DESIGN OF AGRO-AIDS FOR ONE ACRE FARMING

PRODUCT DESIGN PROJECT II

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Project 2

Design of Agro-Aids for 1-Acre Farming

Approval Sheet

The project titled as "Design of Agro-Aids for 1-Acre Farming" by Isaac Junior and Paulanthony George is approved in partial fulfilment of the requirement for the degree of 'Master of Design' in Industrial Design.

Guide:

Co-Guide:

Chairman:

Internal Examiner:

External Examiner:

Declaration

We, hereby, declare that this written submission represents our ideas in our own words and where others' ideas have been included; it has been adequately cited and referenced the original source. We also declare that we have adhered to all principles of academic honesty and integrity and have not misinterpreted or fabricated or falsified any data/idea/facts/sources in our submission. We understand that any violation of the above entitles the institute to take disciplinary action against us to which we shall beanswerable to.

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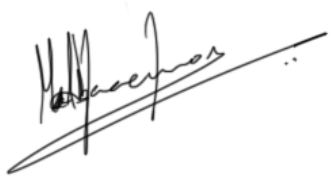

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We are grateful to the members of BAIF, Jawahar, Thane and the people of Jawahar for their hospitality and helping us out in understanding the current scenario well and providing the required information.

Last but not the least, we thank our batchmates who have contributed their insights to this project.

Abstract

This project encompasses the design process we followed to introduce a product that can be used for the process of Harvesting, Threshing and Winnowing of paddy in Subsistence* farming.

The main objective being the integration of existing technologies which helps us cater to a sector of the market that buys very low cost products. Using the existing framework of a Harvesting machine we have tried to integrate the same product for the additional purposes of Threshing and Winnowing.

**Subsistence farming - Nearly all crops / livestock raised are used to maintain farmer and his family, any surplus is used for trade*

Contents

Theme

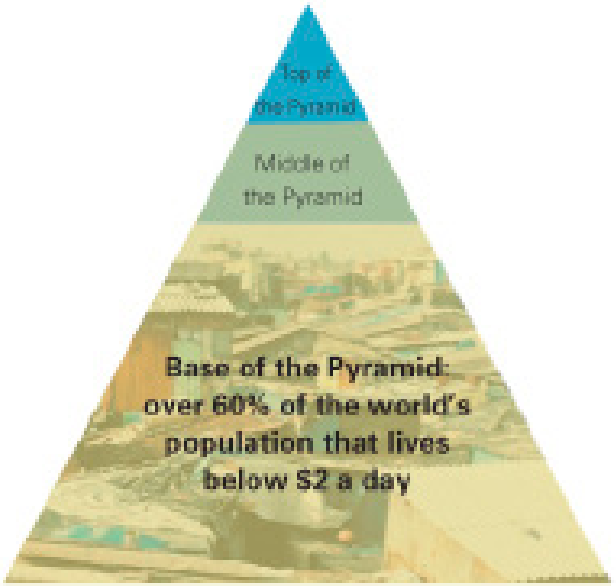

Fig.1: *Bottom of the Pyramid*

Image source: http://www.triplepundit.com/2010/10/paupers-partners-creation-new-framework-base-pyramid/ - As seen on 12/11/2014

The project theme was designing for the bottom of the pyramid (Fig 1). The rural areas in India pose an incredible array of design opportunities as it belongs to a part of India whose needs are largely unmet.

Fig.2: *Intensive farming*

Image source: http://www.thesolutionsjournal.com/sites/default/files/Fea_UN%20Food_Figure3.jpg - As seen on 3/11/2014

Fig.3: *Extensive farming*

Image source: http://carbonfarmingcourse.com/wp-content/uploads/2011/10/Contour_Hedgerows.png - As seen on 3/11/2014

Present Scenario

Types of Farming

3.1 Intensive farming

This is a method of cultivation which involves relatively larger amounts of capital for smaller land holdings and also invests in large amounts of labour (Fig 2). The large amount of labour and capital are necessary for application of fertilizer, insecticides and fungicides and herbicides for crop growth. The capital is also invested in acquiring and maintaining state of the art machines for purposes of planting, cultivating and harvesting along with the required amount of irrigation

3.2 Extensive farming

In agricultural economics, this is a system of crop cultivation using low labour and capital in relation to area of land being farmed (Fig 3). The crop yield in extensive agriculture depends primarily on the natural fertility of the soil, the terrain, the climate, and the availability of water. Extensive farming is a method of cultivation that uses low labour and capital compared to the area of farm land. The yield of crops depends mainly on the natural fertility of soil, topography, the climate and availability of water.

Subsistence Farming

Fig.4: *Cluster farms*

Fig.5: *Smaller farm fields [above & below]*

Fig.6: *Difficult terrains of farmland*

Fig.7: *Farming family*

It involves mainly a farmer and his family(Fig 7) practicing cultivation solely for the purpose of food, only the surplus is meant for sale or trade.This has been the mode of agriculture that has and is practised before industrialization took over agriculture. Subsistence persists in India and sub-Saharan Africa in relatively wide scale. Here one of the main aspects to understand is the size of the landholding, which is often no more than a few acres and the terrain around (Fig 6). The farming technology tends to be primitive and of low yield.

This type of farming also deals with a lot of collaboration between farmers who are cultivating near each other (Cluster farms - Fig 4,5) sharing of farming equipment and resources are quite common.

Image sources as seen on 12/11/2014:

Fig 4 - *http://i.dailymail.co.uk/i/pix/2014/08/07/article-urn:publicid:ap.org:626fdc371ecb46a981aa16357f5496cc-6ReKF7Bx8-HSK1261 _634x410.jpg* **Fig 5** - *https://classconnection.s3.amazonaws.com/767/flashcards/1071767/jpg/dsc_05971358629619952.jpg* **Fig 6** - *http://1.bp.blogspot.com/_H6XrbgfcO5c/S7wA2bu9rNI/AAAAAAAAAEI/LZNtcf0Zio8/s1600/Terrace%20Farming%201.JPG* **Fig 7** - *http://www.goimonitor.com/sites/default/files/styles/medium_300x300_/public/lead.jpg?itok=79tRV5xe*

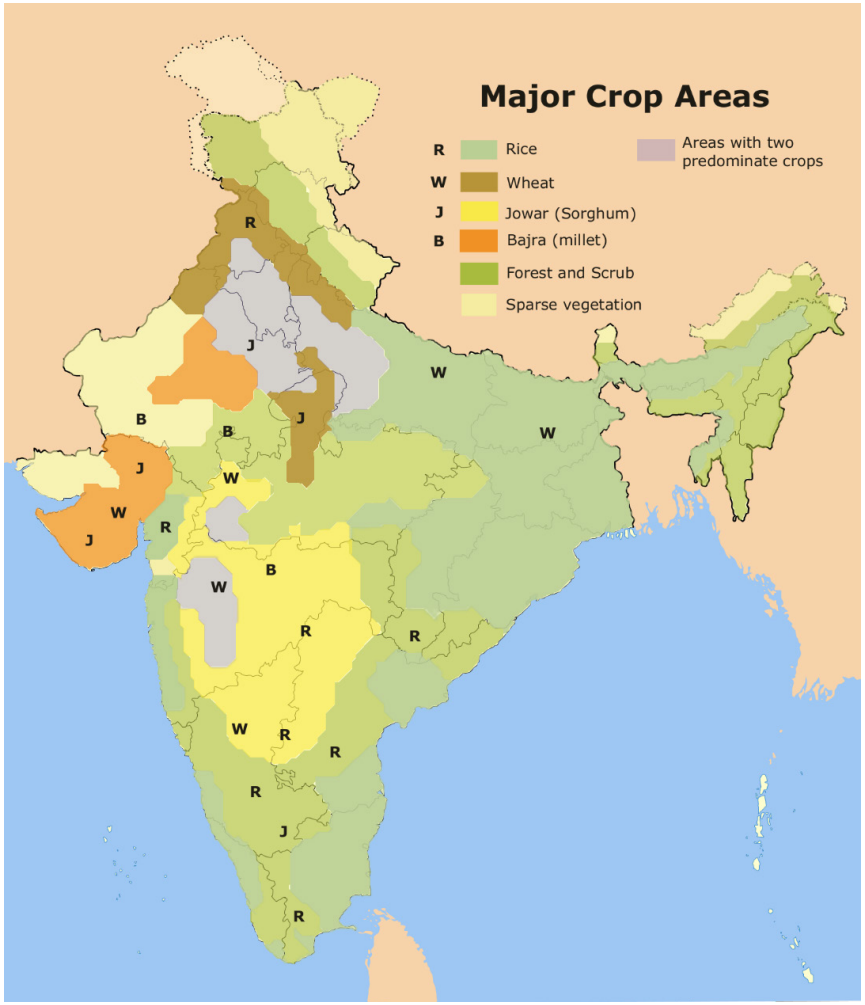

Fig.8: *Paddy farming in India*

Image source: http://upload.wikimedia.org/wikipedia/commons/b/b5/Major_crop_areas_India.png as seen on 3/11/2014

Opportunities

5.1 Why Paddy farming

One-third of the world's paddy cultivation area, i.e., 83 million hectares, is in India. Paddy in the form of rice feeds nearly 50% of the world's population. India has the largest area under cultivation amongst the paddy growing countries, yet its productivity is much lower than in Egypt, Japan, China, Vietnam, USA and other countries.In India the states of Assam, West Bengal, Bihar, Madhya Pradesh, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Maharashtra, Gujarat, Uttar Pradesh and Jammu and Kashmir. Paddy in India is grown in areas of water logging, high rainfall, salinity, alkalinity, acidity, high temperatures and high humidity during the months of May to November, once every year.

Paddy farming can be categorised briefly into:-

-Seed selection

-Land preparation

-Crop establishment (Fig 8,9)

Fig.9: *Re-planting paddy*

Image source: http://www.bioforsk.no/ikbViewer/Content/80281/women%20in%20rice%20field%202.jpg - As seen on 3/11/2014

Fig.10: *De-weeding paddy*

Image source: http://www.rkmp.co.in/sites/default/files/eis_states/A%20406.jpg - As seen on 3/11/2014

-Water management

-Nutrient management

-Crop health management(Fig 10)

-Harvesting (Fig 11)

-Post harvest (Fig 12,13,14)

Considering the scope of the project as a redesign project during the months of July till November end, both the challenging nature of this type of farming and the time constraints seemed ideal. Our main area of concentration will be in the harvesting (Fig 11) and post harvest practices of threshing (Fig 12,13) and winnowing (Fig 14) of paddy which fit within the time frame.

(*Ref*: *"Paddy Production: What's Holding India Back?", S. Umadevi, October 2012*)

5.2 Absence of equipment for subsistence farming

The automatic machinery that dominates the field of agriculture is largely for large land holdings and require generally large capital investments. Subsistence farmers generally practice agriculture using manually operated tools to semi automated machinery which require lower capital investments and can be repaired easily. The usage of even small tractors in landholdings less than 1 acre is impractical in terms of functionality as well as cost.Thus an absence of an automated machine that can be easily used for harvesting and post harvesting practises is felt.

Fig.11: *Harvesting paddy*

Image source: http://www.rkmp.co.in/sites/default/files/eis/A%20287.JPG - As seen on 3/11/2014

Fig.12: *Paddy threshing*

Image source: http://f1.haveeru.com.mv/photos/2011/12/0_13234957371111_news.jpg - As seen on 3/11/2014

Fig.13: *Semi-automated threshing*

Image source: http://cwave.eu5.org/trips/bhalopahar/thresh2.jpg - As seen on 3/11/2014

Fig.14: *Traditional winnowing using winnowing fan*

Image source: http://blog.thomsonreuters.com/wp-content/uploads/2012/07/RTXWAPD.jpg - As seen on 3/11/2014

Fig.15: *Family based co-operative farming*

Image source: http://i.dawn.com/2010/08/bu-cotton-543x275.jpg - As seen on 3/11/2014

Fig.16: *Livelihood farming*

Image source: http://metrovaartha.com/en/wp-content/uploads/sites/2/2014/10/farming-paddy-kerala.jpg - As seen on 3/11/2014

5.3 One Acre Paddy farming

Paddy farming in India is often practised in small land holdings (1 acre or lesser) for the purpose of feeding the family and any surplus is sold into the market. As mentioned before the farmers cultivate and harvest the paddy crop during the months of May till November, post which their income generally depends on either cultivation of other parallel crops or be hired for manual labour. Understanding their livelihood (Fig 15) became the crux of our project as making any product for these type of subsistence farmers means pitching the product that is affordable as well as durable for the type of environment where paddy farming is practised.

A void in evolution of this type of farming was made lucid based on the interactions with Mr Lakshmanan Iyer who teaches school children farming & Dr Kesari (Natueco farming) who has been supporting marginal farmers.

One acre paddy harvesting has largely been practised using traditional tools like sickles, to introduce a product here that has some level of automation is a challenge in itself, however it has been noticed that the farmers have increasingly been shifting from manual to semi automated machinery, so there is no aversion towards technology that makes sense to them.

5.4 Promoting agro- entrepreneurial , subsistence livelihood

A recent trend amongst non-agro related population of India has been the purchasing of small farm lands and hiring local manpower for maintaining and cultivating the land (Fig 16). These

Fig.17: *Combine harvester*

Image source: http://i.ytimg.com/vi/_zZgkyWxIWI/maxresdefault.jpg - As seen on 3/11/2014

Fig.18: *Combine harvester*

Image source: http://www.colsudhirfarm.com/img/combine_harvester_guys.jpg - As seen on 3/11/2014

farming entrepreneurs are heavily involved in organic farming as well. This segment of the Indian population has the ability and the means to afford both small land holdings as well as the machinery required for the upkeep of the crops.

5.5 Integrating different tools for different purposes

For large land holdings there are machines like the combine harvesters (Fig 17, 18) which is the workhorse as it is capable of performing various functions from harvesting to post harvest functions. However these machines are impractical in small land holdings as is the affordability of such multi-purpose machines. Thus there is a void that is felt by subsistence farmers for a portable machine that can be used for multiple purposes. The challenge here being the integration of existing technology for a set of tools that is both easy and safe to use, durable and requires a small learning curve.

Target Audience

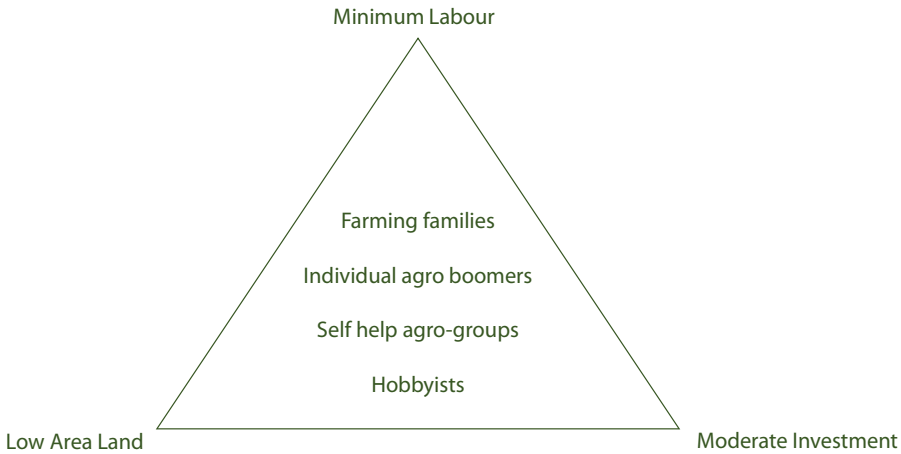

Fig.19: *Intended users*

Based on the literature survey we narrowed down the target audience (Fig 19) to pitch the product.They largely consist of farming families that practise subsistence farming and prefer having the family members practise farming rather than hire labour for cultivation and other agrarian practises.Also considered are the afore-mentioned individual agro boomers who are new to this field, who have a disposable income but chose to invest it in parallel occupations.Self-Help agro NGOs generally form the hub of information and other tangible resources in rural areas, often connecting local farmers with the latest news and farming trends happening within the country as well as from a global point of view.

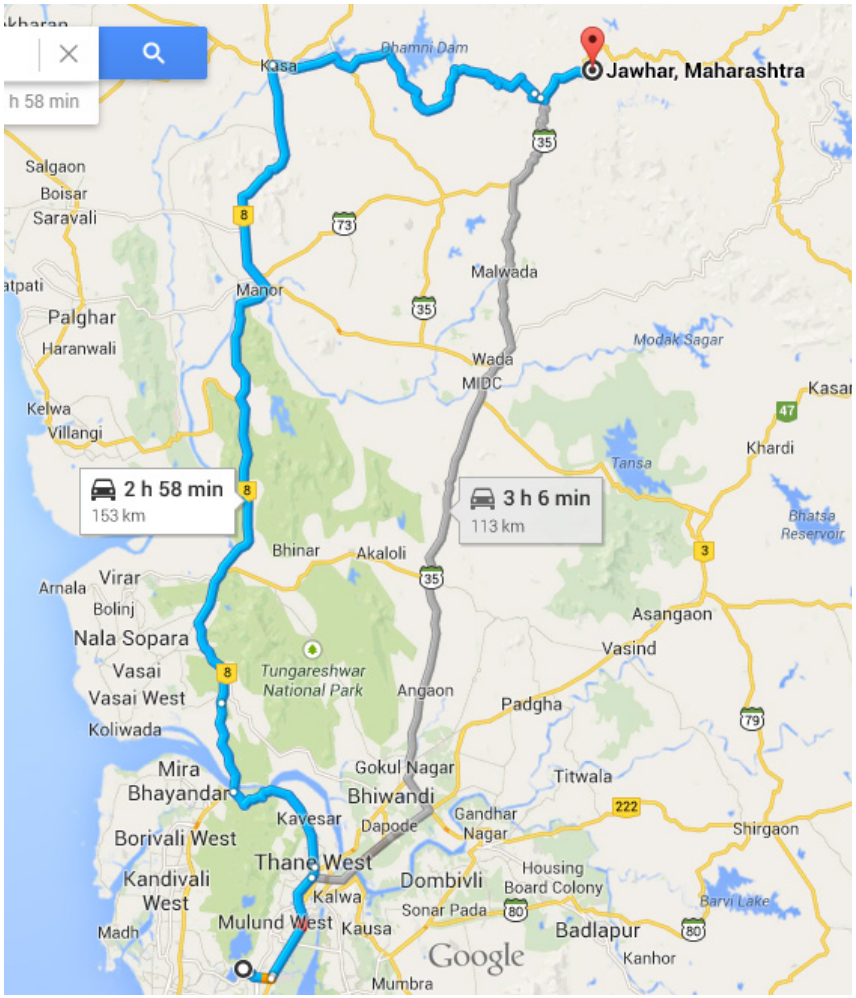

Fig.20: *Route from IITB to Jawahar*

Image source: https://goo.gl/maps/0Yz2S - As seen on 3/11/2014

Field visit

Based on our initial assumptions, we went to Jawhar in Thane district, 150km away from the IIT campus(Fig 20, 21), where one acre subsistence paddy farming is largely practised, to understand the process and the terrain.

In Jawhar, paddy farming is practised in square plots which are generally 1 acre or lesser. The access points to these farms are generally steep inclines which start from the farmers homes and then lead gradually down to the farmers.The farms are arranged in clusters(Fig 23), where the neighbouring farmers generally share tools and other resources, often collaborating in terms of labour required during cultivation or harvesting and post-harvesting.

As explained the condition of the field during cultivation of the paddy is generally very muddy, which dries out by the time the paddy rises up(Fig 24). By October end the earth is dried to point of cracking.Bharatiya Agro Industries Foundation (BAIF) acts as the hub helping the farmers coordinate with agro-related bodies outside of Jawhar. It is generally tapping point for farmers to get a know about the new tools and trends in farming.

Fig.21: *Life in the village*

Fig.22: *Tight spaces between grown paddy*

Important observations made in the fields:-

- The tight spaces between grown paddy stalks (Fig 22.)
- The 1 foot (approx.) height distance between farm and walk-way areas.
- Harvesting is carried out by hand and sickle, generally by two members of the family, by holding the stalk an inch from the base swiping the sickle, followed by laying the stalk to dry (Fig 25-27).
- Threshing is done either by traditional method of stamping or beating with bats, but threshing drums have been introduced.
- Winnowing is carried out mainly using the winnowing fan.

A secondary field visit was conducted to understand the usage semi-automated harvester for paddy, by experiencing a weed whacker - which can be converted into the harvester. (Fig 28)

The learnings from the trial were:-

- Learning curve to assemble and use is relatively easy.
- Mobility wise since the person is carrying the equipment, the issue of uneven terrain can be surpassed
- Certain issues that do crop up is fatigue during long hours of swinging action.

Fig.23: *Paddy field cluster*

Fig.24: *Soil texture of paddy field*

Fig.25: *Traditional harvesting tools*

Fig.26: *Harvesting farmer*

Fig.27: *Paddy laid after harvesting*

Fig.28: *Operating weed whacker*

CHAPTER 7

Field visit : Conclusions

Fig.29: *Storage shelter near paddy field*

8.1 Why not a modified vehicle

Modifying the existing vehicle in a rural scenario is something that seems like a lot of work for the farmers.Also they are apprehensive as to whether "Jugaad" would prove to be a long term solution.Another inference from the visit is considering the space constraints to operating such a vehicle. Summed up, the money, the space constraints and the serviceability of a modified vehicle is something that does not seem viable in the long run.

8.2 Why not electricity based equipment

Farm storage areas are generally places exposed to weathering elements (Fig 29) that reduces the durability of components like battery / electric power units. Both lead acid battery and solar powered concepts were thought of before the field visit, however these modules for power seems improbable as the power supply is intermittent. Also considering the availability of cheap and durable solar powered battery modules for the kind of affordable unit that is feasible in remote places like Jawhar.

8.3 Why fuel engine

The availability of petrol as fuel and small compact 50cc engines that can be used to power small portable units with adapter type heads for different purposes, is a more realistic and achievable product system considering the people using it, affordability and serviceability.

8.4 User learning curve

The machine as mentioned before has to be portable and cater to multiple purposes. For compact, transportation, a certain level of disassembling is required and re-assembling which requires a certain level of expertise on the part of the user. Considering the people in Jawhar it is safe to assume a DIY approach if carried ahead requires an easy to understand assemblage and tool set.

8.5 Trend shifts & Co-operative farming

The farmers have started experimenting with recent advances in technology, in the field of mechanization and hybrid paddy. They have also realised that working with NGOs and groups like BAIF are important to get an understanding of the recent development in the domain of paddy farming be it government grants, weather patterns.Co-operative farming is a crucial aspect of one acre subsistence farming as the pooled in set of resources increases the chances for good yield at relatively lower costs.

CHAPTER 8

Design Brief

Despite advances in agro-based technologies, there is a void felt by present day subsistence farmers in terms of an affordable universal tool set.

Brief: Design a multipurpose tool set that caters to harvesting, threshing and winnowing process in one acre paddy farming, keeping in mind safety, affordability and serviceability.

The product has to be compact, easy to transport and should be easy to assemble and disassemble, without having a high learning curve.

CHAPTER 9

Objectives and Goals of new design

Objective:

To design a Universal 1 Acre farming agro tool set for harvesting and post-harvesting purposes of paddy.

Goals:

- Integrate different tools and implements into one optimized tool
- Design of a tool set that is safe to use and less cumbersome for an individual
- A tool-set that encourages low-labour force farming
- A tool set that is a low cost solution in a high cost market segment
- A tool-set that is able to perform as a workhorse in 1 Acre farming

Cornerstone

Machine Anatomy

Fig.30: *Compact petrol engine*
Image source: http://ep.yimg.com/ay/scootercatalog/50cc-2-stroke-scooter-engine-13.jpg - As seen on 3/11/2014

Fig.31: *Motorcycle engine*
Image source: http://i01.i.aliimg.com/photo/v4/1252697769/2_2_Stroke_Motorcycle_Engine.jpg_220x220.jpg - As seen on 3/11/2014

Fig.32: *Battery powered engine Image source: http://www.justlawnmowers.co.uk/pages/commonimages/stihl/2012/HSA65.jpg- As seen on 3/11/2014*

11.1 Heart: Gasoline powered driving unit

The product will consist mainly a power unit which is a fuel powered engine which has a modulator for variable rpm.This unit has to be light weight and easy for an average motor mechanic to understand and fix.

The unit has to run for a duration of 30mins continuously for harvesting, for threshing and winnowing its purpose would be relatively stationary. Possible candidates for the heart were diesel engines, petrol engines and battery powered engines (Fig 30,31,32). Compared to small diesel engines the petrol engines are lighter in weight and cheaper. Also diesel engines tend to have heavy vibration and for the same weight and compression ratio the produced maximum RPM is lower for diesel engines.

Battery powered units would be much lighter in weight and lower on vibration and carbon emissions. However due to intermittent power supply and the cost factor of existing solar powered units, for a project of this duration and this scale we chose to select a petrol powered power unit.

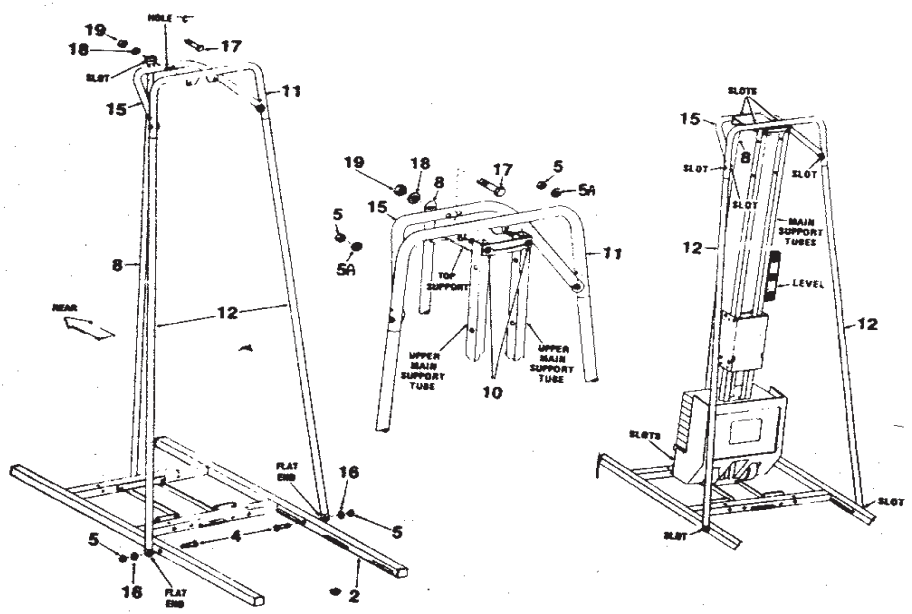

Fig.33: *General chassis concept*

Image source: http://c.searspartsdirect.com/lis_png/PLDM/00038704-00002.png - As seen on 3/11/2014

11.2 Chassis: Frame

The frame that connects the power unit to the harvester, thresher and the winnower has to be sturdy and rigid but light weight (For example Fig 33). As there are three purposes to be carried out the product can either consist of all 3 units simultaneously or work in an adapter system. Envisaging the case of 3 in 1 unit, the processes of threshing and winnowing happens sequentially much later. So it does not seem feasible to carry dead weight while performing harvesting. Yet if similar modules can be used in all 3 purposes it takes away additional costs that have to be spent.

Activity Analysis

Traditional Harvest and Post Harvest Practises

12.1 Harvesting (Reaping)

Fig.34: *Posture 1*

- Stoop down with Sickle in Hand
- Target ripe paddy

Fig.35: *Posture 2*

- Clench the paddy in the fist
- Swipe the Sickle fist's height from the base
- Repeat until palm is laden with Paddy stalk

Fig.36: *Posture 3*

- Twist torso to the side
- Lean forward and spread the collected Stalk for drying

12.2 Post Harvesting: Threshing

Fig.37: *Bundling*

Fig.38: *Threshing ground*

Fig.39: *Manual Threshing*

Image source:http://upload.wikimedia.org/wikipedia/commons/3/30/Threshing_harvest_Sangrur_Punjab_India.jpg - As seen on 3/11/2014

- Bundle the dried Paddy and tie together

- Gather Stalk on a levelled ground

- Take dried Stalk in clumps and beat it against hard surface
- Rotate the Stalk clump and repeat
- Collect loose Grain and Stalk

12.3 Post Harvesting: Winnowing

Fig.40: *Traditional winnowing*

Image source:http://www.lifescapes.org.in/wp-content/uploads/2009/10/Winnowing.jpg - As seen on 3/11/2014

- Take threshed stalk and chaff in the winnowing fan
- Sift the fan at a height (Fig 40)
- Heavier grains fall close to the winnowing fan.
- Lighter loose chaff and poor quality grains and stalk are carried away to a distance away from the winnowing fan.
- Grains are collected and stones and insects are separated away by sifting.

Ideation

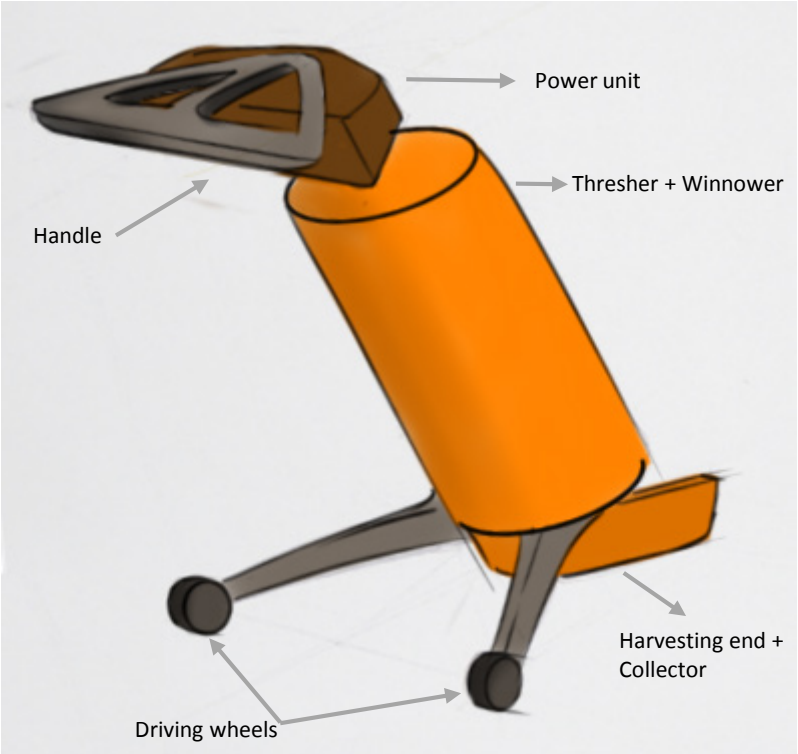

Fig.41: *Concept 1*

The process of ideation started off on an empty canvas, where there were no guidelines or constraints apart from the insights. The initial thoughts were to perceive how the equipment we design would be used by the farmer.

The idea generation was towards the concept of a single person being able to perform most of the tasks, even though generally people operate in farm as a group of two atleast. Also the field visit observation of cylindrical unit as the threshing element and the cornerstone specifications of power unit were noted and given due importance.

Different aspects of the product such as contour, functionality, and feasibility were brought out towards the end of ideation.

Our product ideally consists of three units:

- Harvester: Unit for reaping/shearing/cutting the paddy and guiding it to a stacked unit
- Thresher: Unit for beating/ crushing the stalk to obtain the grains
- Winnower: Unit for separating the lighter unwanted chaff and stalk from the essential paddy grains which are heavier

Fig.42: *Concept 1 usage*

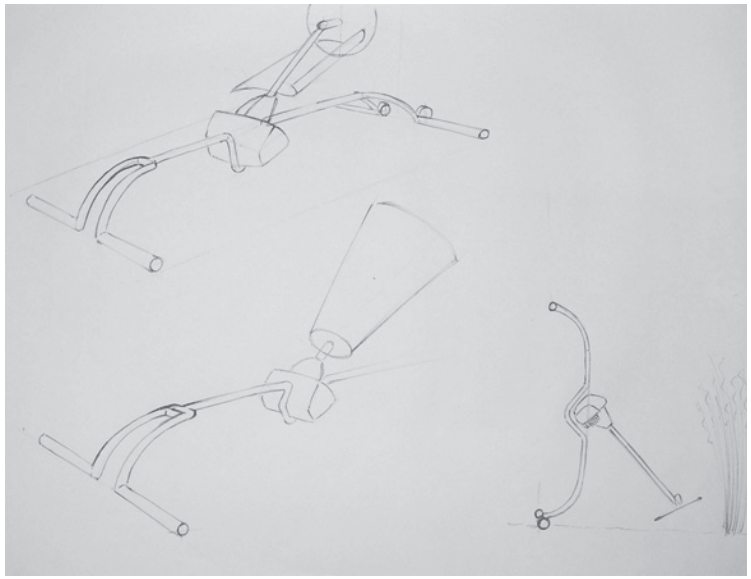

Fig.43: *Harvesting unit & Thresher-winnnower concept 2*

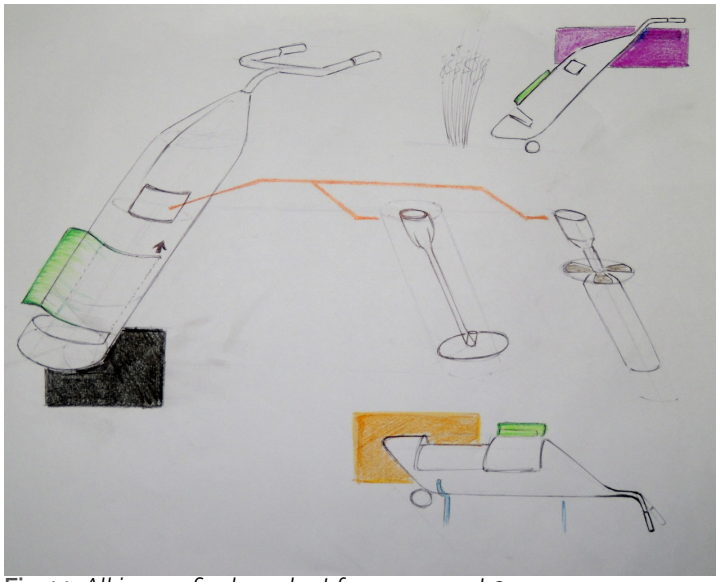

Fig.44: *All in one final product form concept 3*

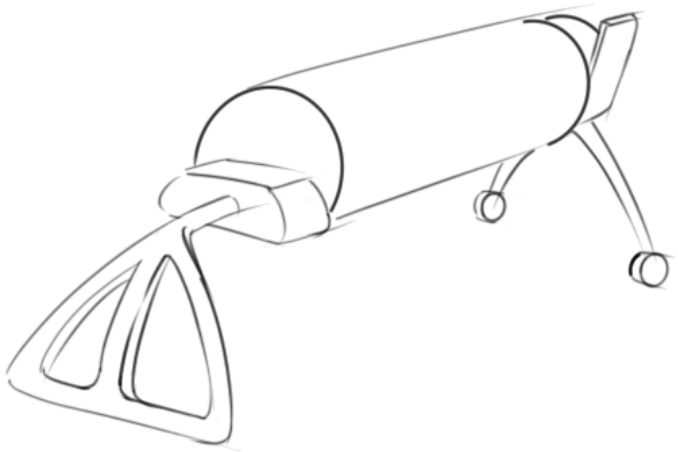

Fig.45: *Concept 1 threshing orientation*

Exploring different orientations and final outer form of the equipment. Speculating on how the different processes of harvesting, threshing and winnowing can be carried out

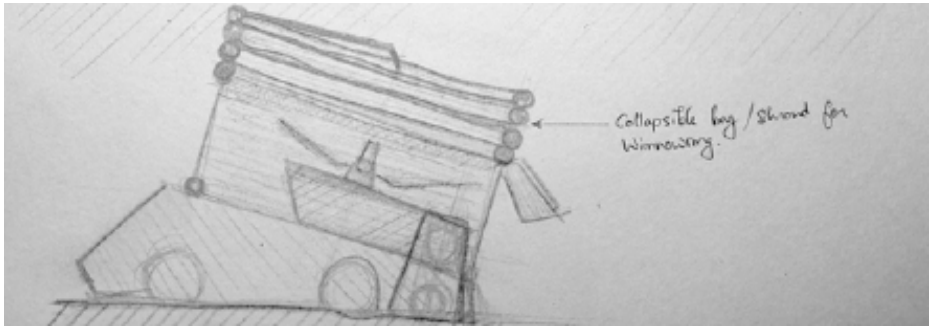

Fig.46: *Collapsible shroud*

A single unit catering to the harvesting, winnowing and threshing process that operates along the lines of a lawn mower. Features such as collapsibility, pivot arm and grain storage were ideated upon.

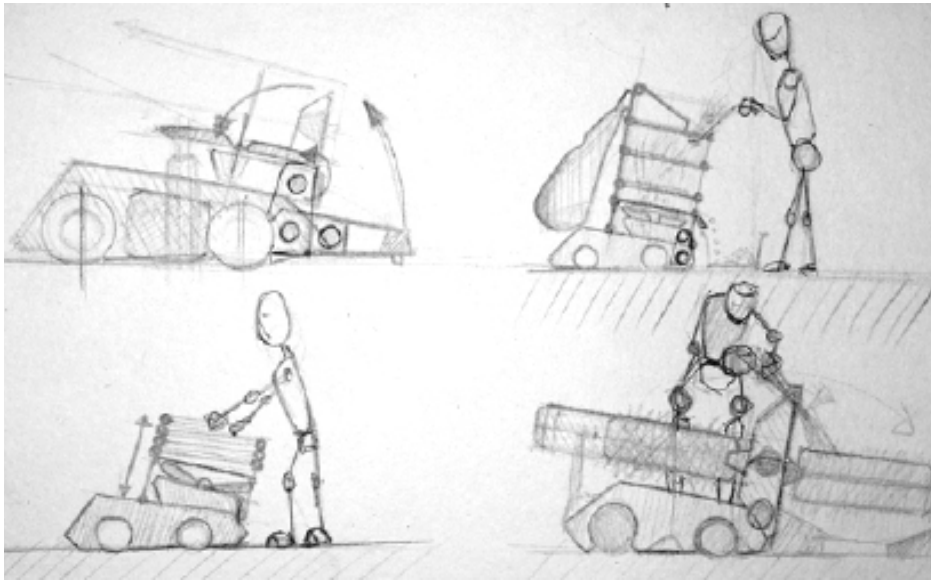

Fig.48: *Multiuse postures and orientations*

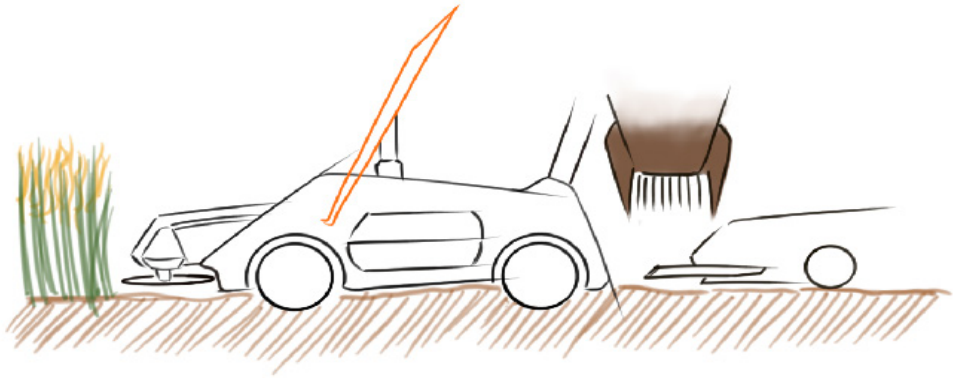

Fig.47: *Razor inspired harvesting blade*

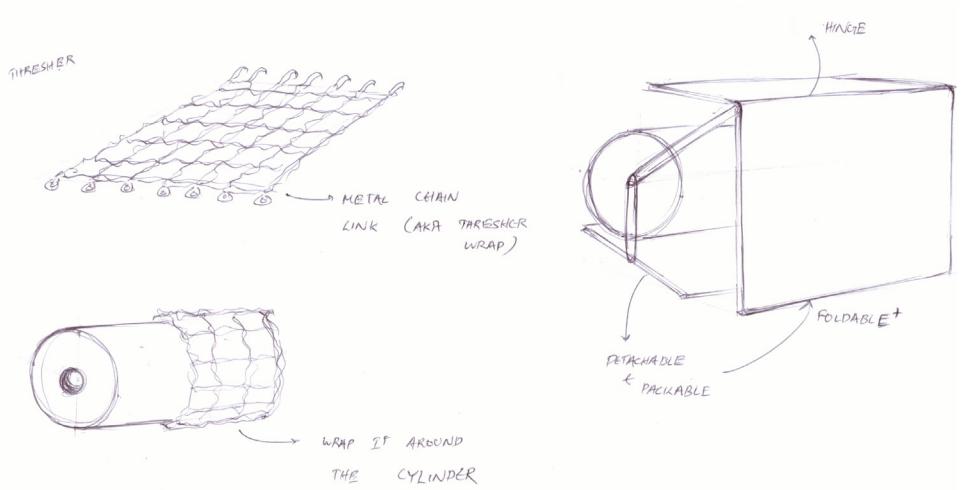

Fig.49: *Threshing drum with chainlink surface profile*

Threshing drum contact profile and foldable outer shroud

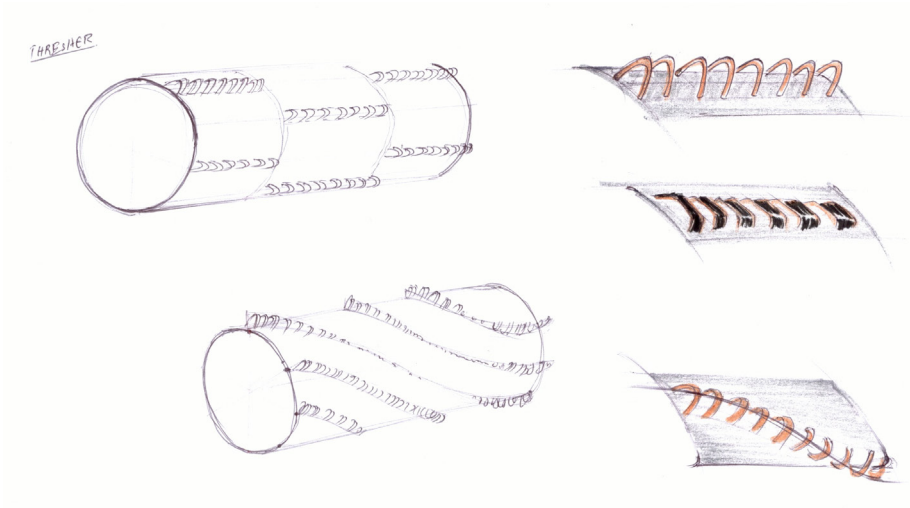

Fig.51: *Threshing element and pattern iterations*

Fig.50: *Blower fan with different air outlets*

Concepts of blower unit that could be used for the winnowing activity

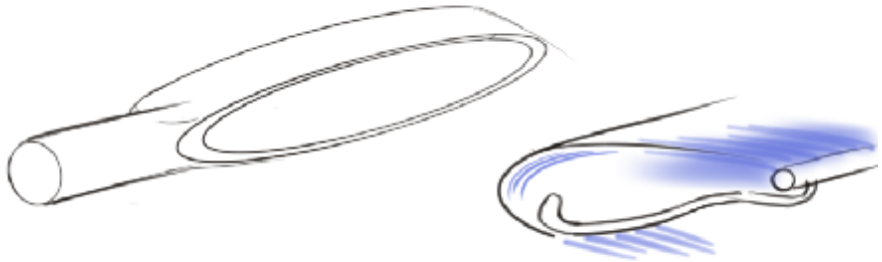

Fig.52: *Bladeless blower fan concept*

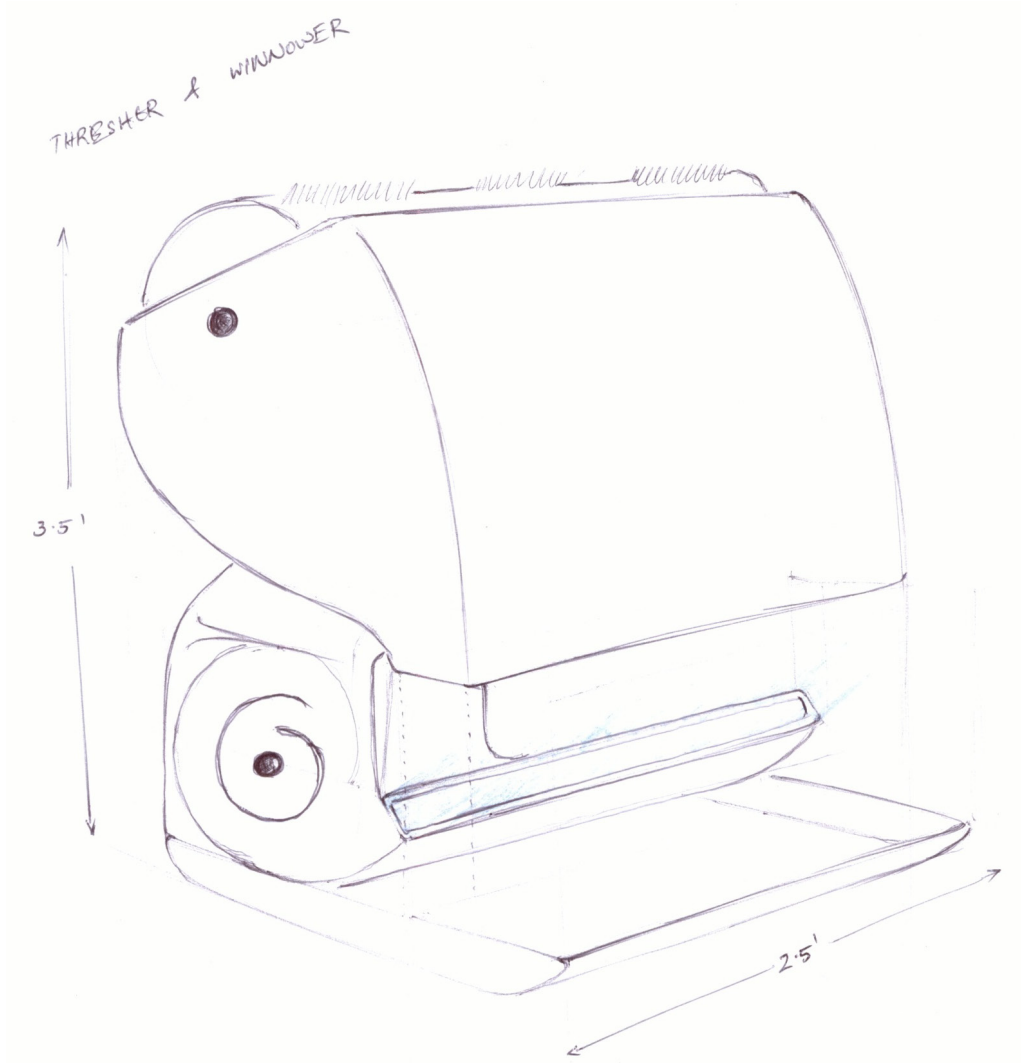

Fig.53: *Combined unit with blower exhaust arrangement 1*

Combining the activities of threshing and winnowing in to a single operational unit that has different orientations of wind direction to help out winnowing.

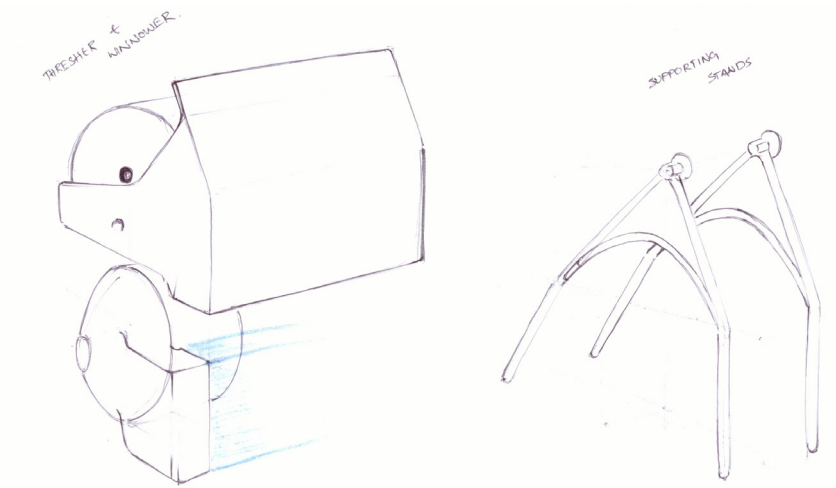

Fig.54: *Combined unit with blower exhaust arrangement 2 & fixing stands*

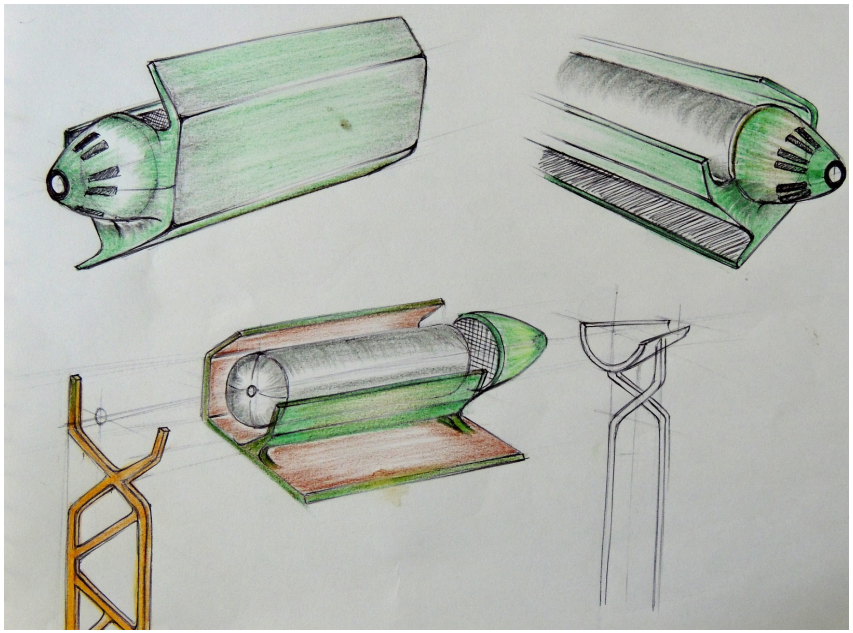

Fig.55: *Axial winnower fan loaded on to the side of threshing drum*

Concept of thresher and axially loaded winnower unit with guiding shroud to collect seperated grains.

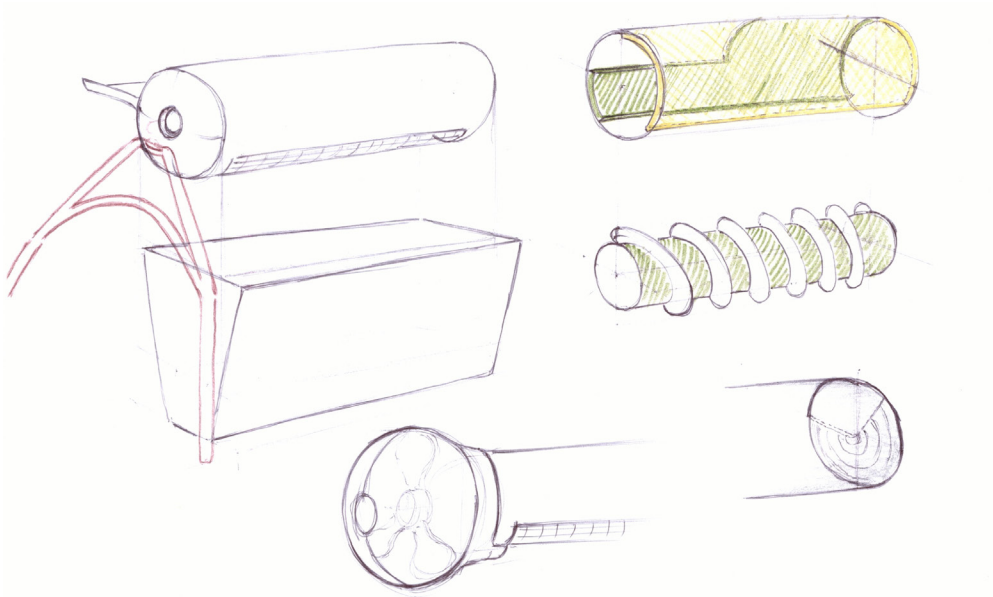

Fig.56: *Fully automated concept with grain collector*

Fully automated threshing and winnowing unit based on the principle of Archimedes screw

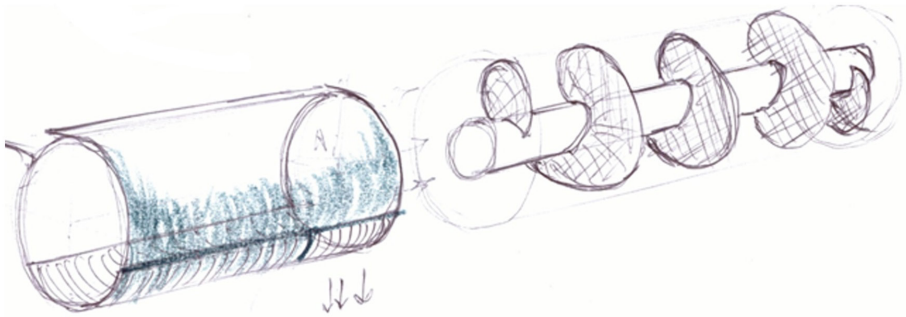

Fig.57: *Archimedes screw concept for threshing*

CHAPTER 13

Concept Directions

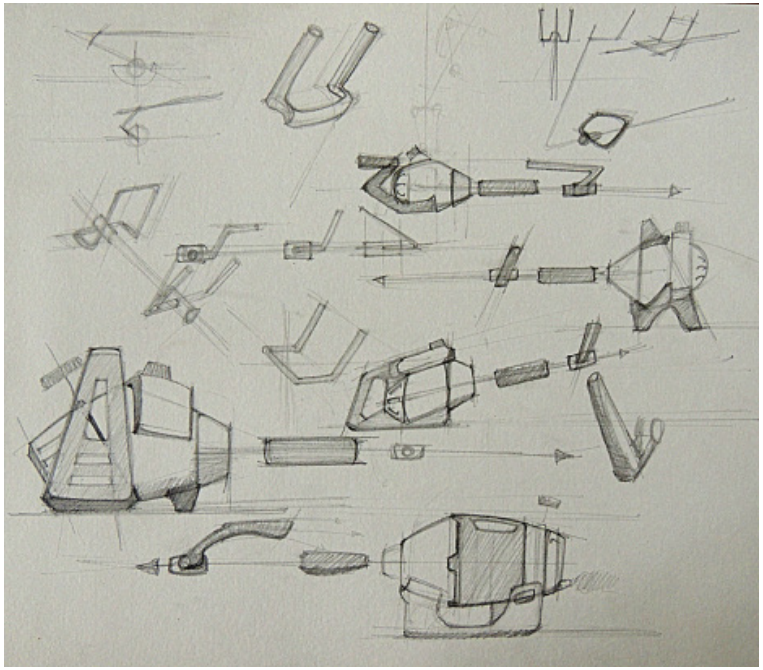

Fig.58: *Power source concept for semi-automation*

After the process of ideation we could broadly classify and analyze the directions in the processes we were adressing to. The harvesting and post-harvesting activities related to paddy farming were evaluated and looked upon.

The ideas that came out initially depended upon the assumption that the power source utilized (Fig 58) as part of semi-automation would be small and powerful. Fuel powered and battery powered engines were considered as part of it.

Also looking into the manners in which the farming operations are carried out gave an understanding to the existing conventional methods / physical activities required to complete post-harvesting activities. Incorporating unconventional methods or technology along with the above was the final aspect that was covered to bring out the concept directions (Fig 59).

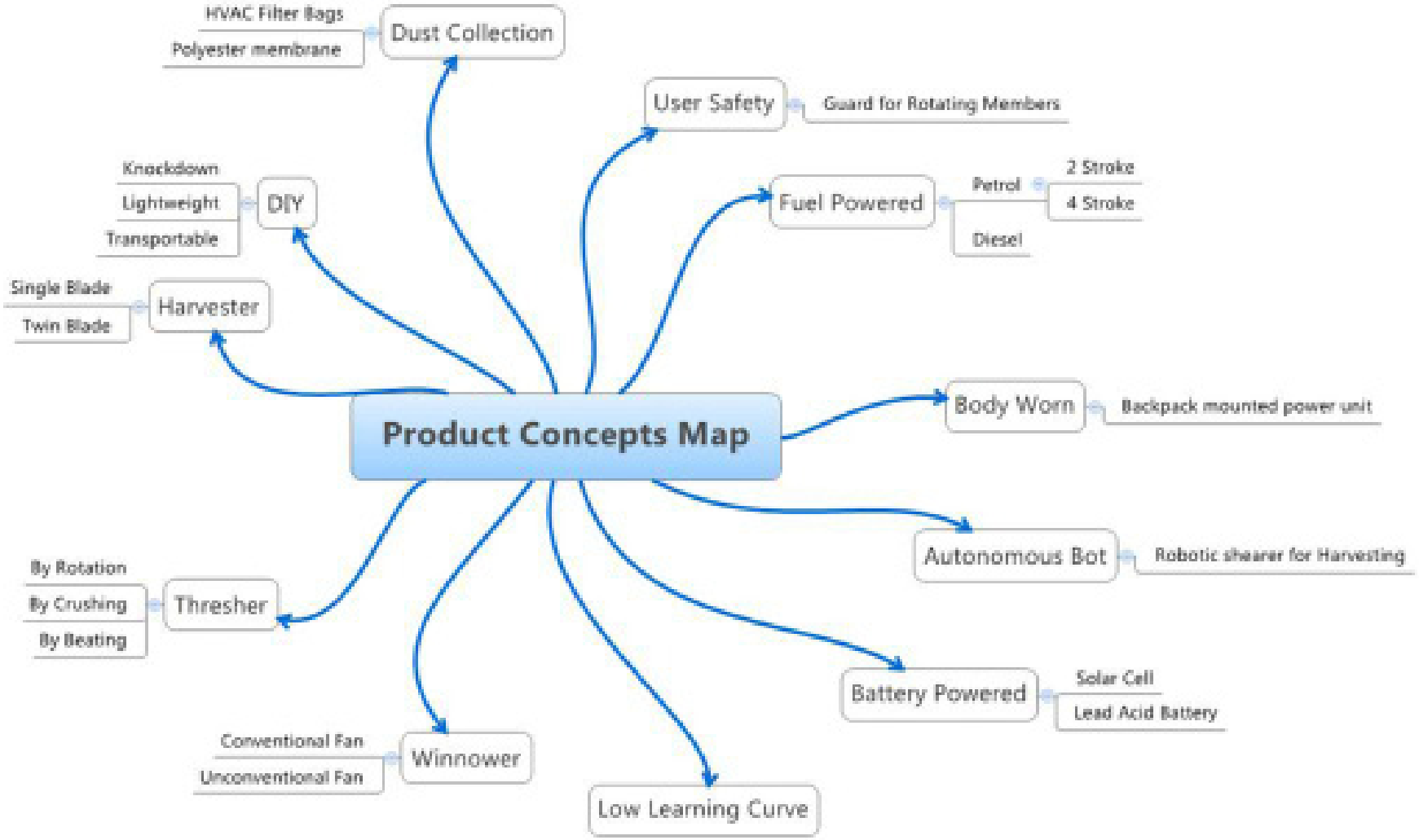

Fig.59: *Concept directions*

Fig.60: *Dremel tool kit*

Image source:http://mdm.boschwebservices.com/files/Dremel%20Rotary%20Tool%20Kit%204000-6-50%20(EN)%20r48401v15.jpg - As seen on 3/11/2014

Fig.61: *Assorted tools concelaed in a box*

Image source:http://www.ufixit.info/image/cache/data/Product/combination-set-toolkit-500x500.jpg - As seen on 3/11/2014

Concept Parallels

Upon finalizing the concept, we explored products with the similar nature - additional functionalities with additional attachments (Fig 60,61).

On the basis of our ideation and concepts, we researched on existing market products in different segments the keywords here being multi-purpose tools, adaptability and user friendly.

A major influence was the products from Stihl, which focused largely on the products dealing with hobbyist gardening (Fig 63,64,65,67). Their products largely revolve around a power unit carried by a light weight chassis which can be fitted with various head mounts for different purposes.

Another Indian product was the KSNM Direct Paddy Seeder (Fig 62) which both tills the land and drops the paddy seeds into the tilled land.

We were also inspired by Dremel tools and other toolkits which come with a core unit which have many tool-bits for different purposes.

Fig.63: *Stihl weeder*

Image source:http://www.stihlusa.com/WebContent/Images/Product/524/mm55.png?preset=Product.ProductDetails - As seen on 3/11/2014

Fig.62: *KSNM direct paddy seeder*

Image source: http://www.efreshglobal.com/efresh/content/en/farmtools/images/Farmtoolsandmechinery/image044.jpg - As seen on 3/11/2014

Fig.67: *Stihl earth auger*

Image source: http://rockohire.com.au/wp-content/uploads/2013/12/stihl-BT-121-earth-auger.jpg - As seen on 3/11/2014

Fig.64: *Grass cutting nylon blade*

Image source: http://www.trueshopping.co.uk/images/products//full/55826_image.jpg - As seen on 3/11/2014

Fig.65: *Stihl gardening tool set*

Image source:http://www.balcluthahonda.co.nz/assets/images/stihl/combisystem.jpg - As seen on 3/11/2014

Fig.66: *50cc petrol engine operated weed whacker*

Image source:http://2.imimg.com/data2/PE/UC/MY-2664323/juki-43-250x250.jpg - As seen on 3/11/2014

A parallel product much cheaper than the Stihl was found in Indian market. This modified version of weed whacker (Fig 66) was exclusively marketed as paddy harvester (Fig 67). It comes along with the guiding profile for cut paddy.

The equipment was made available at a cheap rate owing to production in China. Components are imported seperately and assembled in the local market here.

Fig.68: *50 cc petrol engine operated harvester*
Image source: http://media.sheryna.in/fotos/rajkumaragro_1_1345726461.jpg - As seen on 3/11/2014

Concept

Fig.69: *Semi automated threshing*

Image source: http://cwave.eu5.org/trips/bhalopahar/thresh2.jpg - As seen on 3/11/2014

After ideating on the different possibilities and figuring out the design directions, the concept of threshing and winnowing unit was brought out.

On the field the activity of winowing follows that of threshing (Fig 69). While threshing seperated the seed from the stalk, winnowing helps in removing the residual chaff out of the threshed seeds. The concept also drew parallels from the way semi automated threshing occurs in the country with farmers relying on the rotating cylinder profile as the threshing unit.

The unconventional fanblade used in wind curtains was utilized here as part of integrating the winnower and thresher

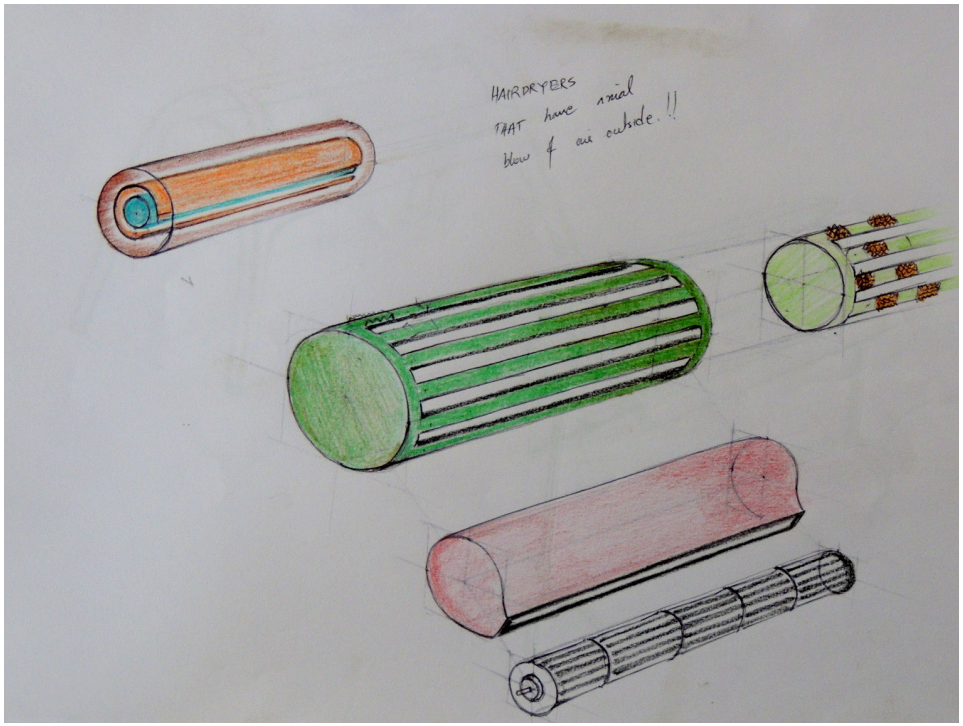

Fig.70: *Combined winnower and thresher exploded view*

The threshing and winnowing processes are integrated into one attachment which has an outer shroud thats designed to guide the threshed seed and chaff. It serves as the safety guard and guide to blow chaff away.

The threshing element is cylindrical in shape and has surface profile to seperate seeds from stalk when rotated at high speeds. The threshing drum has got hollow spaces to allow passage of air blown out from the vertical fan blade loaded within it in the same driveshaft.

Within the threshing drum the wind curtain fan blade and its protective shroud are loaded which generates the required amount of wind to blow away the remaining chaff after initial threshing, so as to carry out winnowing (Fig 70).

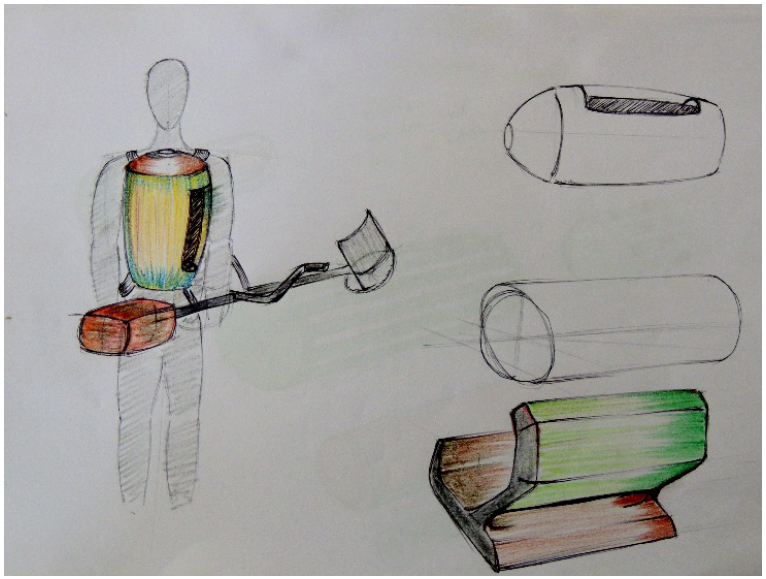

Fig.71: *Concept of user carrying the equipment*

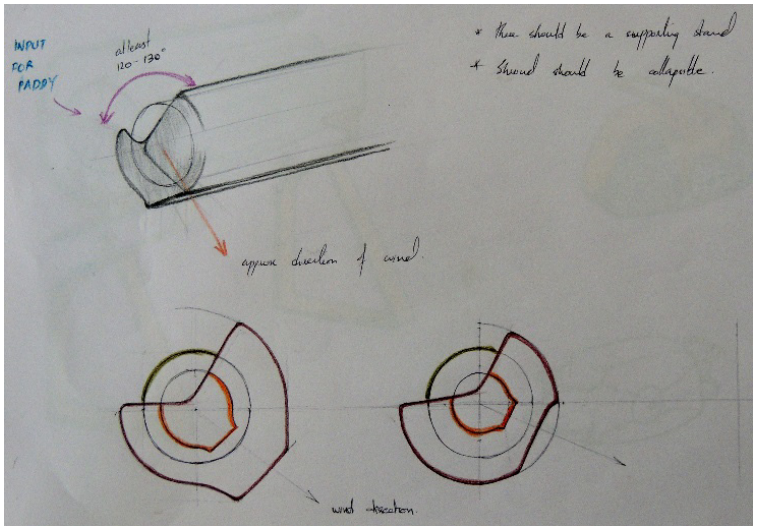

Fig.72: *External shroud design with chaff outlet*

The threshing and winnowing unit is envisaged to be an attachment which the user can carry along with him(Fig 71) when he walks to the field. The proportions of the product ensure that it does not fall into the category of heavy machines that are difficult for the user to move around.

The outer shroud of threshing drum(Fig 72) is conceived in a manner that allows free falling of the seperated seeds and a guide to remove the chaff and dust, post winnowing.

CHAPTER 16

Benchmarking

Fig.73: *Paddy harvester body worn*

17.1 Harvester

After analyzing the market we identified the product to be procured that will enable us to realize the concept. Paddy harvester which happened to be a modefied version of body worn weed wacker was bought(Fig 73). The equipment is marketed and used as a paddy harvester which has the 50cc petrol engine oriented behind the user. The machine has no element that comes in contact with the ground during its intended operation.

Currently many farmers use this machine for harvesting comparitively smaller plots of paddy farming, as the product offers better maneuverability and ease of cutting.

Fig.74: *Unboxing paddy harvester*

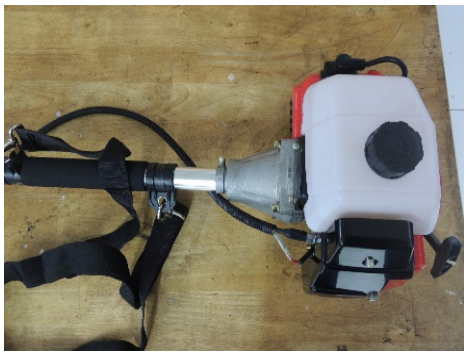

Fig.75: *Paddy harvester motor*

Fig.76: *Choke valve*

Fig.77: *Pull chord of motor and fuel tank*

Fig.78: *Kill switch of motor*

Fig.79: *Spark plug of motor*

Based on our market search, we were able to procure a H411 Paddy harvester from a local vendor for Rs 4500. This device is sold in a disassembled state(Fig 74) which reduces its cost by a large extent.The unit is sold in two cartons, one which contains the long shaft which contains within it the rotor shaft and the second carton which contains within it:

- 1 Motor (Max Power: 1.45/7000 kW/r/min) (Fig 75, 76, 79)
- 1 Harvester guide
- 1 Blade guard
- 1 Blade
- 1Toolkit
- 1 Fuel mixing bottl
- 1 pair of Handles with speed modulator
- 1 Harness
- 1 Manual and a CD with assembly details and videos.

The assembly of the product is in the manner of a DIY project where the user can couple the shaft to the coupling cone on the motor with the help of the allen keys provided in the tool kit.

The use of the Harvester can be broken down into the following steps:-

- Starting the motor by pulling the pull chord (Fig 77)
- Lifting the entire unit-Securing the unit by means of the harness provided (Fig 80)
- Adjusting the height of the blade with the help of the harness belt
- Using the swaying motion cut the paddy and lay to one side by means of the Harvester guide(Fig 82,83).

The motor has a fuel capacity of 0.6Lit and can run continuously for half an hour.

Fig.80: *Paddy harvester in action*
Image source: http://www.brushcutters.in/images/rice%20reaper.jpg - As seen on 3/11/2014

Fig.81: *Harvester blade mount*

Fig.82: *Harvested paddy in an array*
Image source: http://i.ytimg.com/vi/JMzjAwkU4tA/hqdefault.jpg - As seen on 3/11/2014

Fig.83: *Harvester entry into ripe field*
Image source:http://www.nacsinternational.com/imagescat/1385542121664044.jpg - As seen on 3/11/2014

17.2 Winnower

Fig.84: *ACO tower fan*

Image source: http://jvelectric.co.in/stores/image/cache/data/tower2%20copy-300x450.jpg - As seen on 3/11/2014

The winnower is traditionally a fan-basket which is used to sift the loose chaff and stalk , outputs from threshing at a height there by separating the heavier paddy grains which fall closer to the ground by means of gravity.

As our product has many longitudinal rotating members to have separating axial blower fan at one end would require a counter balance at the other, the stresses induced on the shaft would also be imbalanced and the entire unit becomes bulky.

With the help of our guide we focused on the concept of a longitudinal fan, like a squirrel cage axis fan used in vertical cooling units. This units mainly consist a rotating longitudinal fan enclosed by a shroud which consists guiding vanes, to guide the flow of air from the inlet suction to the outlet.

Our main aim was to procure such an axial squirrel cage fan (Fig 84) and the aerofoil guide vanes for building and testing our winnower. After getting hold of a tower fan, the internal layout and assembly of the winnower fan were observed (Fig 85-90).

Fig.85: *Fan blade of wind curtain*

Image source:http://img.weiku.com/waterpicture/2011/10/22/7/split_wall_mounted_air_conditioner_fan_blade_fan_wheel_fan_impeller_6345895213189796 65_5.jpg - As seen on 3/11/2014

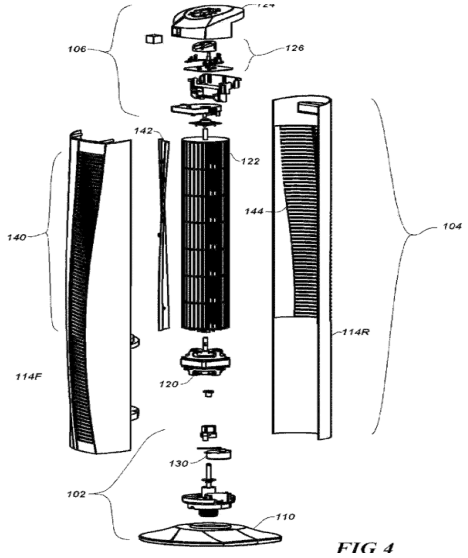

Fig.86: *Tower fan exploded view*

Image source: http://www.faqs.org/patents/img/20090290973_04.jpg- As seen on 3/11/2014

Fig.87: *Shroud of tower fan*

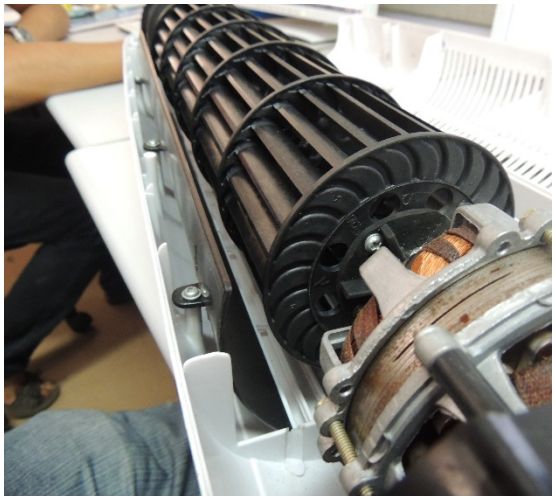

Fig.88: *Fan blade , shroud and motor*

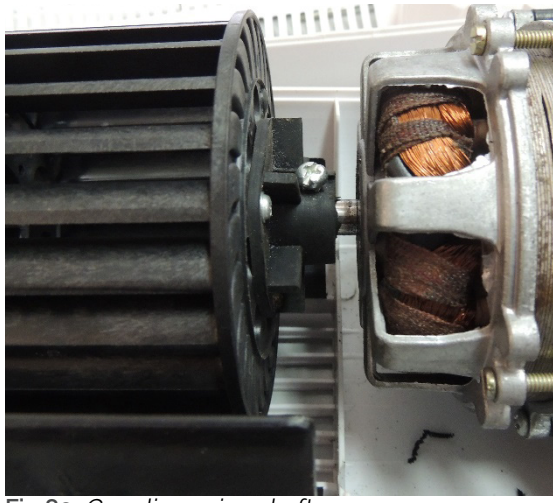

Fig.89: *Coupling using shaft*

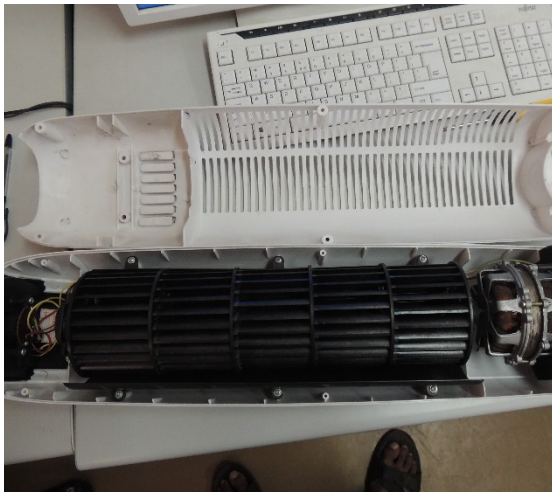

Fig.90: *Shroud profile for air intake*

CHAPTER 17

Intended Direction

Based on our concepts and the existing time frame of the project we decided to use the synergy of the existing Harvester product and its product system and use its power unit and coupling units to help create the basis for a combined threshing and winnowing unit.

The combined threshing and winnowing unit would consist of an outer shroud for collecting loose chaff and stalk which is blown by a winnower enclosed by a threshing drum. The whole unit would be mounted on a rigid light weight stand.

CHAPTER 18

Product Detailing

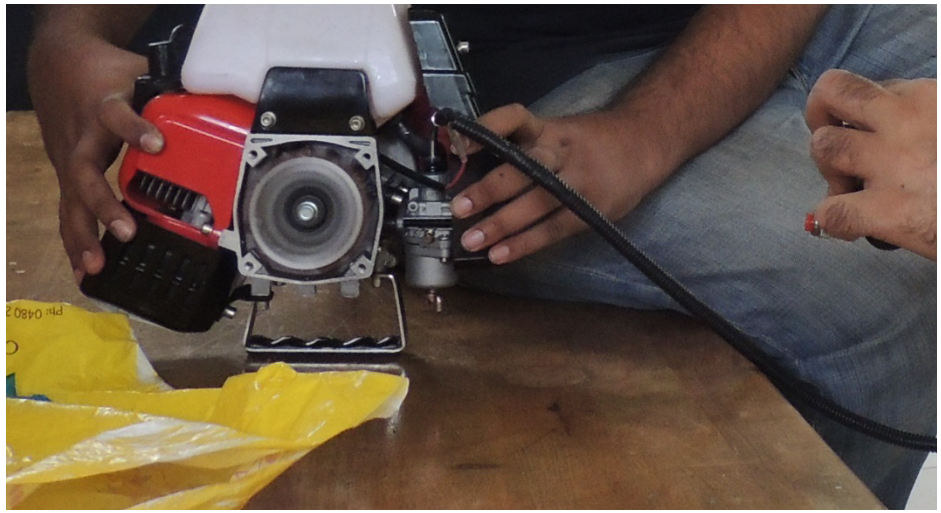

Fig.91: *Observing motor coupling area*

19.1 Rig testing

The rig used to test our basic concept mainly consisted of the motor from the harvester(Fig 91), a threshing drum made using the PVC cylinder on which to simulate the teeth profile we attached PVC wire mats using adhesive(Fig 92).

To simulate winnowing our initial concept was to use an axial exhaust fan. The fanblade was loaded on to the driving shaft, closer to the motor(Fig 93).

This rig gave us an understanding of the imbalance of the entire unit if it were used without a rigid stand. It gave us an understanding of the type of vibrations and the importance of centring the shaft using proper means. Makeshift adjustments were required throughout the test(Fig 94,95).

The application of the exhaust fan was a failure as there was little or no air current generated for the purpose of winnowing. This confirmed our assumption of using the longitudinal fan with a proper shroud.

Fig.92: *Mockup of threshing drum*

Fig.93: *Mockup of conventional fanblade loading*

Fig.94: *Re-engineering kill switch*

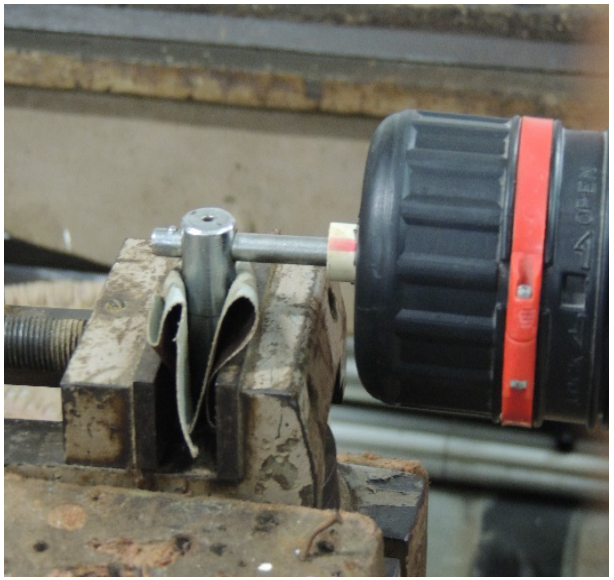

Fig.95: *Temporary fixing other end of shaft for stationary operation*

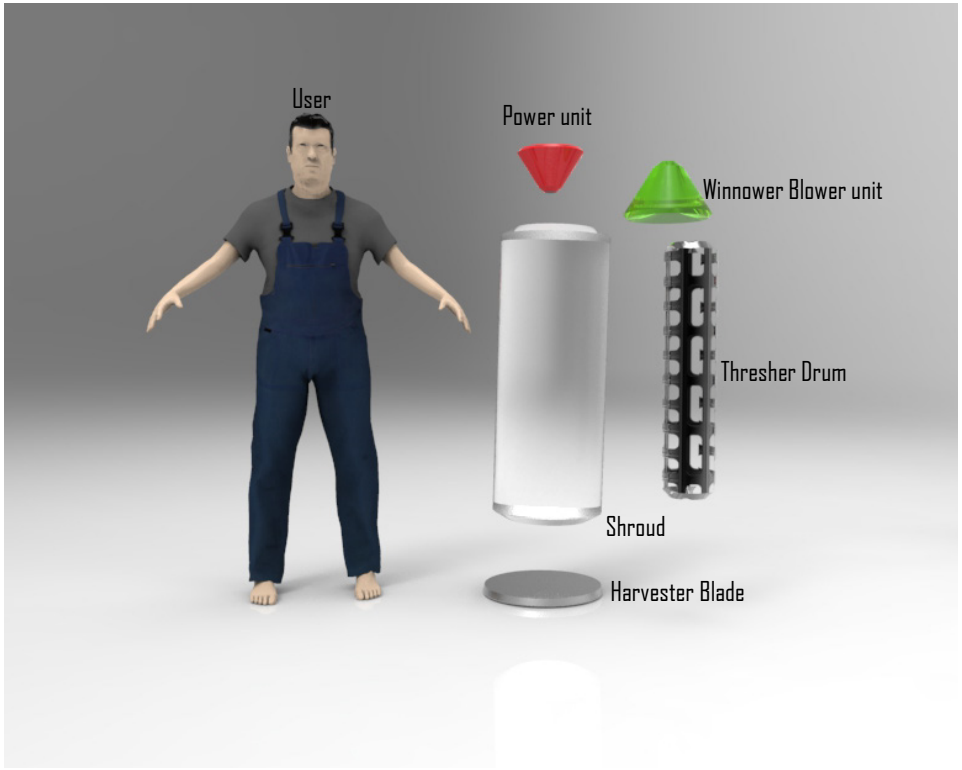

Fig.96: *Components involved*

19.2 Human factors

To understand the role of configuration of each unit in terms of a human-product interaction, we divided the entire system into 6 basic units (Fig 96):-

- the user (180cm Height)
- the motor/ power unit
- the threshing drum
- the winnower fan
- the harvester blade
- the outer shroud

Different configurations of the above six units are shown below with pros and cons that were understood for each scenario (Fig 97-104).

Key points that came about as a result of this exercise the kind of fatigue that the user would undergo with the positioning of each unit and the type of safety hazards he would have to endure.

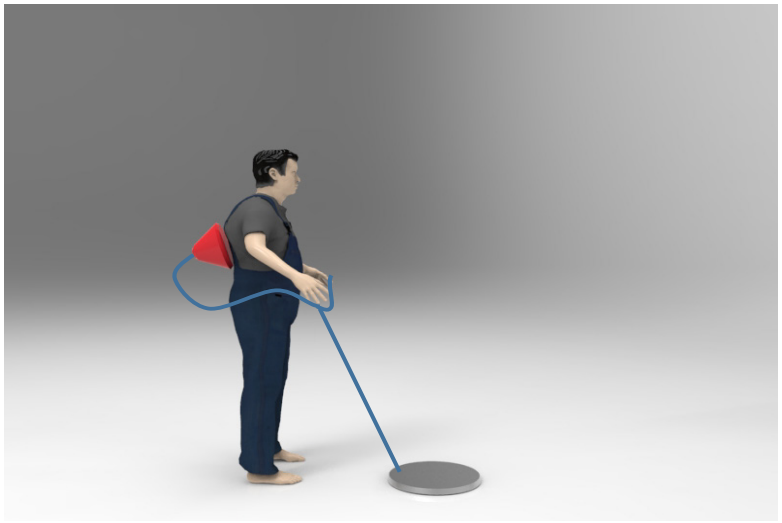

Fig.97: *Pros: Manoeuvrability, Even Weight distributionCons: User Fatigue due to vibration and heat, Wear and tear of shaft*

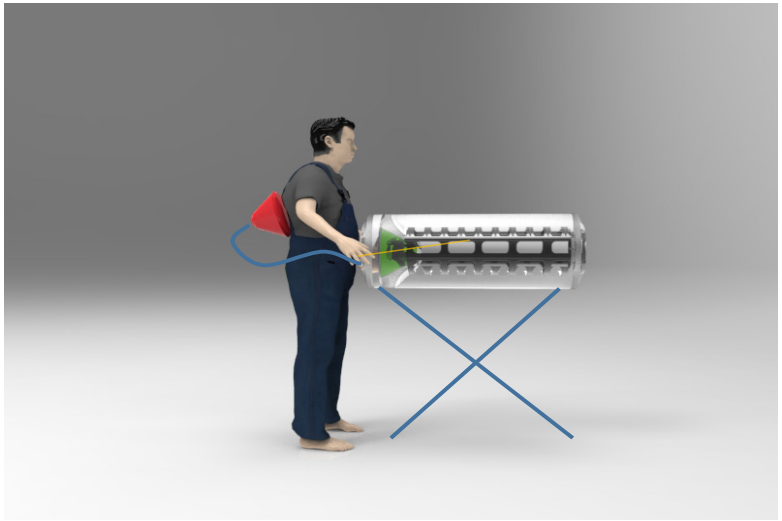

Fig.98: *Pros: Manoeuvrability, Even Weight distribution, Easy loading of paddy stalkCons: Unstable Structure of Winnower and Threshing unit*

Fig.99: *Pros: Rel. stable structure, Rel. efficient means of obtaining grainsCons: Manoeuvrability, Intimidating product appearance*

Fig.100: *Pros: Manoeuvrability, Lower weight distribution with guide castorCons: Vibration along the shaft, Maintenance of the power unit*

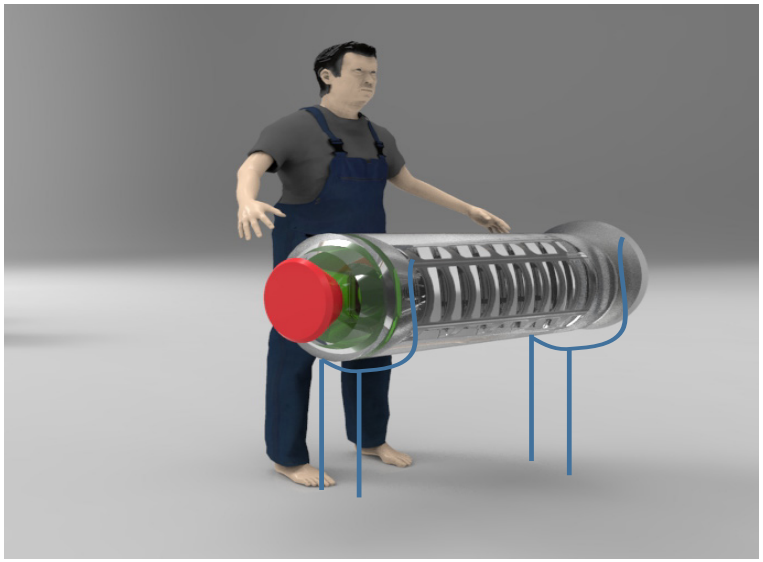

Fig.101: *Pros: Manoeuvrability, Even Weight distribution, Easy loading of paddy stalk, Unified productCons: Unstable Structure of Winnower and Threshing unit, Bulky, Material intensive*

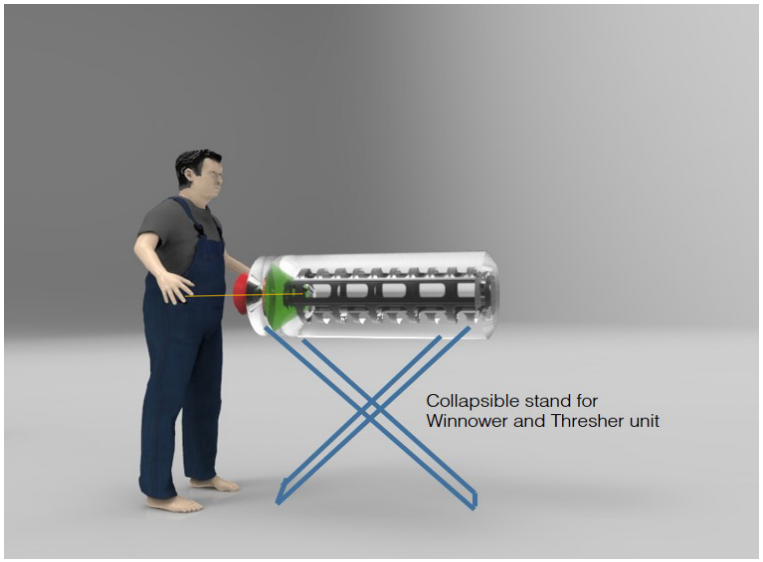

Fig.102: *Pros: Easy loading of paddy stalkCons: Unstable Structure of Winnower and Threshing unit, Bulky, Material intensive*

Fig.103: *Pros: Manoeuvrability, Sweeping/ Mowing action possibleCons: Vibrational fatigue in the hands*

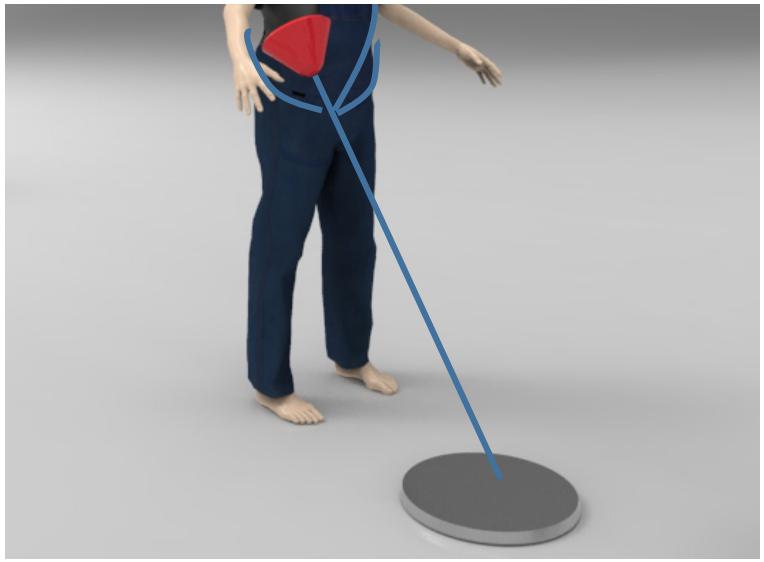

Fig.104: *Pros: Manoeuvrability, Power unit's weight is counter-balanced by shaft+ blade unitCons: Fatigue due to uneven weight distribution*

19.3 Assembly Details

Based on the Rig testing conducted we finalised our assembly details, where in we cannibalize the existing power unit and the coupling units of the Harvester.

The basic principle of assembly is to connect the axial squirrel cage blower fan from the vertical cooler to a manufactured shorter rotor shaft, which engages with the motor at one end and rotates freely in the bearing present in the end unit of the harvester attached at the other end .

An outer shroud is placed over this rotating shaft which has guiding vanes inside,this is a static member which has to be connected to a static shaft at the motor's coupling unit, this member acts as a cantilever support.

The threshing drum fits over the outer winnower shroud, the torque of the motor is transferred to the threshing drum at the end unit before the rotor shaft enter the end coupling unit.

At the motor end the threshing drum engages with a bearing fixed on the static pipe, causing the outer cylinder of the bearing to rotate while the inner one remains static, snug fitted on to the static pipe (Fig 105-110).

Fig.105: *Loading driveshaft*

Fig.106: *Winnower fan blade on shaft*

Fig.107: *Winnower fan shroud on shaft*

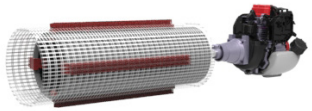

Fig.108: *Attaching threshing drum*

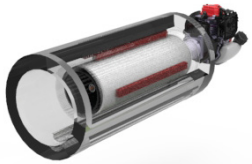

Fig.109: *Thresher drum shroud attachment*

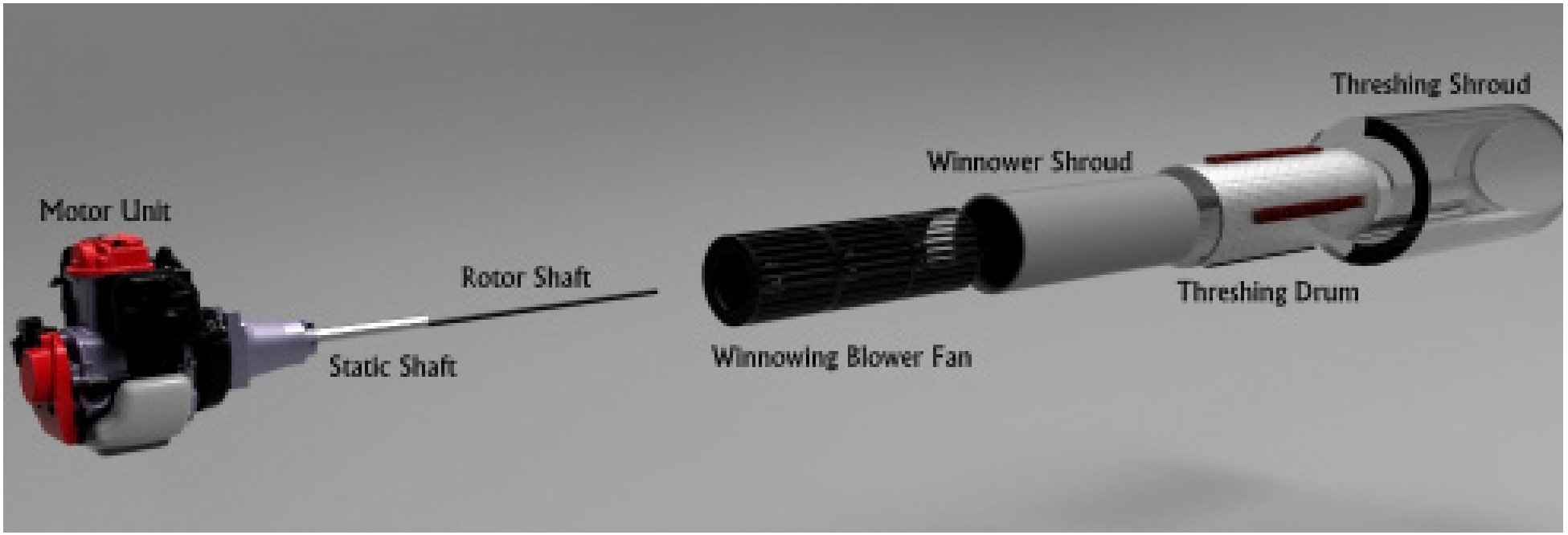

Fig.110: *Thresher and winnower assembly*

19.4 Engineering Drawing

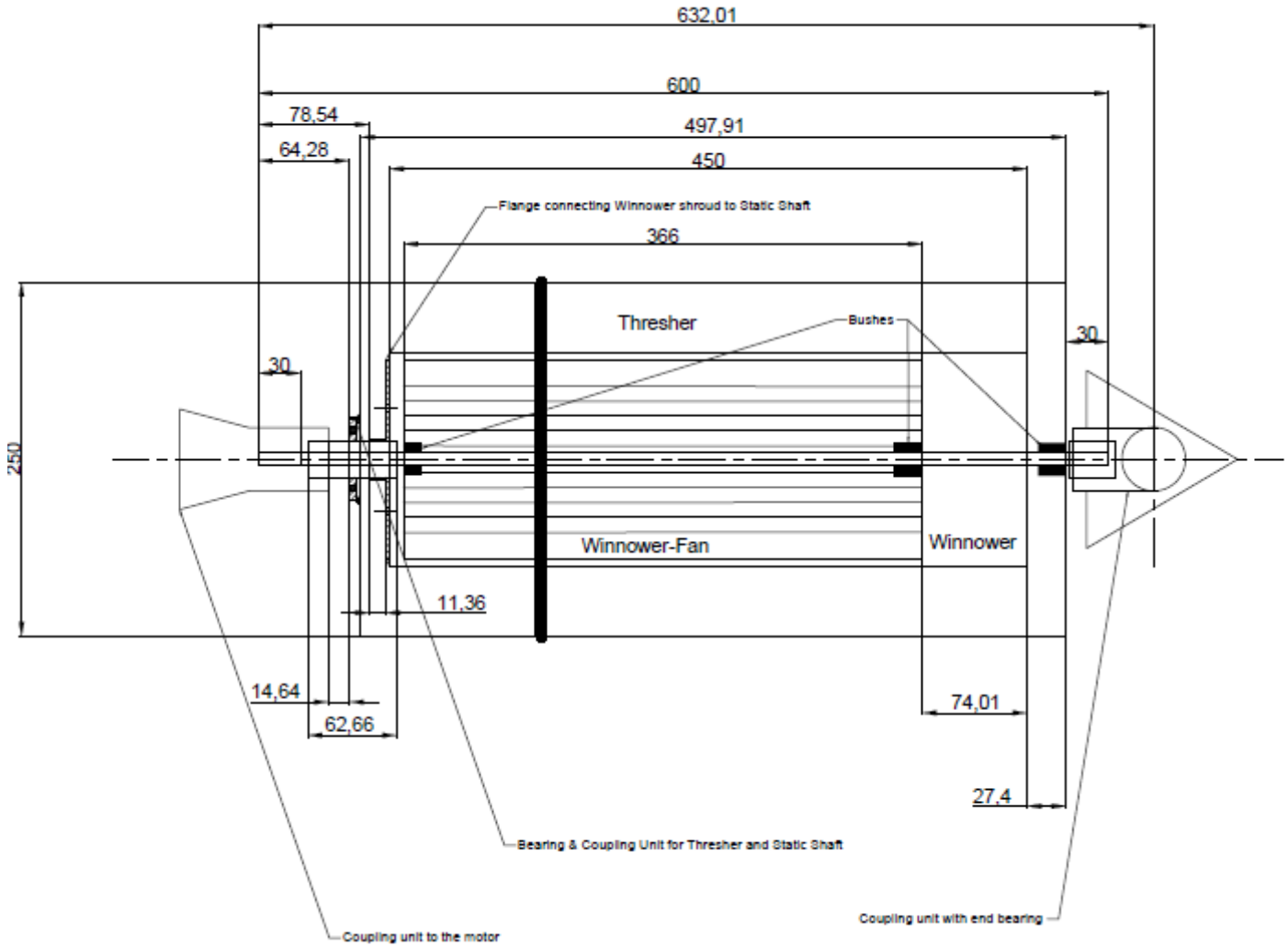

Fig.111: *Top view of combined threshing & winnowing unit (w/o stand)*

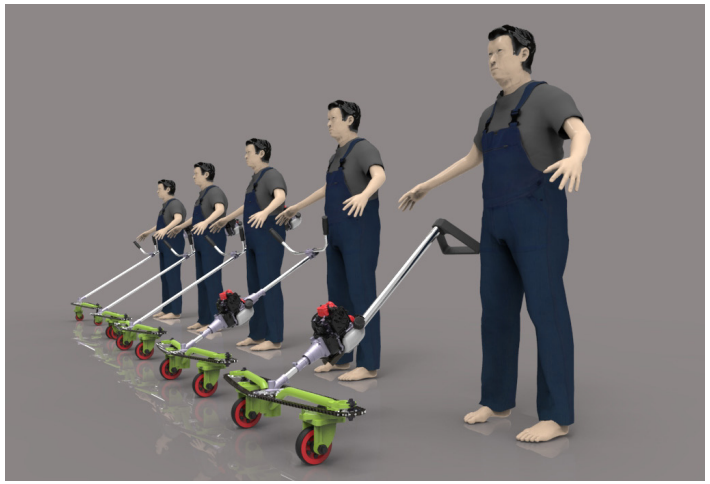

Fig.112: *Harvester end redesign*

Fig.113: *Iterations of harvesting end*

Future Scope

- Possible reorientation of Harvester

The harvester which was procured from the market requires the user to perform continuous motion along his hipline to cover sufficient area for harvest, in order to increase the efficiency. This repetitive motion causes physical stress.

Redesigning the cutting end would open up a path to address the problem effectively.

- Business Model

Implementing a business model along the lines of co-operative farming where one such unit of harvester and thresher plus winnower could be shared amongst a group of farmers would ensure minimal investment per head and lower operating costs as people tend to help each other out in their chores.

CHAPTER 20

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