

REPORT

Design of head gear and personal protective suit for wild honey bee harvesters

Industrial Design Project -III

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Guide- Prof. Sandesh R



IDC- School Of Design
Indian Institute of Technology
2017

Declaration

I declare that this written submission represents my own ideas and where other's ideas or words have been used, I have adequately cited and referenced the original sources. I also declare that I have adhered to all the principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any ideas/source/fact in my submission. I understand any violation of the above will be the cause for a disciplinary action by the institute and can also issue penal action from the sources which has been thus not been properly cited or from whom proper permission has not been taken where required.

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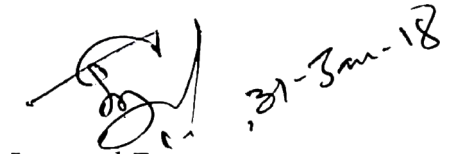
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Approval

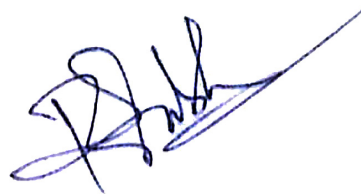
This project titled “Design of head gear and personal protective suit for wild honey bee harvesters” is prepared and submitted by Arjun Prasanth in partial fulfilment of the requirement for the degree of ‘Masters in Design’ in Industrial Design. It has been examined and is recommended for approval and acceptance.

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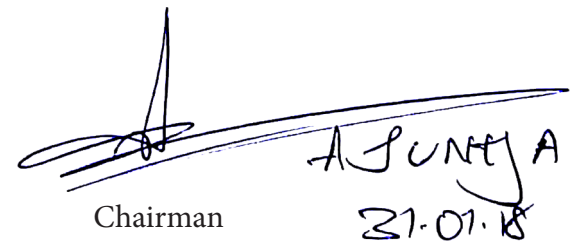
External Examiner

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Internal Examiner

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Project Guide

A handwritten signature in blue ink, featuring a stylized 'A' or 'J' shape, followed by a long horizontal stroke and the name 'A. SUNNY A' and the date '21-01-18'.

Chairman

Acknowledgement

This project is a result of lots of constructive feedback and inspiration from my project guide Prof Sandesh R and his method of understanding a situation to the core level with deep insights. I would like to express my sincere gratitude to all my PD classmates who gave useful suggestions that helped me throughout the design process.

Abstract

The project addresses the issues faced by wild honey harvesters by having a comprehensive study of the entire wild honey harvesting process.

The non-violent harvesting of rock bee honey and wax and their post-harvest storage is taken into consideration for developing a comprehensive design approach. Wild bee (*Apis Dorsata*) is considered as the most defensive of all honey bee species and their nests are mainly built in exposed areas far from the ground, like on tree limbs, under cliff overhangs, and sometimes on buildings.

A site visit to Wardha, Maharashtra, improved the knowledge of wild honey harvesting process with the interaction of honey harvesters. The visit to a workshop where the protective suits are made helped in understanding the issues with the existing suit design and manufacturing process. The tools and methods used to make the suits are very frugal, and a similar approach was continued in the project in order to make it easy for manufacturing. After analyzing the manufacturing process and the interaction with honey harvesters, the design direction to the project was formulated.

The design direction was to achieve an optimized solution for the manufacturing of the suit, use of locally available facilities. The protective suit had required to withstand bee sting and wear and tear from bark of trees while climbing and crawling during the harvesting process, to ensure safety and personal protection for honey harvesters. Hence, the fabric chosen should be durable enough, so canvas cloth is chosen as the material. Industrial hard hat had also been integrated to ensure safety of the skull area. The need for cleaning the suit after every honey collection was taken into account in the design process. The design had evolved to ensure smooth working and safety of the personnel, climbing several beehives one after another without compromising on comfort.

Initial ideations with mockups were made and further, feedback from actual users was obtained. Prototype testing with the mock ups helped in refining the concept. Based on the feedback received from the harvesters, some ideas were taken forward to develop them as concepts with features like - quick fixing of canvas with the helmet, lightweight and durability, ease of washing and ease of manufacturing. Anthropometric measurements of three sizes (small, medium and large) were adopted during fabrication. A full protective suit was made for demonstration and constructive feedback was received.

The project was useful in the field of wild honey harvesting to bring in an awareness of safety and self-protection while carrying out the harvesting process.

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WILD HONEY BEES

Wild honey bees

Introduction

Apis Dorsata



Fig 1

Giant honey bees (*Apis dorsata*) of southern Asia are vital honey producers and pollinators of cultivated crops and wild plants. They are known to migrate seasonally up to 200 km. It has been assumed their migrations occur stepwise, with stops for rest and foraging, but bivouacking bees have rarely been seen by scientists. They are typically around 17–20 mm (0.7–0.8 in) long. Nests are mainly built in exposed places far off the ground, like on tree limbs, under cliff overhangs, and sometimes on buildings. These social bees are known for their aggressive defense strategies and vicious behavior when disturbed.

Ref- <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0044976>

Ref- https://en.wikipedia.org/wiki/Apis_dorsata

Wild honey bees

Introduction

Apis dorsata has been described as one of the most dangerous animals of the southeastern Asian jungles due to their threatening defensive behaviors. It is considered the most defensive of all of the honey bees, even more defensive than the African honey bee (Ellis and Ellis 2009; Hall et al. 1995).

Their main weapons are stingers that are up to 3 mm long and easily penetrate clothing and even the fur of a bear. Attached to the stingers are large venom glands with accompanying muscles that pump the venom into the skin, thus delivering a painful sting.

Large numbers of *Apis dorsata* attack a perceived threat, though only a few provide the painful stings because the bees will die shortly after stinging. The other bees will buzz loudly and bite the threat to deter the threat, without risking the life of many individuals.



Fig 2

Apis dorsata is found throughout the southern countries of Asia, including Malaysia, Indonesia, and the Philippines. The greatest number of *Apis dorsata* colonies are found in dense forest areas or on cliffs, but nests are occasionally found in urban areas on building ledges.

Wild honey bees

Life cycle



Fig 3

Wild honey bees

Life cycle

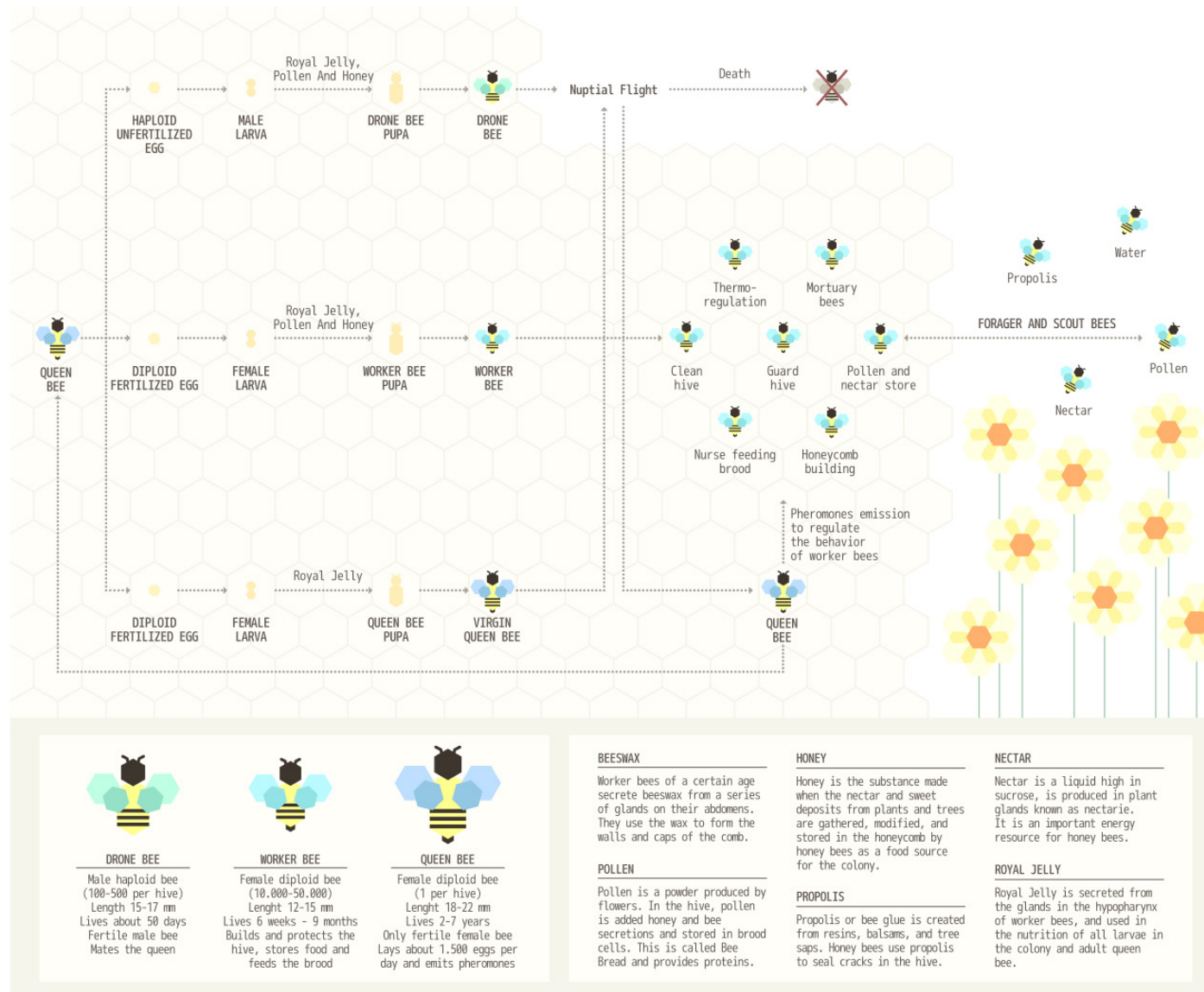


Fig 4

Wild honey bees

Beehive of wild honey bees



Fig 5



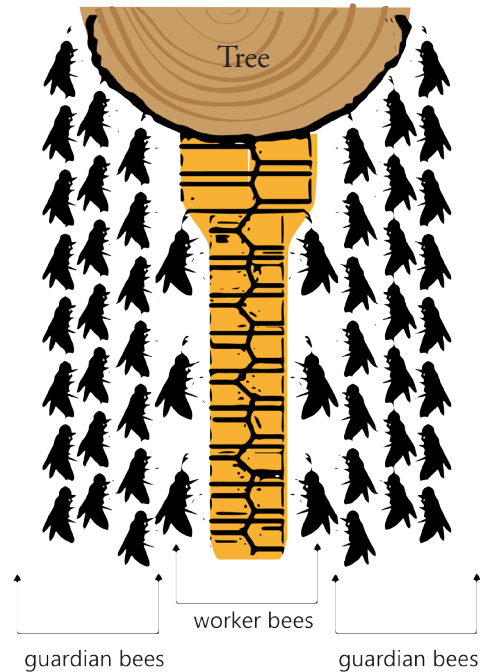
Fig 6

Apis dorsata differs from the other bees in its genus in terms of nest design. Each colony consists of a single vertical comb made of workers' wax suspended from above, and the comb is typically covered by a dense mass of bees in several layers. Nests are mainly built in exposed places far off the ground, like on tree limbs, under cliff overhangs, and sometimes on buildings. The nests are mostly conical in shape and vary in size, reaching up to 1 meter in width. Each cell within the comb is hexagonal in shape. *Apis dorsata* store their honey on the top right-hand corner of the comb and rear the worker and drone brood in the same location of the nest. They build a single large comb up to 150 cm in length and 70 cm tall. The comb is permanently covered by a curtain of up to 100,000 worker bees.

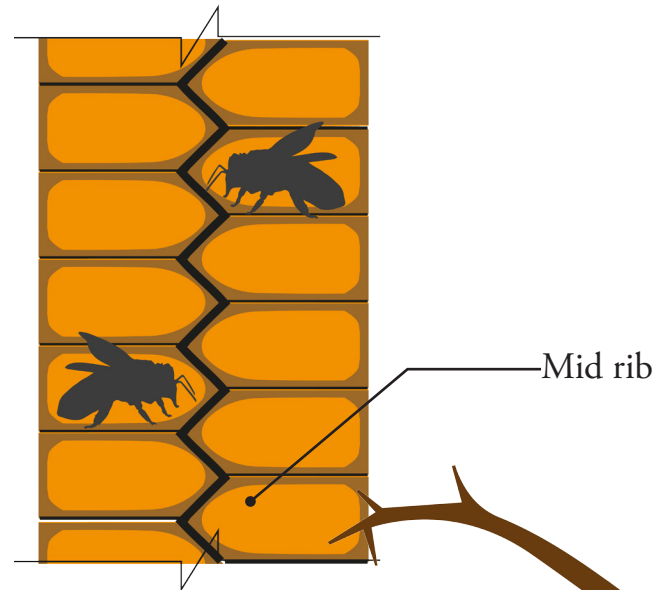
This curtain is several layers of bees thick and forms a protective barrier separating the vulnerable brood from the environment. This curtain is sufficient to protect the nest during storms with heavy wind and rain.

Wild honey bees

Beehive of wild honey bees



Cross section

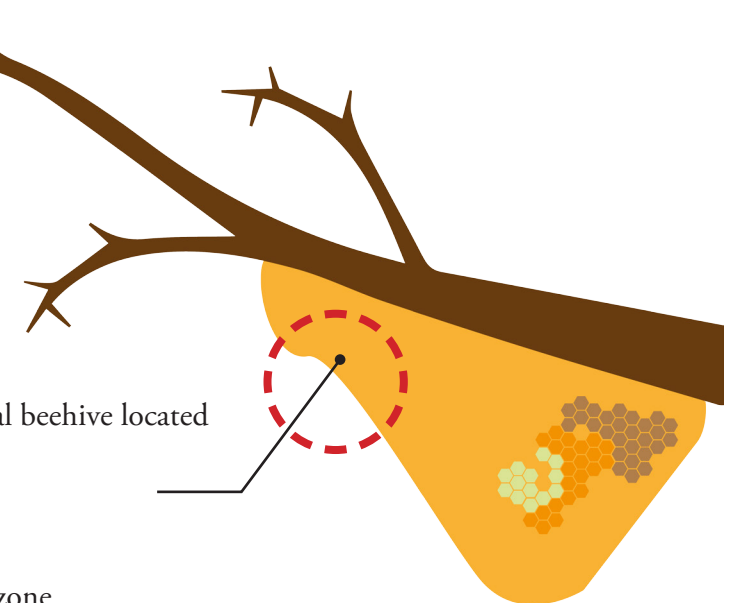


Top view

70% of the stock honey is present in the 30% of the total beehive located upper portion of a slanting branch, bulged portion.

Reason

- CG in accordance to angled branch is here
- Proximity of bees to reach the branch is high at this zone



Wild honey bees

Pollen and productivity

Although the bees are not managed for pollination, many crops throughout southern Asia depend upon *Apis dorsata*. Some of the major crops thought to be heavily dependent upon *Apis dorsata* pollination include: cotton, mango, coconut, coffee, pepper, star fruit, and macadamia.

Rockbee forage during summer, winter and rainy season are listed below

Summer



Amla

Winter



Utran

Rainy



Nirgudi



Mango



Mehandi



Teakwood



Karvand



Bawachi



Yellow gulmohar

Wild honey bees

Bee vision

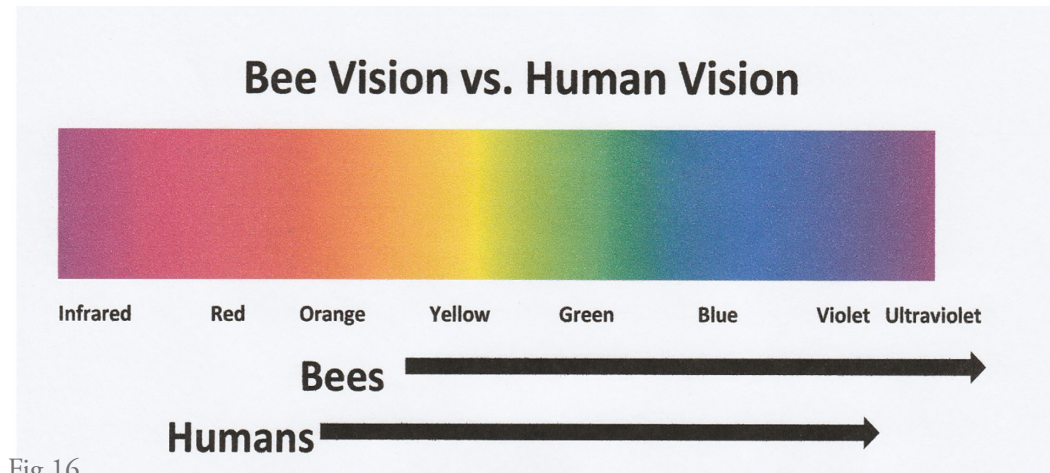


Fig 16

The eyesight of bees has long been a source of fascination in the scientific community. Even though humans can see more colours, bees have a much broader range of colour vision. Their ability to see ultraviolet light gives them an advantage when seeking nectar. Many patterns on flowers are invisible to humans. These nectar “bulls-eyes” are visible only to animals, such as bees, that have the ability to see ultra-violet light.

This “bee vision” makes finding nectar much easier.

Like us, bees are trichromatic. That means they have three photoreceptors within the eye

and base their colour combinations on those three colours. Humans base their colour combinations on red, blue and green, while bees base their colours on ultraviolet light, blue and green. This is the reason why bees can't see the colour red. They don't have a photoreceptor for it. They can, however, see reddish wavelengths, such as yellow and orange. They can also see blue- green, blue, violet, and “bee's purple.” Bee's purple is a combination of yellow and ultraviolet light. That's why humans can't see it. The most likely colours to attract bees, according to scientists, are purple, violet and blue.

Ref: <http://www.beeculture.com/bees-see-matters>

Wild honey bees

Bee sting pain index

The Schmidt Pain Index was developed by Dr. Justin Schmidt, an entomologist, as a method for comparing the pain of various different insect stings he experienced during his work. The scale runs from 1 to 4, with four being the most painful. Pain can be subjective, varying from person to person, and this scale is therefore not absolute.



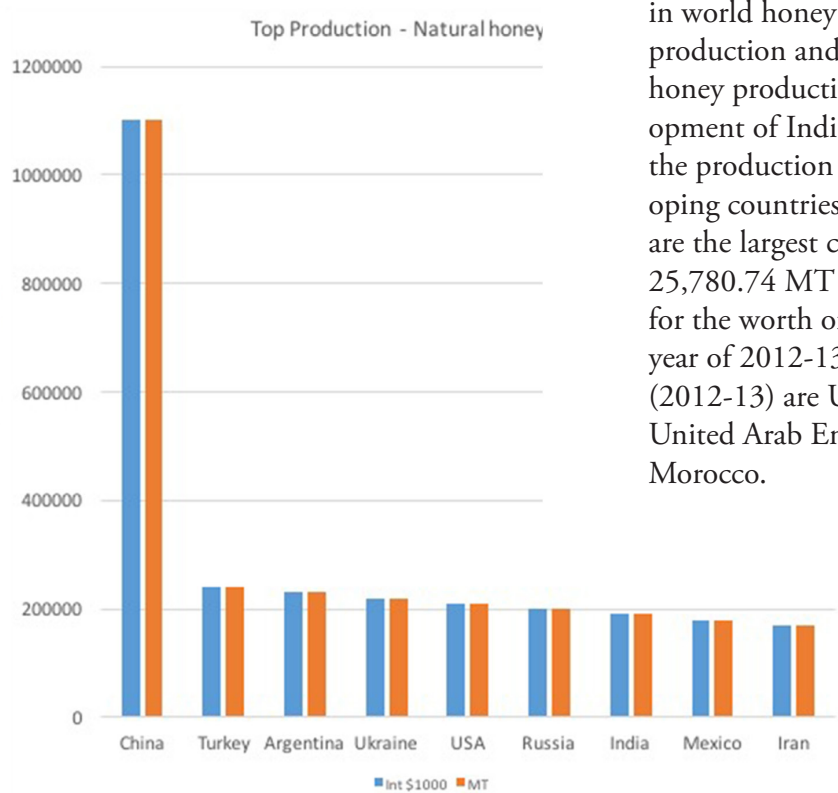
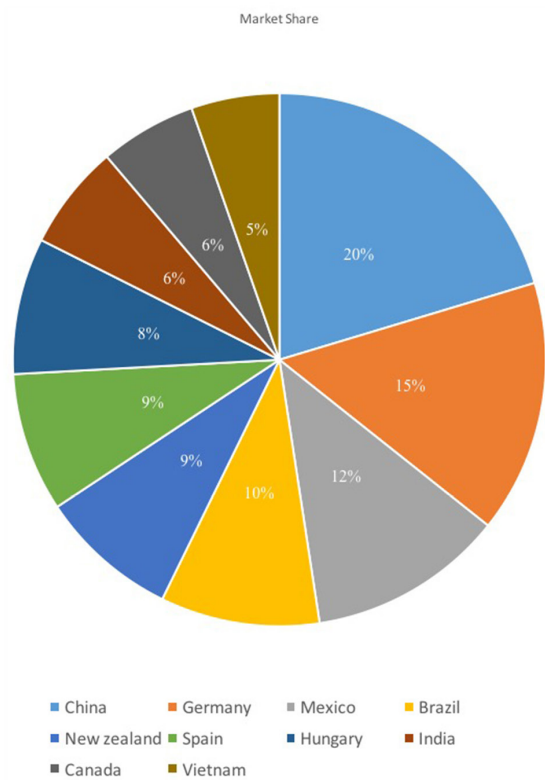
Note: circles sizes relate to duration, but are for purposes of comparison only, and are not to scale. All durations are an average, and as with pain, are subject to variation.

Ref- <http://www.compoundchem.com/wp-content/uploads/2014/08/The-Schmidt-Insect-Sting-Pain-Index.pdf>

The background features a decorative pattern of orange hexagons. In the upper left, there is a cluster of hexagons, some of which are white with orange borders. A large, solid orange shape occupies the lower half of the image, containing a single white hexagon on its left side. The title text is positioned in the lower right area of this solid orange shape.

WILD HONEY HARVESTING

Wild honey harvesting | Honey Trade



India, one of the largest honey producer and exporter in the world, plays an important role in world honey production and trade. The change of world honey production and trade affects the development of Indian apiculture. The majority of the production of honey takes place in developing countries, while the developed countries are the largest consumers. India has exported 25,780.74 MT of natural honey to the world for the worth of Rs. 356.28 crore during the year of 2012-13. Major Export Destinations (2012-13) are United States, Saudi Arabia, United Arab Emirates, Yemen Republic and Morocco.

Ref: <https://goo.gl/5hkbdw>

Wild honey harvesting | Traditional method In cliffs



Fig 17

The basic method of lighting fire under the bee cliffs to smoke the bees from the combs appears to be universal



Fig 18

A ladder is suspended from the top of the cliff, tightly secured to trees at both upper and lower ends. Honey hunter is fastened to the ladder by a rope and descends the rope ladder.



Fig 19

Two to three persons are responsible for checking, raising and lowering the rope to send items down from above and pull items up from the floor as necessary.

Ref- <http://thebeephotographer.photoshelter.com/gallery/INDIA-Honey-of-the-untouchables/G0000QXrThgpVfi8>

Wild honey harvesting | Traditional method

In cliffs



Fig 20

Near the ladder a large woven collecting basket is lowered to the nest site through another rope. When the honey hunter gets near the nest to be harvested, he uses a long stick to balance the collecting basket exactly under the comb.



Fig 21

The honey hunter uses a bamboo stick to pierce a hole in the brood comb area of the colony to be harvested. By piercing the comb and attaching hook to the comb, honey hunter cuts the brood portion of the comb safely. After that, wooden or iron sickles fixed to the bamboo stick cut honeycombs.



Fig 22

The Gurung tribesmen of Nepal are master honey hunters, risking their lives collecting honeycomb in the foothills of the Himalayas, using nothing more than handmade rope ladders and long sticks known as tangos. Most of the honey bees' nests are located on steep inaccessible, south-west facing cliffs to avoid predators and for increased exposure to direct sunlight.

Wild honey harvesting | Traditional method

In trees



Fig 23



Fig 24



Fig 25

To protect himself from stings, the honey collector covers his face and limbs. He climbs up the tree with the smoking flame in his hand. He uses it to scare off the bees from their home and from himself as well. As the bees slowly abandoned their home, the expert climbs up directly above the beehive and positions himself so he can start extracting the honey. The startled bees buzz around the man as he throws down the section of the hive which has very little honey. The container he holds in one hand is used to collect the honey as he starts cutting the beehive.

Wild honey harvesting | Traditional method In trees



Fig 26



Fig 27



Fig 28

The man on the branch at such height has every chance of being stung by a bee and also falling to the ground.. The people helping on the ground collect the bits of the hive that have fallen down and squeeze and filter the honey out of it into a container. Honey extraction through the traditional methods like these result in the death of large number of bees

VISIT TO WARDHA

CBeeD (Centre for Bee development)

Visit to Wardha | INTRODUCTION

CBeeD (Centre for Bee Development)

Centre for Bee Development (CBeeD), Wardha, is a registered non-governmental organization (NGO), functioning since 2000, as a technology resource group in the field of rockbee management. It works on the philosophy of Nai Talim, as proposed by Mahatma Gandhi for building a self-reliant society. Exactly suited with 'this' thinking, our centre has evolved and optimized the necessary knowledge for the non-violent harvesting of rockbee honey and wax, their post-harvest storage, processing, product diversification, quality control and market promotion. Furthermore, the CBeeD is also working hard for the dissemination of evolved knowledge to benefit the society and the Nature, in general. Thus, by conserving the rockbee population, our centre is trying to rejuvenate the age-old traditional occupation of the tribals and availing quality honey to the consumers. Overall objective is being implemented in the various rockbee-rich forest pockets of our country through the local NGOs under several government schemes.



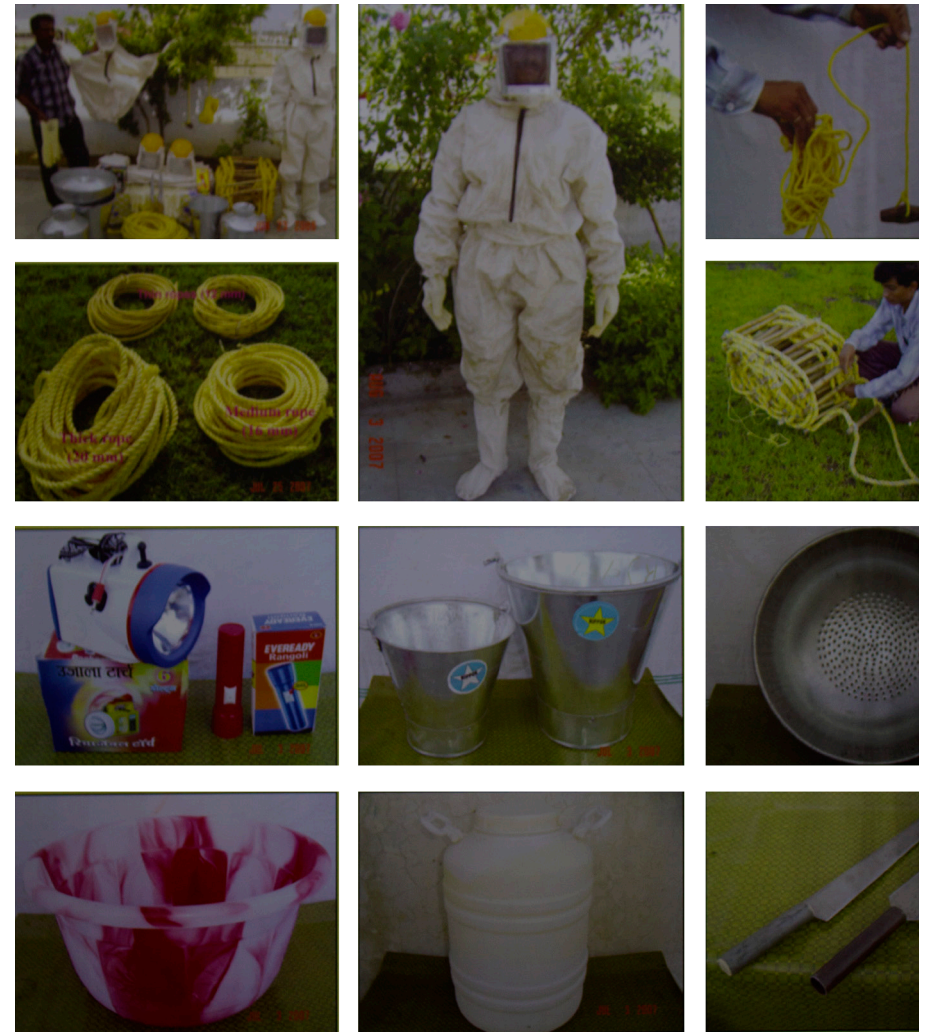
◀ Dr Gopal Paliwal(L) Secretary & Director at CBeeD and honey harvester, Manu(Centre), wearing the existing suit used for harvesting wild honey bee at CBeeD Wardha

Ref- <http://cbeed.blogspot.in/>

Visit to Wardha | CASE STUDY

Equipments for Rockbee honey wax collection

Around 90 MT honey-waxes are annually gathered by about 2200 trained honey collectors of 27 districts in 6 states of our country. They earn Rs. 70-80 lakh per annum with an individual income ranging from Rs. 5000-30000/-. Another 1000 tribal youths are also trained in Orissa, Andhra Pradesh and Maharashtra through the trainers trained by our centre CBeeD. Thus, CBeeD is directly working to save & strengthen the age-old 'traditional occupation' of tribal people



Visit to Wardha | CASE STUDY

Process of collecting wild honey



1 Securing a rope for tree climbing by using string and hammer

A metal piece is tied to a end thin rope which is then thrown over the bee hive containing branch



2 Aiming at the branch

The end of the portable rope ladder is tied to the other end of the thin rope and then hoisted up by pulling the metal end of the thin rope.



2 Climbing by rope

The rope end of the ladder is then tied to a adjacent tree firmly and a second harvester holds the rope ladder in the ground while the primary harvester climbs the rope ladder with his accessories tied to his body

Visit to Wardha | CASE STUDY

Process of collecting wild honey



3 Cutting the bulky honeycomb

The primary harvester reaches the beehive containing branch and then a bucket with knife is hoisted by the same method as ladder hoisting.



4 Bucket containing isolated bulky honeycomb roped down

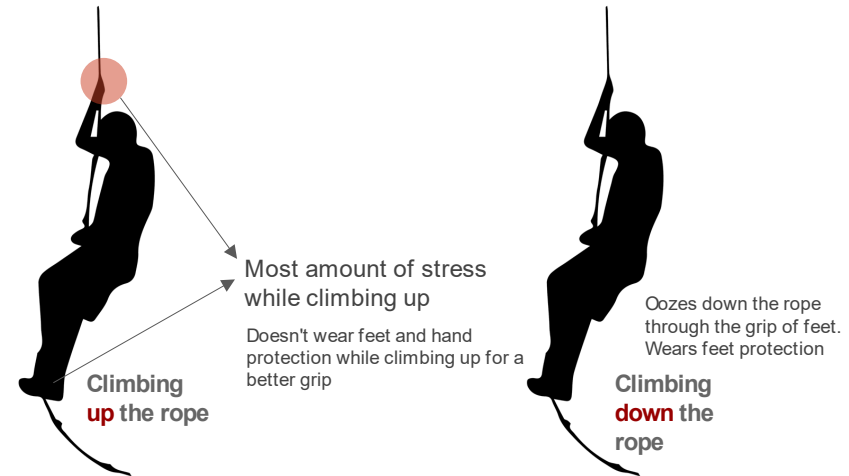
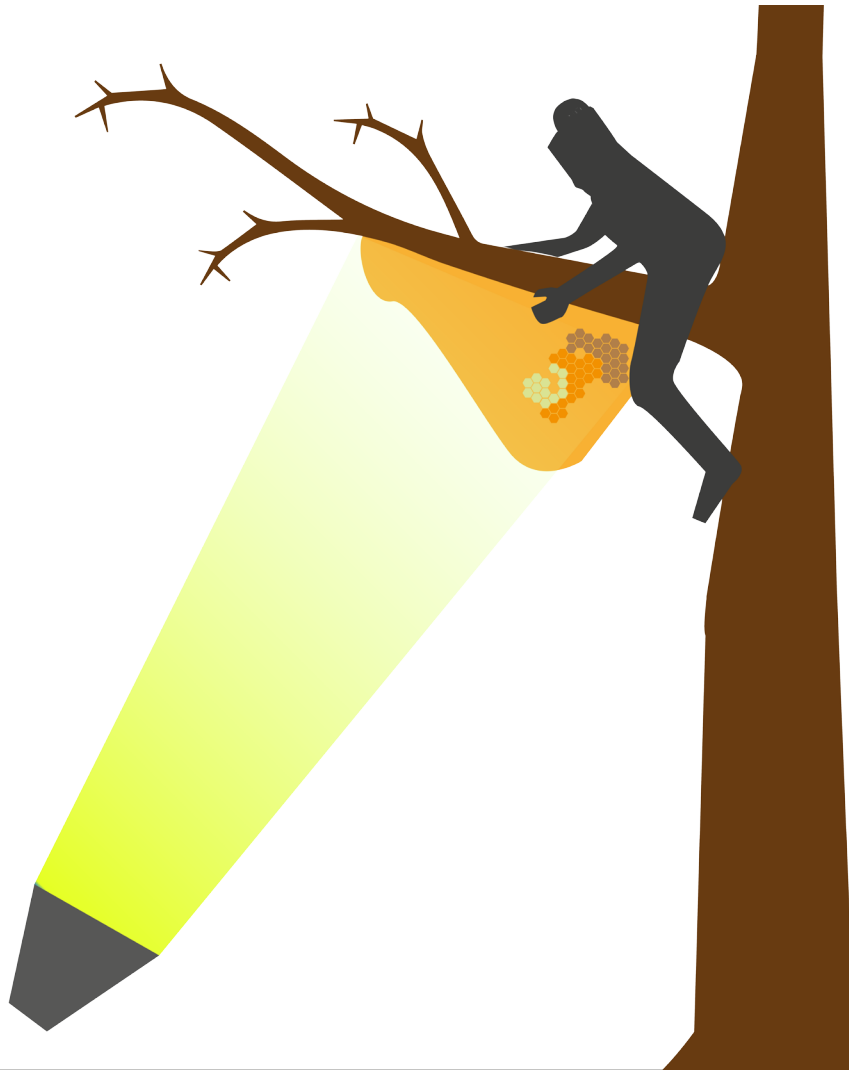
The harvester uses the knife to slice off a part of the comb and leaves the rest. He uses the same bucket to collect the honey combs. If the comb is small and is not reachable by hands, the hunters use a long bamboo stick with a knife tied to its end to cut the comb. Usually 3 or 4 men are sufficient to harvest honey by this method. A fire is lit on the ground just below the nest, to drive away the bees. Two of the harvesters spread out a net and hold it below the comb. Another harvester cuts off the honey comb using a long bamboo stick with a knife tied to its end. The honey combs which drop into the net are collected by the harvesters. The honey is squeezed into a large vessel and stored in large cans.



5 Coming down by rope

Visit to Wardha | CASE STUDY

Process of collecting wild honey



Team of honey collectors- 5-6 people, (1 or 2 people climb tree), others carry the equipments and assist the person who is climbing.

A person will light up the torch from ground to spread light evenly, not focussed on a single area, to not to distract the bees

Visit to Wardha | CASE STUDY

Process of collecting wild honey

Facts

- Honey collecting process happens at night time most of the times, so no smoke is used to scare away the bees.
- Honey harvested during March, April, May, June, November and December.
- 70% of the stock honey is present in the 30% of the total beehive located upper portion of a slanting branch, bulged portion.
- Second harvesting is done after 30 days as the rebuilding of the cut portion of the nest takes place during this time.
- 10-15 trees a month is climbed by a honey harvester on an average.
- Approx 10 min to climb up the rope, 20 min to cut the bulky honeycomb, 7min to climb down the rope
- On an average of 500 protective suits are made and distributed in a year

Visit to Wardha | CASE STUDY

Visit to CSV(Centre of Science for Villages, Wardha)



Non violent rock bee honey harvesting technique explained during the visit at Centre of Science for villages, Wardha



The bee protective suit which has been in use earlier

Primary goal of the centre is to “improve life conditions in the rural areas of India”. The techniques evolved by the CSV range from mud housing technology to various methods of energy procurement and crop cultivation. CSV actively works in the areas of promoting hygiene and development of alternative approaches of local industries. These techniques are primarily based on locally available materials.

To make honey collection technique non violent and eco friendly “Centre of Science for Villages”, Dattapur, Wardha has evolved a set of appropriate and simple technologies which are non destructive and non violent.

Visit to Wardha | CASE STUDY

Existing suit

Making of the existing suit

The place where the suits are made and its warehouse are two adjacent buildings. A long hall where the workers lay down the denims and fabric cut outs are been done. Denims are arranged in layers and the pattern to cut for the protective suit is traced on the cloth which is then taken back to the adjacent building for the stitching work.

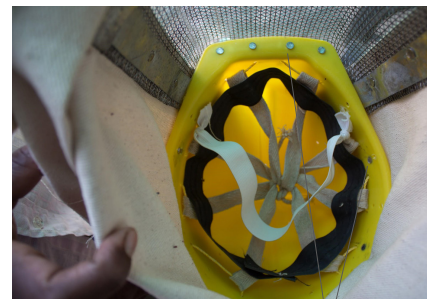


Visit to Wardha | CASE STUDY

Existing suit

Making of the existing suit

The crude methods followed in the process of manufacturing of the head part of the protective suit makes the process time consuming and rudimentary.



Visit to Wardha | CASE STUDY

Existing suit



Hand stitched

Set of helmets arranged



1 day to make only the head part

45 drills, 25 rivets and 2 nut and bolt in the head protective system.

Tight elastic which reduces the minimum air gap present between the suit and the skin

The head and the rest of the top part of the suit is stitched together and is a single unit with no connectors like zip, buttons or velcro.

Visit to Wardha | CASE STUDY

Existing suit

Wearing of the existing suit



The sequence of wearing the full suit. The suit is primarily divided into two parts i.e. one part from head till the waistline and the other part, below the waist line to the ankle. The bottom part is worn first and next the top part is worn with the help of another person due to the bulkiness of the head part. For the entire suit double layered denim is used.

Visit to Wardha | CASE STUDY

Existing suit

Issues with the existing suit design and the process of manufacturing of it



Fig A

- Difficult to be worn by a single person and needs help from another person as the head part is slightly bulky head part and tight elastic at the sleeve end (Fig A)
- Tight waistline elastic of the upper part of the suit impedes the process of wearing it comfortably (Fig B)
- Lack of air circulation due to double layered denim in the entire length of the suit used for clothing.
- Double layered denim throughout the length of the suit results in suffocation for the harvester
- The bee veil does not provide adequate viewing angle



Fig B

Visit to Wardha | CASE STUDY

Existing suit

Issues with the existing suit design and the process of manufacturing of it

The tedious tasks during the process of making the top part of the suit



Fig a



Fig b



Fig c



Fig d



Fig e

- The seating position for the assembly of mesh, helmet and GI sheets for 3- 4 hours is shown in Fig a,b
- 8-10 hours taken to make(cut, assembly and stitch) a single suit
- Excess usage materials (GI sheets, rivets, nut and bolt)
- Bending the exposed sharp edge of GI using plier one by one
- Thick GI wire mesh used(results in corrosion) (Fig d)
- Aluminium strips placed over the helmet vaguely creating sharp edges (Fig c)
- 45 drills, 25 rivets and 2 nut and bolt in the head part of the protective suit. (Fig e)
- Hand stitching can only be carried out for stitching denim at the head part
- The entire process of manufacturing the head part is done vaguely without any proper jig or measurements resulting in non uniformity of design from one suit to another
- Needs an experienced personnel to make the head part

DESIGN DIRECTION

Design direction

Positive takeaways from CBeeD

Fabric chosen- Canvas

- The cloth withstands from minor injuries while crawling on trees
- Durable to withstand the poking of bees and twigs of trees
- Wild honey harvesting generally happens during night time , so outside temperature factor need not be considered

Integration of protective helmet

Hard hats are designed to protect the head against falling objects and the side of the head, eyes, and neck from any impacts, bumps, scrapes, and electrical exposure. Head protection is extremely important because traumatic brain injury (TBI), a common outcome of impact to the head, can cause physical, cognitive, social, emotional, and behavioral effects that may result in short-term or permanent impairment. Wearing a hard hat is a mandatory requirement set forth by OH&S (Occupational Health and Safety) as it ensures an accident-free environment and Health and safety of the employees is one of the most important aspect.

Design direction | Project goals

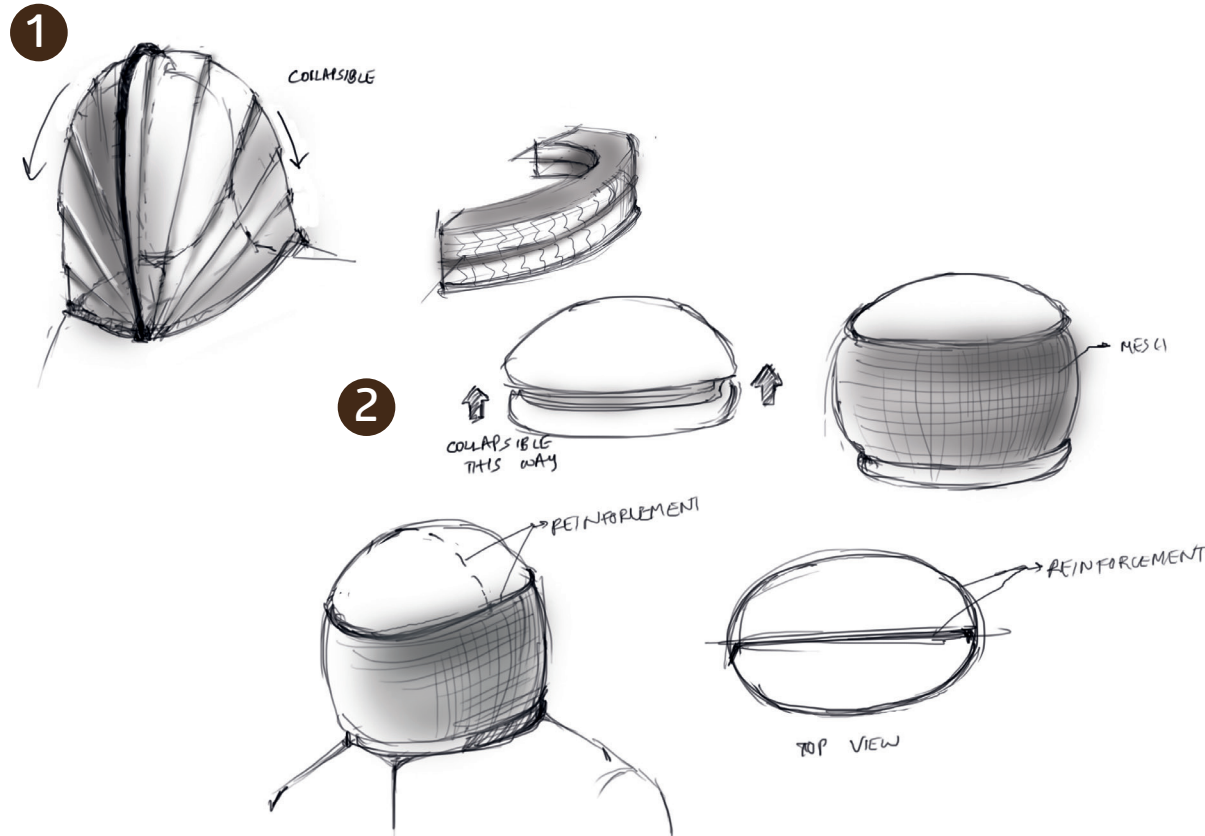
- The suit to be fully packed with no sort of air gap in the sense to not to allow any chance of wild bee entering in the suit.
- To be worn for approx 40 min during the entire process, so it should be comfortable wearing
- The benchmark price of the protective suit to be below than the current price of Rs2500 (Rs 700- raw materials, Rs1400- labour cost, Rs 400- inventory cost)
- The protective suit should withstand from injuries due to any accidents while climbing up or down from the trees, primarily head part(Safety of the personnel)
- The material chosen should be durable enough to withstand the poking of bees and twigs and bark of the trees while climbing and crawling during the harvesting process.
- To ensure smooth working with several beehives and to get higher efficiency
- Quick to wear the suit before the harvesting process single handedly.
- The suit needs to be washed after every honey collecting process.

Design direction | Project Brief

- To study the existing wild honey collecting process and find an integrated solution for the development of headgear and personal protective suit for wild honey bee harvesters.
- To ensure safety and personal protection for honey harvesters of central India who has to climb and crawl tall trees in order to conduct the harvesting process.
- To reduce or eliminate injury to body of the collector because of the rough conditions which involves wear and tear through the entire process
- To increase the degree of usability of the protective suit for the honey collector during the harvesting process
- Optimisation and standardization in the manufacturing of headgear and protective suit to enable
 - a) Efficient and easy tailoring
 - b) Quick manufacturing process reducing drudgery for the people who work in the production of suits, in the context of frugality, to keep the cost as low as possible

DESIGN IDEATIONS

Design ideations | Initial ideations

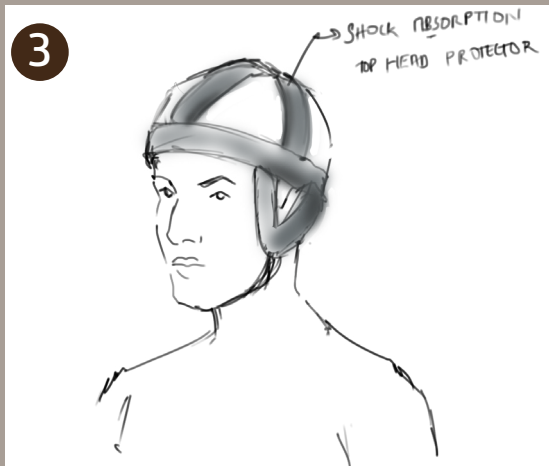


Initially, overall design solutions for the head protection is addressed with considerations of design aspects that can be incorporated which caters specific needs to be taken care of while designing the full body protection system.

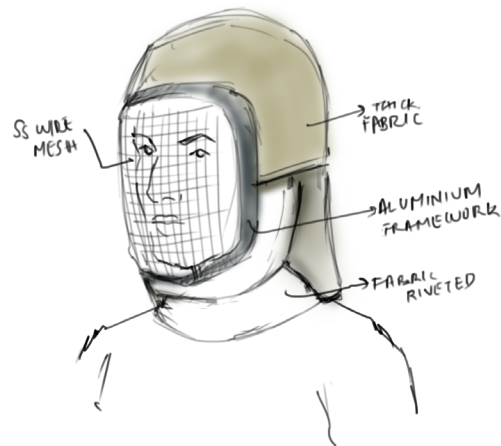
Collapsible designs were looked through which in turn helps in reducing the original size of the product to a considerable scale when folded.

Background study of existing collapsible products such as collapsible laundry bag were the characteristics of the product were tried and tested.

Design ideations | Initial ideations

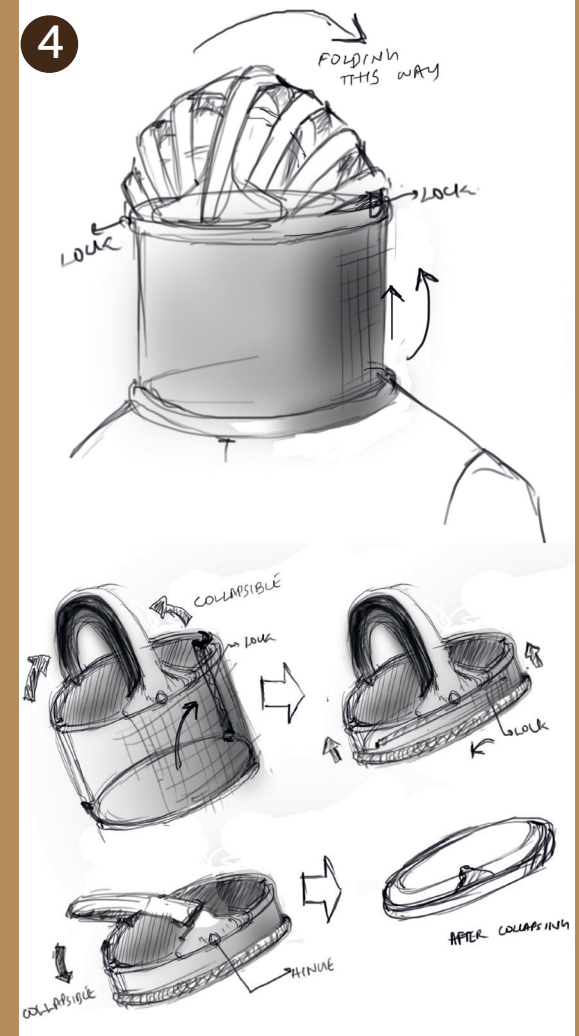


Collapsible safety helmet which is attached to cylindrical veil structure. The veil is made of thin plastic reinforced with curtain wires at the top and bottom of it. The veil itself is collapsible with a locking mechanism at the back of the structure to restrict the free fall of it. Safety helmet is collapsed and folded with respect to the veil and becomes a shortened cylindrical structure.

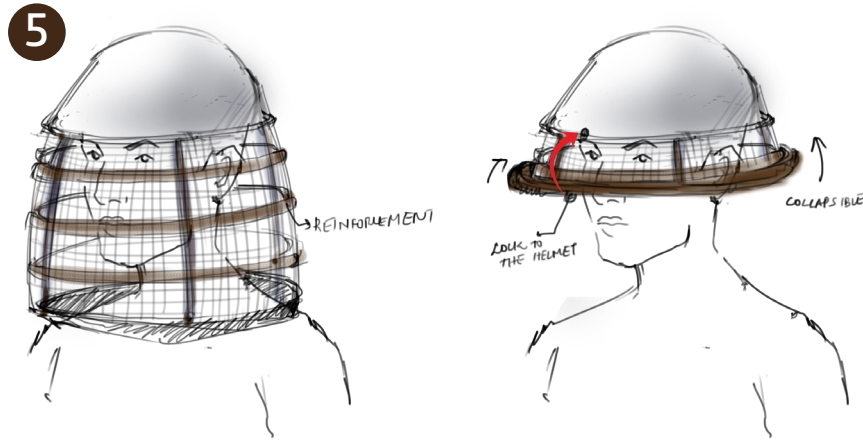


As very thin plastic mesh is used, chance of it getting damaged is very high, and it can not be replaced. The manufacturing process will be difficult and cost will be high.

Lightweight head protection designed for shock absorption from the dangers of physical activity. Foam material with adjustable velcro chin strap. On top of the hood with SS wire mesh and thick fabric riveted over it is worn and is attached to the rest of the suit.



Design ideations | Initial ideations



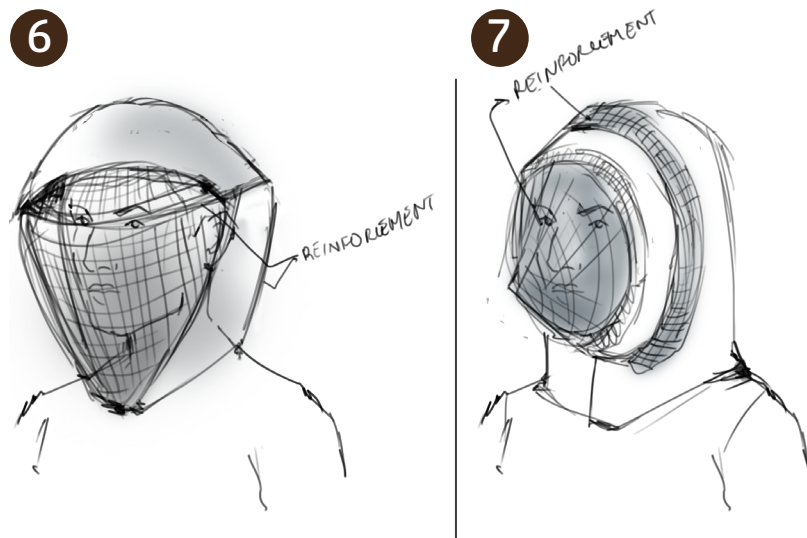
Collapsible framework for the veil, integrated with the design, helps the personnel to open and close the structure easily. Elastic end to reduce air gaps at the bottom.

The structure can be easily pulled down, covering the face of the bee collector, and locked with the suit at the chest region.

The structure is collapsed to the top of the head protection part

and can be locked there restricting its free fall.

The issue regarding the design is that very thin plastic mesh is needed to be used which in turn gets spoiled in time after tear and tear. There is a chance of air gaps to be present at the bottom of the structure near the locking area at chest region, during head movement, invites the attack of bees.



Mock up prototype

Replaceable veil

Different shapes were ideated to provide offset from the face to give protection from bee stings.

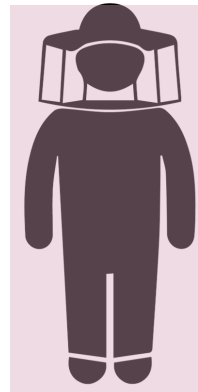
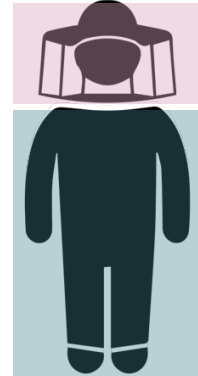
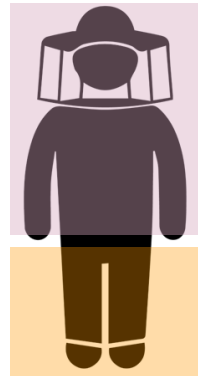
Replaceability of materials due to wear and tear, in time, which is cheap and easy to manufacture is taken into consideration.

The conical net can be attached to the hoodie with velcro so that it can be replaced easily when it gets damaged

Design ideations | Initial ideations

Head part integration with the suit

How the protective suit can be divided into different parts



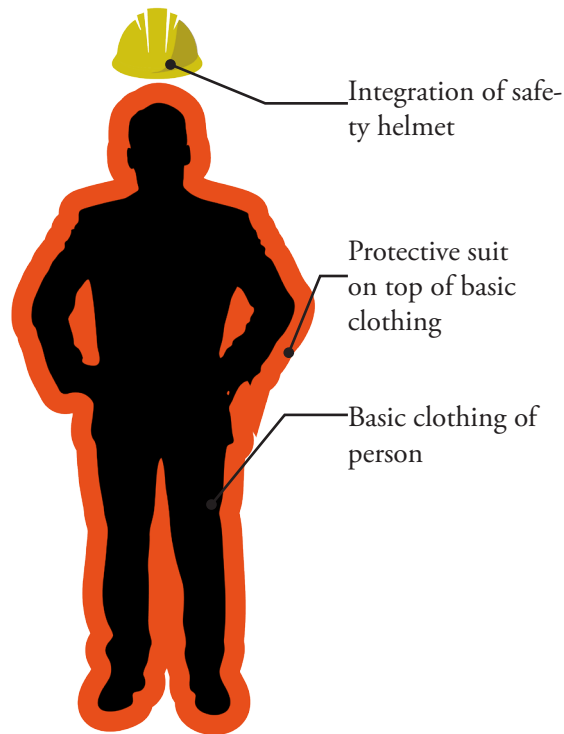
- The sequence of wearing of the protective suit is looked through.
- Personal protective equipment refers to full length body protection which includes protective clothing , helmets, goggles etc whose sole purpose is to reduce exposure to hazards for the employee when the engineering and administrative controls are not feasible or effective to reduce these risks to accepted levels
- The types of connectors for the connection of different parts of the suit has been studied with the references of different types of suits such as hazmat suits, fire fighter suits, wet suits, bee suits.

Design ideations | Basic concept

From the study of initial ideations, basic concept for further development of the primary goal has been filtered out.

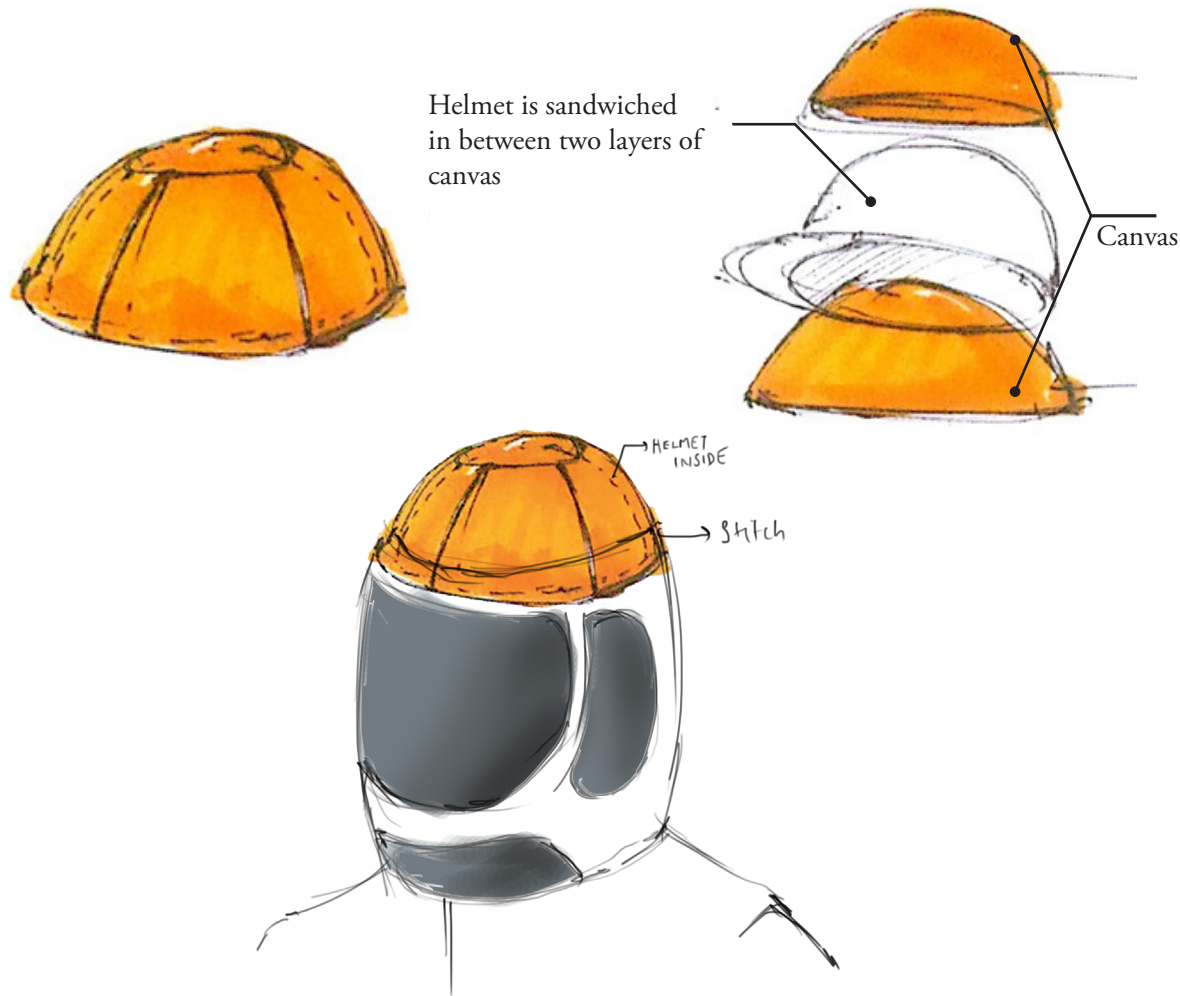
A trade off between safety and comfort to be achieved through

- Thick fabric is used so that even if the bee stings, the sting doesn't reach the other side
- Double layered fabric to be used in the regions of the body where bees sting the most and where stretching of the body parts happens due to the activities of the personnel during the process of honey harvesting
- Integration of hard hat to ensure safety and personal protection for honey harvester, who has to climb and crawl tall trees in order to conduct the harvesting process, .
- Design methodology to increase the degree of usability of the protective suit for the honey collector during the harvesting process



Ideations

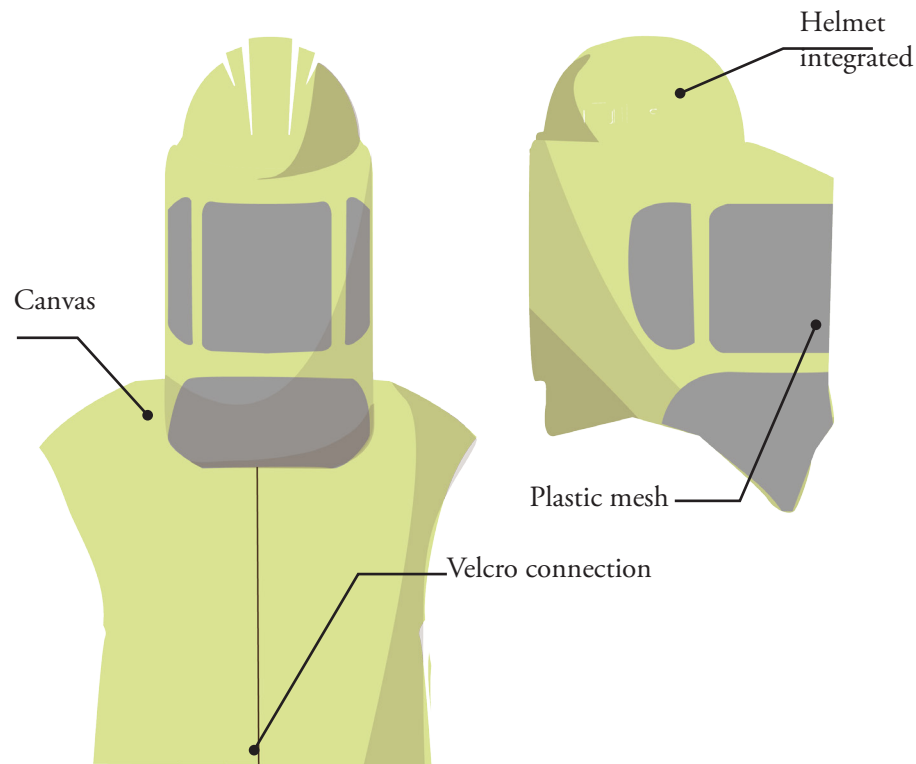
Design ideations | Ideation 1



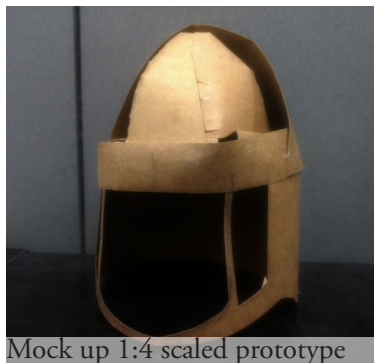
Sandwiching helmet with two layers of canvas and integrated to the rest of the head part of the suit with stitching. Hiding the helmet with the same fabric as the rest of the head part brings in uniformity and blending in with the design and the helmet doesn't shout out compared to the rest of the part.

- Protective head part can be made with efficient and easy tailoring.
- Quick manufacturing method which involves processes that are less drudgery

Design ideations | Ideation 1



- Plastic mesh integrated with the canvas makes the product flexible and lightweight which is essential for the honey harvesting process that involves a time period of approx 40 min of wearing it.
- Larger area of visibility and air circulation
- Stitched to the rest of the suit and velcro connection enables the ease of wearing of it
- Ensures comfort for the smooth working with wild honey bees



Mock up 1:4 scaled prototype



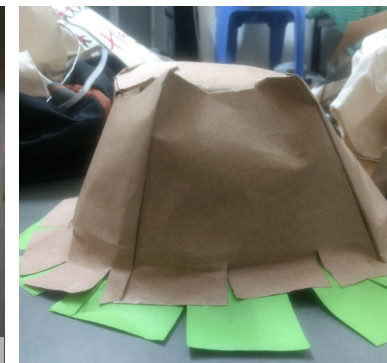
Outer layer



Inner layer



Both layers stitched



Mock up prototype study using chart paper

Design ideations | Ideation 1



Prototype



Prototype



In discussion with Prof. Sandesh

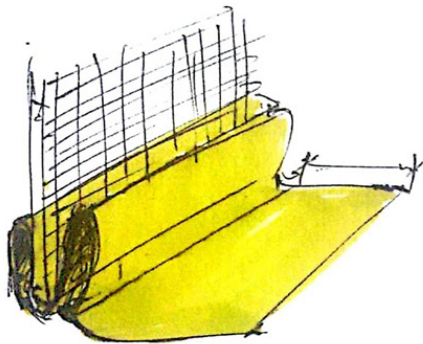
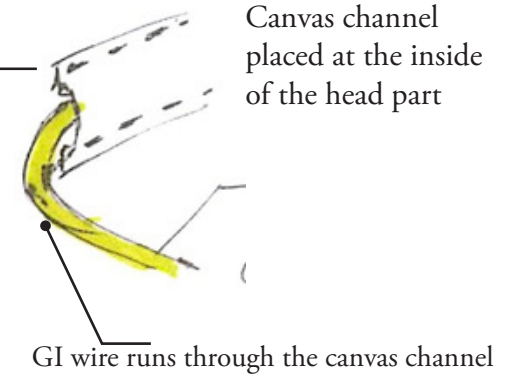
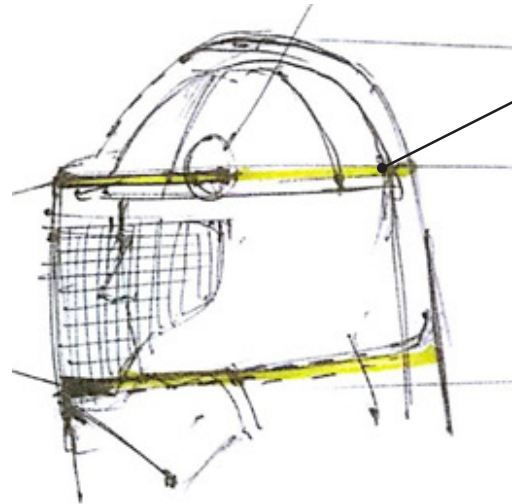
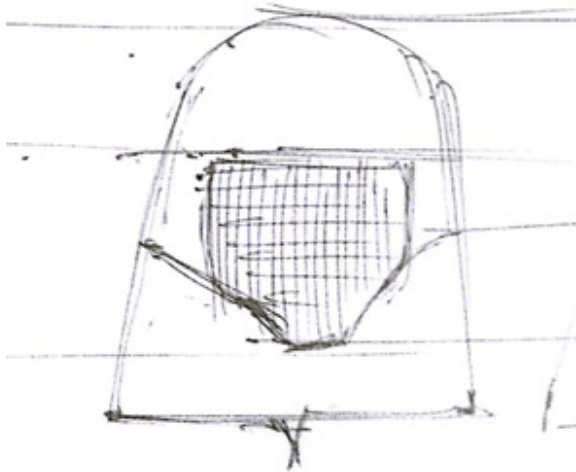
Mock up prototype study with canvas and plastic mesh was made to visualize the concept

Issues

- Plastic mesh will get damaged in time by rough handling and penetration of twigs
- Mesh is not sturdy and is in contact with the face during the movement of head.
- Proper offset from face is not achieved
- Washing of the suit is a problem as the helmet integrated is not removable and has two layers of canvas at the helmet region

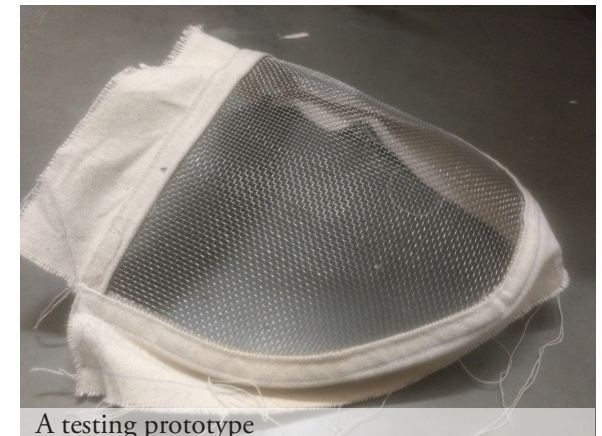
Design ideations | Ideation 2

Easy assembly of parts



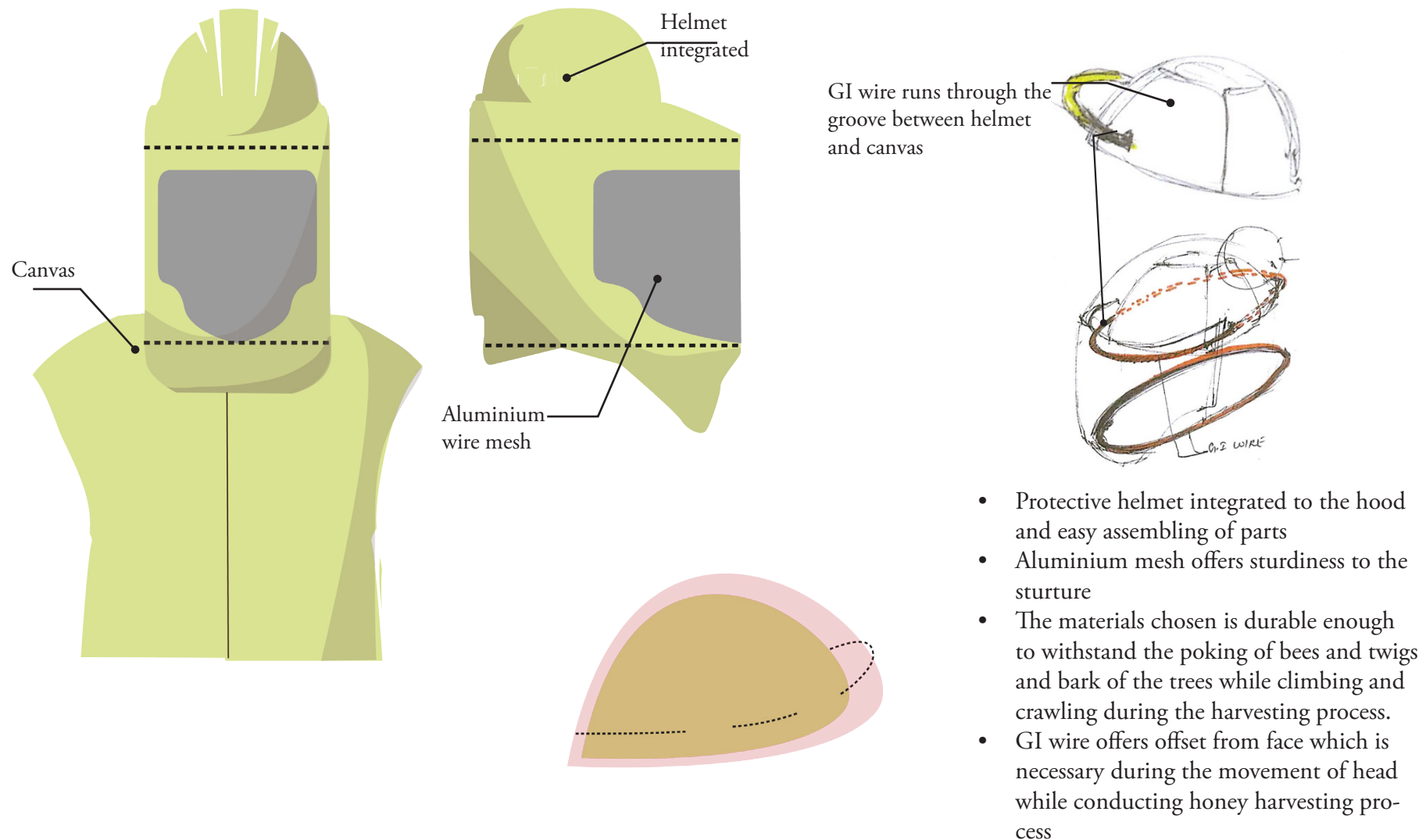
Framework for Aluminium mesh with canvas

Sandwiching helmet with two layers of canvas and integrated to the rest of the head part of the suit running GI wire through the groove between helmet and canvas and the canvas channel integrated at the inside of the head part. Helmet is completely invisible, layered with canvas to bring in uniformity and subtlety to the design considering the totality of the suit.

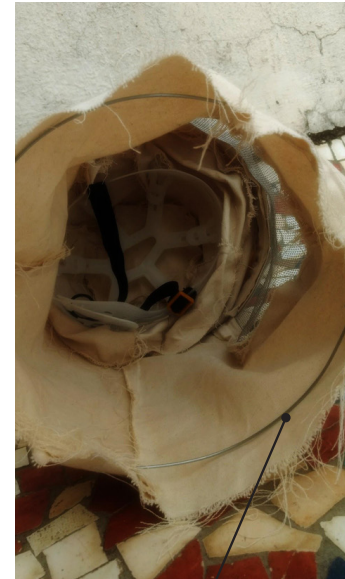


A testing prototype

Design ideations | Ideation 2



Design ideations | Ideation 2



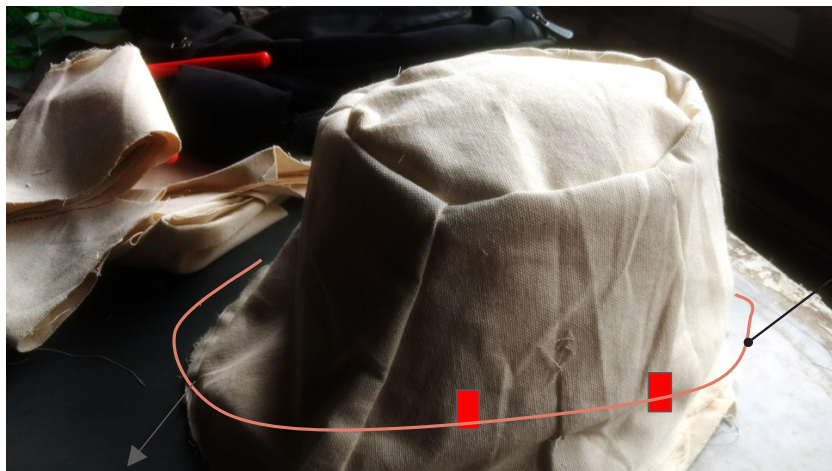
◀ Mock up prototype study with canvas and Aluminium mesh was made to visualize the concept

Why Aluminium wire mesh?

- Aluminum wire mesh is also corrosion resistant in most normal environments and is approximately 1/3rd the weight of stainless

Issues

- Difficult to stitch in the curved areas of wire mesh visor
- Wastage of material due to the curved design of the visor
- Washing of the suit is a problem as the helmet integrated is difficult to remove because of GI wire runs and connects two parts, and has two layers of canvas at the helmet region and on top of that an additional layer of canvas layers that covers the entire head part

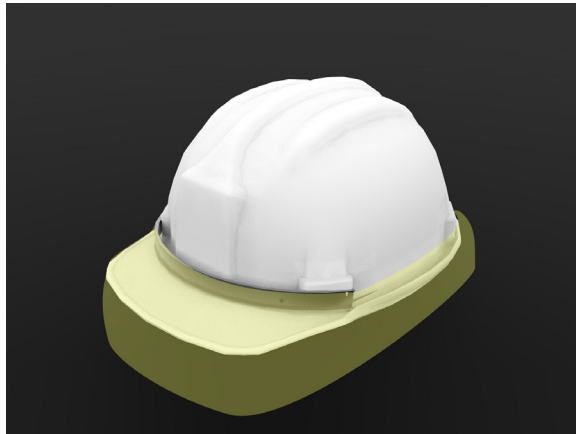


GI wire runs through canvas channel

GI wire runs through canvas channel inside and connects helmet and outer canvas layer

Design ideations | Ideation 3

To enable quick fixing of canvas with the helmet.



Conceptual drawing

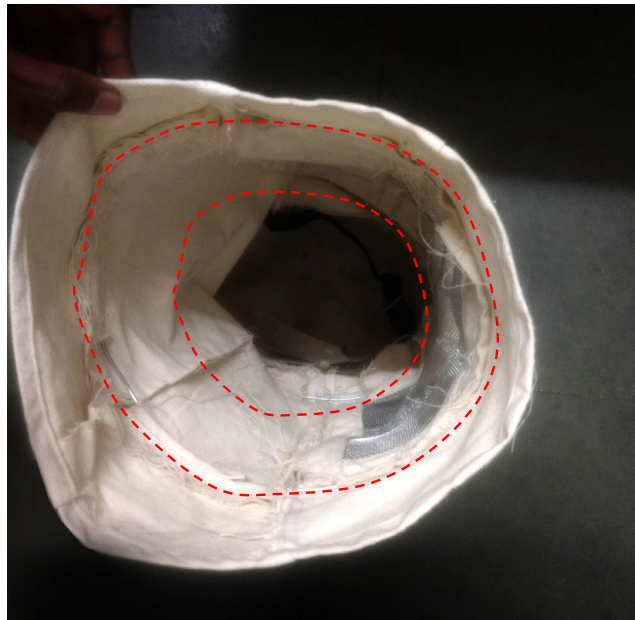


Aluminium channel bend to create the profile for the canvas to be quickly and easily attached to the helmet

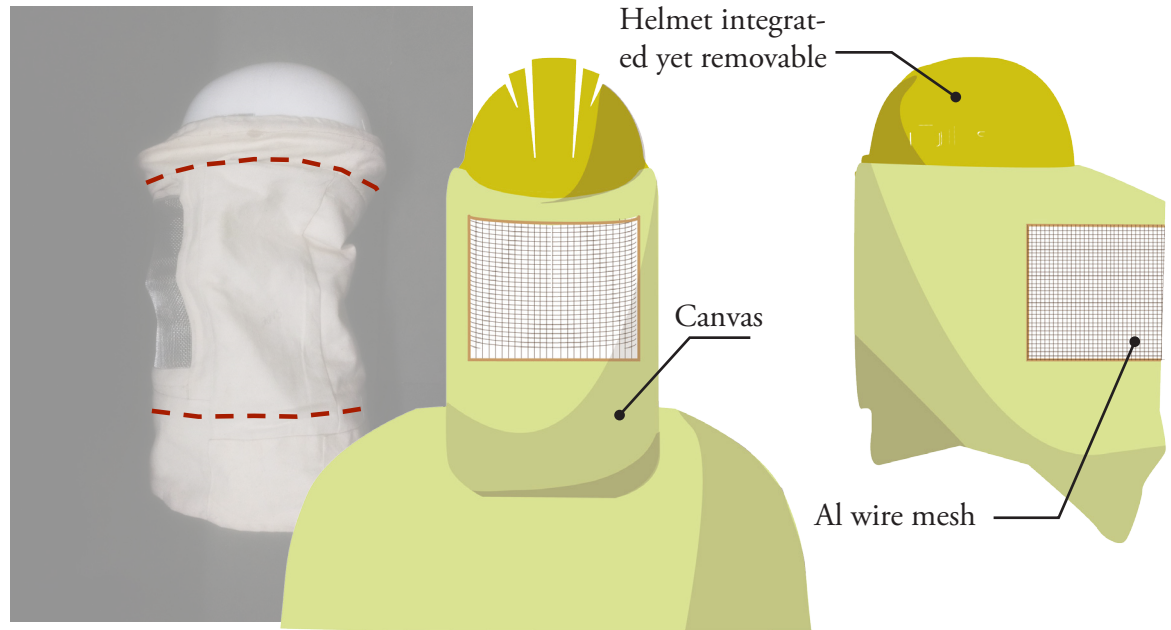
- The elastic band allows the cloth to seep in through the aluminium channel and hold tightly with the rest of the suit
- The cloth can be easily removed from the helmet during washing of the suit



Design ideations | Ideation 3



Cylindrical hood with curtain wire running along the bottom edge and top edge for reinforcements and to keep the hood net away from the face so that the bee sting does not reach through it.



Design ideations | Ideation 3



The bend aluminium is strategically placed in a position where easy fixing of the rest of the head protection part is concerned and attachment of it with the helmet with rivets reducing the usage of any additional materials, manufacturing processes or structures for catering the design



Bend Aluminium channel acts as a possible locator so that canvas cannot slide off. Manual industrial process adds on value considering the totality of the production and current workspace setup at CBeeD, Wardha

Design ideations | Ideation 3



Framework for SS mesh with canvas



The prototype



- Ease of manufacturing
- Ease of assembling of helmet and the rest of the part of head protection
- Washable without the contact of helmet as it is removable
- Less wastage of material as the shape of veil is rectangular, which can be cut accurately, reducing the drudgery for the workers during production
- The materials chosen are durable enough to withstand the poking of bees and twigs and bark of the trees while climbing and crawling during the harvesting process.
- Aluminium wire mesh helps the bee collector for better vision and to stay secured and can be easily cleaned
- Metal wire offering offset from face which is required during harvesting process

Design ideations | Ideation 4

Creating no connection between helmet and the hood



Sequence of wearing the head part of the protective suit



The helmet is worn initially by the honey collector, then pulls down the hood which is connected to the suit.

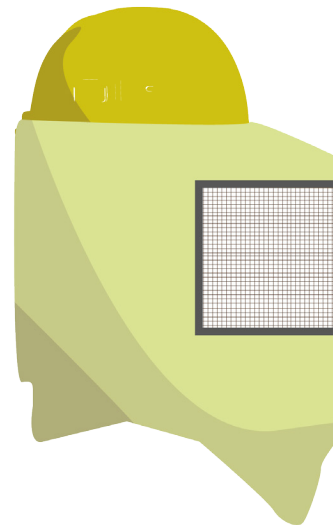
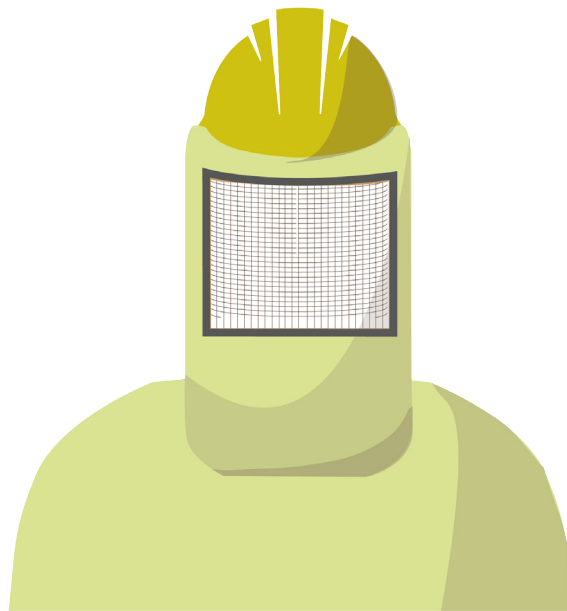
Issues

- As the helmet is completely detached from the suit, wearing the helmet becomes an option and there is a high possibility of not wearing it during the honey harvesting process

◀ Mock up prototype study with canvas and SS wire mesh was made to visualize the concept

Design ideations | Ideation 5

Providing rigidity with juxtaposition of additional framework with the canvas structure

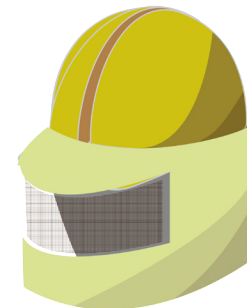


The veil part is given rigid framework using Aluminium channels riveted onto the canvas. The hood part is then integrated to the helmet and assembled later which is removable.

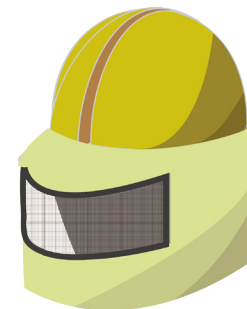
Sequence of manufacture of the head part



Helmet



Canvas with veil connection



Riveting Aluminium framework to canvas

Design ideations | Ideation 5

Providing a rigid framework caters offset of hood from the face of honey collector



Detail of the framework
Framework made of aluminium channel is riveted to the veil part for a rigid structure

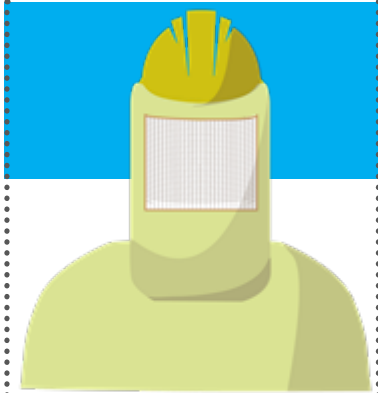
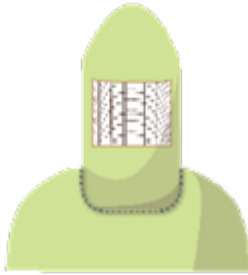
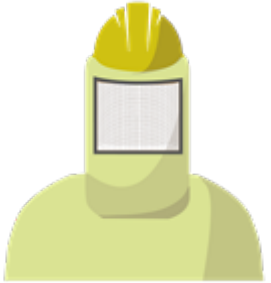
Issues

- Additional manufacturing process of the framework is time consuming and increases the price of the product

Design ideations

Ideation selection

Ideation 3 is taken forward, after a trade- off between the positive features and manufacturing aspect of the product for these 5 ideations is considered, to develop it as a solution

1	2	3	4	5
				
• Flexible and lightweight	• Lightweight and durable • Ease of assembly of different parts of head protection	• Quick fixing of canvas with the helmet • Lightweight and durable • Easy to wash as helmet can be completely detached from the rest of the suit • Ease of manufacturing	• Helmet and hood are completely separated	• Rigid framework for a good offset from face

PROTOTYPE TESTING

At

CBeeD (Centre for Bee development, Wardha)

Prototype testing



In discussion with Dr Gopal Paliwal, Secretary & Director at Centre for Bee Development and the workers who make suit, about the initial prototypes made

Prototype testing | Takeaways

After discussion with Dr. Paliwal

Ideation 2



Pros

- Light weight
- 3 hours taken to make(cut, assembly and stitch)
- No drills in the helmet
- Good all round vision
- More breathing space in the head region
- Optimisation of materials
- Easy to construct
- Aluminium wire mesh used(corrosion resistant)

Cons

- GI wire which connects helmet to the mesh will become flexible in time

Prototype testing | Takeaways

After discussion with Dr. Paliwal

Ideation 3



Comparison

Ideation 3

Pros

- Light weight
- 2.5 hours taken to make(cut, assembly and stitch)
- 3 drills in the helmet
- Optimisation of materials
- Easy to construct
- More breathing space in the head region
- Aluminium wire mesh used(corrosion resistant)

Cons

- Flexible around mesh region

Current design

Pros

- Sturdiness achieved through thick mess and GI sheet framework

Cons

- Heavy and bulky
- 8-10 hours taken to make(cut, assembly and stitch)
- 45 drills in the helmet
- Excess usage materials (GI sheets, rivets, nut and bolt)
- Needs an experienced personnel to make
- Congested in the head region
- Thick GI wire mesh used(results in corrosion)



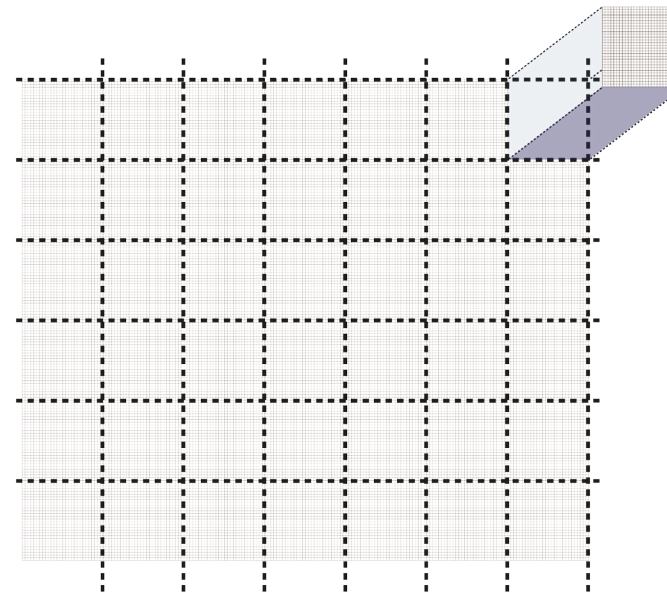
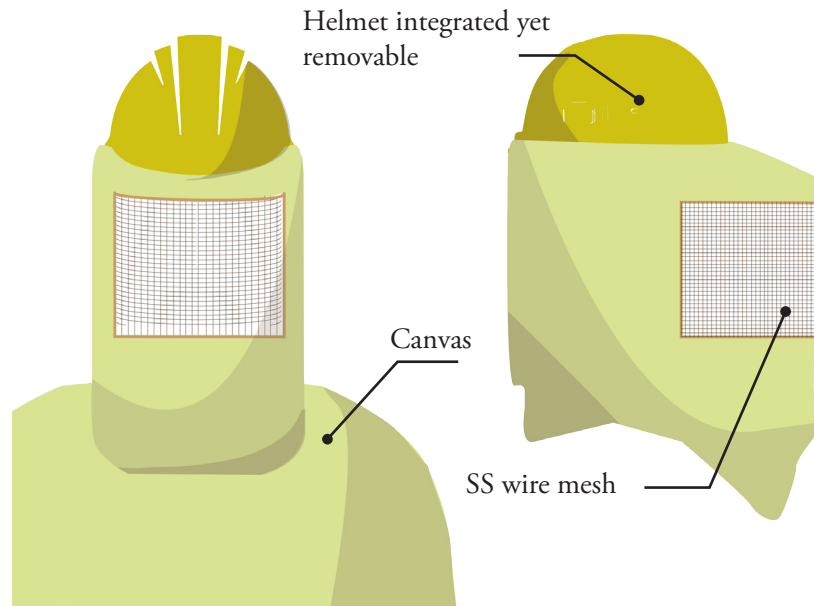
CONCEPT DEVELOPMENT

Ideation 3 has been taken ahead to
develop it as a concept

Concept development | Ideation 3

Concept developed into two types A&B according to the shape of the veil

Type A

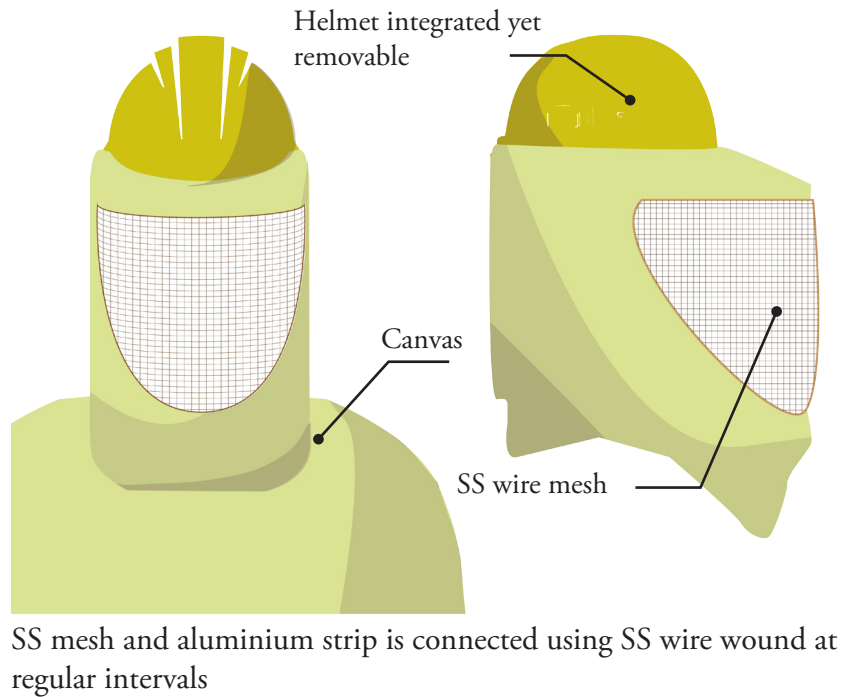


Why Stainless steel wire mesh?

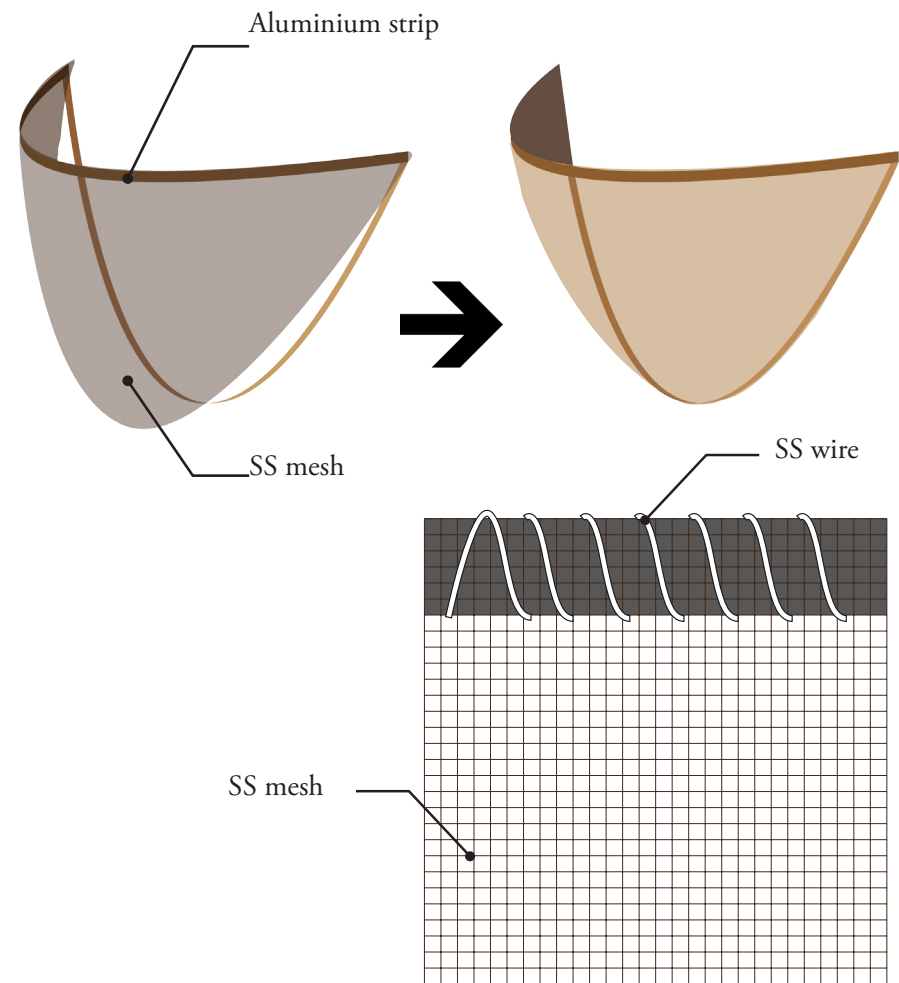
- Wire cloth specification is very fine mesh that will behave more like a cloth than a rigid and stiff mesh. It has excellent corrosion resistance.
- Is heat resistant
- It is also excellent for fabrication purposes – it can be formed and cut to size with appropriate tools and machinery

- Less time to make as it being a rectangular shape, less wastage of material and easy and faster to cut SS wire mesh

Concept development | Ideation 3



Type B



Concept development | Ideation 3

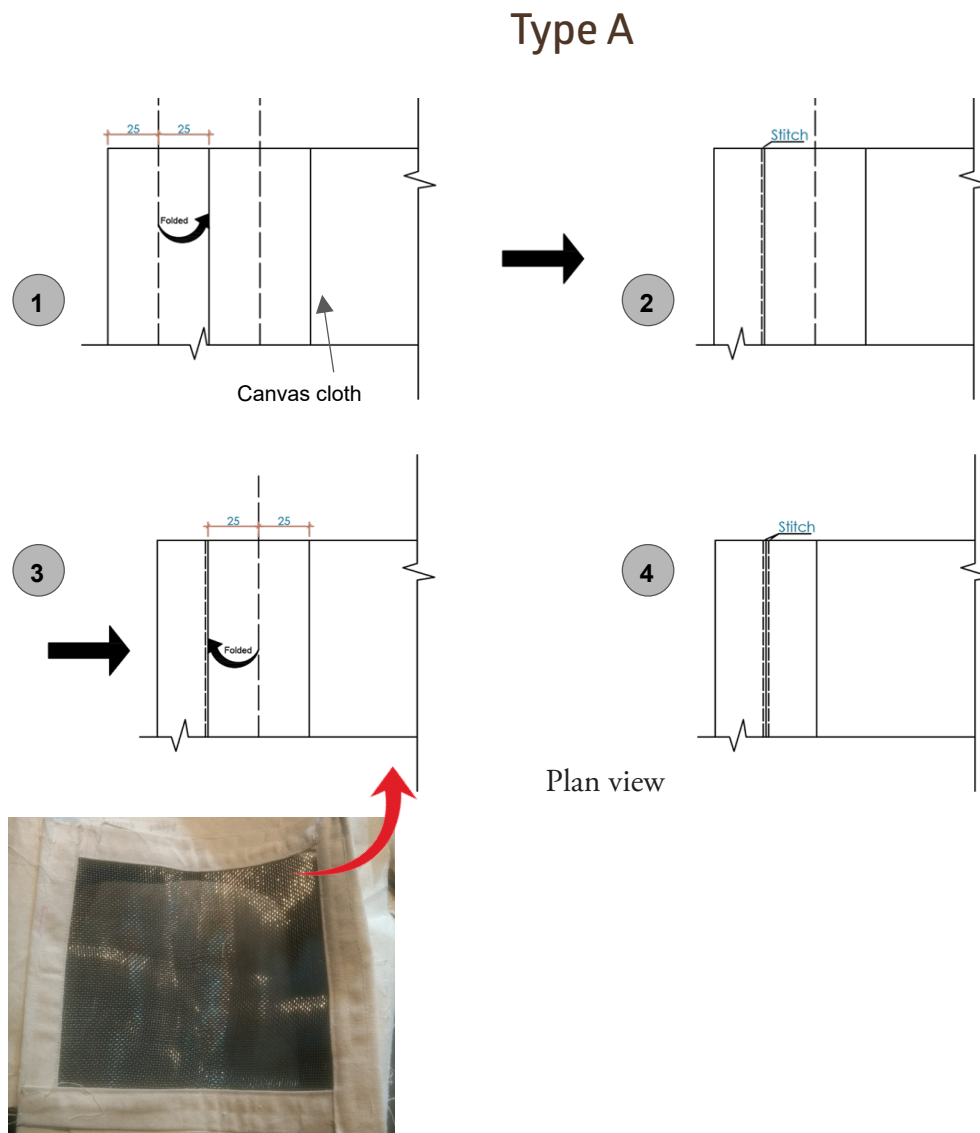
Type B



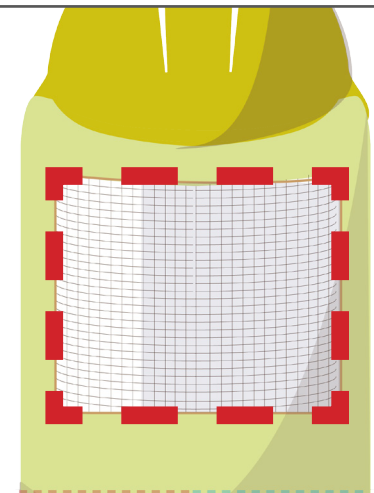
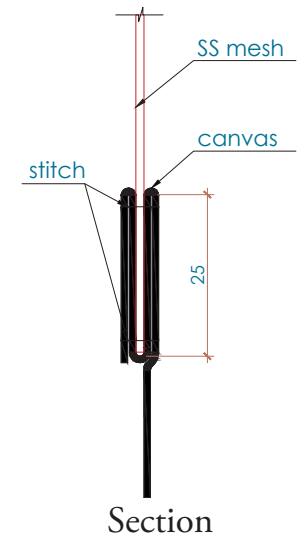
Type A is taken forward, after a trade- off between the positive features and manufacturing aspect of the product for these 2 types is considered, for development

Concept development | Ideation 3

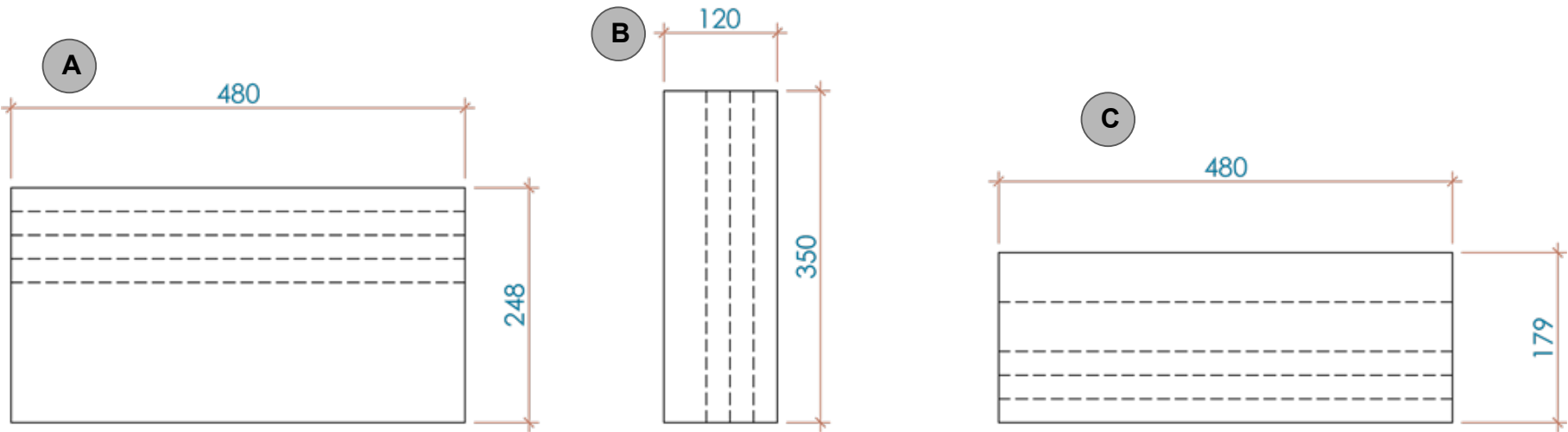
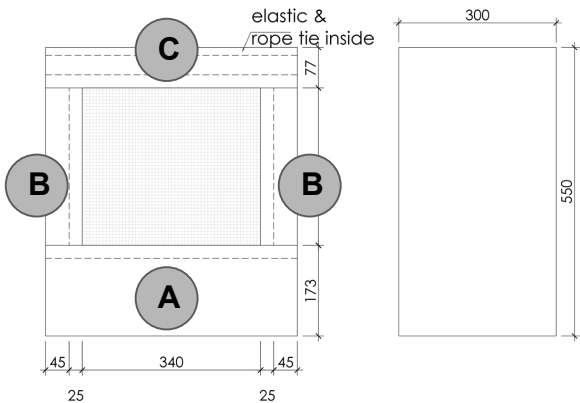
Measurement drawings for the head part



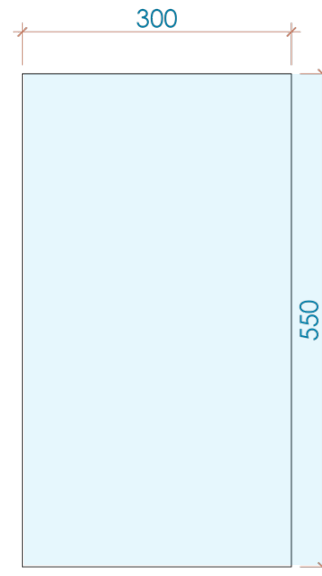
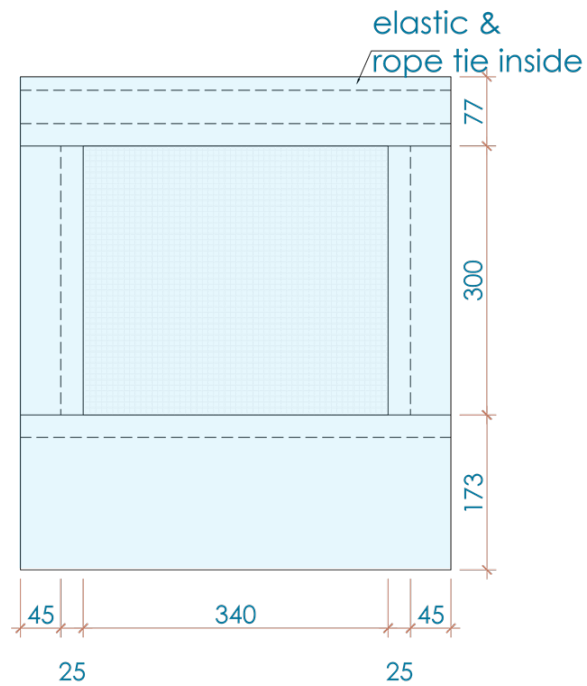
SS mesh is inserted in between the trough created by the folding of canvas, and stitched together for a fully packed framework



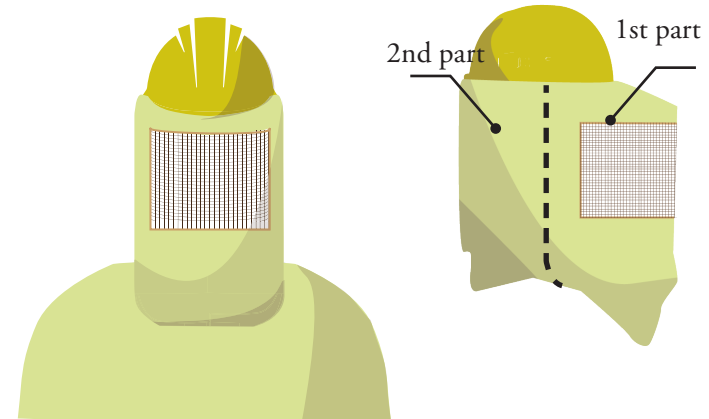
Concept development | Ideation 3



Concept development | Ideation 3

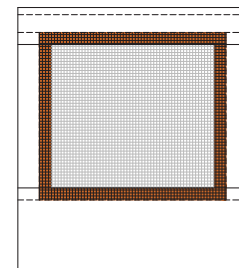
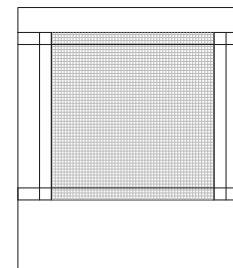
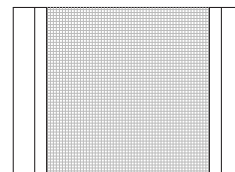
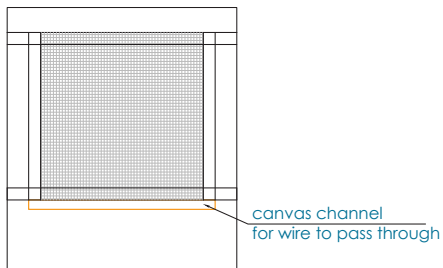


1st part and 2nd part is to be stitched together



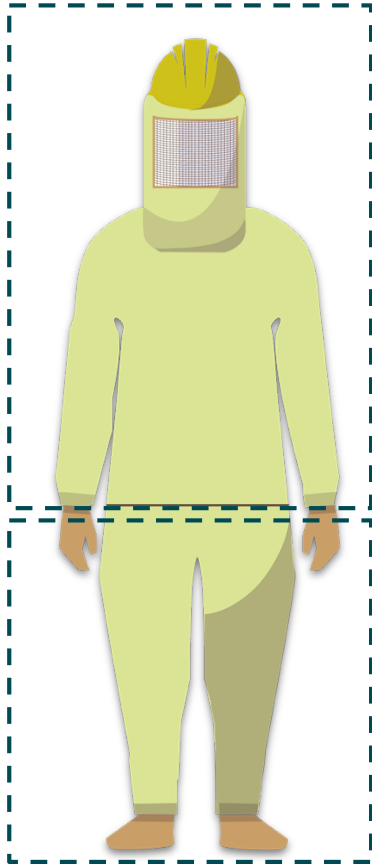
1st part

2nd part



Concept development | Ideation 3

Connection with the rest of the suit



Head veil stitched to upper part of the suit

- Difficult to be worn by a single person and needs help from another person as the head part is slightly bulky head part and tight elastic at the sleeve end
- Tight waistline elastic of the upper part of the suit impedes the process of wearing it comfortably

OR

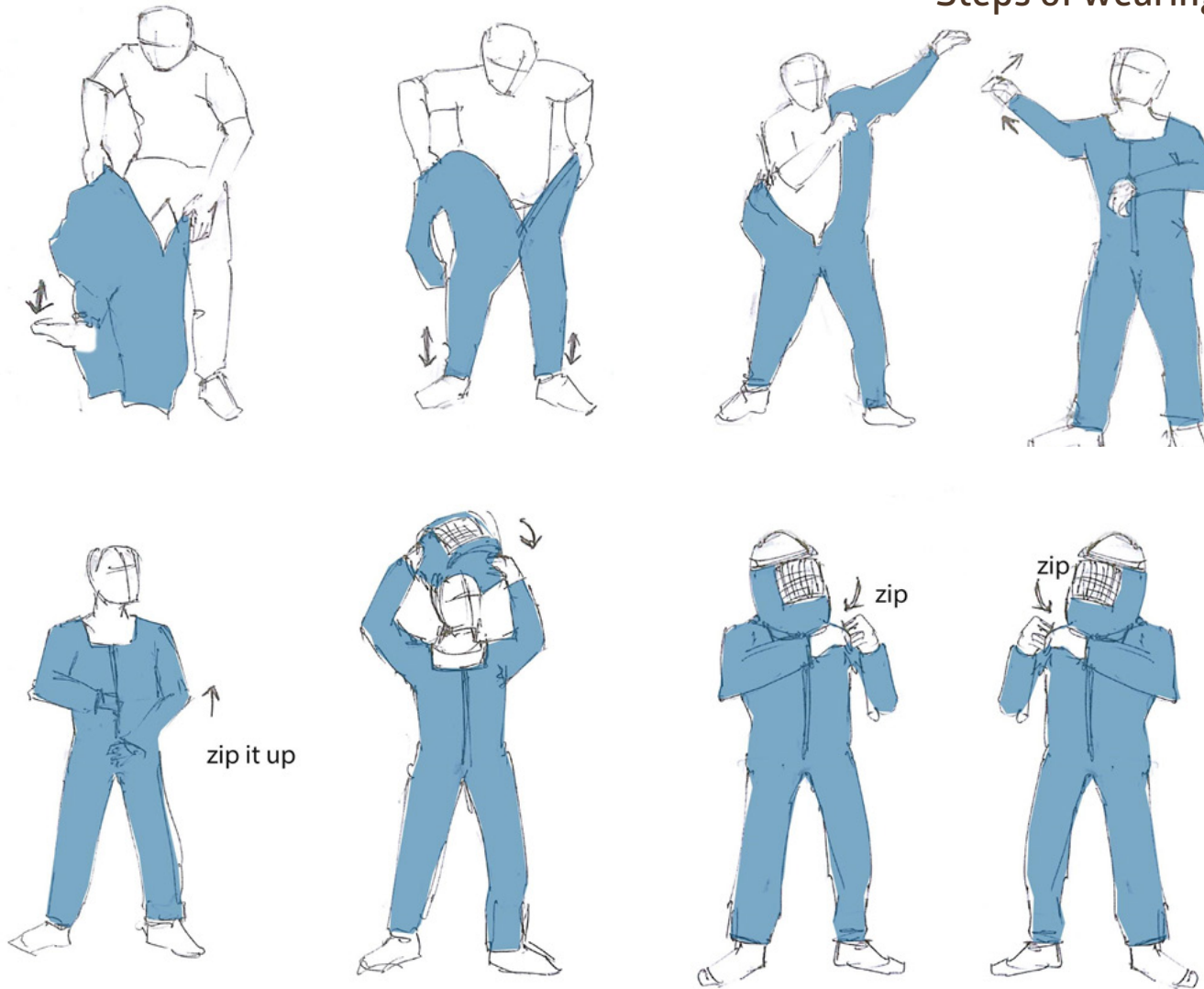
- Easy to be worn by a single person as the parts of the suit are connected by zips, tich buttons and velcros.
- The suit is more flexible during harvesting process activities.
- Easy to put chin strap of helmet and tighten it



Veil hood attached to the suit using connectors. An 'Unified suit'

Concept development | Ideation 3

Steps of wearing the suit



Concept development | Ideation 3

Mock up prototype



Mock up prototype with cotton fabric



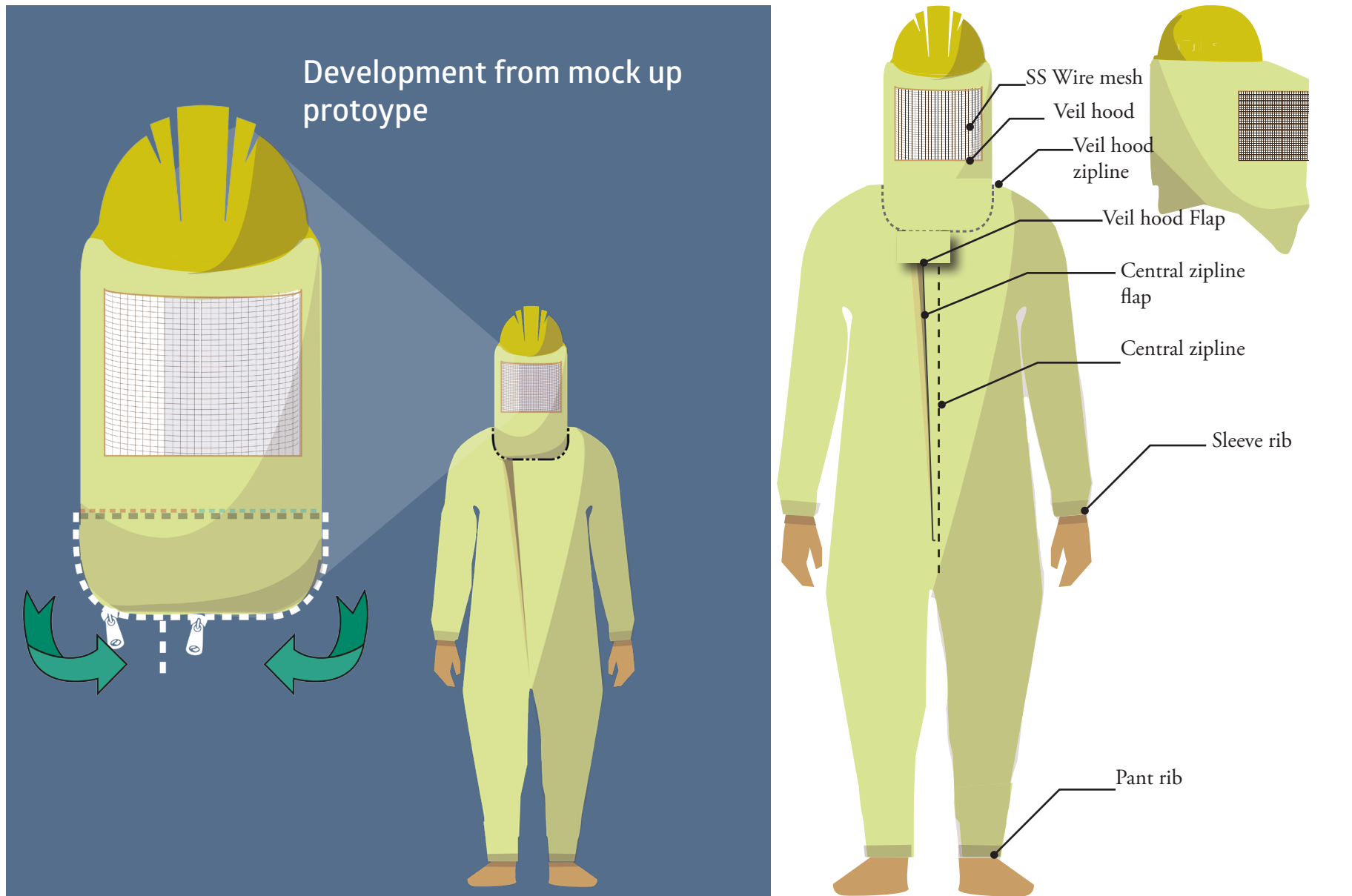
Findings

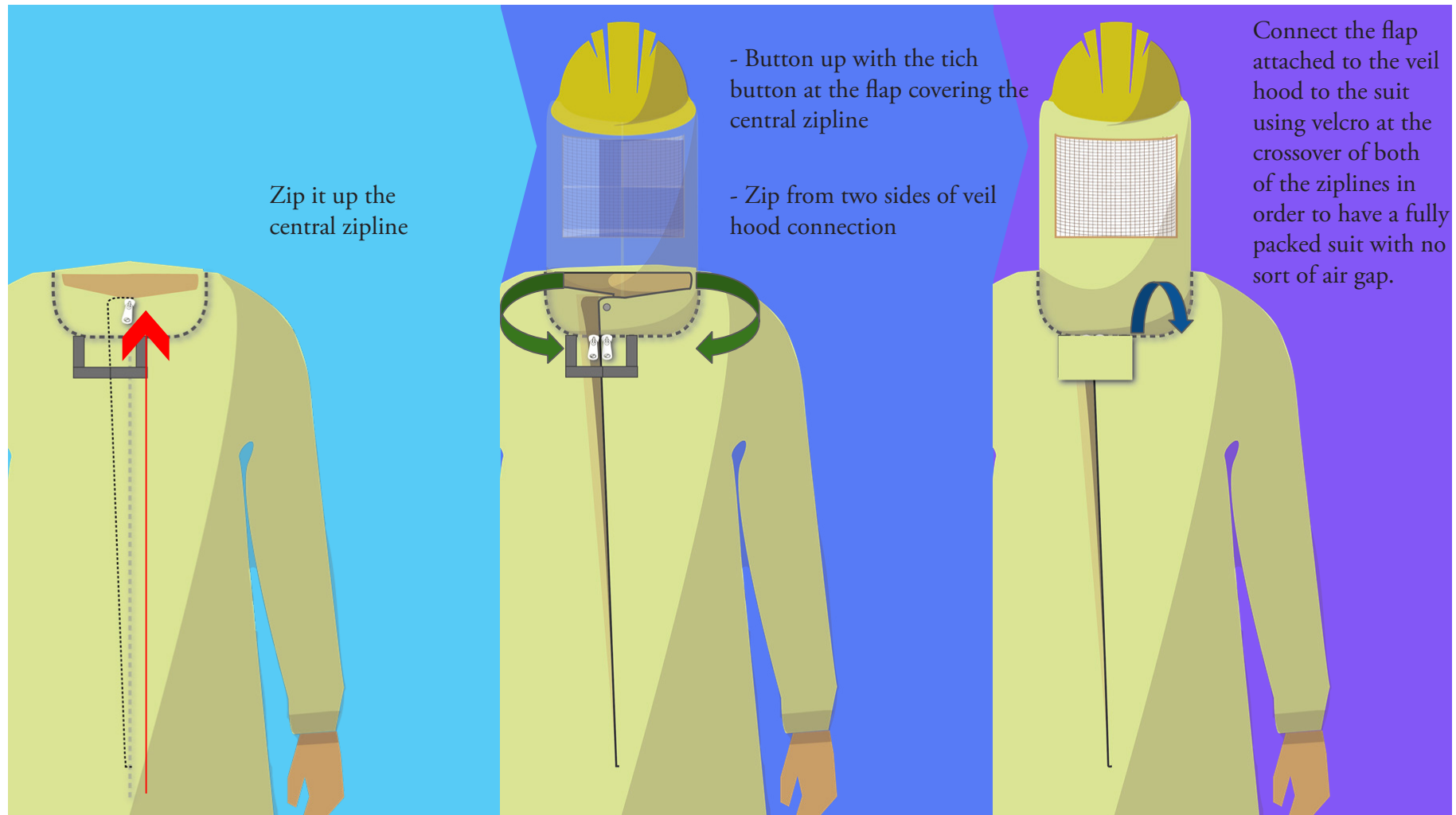
Cons

- Loosly fit sleeve end and ankle end invites danger of wild honey entering through it
- Slight gap at the intersection of central zipline and veil hood zip line

Pros

- Easy to be worn by a single person as the parts of the suit are connected by zips, tich buttons and velcros.
- The suit is more flexible during harvesting process activities.

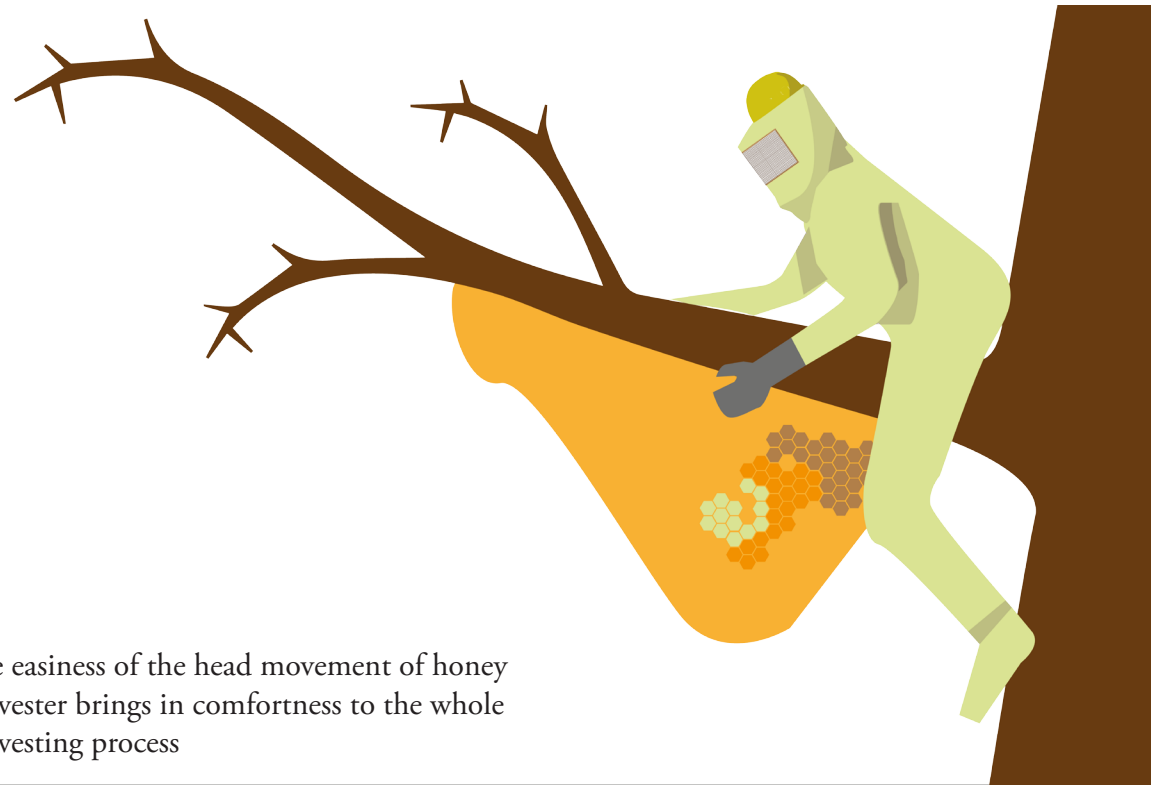
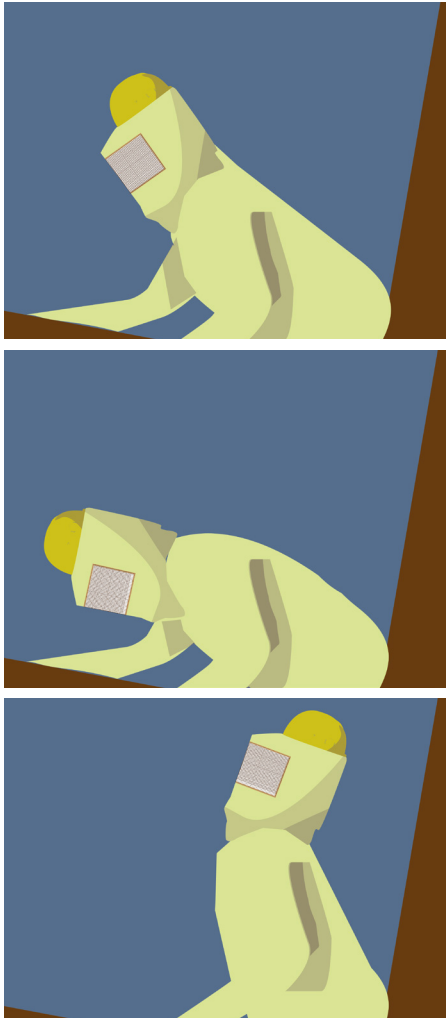




Steps of wearing the suit

The steps undertaken for wearing the suit order wise

Concept development | Ideation 3



◀ The easiness of the head movement of honey harvester brings in comfortness to the whole harvesting process

Concept development | Ideation 3

Anthropometric measurements of three sizes adopted while fabricating the design

S.no.		Small	Medium	Large
	Height	5'5"	5'7"	5'9"
	Upper Garment			
1.	Chest Circumference	36"	40"	44"
2.	Round wrists	7.5"	8"	8.5"
3.	Round waist	30"	34"	38"
4.	Shirt length	27"	29"	31"
5.	Round neck	15"	15.5"	16"
6.	Across shoulder	16.75"	17.25"	17.75"
7.	Sleeve length	22"	24"	26"
8.	Shoulder to waist	18.5"	19.5"	20.5"
	Lower Garment			
1.	Round hip	38"	42"	46"
2.	Crotch depth	10.5"	12.5"	14.5"
3.	Pant length (waist – heel)	40"	42"	44"
4.	Waist to knee	18"	19"	20"
5.	Pauncha	17.5"	18"	18.5"

Ref- <https://goo.gl/emgjmj>

Concept development | Ideation 3

Anthropometric measurements of three sizes adopted while fabricating the design

The measurements for accessories have been adopted for medium size because of the flexible quality of accessories. It was felt that the medium size accessories could easily be worn by all beekeepers irrespective of small, medium and large sizes.

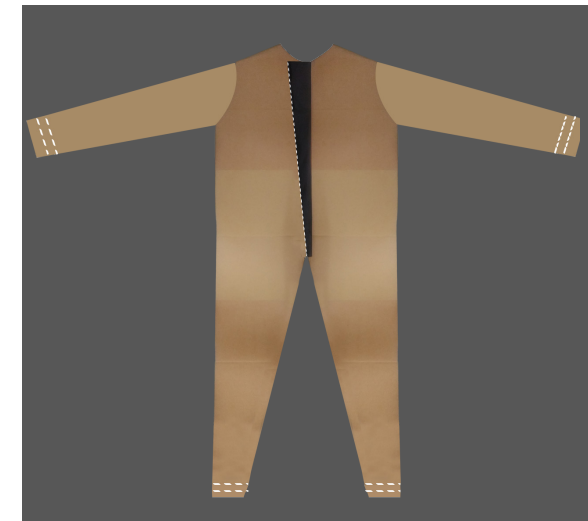
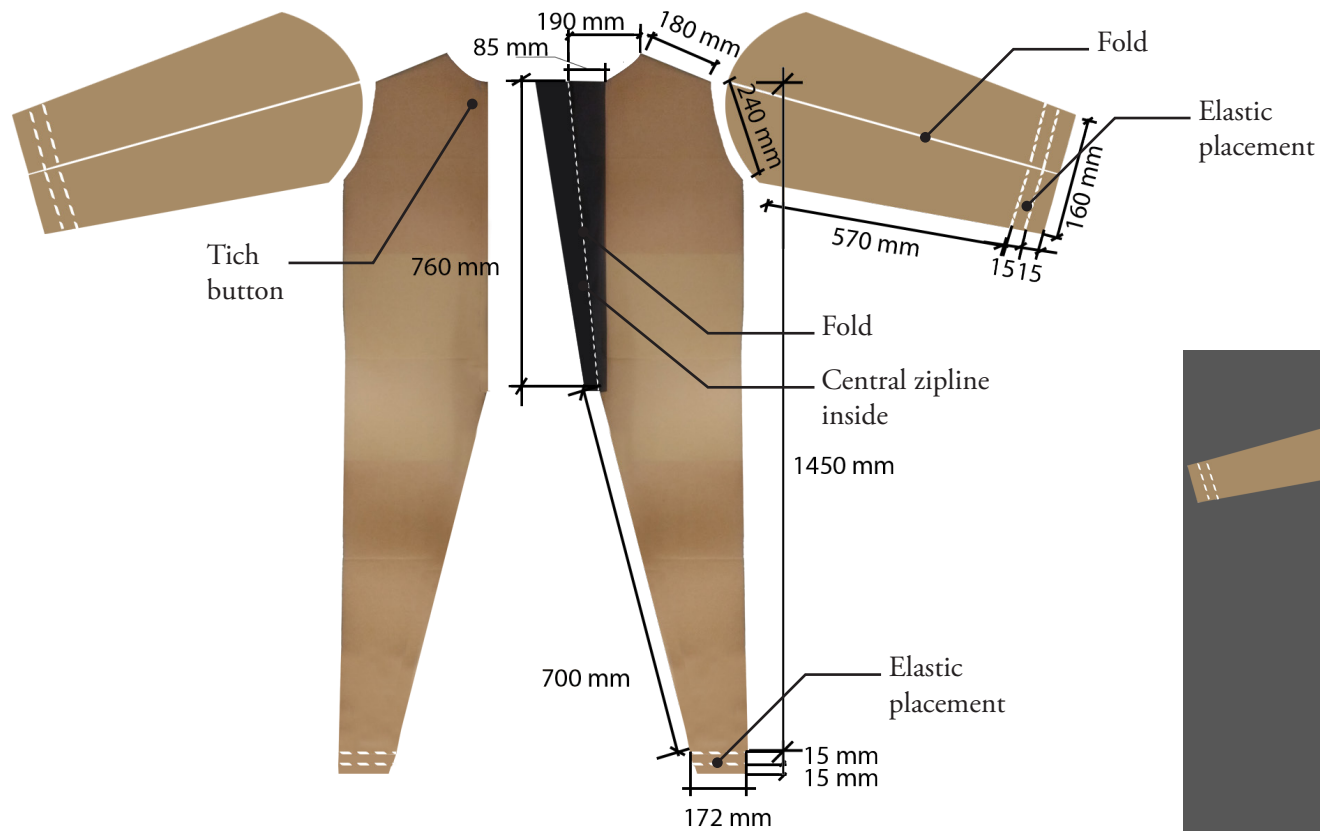
Dresses and accessories were stitched using appropriate sewing techniques. Counter seam, run and fell seam, plain seam, top stitched seam were used to provide adequate protection at stress points.

Gloves	
Round wrist	8"
Round forearm	9"
Wrist – forearm	8"
Index finger - wrist	7"
Middle finger - wrist	7.5"
Little finger - wrist	5.5"
Length of thumb	3.25"
Palm length	4"
Palm width	4"

Foot Accessories	
Round calf	11"
Round Ankle	9.5"
Calf – heel	8"
Calf – ankle	6"
Heel – big toe	9.5"
Foot Width	5.5"

Concept development | Ideation 3

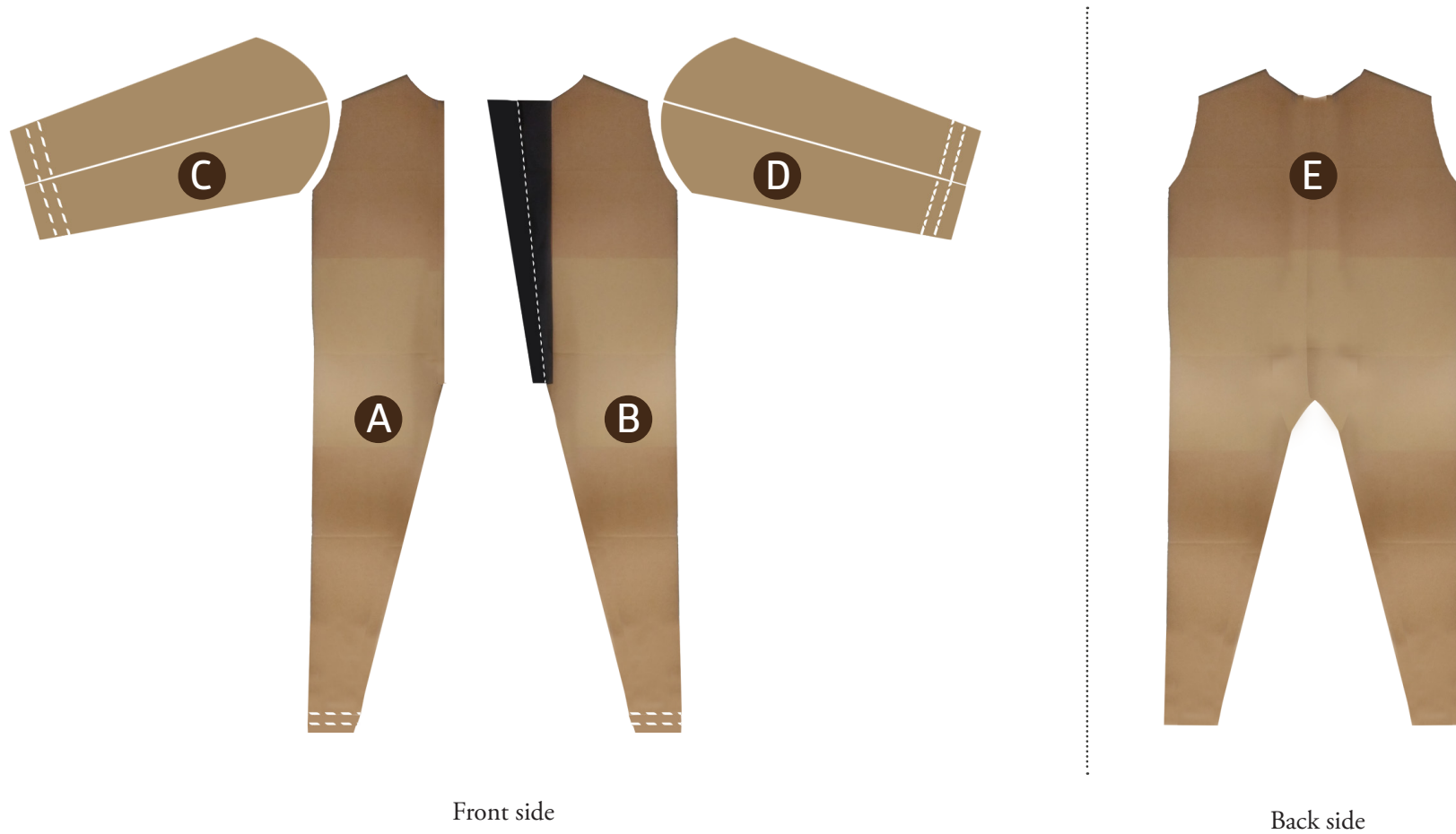
Cloth cutout drawing for the suit



Placement of all the cutouts in position

Concept development | Ideation 3

Cloth cutout drawing for the suit



Concept development | Ideation 3

Demonstration of prototype at CBeeD, Wardha







The sequence of wearing the suit

Concept development | Ideation 3

Mapping the areas for double layered canvas

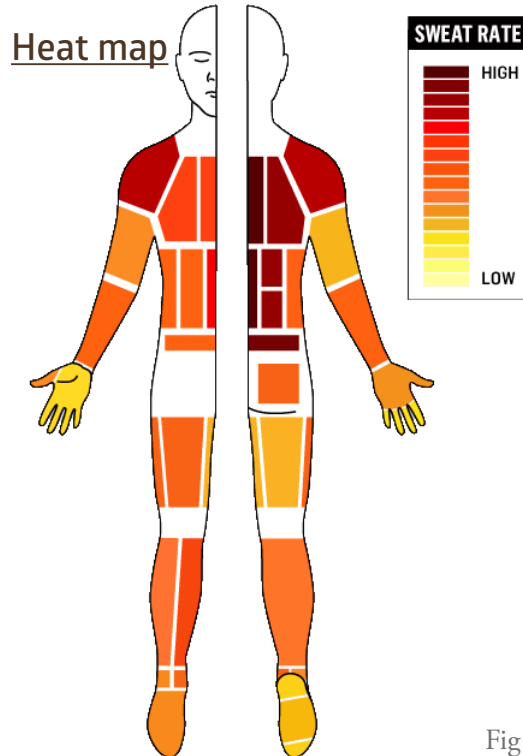


Fig 29

Wild honey bee harvesters usually wear suit on top of their shirt and pants, so the regions where it sweats more can be covered with single layered, while the rest can be covered with double layered canvas

Sting locations

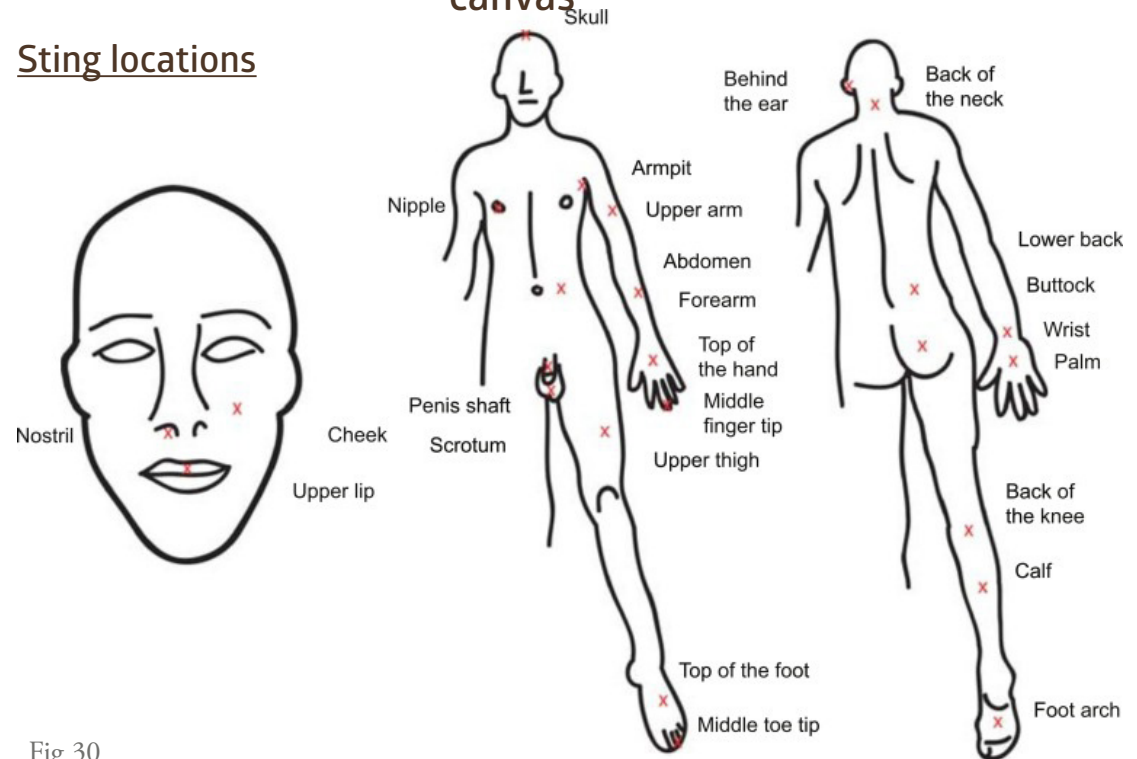


Fig 30

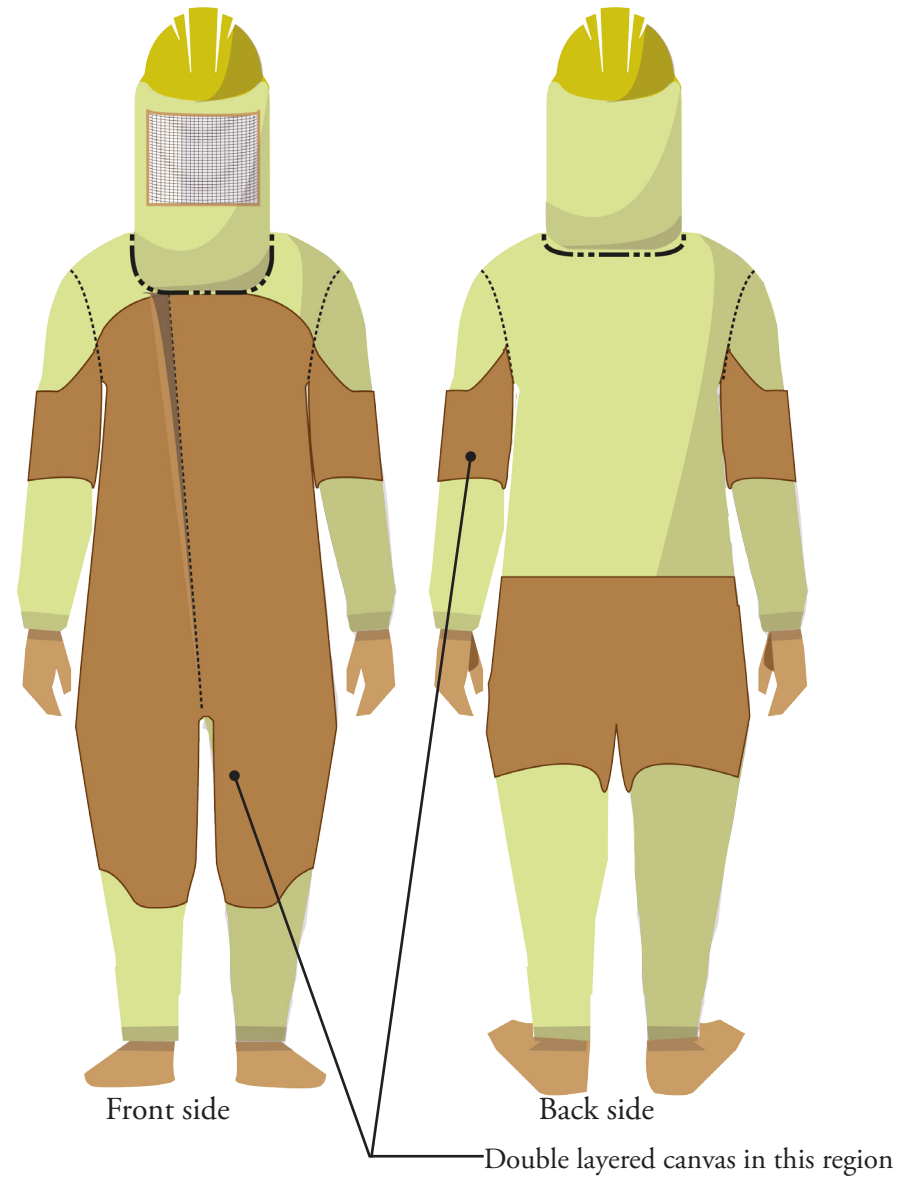
Understanding the areas that are the most painful to be stung by the wild honey bees and the areas where the honey bees sting the most. With the help of that, identification of the areas on our body where there is less probability of getting stung by the bees and the areas where, even if the bees sting, it would pain less

Mapping the zones where double layered canvas is required for extra protection.

This is the reason the suit is slightly loose at the abdomen and crotch region

Other factors which influence the area of doubler layer zone

- Activities like climbing up and down the rope
- Crawling on trees from one bee hive to the adjacent one
- Movement of the joints(elbow joints, knee joints) during the harvesting process results in stretching of the fabric in that area



Concept development | Ideation 3
Prototype testing

Comparison

CBeeD existing suit



Ideation 3



Time taken to wear the suit

2 min 15 sec

1 min 11 sec

Total weight of the suit

2.9 Kg

1.62 Kg

Manufacturing price

Rs 2100

Rs 1900
(will be considerably less when mass manufactured)

Concept development | Ideation 3

Prototype testing



The existing suit, which is being used in CBeeD, and the prototype made was tested at IDC by wearing it and climbing on a tree.

References

Image reference

- Fig 1<https://goo.gl/bg2rUZ>
- Fig 2<https://goo.gl/cWuu67>
- Fig 3<https://goo.gl/5yj1YR>
- Fig 4<https://goo.gl/7phR1H>
- Fig 5<https://goo.gl/KCqiPA>
- Fig 6<https://goo.gl/6Hh1GC>
- Fig 7<https://goo.gl/hKfXnd>
- Fig 8<https://goo.gl/ui2qea>
- Fig 9<https://goo.gl/kPYtPX>
- Fig 10.....<https://goo.gl/asWepR>
- Fig 11.....<https://goo.gl/ZMXo3b>
- Fig 12.....<https://goo.gl/CpYws4>
- Fig 13.....<https://goo.gl/5UNF6R>
- Fig 14.....<https://goo.gl/tg1E7B>
- Fig 15.....<https://goo.gl/DutSQa>
- Fig 16.....<https://goo.gl/7fAm32>
- Fig 17.....<https://goo.gl/sg9ks5>
- Fig 18.....<https://goo.gl/wtDxZQ>
- Fig 19.....<https://goo.gl/uS7fdW>
- Fig 20.....<https://goo.gl/mQe7Tb>
- Fig 21.....<https://goo.gl/ymmwhs>
- Fig 22.....<https://goo.gl/3Jfqes>
- Fig 23.....<https://goo.gl/HjNaCa>
- Fig 24.....<https://goo.gl/dGvMUu>
- Fig 25.....<https://goo.gl/9AswPM>
- Fig 26.....<https://goo.gl/SuKx3T>
- Fig 27.....<https://goo.gl/MyzKx5>
- Fig 28.....<https://goo.gl/MFowaB>
- Fig 29.....<https://goo.gl/SVdMga>
- Fig 30.....<https://goo.gl/YGKv6X>

Note:

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1. <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0150362>
2. <https://www.motherearthnews.com/homesteading-and-livestock/wild-honey-zmaz82mazglo>
3. <http://www.bbc.co.uk/nature/28290890>