfilment of the requirements for bachelor degree in design.

Project Guide:

Chairperson:

Internal Examiner:

External Examiner:

Date:

Industrial Design Centre, Indian Institute of Technology, Bombay

DECLARATION

I declare that this project report submission contains my own ideas and work, and if any pre-existing idea or work has been included, I have cited the referenced original author(s).

I also declare that I have adhered to all the principles of academic honesty and integrity and have not misinterpreted, fabricated or falsified any idea/data/ fact source in my submission.

I understand that any violation of the above will cause disciplinary action by the institute and can also provoke penal action, from the sources.

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This project was not possible without the support and input from various people.

I use this opportunity to thank Prof. P. Kumaresan for his support and guidance throughout the entire project.

I use this opportunity to thank Fine Tech Engineering and their staff for providing me with insights into the design and for allowing me to fabricate the physical prototype.

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CONTENTS

1. ABSTRACT

A new thoomba was specifically designed to be used for farm work by commonfolk of South India. it comprises of three sections (head, handle and joint) with five pieces of equipment (head, dampener, shaft, grip and joint). This is a redesign project on the traditional thoomba of South India focusing on efficiency, functionality and usability. The new joining method increases ease of maintenance and creates room for modularity. A virtual and physical prototype has been executed, receiving constructive feedback.

2. INTRODUCTION

Growing your own crops is a good action from our part. To do this, you need tools. Tools for planting, maintenance, harvesting and storing it. During one of such a harvest process, I came across a hurdle. We were using long pole sickle to pluck fruits and the home-made tool was not enough as the trees were too tall. Increasing the height meant much heavier weight and that was not a suitable solution.

This led me to want to create a tool for harvesting fruits irrespective of the tree height. When I started researching about this, I came across an entrepreneur who had the same idea as e and created what I had envisioned and made it much better.

This led me to look into other agricultural and farming tools and the **thoomba** (Kerala shovel) caught my eye. We had an assortment of thoombas at my home and nearby houses. All of them happen to be quite old, ranging from 10 to 30 years or older and where usable due to handwork maintenance.

Inspired by the redesigning of the long pole sickle, I decided to redesign the thoomba to make it last longer in better conditions, while improving it.

3. AIM

In this project I aim to redesign the current tool by identifying drawbacks of the current design and make targeted design interventions to improve the tool.

During the course of the project. I will:

- Explore the existing product market
- Research materials and manufacturing
- Identify problems of and caused by the tool
- Create a physical prototype
- Create a software prototype
- Identify scope for future work

4. RESEARCH

4.1. Defining User Profile

People who use thoomba are those who work in the agricultural fields, farms- small, moderate and large scale, family holding fields and farms, construction sites, etc. People who own thoombas are different. They include almost every house hold, irrespective their owning of an agricultural fields.

Construction workers and construction sites are not included as their usage needs are vastly different from farm work. Functions served in a construction are small scale mixing and reallocation of materials.

For the scope of the project, considerations are:

- Age group: 18-65 years
- Gender: Both male and female
- Height: 150-190 cm
- BMI range: 17-29

4.2. Market Study

4.2.1. Existing Products in Market

Local market provides a variety of thoombas, for gardening, farming and construction work, and provides a wide variety of materials and methods for their required specifications, including various weights, materials and measurements.

Heavy slim heads used on semi hard soil. Only used for soil loosening.

Weight: ~1.5-2kg

Wide head, most commonly used. Used for ploughing, material moving, mowing and trench making.

Weight: ~1.4-1.8kg

These heads mostly use a 5 to 5.5 feet long wooden pole as the handle. They have rectangular base that is cut to shape to fit the head and the extra pieces are used as wedges for future tightening.

Weight: ~300-500grams

Currently most available design. Long handle, welded joint, medium width. Can be used for moving material, digging and mowing grass.

Weight: ~1.6-2.3 Kg

Short handled, broad head, used in constructions for moving loose materials. Not suitable for home use.

Weight: ~1-1.4kg

Thin blade used to remove rubbles and lose hard soil. Thicker than normal blade.

Weight: ~1.3-2 kg

Hand held models, short and super easy to handle. Not suitable for land work more for small loose soil plots and pot work.

Weight: ~400-500 grams

4.2.2. Style

The handle is shaped as a cylinder, both for manufacturing ease and ease of gripping. The handle girth ranges between 0.75 to 1.25 inches. Beyond this range, it gets harder for applying pressure of gripping. The length of the handles ranges from 50 cm for short handles and 125cm for long handled models. These also can vary according to the user's comfort and can be adjusted while manufacturing. Hand held models have a max length of 50 cm and can go down to 10 cm, the smaller versions are called ‘kuttithoomba (baby shovel) and are only used as kids’ toys.

The heads are shaped as a trapezium, with the longer edge as blade and the shorter edge for jointry, or vice versa. The jointry side usually features curved vertices ranging from 5 to 7cm radius depending on the size. They rarely come without the curved vertices. The blade vertices are also curved, but they have radii between .5 to 2 cm. The head size varies from 25X30cm to 40X45cm with respect to manufacturers and customer demands.

The heads are not flat and are curved inwards. There is a sharper curve between the line of rest and joint, as compared to line of rest and blade. Some models come with grooves from the jointry till the line of rest for mechanical support.

4.2.3. Materials and Manufacturing

Traditional handles are made of maruth wood, while any wood can be used for it. A rectangular piece of wood is cut to shape and smoothened to shape using a planer and chisel. With the advancement of technology, this can be easily be done in machines. Palm wood is another commonly used piece for the handle, but they damage the palm as splinters. Bamboo wood is the most suitable material for using wedges. The handle pole is slid into the joint hole and wedges are hammered from either or both sides to tighten.

The more recent handles (from around 30 years or so) galvanised iron pipes are also used. The metal pipes are welded to fit, but sometimes, the handle diameter will be much shorter than the hole diameter. A smaller piece of pipe is soldered into the socket in such cases and the pipe is welded to this. The most recent models (from around 5 years) have started to use PVC pipes and use nuts and bolts to fix it to the head.

The head is made of cast iron and steel. They are forged in moulds. The blade is then hammered into shape and tempered for hardness. The blade is not sharpened but only hammered to prevent deformation and damage. Lately hard plastic heads are used, but they tend to wear out much faster than their metal counterparts. The hard plastic heads are blow moulded and compressed to shape. This gives more structural support compared to single moulding.

4.2.4. Uses

Thoombas are used for a wide variety of purposes. Their primary uses in farms comprise:

- Digging
- lifting
- Material moving
    - Dirt and soil
    - Crops
    - Fertilizers
- Harvesting root crops
- Uprooting trees and stumps

Their secondary uses comprise:

- Clearing dirt from footwear
- Act as
    - Hard base
    - Hammer
    - Lever
    - Weight
    - Weapon (situations arise for this purpose against pests)

4.3. Insights and Analysis

- Broader heads are thinner, while slimmer heads are thicker.
- Anything lighter than 1 kg does not apply adequate force.
- Anything heavier than 3 kg gets harder to handle.
- The use of thoomba requires a small amount of bending down for comfort.
- Shorter handles require bending down beyond a limit and can cause back injury in the long run.
- Longer handles get harder to handle.
- Broader heads are used for moving materials and not great for loosening.
- Slimmer heads are used for rubble clearing and loosening hard soil, but they are not great for moving soil.
- Right angle joint is bad as the center of balance is closer to the edge and it can cause the thoomba to fall over.
- Flat head does not provide support while resting and can break easily.

4.4. Problems Identified

- Requires additional tools for loosening hard soil.
- Wooden handles come off after a time, increasing need for maintenance.
- Metal handles tend to bend and cause a change in way of gripping.
- Increased duration of bending down causes back pain and leads to back injury in the long run.
- Having to apply more force leads to muscle pain in one’s arms.
- Corrosion of head leads to curving of blade on impact. This leads to unwanted leaning and leads to injury.
- Long time use increases injury to palms.

5. DESIGN

5.1. Final Design Brief

To redesign THOOMBA, the most common agricultural tool of South India for lower- and middle-class family for use in family smallholder farms.

5.2. Scope of Project

The final scope of the project includes:

- Ideation and conceptualization
- Software prototype modeling
- Physical prototype modeling
- User testing
- Identifying scope for future

The scope of the design includes:

- Optimizing weight distribution
- Improve ease of use
- Improve durability
- Increasing functionality
- Increasing efficiency
- Increasing ease of maintenance
- Reducing cause for maintenance

5.3. Design Ideations

5.3.1. Inspirations

Ice axes have an **adze** behind the blades that can be used as a hammer and a lever to apply pressure. They have **serrated and pointy edges** to help dig easier into ice.

Nylon and cloth grips **reduce the shock** on receiving an impact.

Screws are used to **tighten** pieces together. They are **easy to remove** as well.

Motherboards use of **clamp holds** to secure the RAM.

Excavators use **high pressure** to dig through the soil.

They also have **broad heads** and **bucket shape** that help in carring a lot of material.

Katanas and swords have **extremely sharp edges** that helps in cutting.

They are also **durable** due to their making.

Pick axes use **pointy edge** to dig into hard soil.

Spanners have **forged shafts** that does not buckle under heavy load.

Perpendicular shape of the I beam provide immense structural stability.

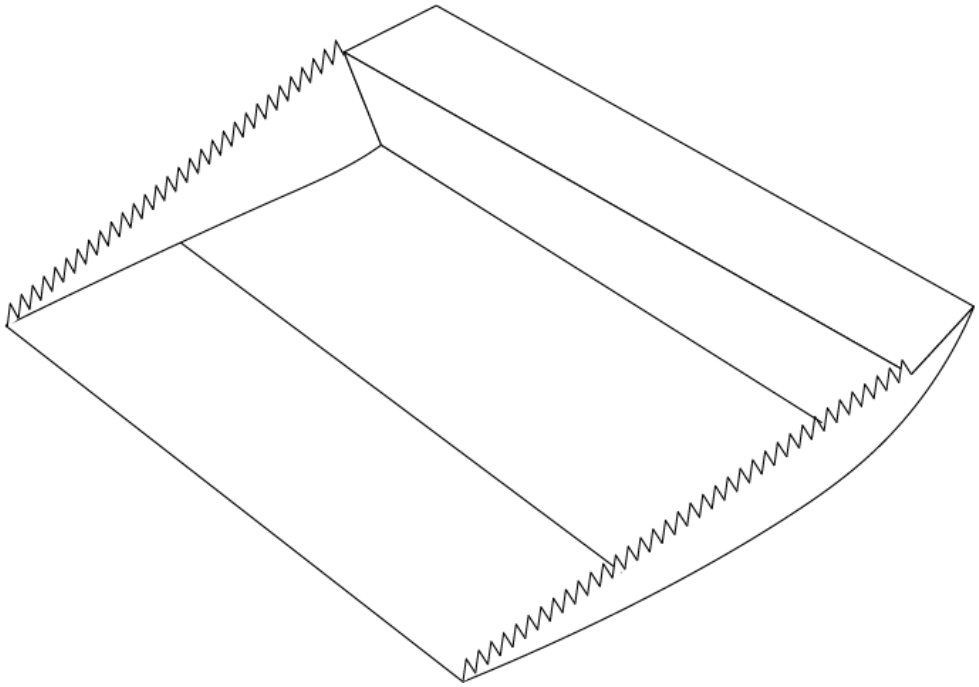
Rubber dampeners **reduce vibrations** received from impact.

5.4. Concept Generation

5.4.1. Head

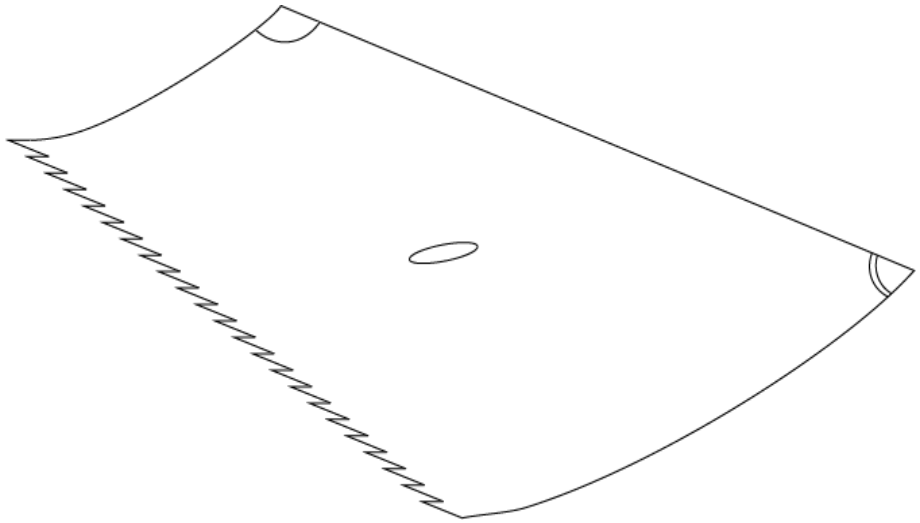
Concept 1

- Basin shape to carry more material
- Serrated edges for grass cutting
- Have back plate for applying extra force



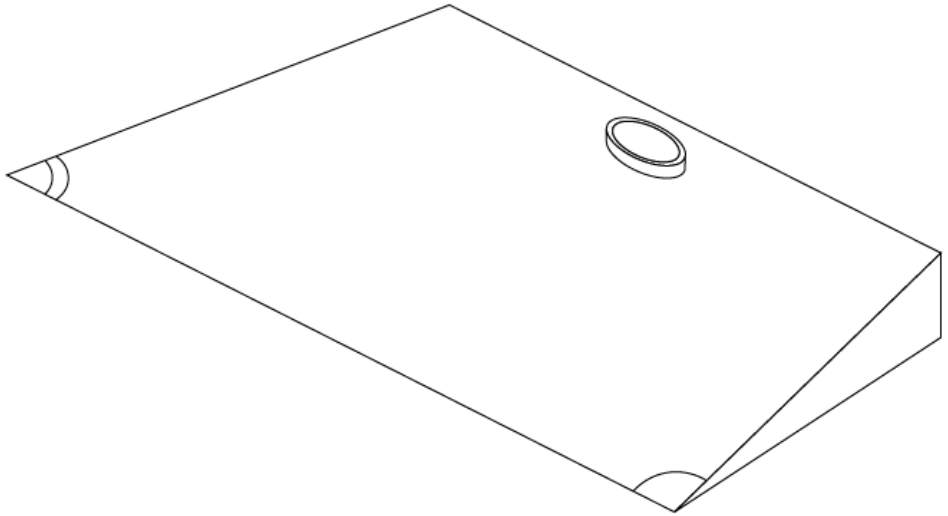
Concept 2

- Serrated edges for grass mowing
- Dual angle edges for different type of digs
- Dual length sides from joint for easier deeper digging and large material moving.



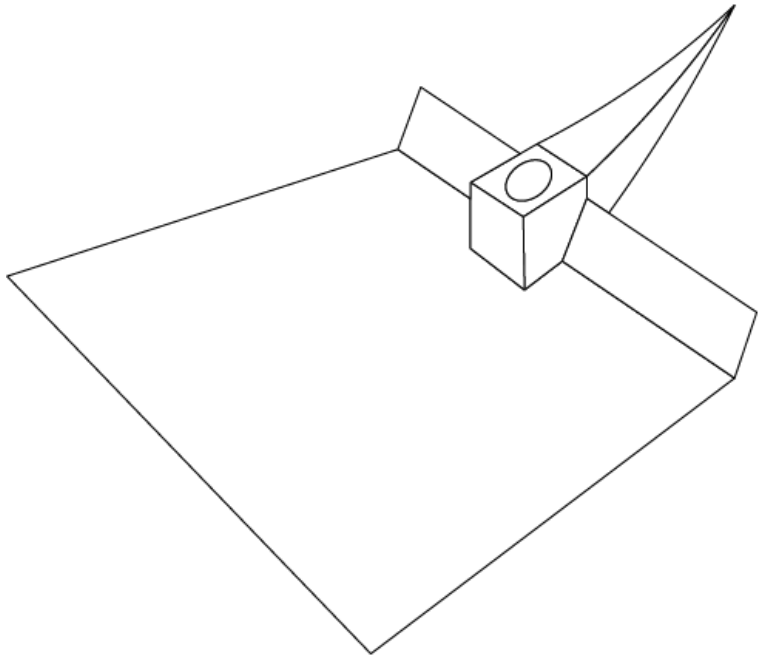
Concept 3

- Heavy head that increases digging efficiency.
- Dual angle blade for different typed of digging.
- Strong back end that can be used as hammer.
- Strong back edge can be used as support.
- Ambidextrous, slide the handle in both directions for ambidextrosity.



Concept 4

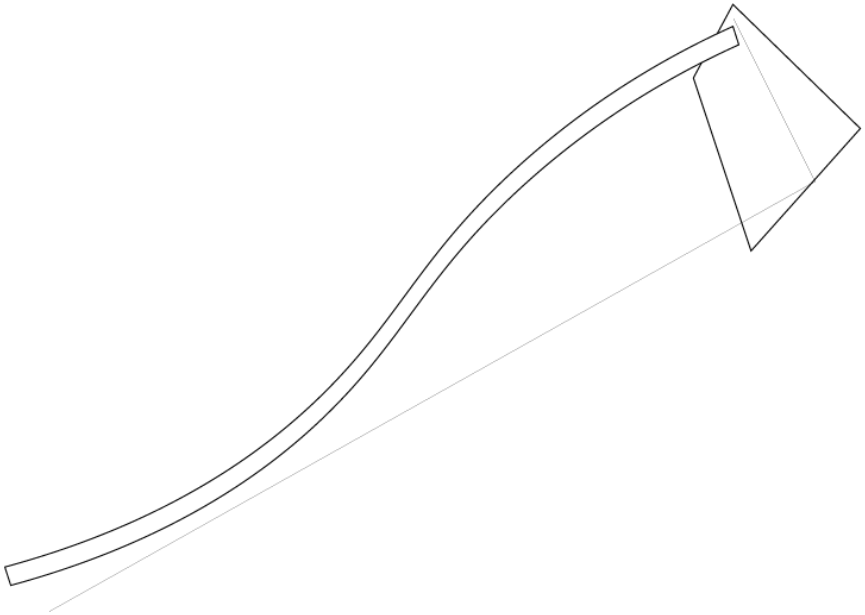
- Adze and back support for extra pressure applying.
- Adze can be used to break hard soil.
- Back support can help increase material carrying.
- Can be used as a hammer.



5.4.2. Handle

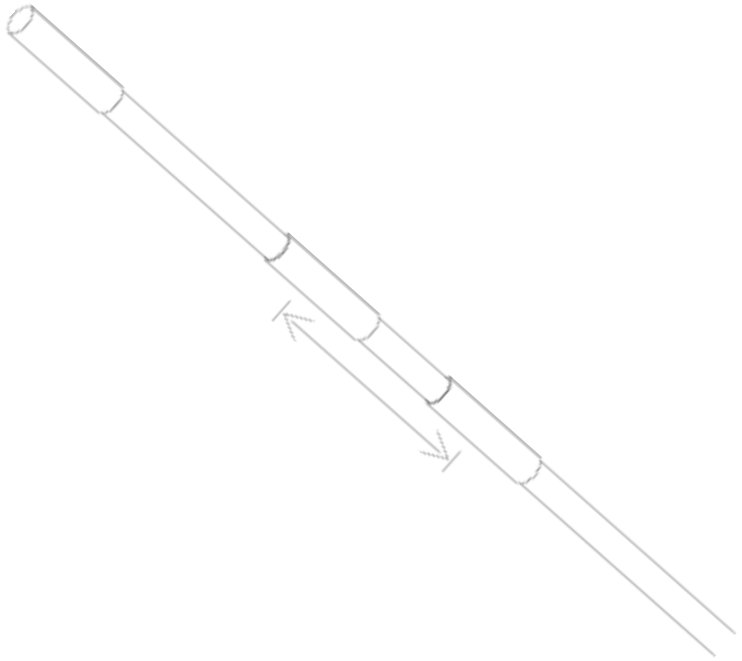
Concept 1

- Curved ergonomic design.
- Increases force delivered.



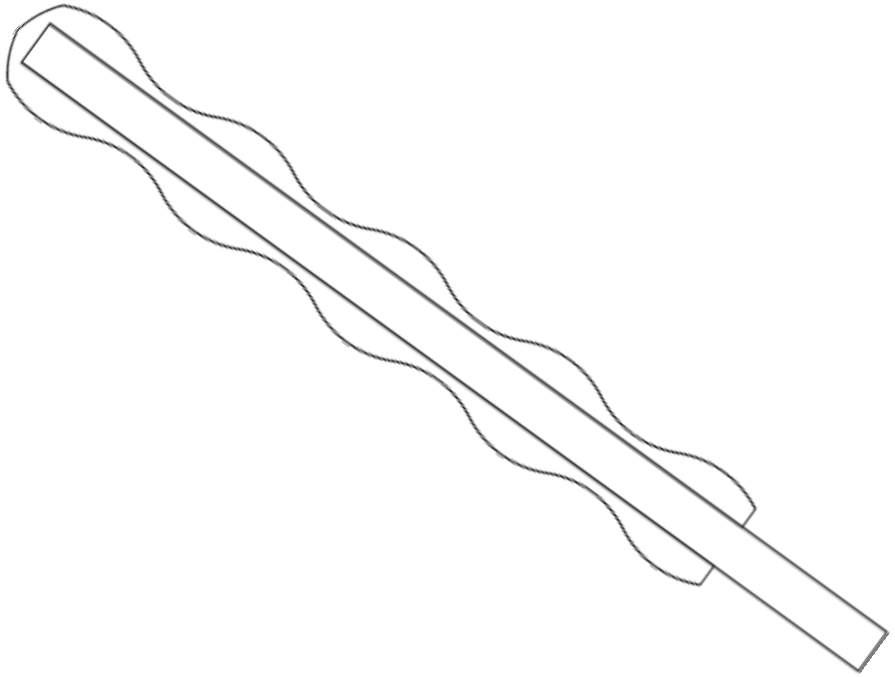
Concept 2

- Grip is included to reduce reactive impulse.
- Low Material usage.
- Sliding grip that moves with the fore arm of the user.



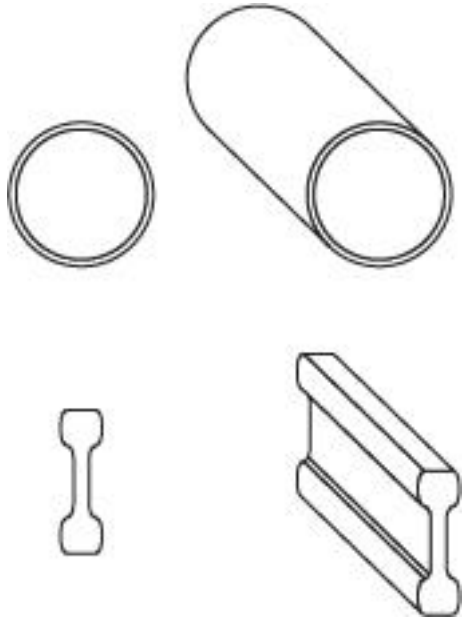
Concept 3

- Single sheet grip.
- No moving parts.
- Easy to use.
- Wavy nature provides improved grip.



Concept 4

- Concept for the shape of the shaft.
- Increase rigidity.
- Reduce chance for deformation.



5.5. Concept Evaluation

5.5.1. Critical Analysis

Head

	Concept 1	*Concept 2*	*Concept 3*	*Concept 4*
Weight	High	Low	High	Moderate
Ease of digging	Low	High	High	High
Ease of grass mowing	Moderate	High	low	Moderate
Ease of carrying	High	Moderate	Low	Moderate
Ease of lifting	High	Low	Low	High
Ease of throwing	Low	High	Low	High
Ease of handling	Moderate	Low	Moderate	High
Chance of injury from handling	High	High	Moderate	Low
Chance of injury from contact	High	High	Low	Low
Ease of maintenance	Low	Low	High	High
Cause for damage	High	High	Low	Low

Handle

	Concept 1	*Concept 2*	*Concept 3*
Ease of handling	Low	Moderate	High
Cause for maintenance	Moderate	High	Low
Ease of maintenance	Low	Low	High
Grip providing	Moderate	High	High
Efficiency	High	Moderate	Moderate
Ease of manufacturing	Low	Moderate	High

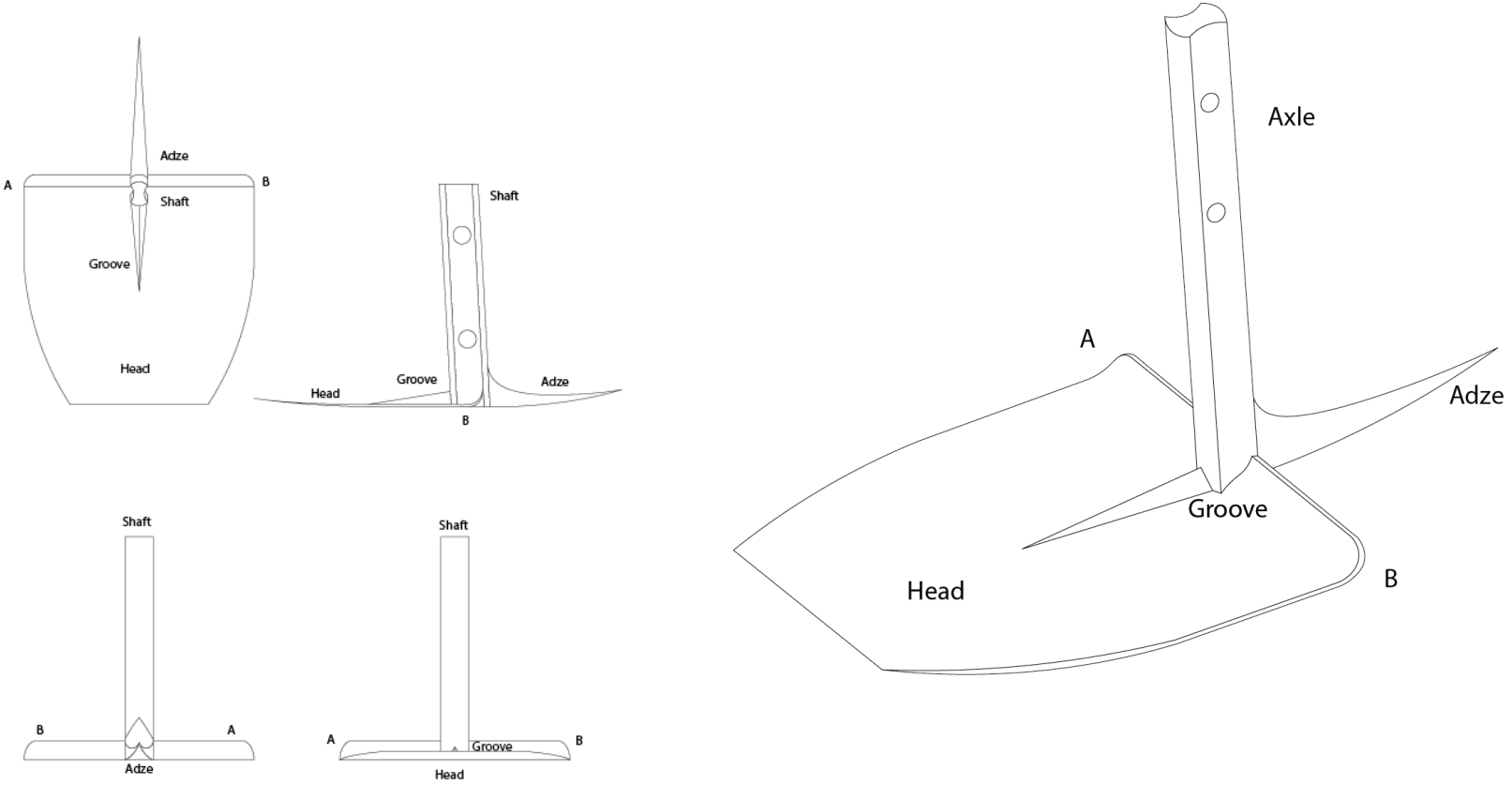
5.5.2. Concept Finalization

For head design, Concept 4 was taken as the most optimal design. It provided most safe usage, low maintenance need and high usability and efficiency. Features from other concepts where added.

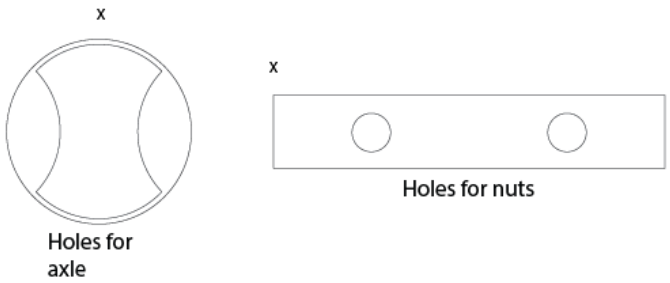
For handle design, concept 3 was taken as it provided least reason for maintenance and least manufacturing needs. Concept 4 was a structural design and a combination of concept 3 and concept 4 was chosen to be used.

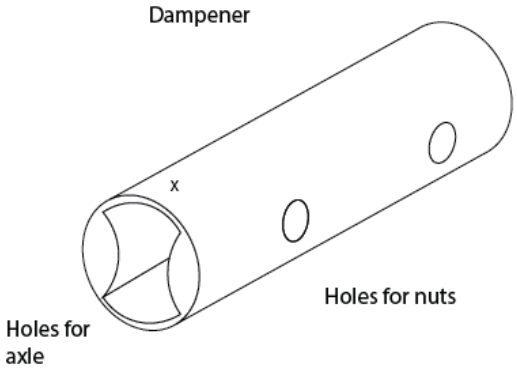
5.6. Final Design

5.6.1. Design Details

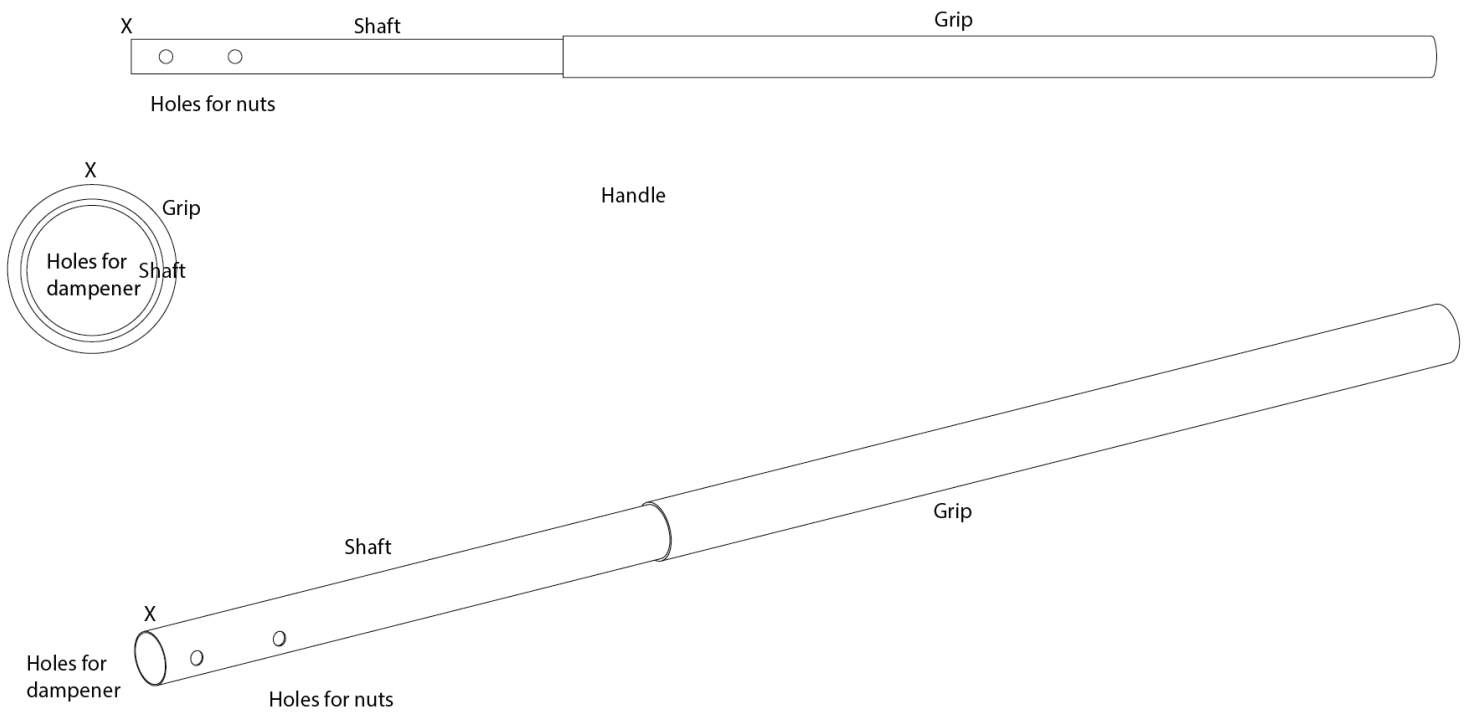


Head sketches



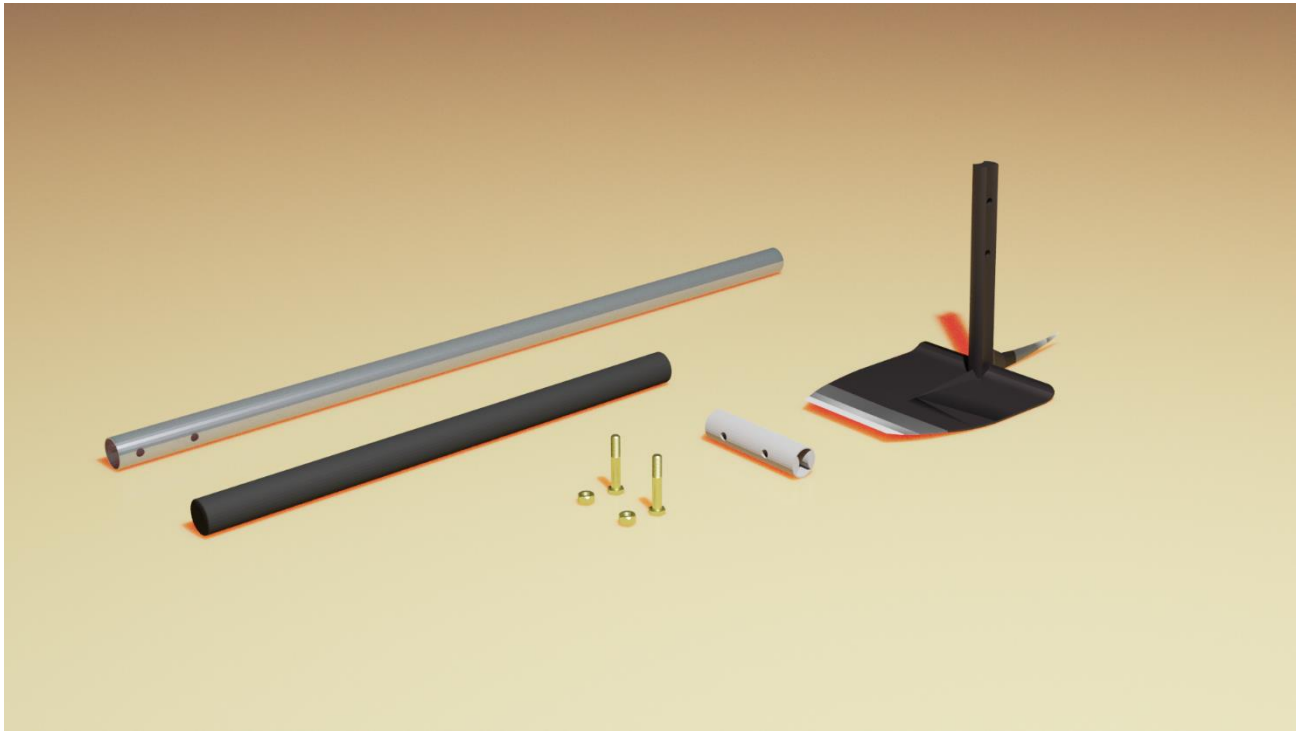


Dampener sketches

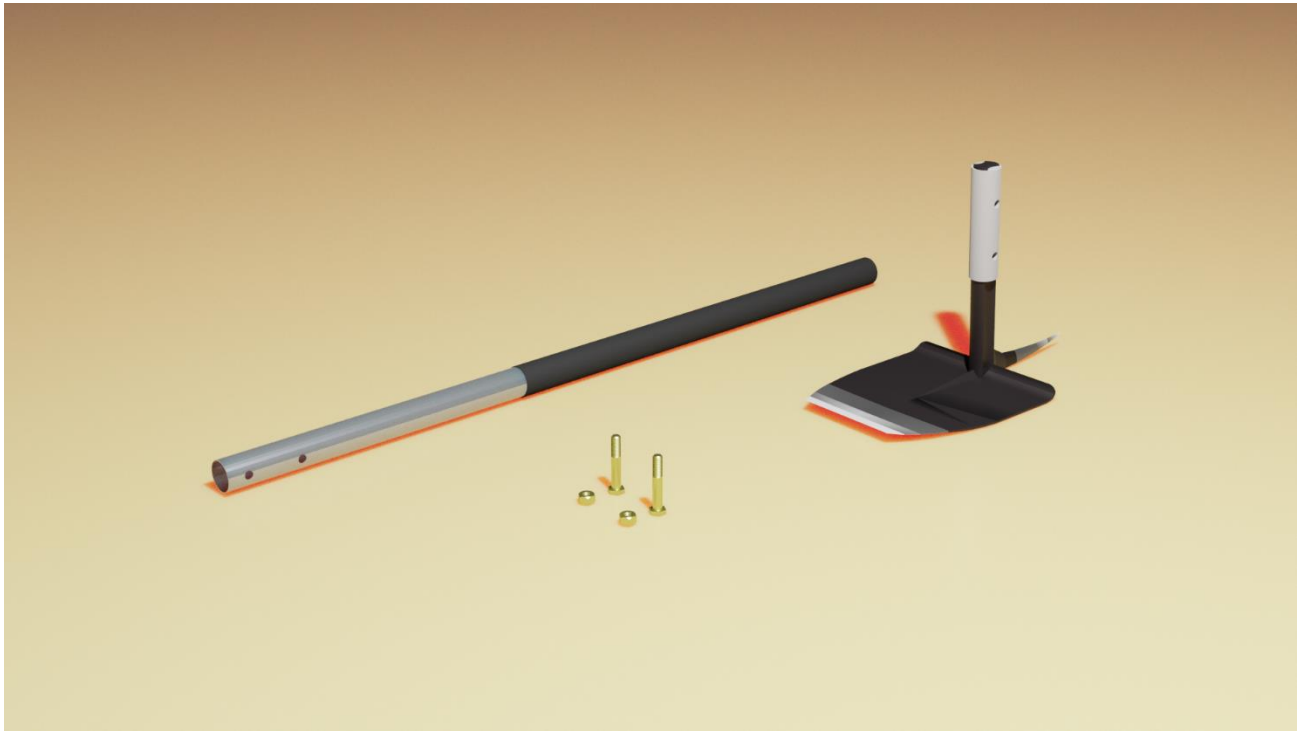


Handle sketches

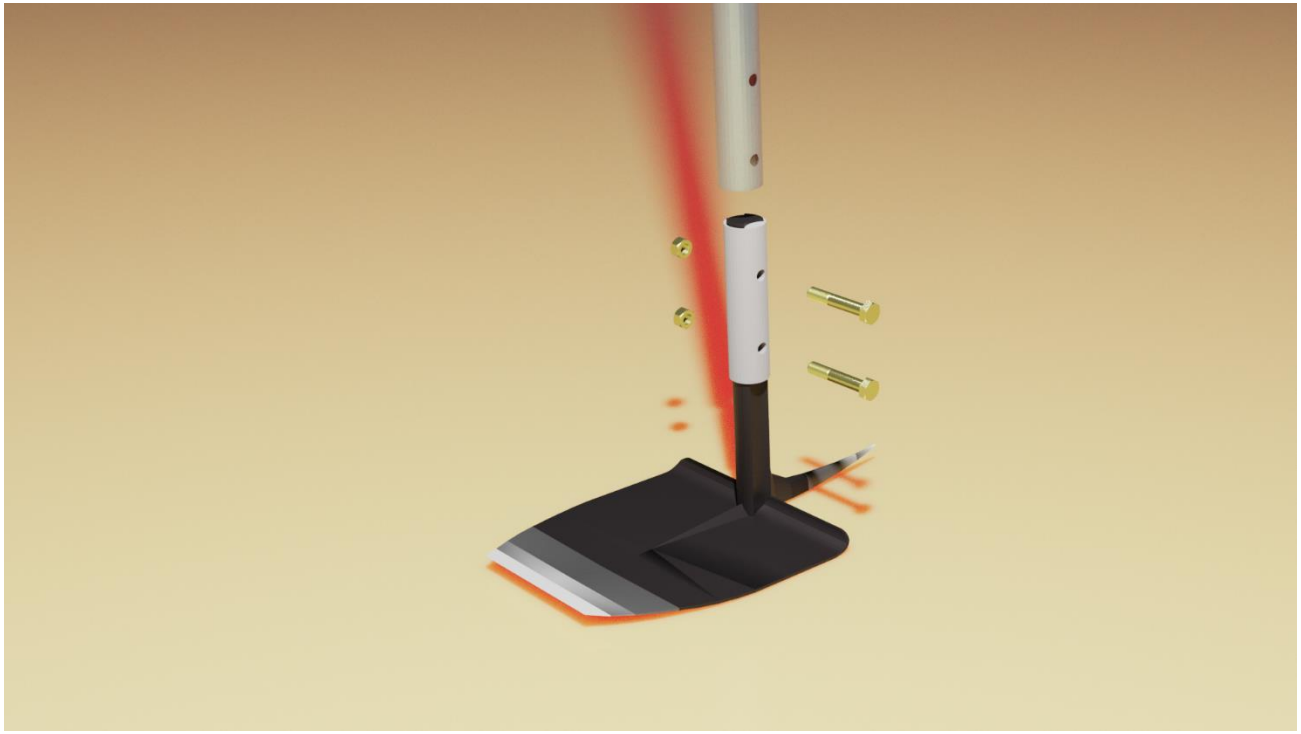
5.6.2. 3D Model



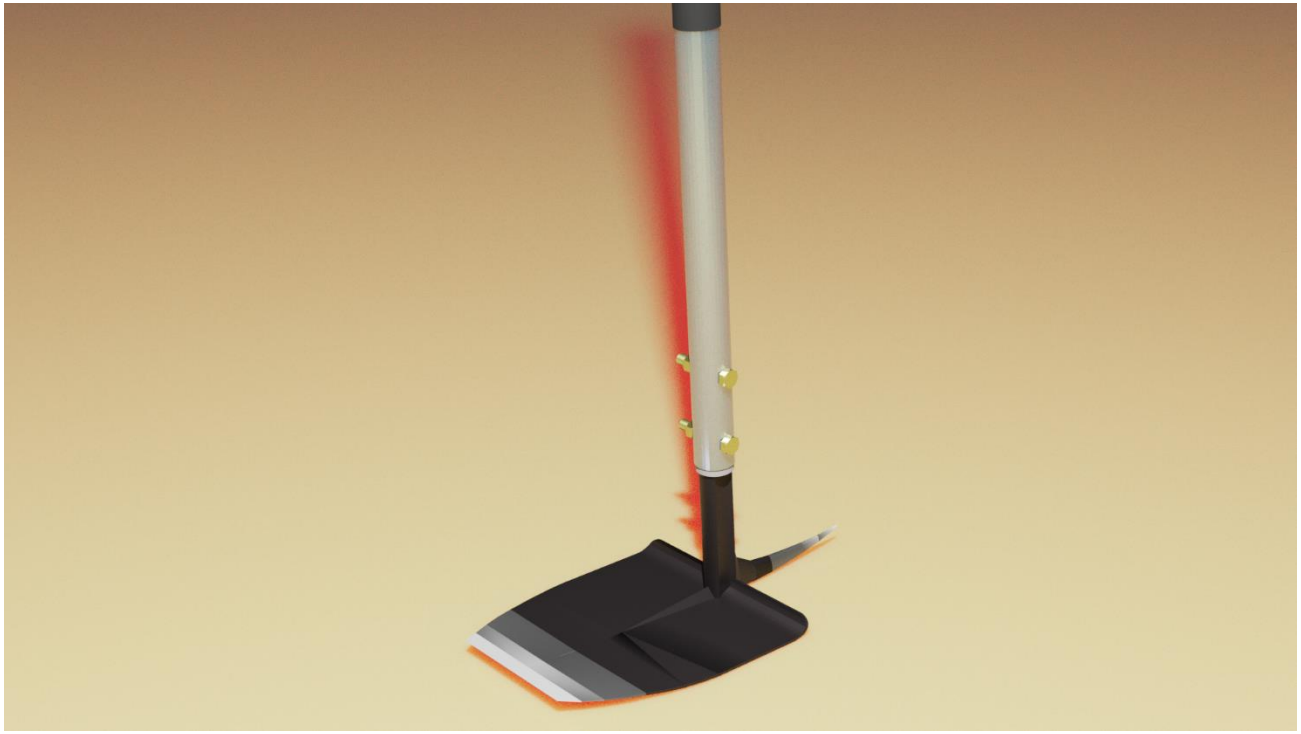
Parts



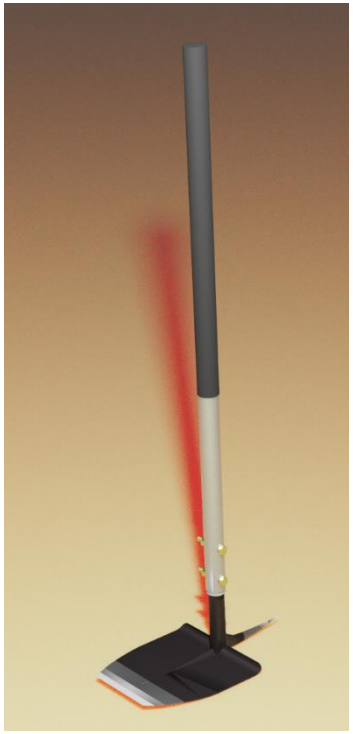
Assembly 1

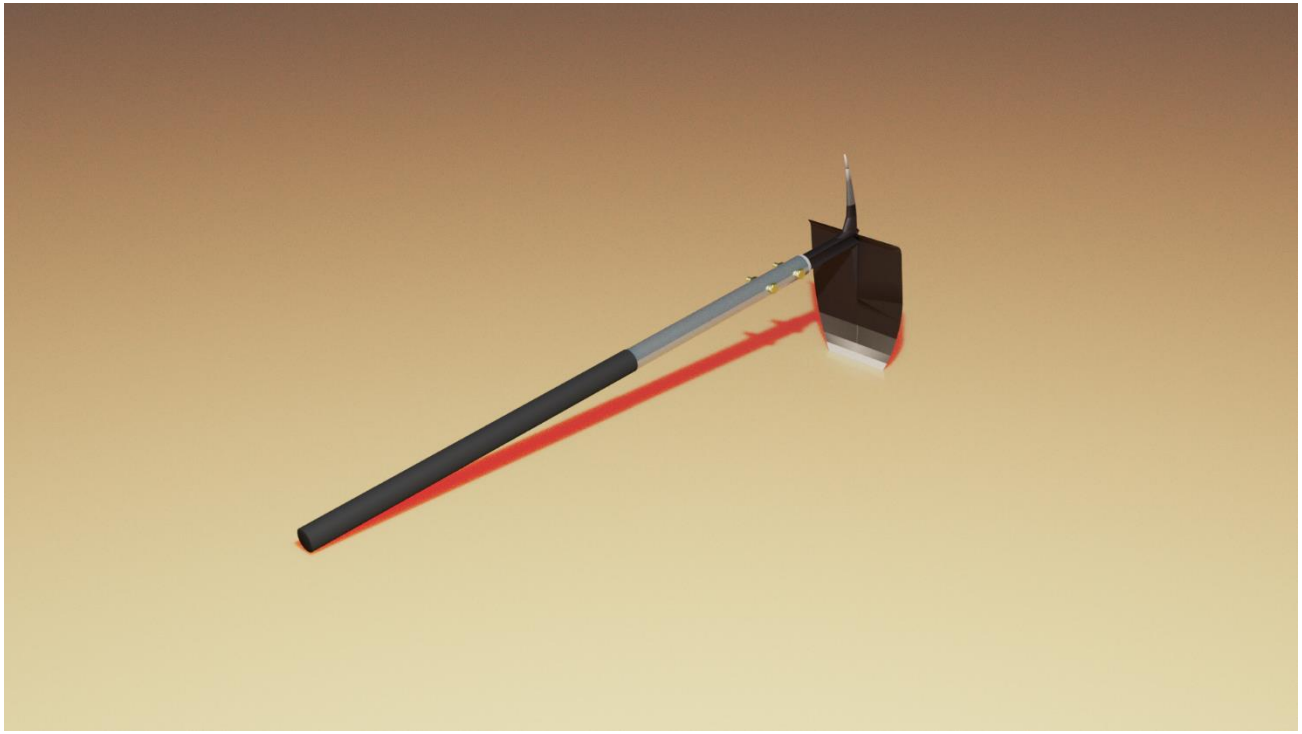


Assembly 2



Assembled head





Fully assembled views

5.6.3. Physical Prototype

For making the physical prototype, I went to Fine Tech Enigineering Fabricators in Odakkali, Kerala.

After consulting with the proprietor and workers, I started working on the prototype. A premanufactured head was bought and cut into shape. Tempering of the freshly cut head would be later done at a blacksmith. A 1 inch pipe of length10 inches was welded to the head joint to simulate the axle. An 8 inch tempered rod was welded to the back of the head for the adze.

The handle was made by welding a 0.75 inch pipe of length 8 inches inside a 1 inch 1meter long pipe. The 0.75 inch pipe was inserted 4 inches into the handle pipe. A 1 inch wide rubber tubing was inserted to both ends of the handle, as dampner and grip.

The handle was inserted into the head and 2 10mm holes where drilled into them with a spacing of 2 inches. These holes use 10mm nuts and bolts to secure both components together.

Rubber tubings were used as grip and dampner. Long grip tube was inserted with the help of motor oil while the dampener tube was secured ith quick fix.

The physical prototype is 130 cm in height. Base dimensions are 50.8x25.4 square cm or 20x10 square inches and weighs 3.5kg.

The head piece dimensions are 50.8x25.4x30.48cm cube or 20x10x11 cube inches and weighs 3kg.

Various stages and parts of physical prototype

Fully assembled physical prototype

5.6.4. User feedback

The prototype thoomba was user tested by people of age group 40-65 for various activities.

User using adze to break soil

User using blade head to scoop in soil

User feedback received:

- Long handle reduces the need to bend. This help reduce stress on the back.
- Prescence of adze helps in breaking the hard soil.
- The head heavy design makes it easier to dig.
- Lack of pointy vertices on the blade makes it hard for some people to cut small portions of soil, especially for people who have wrist issues.
- The long and heavy design makes it a tad more difficult to handle during transportation.
- The head heavy makes it more difficult to lift and thrown soil for shorter and older people.

Creative insights from user feedback:

- Although creating a head heavy design make it more efficient, further optimisation is needed compared to the prototype.
- Increase the length of the grip covering the shaft.
- Further optimise the handle length.

5.6.5. Material Consideration

Ideal materials

Shaft: Carbon Fiber Composite

Properties:

- Light weight
- High tensile strength
- Flexible
- Does not break and returns to shape on removing stress

Grip: Synthetic Leather

Properties:

- Soft and breathable
- Lightweight and comfortable
- Provides superior dexterity and grip in wet, dry and oily conditions

Feasible materials

Shaft: lightweight Galvanized Iron

Properties:

- Light weight
- High tensile strength
- Not flexible
- Retains shape hen force exceeds a particular limit

Grip: Rubber

Properties:

- Soft
- Lightweight and comfortable
- Provides superior dexterity and grip in wet and dry conditions

Ideal materials

Dampener: Sorbothane

Properties:

- Measured in Shore 00 scale
- Absorbs 97% shock on impulse
- Extremely lightweight

Head: Tempered Carbon Steel

Properties:

- Extremely hard and durable
- Can be sharpened by sanding to extreme lengths
- Low wear and tear
- Cannot be tempered after sharpening

Feasible material

Dampener: Silicon Rubber

Properties:

- Measured in Shore A scale
- Absorbs 70-80% shock on impulse
- Lightweight

Head: Tempered Cast Iron

Properties:

- Extremely hard and durable
- Can be sharpened by hammering
- Detectable wear and tear
- Can be tempered after sharpening

Other materials considered include:

- Stainless steel, galvanized steel and black iron for shaft.
- Nitrile, silicone, nylon straps and soft rubber for grip.
- PU, rubber, soft rubber, sponge and slime for dampener.
- Tungsten, carborundum, sheet steel and hard plastic for head.

6. CONCLUSION

The goal of the project was to improve farming tools used in South India. A lot of products were researched, both within the field of project and outside, to get insights and ideas from the existing products. The thoomba was chosen as the tool of focus as it was the most commonly available and used tool for farming purposes. After researching and ideating, an improved design was developed. 3d model was created using blender. A physical prototype was created and user tested, receiving positive feedback and creative criticism.

I learned blender for the scope of the project and it has given me a new spark of inspiration. I learned about materials and manufacturing. I intend to continue working on the project for optimising values and making a final product, and possibly getting it into manufacturing.

7. SCOPE FOR FUTURE

The scope for future of the project includes

- Improve joining
- Improve storing
- Make more compact

Beyond the project, there is scope for:

- Pilot production
- Creating a brand identity
- Marketing
- Exploring into other products

8. REFERENCES

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- https://www.sorbothane.com/shock-absorbing-material.aspx#:~:text=Sorbothane%20is%20the%20best%20solution,%2C%20neoprene%2C%20silicone%2C%20etc.
- https://www.totallyseals.com/blogs/news/what-is-shore-hardness

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