DESIGN OF A COCONUT TREE CLIMBING DEVICE

Dileep Edacheri1, Sudhindra Kumar2, Prakash Unakal3
1-Student, M.Sc. [Engg.], 2- Professor, 3- Professor Department of Design
M. S. Ramaiah School of Advanced Studies, Bangalore 560 058

Abstract

Primary goal of the study is to design a coconut tree climbing device for farmers and residents. It is very difficult to climb on coconut tree manually due to the constant cylindrical structure and single stem. In other type of trees there will be branches for holding and to support the climber. A professional climber with proper training only could able to climb coconut tree. Due to the risk involved nowadays very less people are coming forward to climb on coconut trees. As the educational background of Indian youth is increasing. most of the people may hesitate to come in climbing profession. Considering this scenario, a device which will help the user to climb coconut tree easily will be useful for the people who is having large coconut cultivation as well as residents who is having less coconut trees. This kind of devices will encourage more people to come forward to agricultural sector.

For designing a coconut tree climbing device, it is very important to understand the customer’s aspirations and market segment. This is done by analysing the data of literature review, gemba study, customer survey and market study. Using the outputs of data analysing, quality function deployment (QFD) matrix and product design specification (PDS) were made. According to the PDS, four different concepts were generated to overcome the usability, ergonomic and safety aspects of the problems.

Final concept was selected by customer preference. A working prototype of final concept has made to validate the concept. The result of final model is checked by the customer to validate the usability issues, safety measures and its function. The proposed concept is lighter than those existing by about 30% and is expected to be of lower cost on account of aluminium used in its construction in lieu of steel.

Keywords: Climbing device, Palm, Coconut tree, Ergonomics & Usability, Safety

Nomenclature

Kg kilogram
mm millimeter
Rs Rupees

1. INTRODUCTION

In olden days most of the activities are done by manually. Gradually so many big and small equipments are developed to ease human activities, thus to lessen the human efforts to do the things. Nowadays most of the activities which included human efforts are either replaced or automated by the use of machines or other kind of equipments.

Due to the height and lack of branches, it is very difficult to climb on coconut trees. A professional climber with proper training only could able to climb coconut tree. Due to the risk involved nowadays very less people are coming forward to climb on coconut trees. Due to the lack of professional climbers, the existing professionals may charge more from the owners, moreover as the educational background of Indian youth is increasing most of the people may hesitate to come in this type of profession. Considering this scenario, a device which will help the user to climb coconut tree easily will be useful for the people who is having large coconut cultivation as well as residents who is having less coconut trees. This kind of devices will encourage more people to come forward to agricultural sector.

2. LITERATURE REVIEW

The post-independence period marks a turning point in the history of Indian agriculture is clear from the fact that compared with a rate of growth of less than 0.5 percent per annum during 1904-5 to 1944-45. The agricultural sector recorded an annual growth rate of 2.7 per cent during 1949-50 to 1983-84. This growth has been achieved as a result of high priority accorded to agriculture. The policy makers adopted a twofold strategy for regenerating agriculture immediately after independence. The first element of this strategy was to implement land reforms in order to remove institutional bottlenecks and the second element was to undertake massive investment in irrigation and other infrastructure in order to update the existing agricultural technology [1].

2.1 Coconut Tree Cultivation

Coconuts are exported by the tons around the world, bringing in revenue to various tropical countries. However, they also have other important uses. Appropriately referred as “The Tree of Life” by villagers, every part of the coconut is utilized in some way. The outside husk is used to make strong ropes, while the leaves of the tree are used as roofing material in villages. Inside, tender coconut water is a delicious and healthy drink. More importantly, tender coconuts are used as a medicine for diseases such as thyroid. Therefore, it is not an exaggeration to claim coconuts support many aspects of village life. In 1989, as one of the top five exports in the Philippines, 11.8 million tons of coconuts were produced. In 1998, the world total of coconuts imported was about 220,000 metric tons. In 1998, China was the largest importer of coconuts with 85,472 metric tons. The U.S. imported 23,377 metric tons and Hong Kong imported 16,393 metric tons [1].
2.2 Coconut Tree Climbing Without Any Device

It’s very hard to learn the necessary skills to climb coconut trees. The few first times, peoples barely managed to get a few feet off the ground. In addition to fear, the soft skin on the palms of hands and soles of feet made climbing difficult. During the initial climbing the skin of palm, chest and foot skin may be disturbed. This is what happens when people slide down hugging a coconut tree as hard as they can. There are two basic techniques and they are easy to learn. After that the user just need to practice and to forget about soft skin. It will probably get cut a bit the first time on the tree, but after continuous practice it will be fine. After a week, climbing the trees becomes second nature and the collection of coconuts is one of the easier and more enjoyable survival skills the user will learn. All techniques should be done barefoot and barehanded. A long sleeve T-shirt might save the user’s skin from abrasion against the tree especially when the people are learning [2].

The first method is the front-foot technique. It is similar to rock climbing. The rock climber stuff their hands inside cracks, pull on them and push on the legs in opposition and walk up the rock. This front foot technique to climb coconut tree is very similar. The climbing person has to put his hands close to each other on the back of the trunk, and pull one foot in front of the other one in front of the climbing person on the tree. By keeping pressure on the trunk with the balls of the climbing person’s feet and toes, walk up alternating moving feet and hands. Technically it seems to be the easiest to learn but requires good balance and arm strength [2].

![Fig. 1 The front foot technique](image)

3. DATA COLLECTION

3.1 Product Context Study

Coconut tree climbing equipment helps to climb on coconut tree without much human efforts. At present there are mainly two types of coconut tree climbing devices are available in Indian market. These devices can be operated by the effort of one person. The age limit of the user can be approximately 17 years to 60 years. The two types are:

1) Sitting type climbing device
2) Standing type climbing device

i. Sitting Type Climbing Device

Sitting type coconut climbing device is developed by Tamil Nadu Agricultural University (TNAU). The device has two MS frames; one upper and lower; they are connected by a belt while the equipment is on the coconut tree. The user has to sit on the seat which is provided on upper frame and has to insert his foot between the rubber rollers available in the lower frame. The upper frame can be lift by hands and the lower frame has to be lifted by leg. The process has to be repeated for the continuous climbing. In this type, the size can be adjusted as per the coconut tree diameter. This can be done by adjusting the MS steel bar using the plastic knobs. As both frames are positioned in angle, due to the friction by rubber bush it will get cling to the tree and the process has to repeat for further climbing. Safety belt can be adjusted for proper body posture. Distance between the top and bottom frames can be adjusted by the belt as per the convenience. It will be give more support to the user as there is a provision for sitting. It will help small farmers as well as people who own 15 to 20 coconut trees in the backyard of their houses. Even unskilled person can climb on coconut tree by using this device. The weight of the device is approximately 9 Kg.

![Fig. 2 Sitting type climbing device](image)

ii. Standing Type Climbing Device

Fig. 2 shows typical constructional details of standing type tree climbing equipment. Mr. M J Joseph, an agriculturist in Kerala is the person to bring out the initial concept of this type of coconut tree climbing device.

It has got mainly two assemblies of similar construction. The user has to co-ordinate these two assemblies simultaneously by using hands and legs to climb on coconut tree. In this construction, the user has to stand and operate the device. Initially the steel rope wires of both top and bottom assembly has to be looped with the tree and has to be locked. Then the user can stand by placing foot on both assemblies and has to hold on the handles provided. As the user lift the assembly by foot and raise the either assembly by hand the steel rope will get loosen and when he push back with foot after reaching to a particular height it will get tighten. By this process the user can climb to the tree easily.
To go down the user has to loosen the loop by raising his leg and pulling the handle, then he has to move down the device to a particular distance. From there the loop has to be tightened by pushing the leg towards down. For easy climbing, the body posture has to be kept straight.

In this type of construction the steel rope wire will get adjusted as per the diameter of the tree by the force applied by the user towards gravity. Here the device has to be operated by standing and there is no support for the body while climbing. This may cause fatigue to the climbing person during initial climbing. The weight of the device is approximately 7 Kg. The user can climb 40m in 2-3 minutes.

3.2 Market Study

Market study is essential before introducing new product in market. For the success of the new product, current market trends have to analyse deeply. All variety of a particular product has to be considered to understand their movements in the market. The cost of each product has to be studied to understand at what extent customer are accepting that product.

According to the retailer voice standing type climbing devices are most selling product. As a rough estimation 10 pieces per month are selling out. Sitting type climbers are selling in the range of 6-7 pieces per month. Market prices are below shown.

- Sitting type: Rs 2500
- Standing type: Rs 1300

Sitting type tree climbing devices are manufactured by St. Mary’s industries, Kerala and standing type devices are manufactured by Tamilnadu Agricultural University (TNAU), Coimbatore. Both type devices are export to foreign countries as per the requirement.

3.3 Gemba Study & Customer Survey

Study and understand of user environment is essential for the development of new product. Gemba study will provide answers to many important questions like, how they use the product, what are the issues they face and how the product can be improved etc.

User survey is conducted among the professional climbers as well as those who are climbing only for residential purpose. Video survey is done to understand and analysis the actual climbing process. Study is conducted on professional climbers for analyzing how they are interacting with this. Study separately conducted on the people where they are not using any kind of devices for coconut tree climbing, but they use only rope loops for climbing. Customer survey is done and filled questionnaire to understand their requirements.

3.4 User Study on Sitting Type

In sitting type of coconut tree climbing device, initial stages people used to get back pain. As the leg has to be inserting between rollers, due to rubbing, people used to get pain. Initial training is essential for the climbing. The user has to balance between the top and bottom halves, or else the device may stuck while climbing. There are no accidents reported by using this device. The main structure is made up of iron and can be rust by long use. Most of the time the climbing device during rainy season also, this may lead to corrosion of the main frames.

3.5 User Study on Standing Type

This device is mainly used by coconut farmers and residents in Kerala. The construction of this device is simple and easy to operate by common people. The user has to stand and coordinate with the two halves of the device for climbing.

The main observation indicates that the user get tired soon as he is operating this device by continuous standing during initial climbing. The main advantage of standing type climbing device from sitting type is the less weight; this enables women also to climb the coconut tree easily.

The main problem raised by the people they use the device continuously is the breakage of steel rope wire after 3-4 month of usage.

3.6 Summary of Gemba Study

- There are many methods to climb coconut tree without any devices.
- Professional climbers use rope loop for climbing and they are comfortable with it.
- Still so many researches are going on this field for improved product.
- Sitting type coconut tree climbing device is looking good, but it has more weight compare to standing type.
- As there is a provision for sitting in sitting type climbing device, it will not create much body ache.
- In sitting type device the user has to lift the device by using hands and legs. As weight is more for sitting type device, it gives more tiredness compare to standing type.
- Speed of climbing is more for standing type due to less weight.
In sitting type the size has to be adjusted as per the diameter of the coconut tree, but in standing type it is self-adjusted.

Speed depends on the effort of climbing person

Standing type is simple in construction and easy to use compare to sitting type.

In sitting type device may stuck while climbing on the tree. Standing type doesn’t create this problem

The iron rope wire gets disconnected from the lock area at some time, but the frequency of this is very less. It may happen once after 100 climbing

In sitting type device, the user need not change any parts, but in standing type device the user has to change the steel rope wire as it will damage due to continuous use.

4. PROBLEM STATEMENT

The user’s need and present status of the product is studied by the customer survey and GEMBA study. The designer should have to define the problem with these customer requirements to develop a new product which will satisfy the end user. Problem statement of this study is to design and develop the coconut tree climbing device for improved ergonomics and safety.

4.1 Methodology

- Literature review was carried out from journals, books, manuals and related documents
- Research to understand target user’s (farmers and residents) need was conducted
  - Literature survey
    - Technical specification, product context study, Market study and user study
    - Ethnography study
    - Interviews with focus groups
    - Data collection in the form of visuals, text, videos etc.
- QFD was generated based on the customer requirements and PDS generated by prioritizing the features in the QFD
- Concepts were generated through sketches and software's by using
  - Morphological analysis, Triz, 6-3-5 Method
  - Lifestyle board, Mood boards, Theme boards
- Five concepts were generated by using Pro-Engineer
- Concept evaluation for selecting the final concept was carried out by weighted ranking method
- Final digital model was created with detailed features and mechanisms by using Pro Engineer
- A coconut tree climbing device prototype was made.
- A questionnaire was created, focus groups invited and feedback collected from the targeted users and conclusions drawn

4.2 Quality Function Deployment

QFD is an objective method for ensuring quality from the earliest stages of product development. The aim is to create a product that will fully satisfy users by incorporating their requirements to design. Before preparing QFD, the user voice has been refined in to technical voice. The results from QFD matrices were analyzed. The highest rated Technical characteristics have been taken for the design process.

From the QFD matrices, ergonomics and usability fetch more point as coconut tree climbing device has to be operated by continuous human power ergonomic and usability factor has much importance in it. In present coconut tree climbing device there is some ergonomic and usability issues were found. Mechanism has got second highest points in QFD matrices. Multiple features and material also important for coconut tree climbing device.

<table>
<thead>
<tr>
<th>Table 24 QFD</th>
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<tbody>
<tr>
<td><strong>Technical Characteristics</strong></td>
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<td>Material</td>
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<td>Mechanism</td>
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<td>Multiple features</td>
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<td>Shape and color</td>
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<td>Ergonomics and usability</td>
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4.3 Product Design Specification (PDS)

The product design specification is a set of defined information that helps to meet the design considerations & the requirements. It gives the details all the considerations from design to manufacturing. In the PDS all the specified data has to be defined properly. The proper flow of process will be gained to achieve the concepts with this information. The final Product Design Specification (PDS) is shown in table 4.2.

<table>
<thead>
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<th>Table 25 PDS</th>
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<tr>
<td><strong>Target users</strong></td>
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<td><strong>Type of tree climbing device</strong></td>
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<td><strong>Manufacture</strong></td>
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5. CONCEPT GENERATION

The concepts are generated from the data obtained from QFD and PDS. As per PDS, all the engineering parts were finalized, and then the external shapes and mechanism has been derived. The concept includes the ergonomic considerations, aesthetics and the external shape of the product. The basic specification has been already generated in PDS. These requirements, specifications or technical characteristics are then used as the base for developing various concepts. Mind mapping tool used to explore idea generation and then visual theme board is prepared for understanding the similar kind of devices using in cultivation.

5.1 Mind Mapping

Concept generation process has initiated with the help of idea generation tool “mind mapping”. The idea developed by this method is depends up on their own thinking and knowledge level. Here entire parameter is arranged in common keywords and add link on each item so that many ideas can build up each parameter.

As a result of mind mapping, the idea of changing existing material to reduce weight, providing comfortable handle etc. have come out. On the basis of these outcome five concepts were generated

5.2 Visual Theme Board

Most of the farming equipments are made up of metals and are less aesthetic. The important factors to be considered are ergonomics ease of use and safety.

5.3 Concept

This concept shown in fig.7 is a basic alteration of sitting type tree climbing device. In this sitting type has changed to standing type. It will reduce the weight of the equipment as the extra frame for sitting is eliminated. The adjustable safety belt will support the user and will reduce the back pain while climbing.

5.4 Concept-2

This concept shown in fig.9 is a basic alteration of sitting type tree climbing device. The main difference from the concept 1 is that here the steel rope wire has accommodated in the top assembly. The main advantage is that it will reduce the weight and the size adjustment is by utilising the rings at the end of the steel rope wire.
In this construction, the user has to stand and operate the device.

**Fig. 10 Concept-2 detailing**

### 5.5 Concept-3

In this construction, the user has to stand and operate the device. Initially the steel rope wires of both top and bottom assembly has to be looped with the tree and has to be locked. Then the user can stand by placing foot on both assemblies. As the user lift the assembly by foot the steel rope will get loosen and when he push back with foot it will get tighten. By this process the user can climb to the tree easily.

To go down the user has to loosen the loop by raising his leg and pulling the handle, then he has to move down the device to a particular distance. From there the loop has to be tightened by pushing the leg towards down. For easy climbing, the body posture has to be kept straight. In concept-3 both the half is spited into two. This will help the user to transport the devise easily from one place to other.

**Fig. 11 Concept-3**

### 5.6 Concept-4

This concept shown in fig.13 is a basic alteration of sitting type tree climbing device. In this construction, the user has to stand and operate the device. The foot has to insert between the bottom rubber roller and flat foot rest and the top frame has to move up by using the handle provided. As both frames are positioned in angle, due to the friction by rubber bush it will get cling to the tree and the process has to repeat for further climbing. Safety belt can be adjusted for proper body posture. Distance between the top and bottom frames can be adjusted by the belt as per the convenience. The plastic knob can be used to adjust the size of the top and bottom frame.

**Fig. 13 Concept-4**

### 5.7 Concept-5

In this construction in fig. 14, the user has to stand and operate the device. Initially the steel rope wires of both top and bottom assembly has to be looped with the tree and has to be locked. Then the user can stand by placing foot on both assemblies. As the user lift the assembly by foot the steel rope will get loosen and when he push back with foot it will get tighten. By this process the user can climb to the tree easily.

**Fig. 14 Concept-5**
5.8 Concept Selection

Selecting final concept is very important task in a product design cycle, in which each and every feature has to be cross checked in details. We can do concept selection by so many methods. Here concept selection has been done by Dot-matrixes method and through customer preference.

i. Dot-matrixes method

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In Dot-matrixes method concept 5 has got maximum point.

ii. Customer Feedback

In Customer feedback most of person selected concept-5 and concept-2, but in Dot matrixes method concept-5 got maximum points. So concept-5 was selected as a final concept.

5.9 Concept Iteration

The handle design and locking area design has modified for better ergonomics and usability.

i. Material Research for the Selected Concept

In the present design the frames are made up of mild steel. The weight of the device is 5Kg. If the weight of the device can be still reduced, it will be very useful for the user. One method to reduce the weight is to replace the main frame material from MS to any other material of less density and which should give the same performance as that of MS. As a result of studying the properties of different grades of Aluminium alloys, it has understood that Aluminium alloy 7075 can be used instead of the mild steel frames of the coconut tree climbing device.

At present Steel wire rope of 19 strands is using without any core. If it is possible to use higher grade of steel wire rope, it will eliminate the breakage. 6x19 FC RH OL FSWR will be a suitable steel rope wire which can be used on the final concept tree climbing device for long use without breakage.

6. WORKING MODEL

Working model of final concept has made. Major sequences of operation included in working model development are left and right frame construction, welding, painting and assembly. Major processes involved are bending, drilling and welding.
7. VALIDATION

The working model has assembled and taken into user’s environment. The validation of the coconut tree climbing device has done by self and by a residential user.

8. SUMMARY

The study was started to develop a coconut tree climbing device. Due to the lack of professional climbers, the existing professionals may charge more from the owners, moreover as the educational background of Indian youth is increasing most of the people may hesitate to come in this type of profession.

Considering this scenario, a device which will help the user to climb coconut tree easily will be useful for the people who is having large coconut cultivation as well as residents who is having less coconut trees. The existing products, literature survey and user study have analysed and compiled to generate QFD and PDS. Concepts were generated and selection of the concept has done. The selected concept was developed as a 1:1 working model. The working model has then validated in user’s environment and feedbacks are collected. The proposed working model is lighter than those existing by about 30% and is expected to be of lower cost on account of aluminium used in its construction in lieu of the steel used in other currently available designs.

9. REFERENCES