DESIGN AND DEVELOPMENT OF SAFE CLIMBING AID

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Abstract: Climbing over any surface is a risky job to any human performing any sort of job. Fall from height hazard is one of the important parameter to be considered before performing any sort of height work. This is even more dangerous over climbing trees for performing any work. In this paper we have suggested a safer means of method to carryout height work over the trees by proposing a new platform for the worker. This proposed method reduces workers strain and fatigue while working by ensuring the safety of the worker with no matter the height he is at.

1. Introduction

Climbing has always been a risky job, which lead to serious injury or sometimes fatalities. Working over height is always a hazardous task to carryout. It requires appropriate training and fear free attitude to work at height. It is said by the OSHA that over 100 fatalities occur due to landscape and tree fall fatalities every year. Tree care industries stated even higher fatal rates. In fact the tree care industry is one of the most dangerous in America. Many new innovations are being made for climbing tree and electric poles for any job to be carried out. Most of the operations were carried out manually in ancient days. Actually, most of the Activities requiring human efforts are either substituted or automated with the use of Machines or other devices of some kind. One such technique is being offered in the field of Coconut Growing and Harvesting. One of the main coconut plantations is one of the major Better research and growth of agricultural practices in the southern part of India In the case of these trees, the height and height of such trees. The lack of branches makes climbing on them very challenging. The practice of quickly climbing trees, plucking coconuts or applying pesticides was done manually those days. People who cultivate massive quantities of coconut, as well as residents with less cocoa Equipment to allow harvesting is necessary. In the case of trees of this kind such devices can be used for climbing. In horticulture production, India ranks second worldwide. The horticultural crop situation has been very promising in India. In agriculture, the percentage share of horticulture production has risen to more than 30 percent. The horticulture 2 field has grown by around 2.7 percent per annum over the last decade and annual production has increased by 7.0 percent.

2. Objective

The main objective of this project is to design and develop a climbing aid which is

- Safe
- Light in weight
- Economically feasible
- Easily portable

3. Methodology

These are the step by step process carried out in the whole process of the project.

Designing of the climbing aid

Development of drawing (using solid works)

Static Analysis of the climbing aid using ANSYS (1.4)

Material selection and purchase for the fabrication of climbing aid

Fabrication of the climbing aid

4. Design of the climbing aid

The idea has been derived from several literatures and commercially available equipment's. The design has been derived from "sitting type coconut palm climbing device developed by VV.Agarval. They have used Galvanised iron to fabricate the equipment. Since mild steel is stronger than Galvanised iron, I am planning to use mild steel to increase the load carrying capacity.

The gripping mechanism has been arrived from the "Design and fabrication of coconut tree and palm tree climbing machine developed by C.Thirvasagam, namakkal. In order to make the fabrication more sophisticated, Back rest is added so that climber carrying out the work on top of the tree can feel comfortable and take rest if he is tired and carrying the job for long period of time. This idea has been derived from the patent source patent no 4953662) United States patent,

Where they have provided a chair like arrangement which is used for hunting purpose. In next phase it has been planned to elaborate the design for electric pole climbing in the next phase by providing customizable parts according to the requirement.

5. Plan & Elevation of Climbing Aid

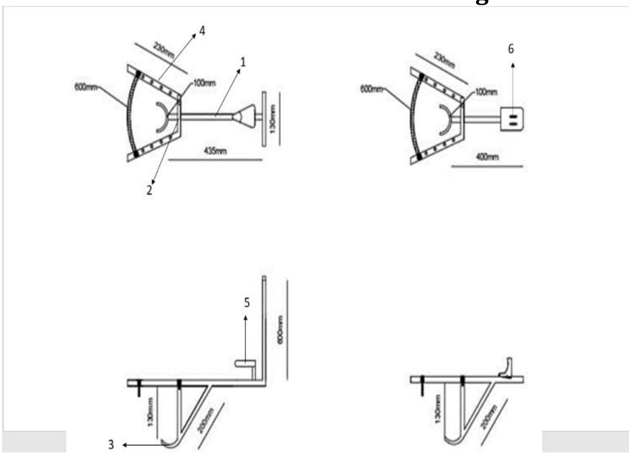

Fig. No 1 – CAD diagram for climbing aid

Fig. No 2 –Bottom Part of Climbing aid

Fig. No 3 – Foot Portion of Climbing Aid

6. Working

There are two components of the coconut tree climber linked by Customizable belts. The upper component is operated by hand and the lower part component with the help of foot. The upper part has been engaged with the arrangement of seating and the lower portion had provisions for Foot holding. On the coconut tree, the machine was fitted with the upper part component above the lower part, component.

By standing on the bottom component, the upper part slid up or down over the trunk. Likewise, by sitting in the upper portion, the lower component can slid up and down. It is possible to slide the element up or down over the tree. The operator could climb or descend the tree by operating the upper and the lower components alternatively. Since, the operator was safely held against the tree by the upper component, there was no problem of falling down of the operator. Even, unskilled persons could easily operate the device.

7. Isometric view of the climbing aid

The model image was derived using the software solid works (2018). This gives the isometric view of the model for better understanding as well as to import the model in IGES (initial graphics exchange specification) format.

Fig. No 4 - Isometric view

8. Static Analysis Procedure

These are the following steps carried out during analysis of the climbing aid using the software ANSYS (1.4) and solid works 2018

Step 1: Engineering data: choose the material properties of design or geometry.
Step 2: Geometry: imported the geometry from solid works model in lGES (initial graphics exchange specification) format
Step 3: Mesh: hexahedral mesh in model number of elements, 1140 number of node: 23081
Step 4: Static structural (support and load): one end fixed support and other end to force 1470N.
Step 5: Solution (results): total deformation &maximum principal strain.

9. Static Analysis Results

The material property of the mild steel with respect to its density, young's modulus, bulk modulus, shear modulus, poison's ratio, ultimate tensile strength, tensile yield strength.

Properties of Outline Row 4: Mild Steel

	A	B	C	D	E
1	Property	Value	Unit		
2	Density	7861.1	kg m^-3		
3	Isotropic Elasticity				
4	Derive from	Bulk Modulus a...			
5	Young's Modulus	1.764E+11	Pa		
6	Poisson's Ratio	0.29			
7	Bulk Modulus	1.4E+05	MPa		
8	Shear Modulus	6.8372E+10	Pa		
9	Tensile Yield Strength	370	MPa		
10	Tensile Ultimate Strength	440	MPa		

Fig. No 5 – Results for Static Analysis

10. Maximum principal elastic strain

Maximum principal strain analysis has been carried out, load has been given as 1470N. The strain of maximum 0.56783mm and minimum of 0.0005709mm has occurred on the application of load. This ensures very minimum strain and concludes that the aid is safe for use until the applied weight is 150kg. The below image shows the complete maximum principal strain analysis with respect to the color coding.

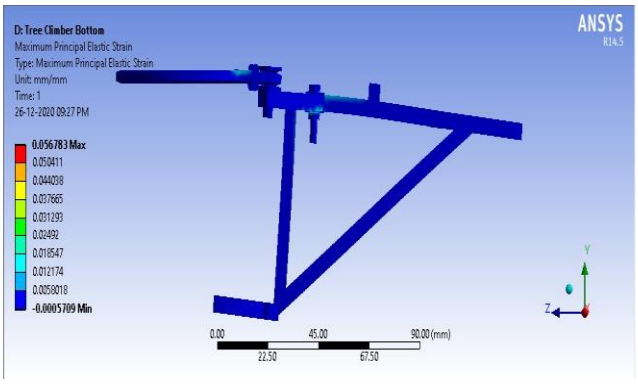

Fig. No 6 – ANSYS Results

Maximum principle strain analysis has been carried out using ANSYS by providing the load of 1470N.

11. Maximum principal elastic strain (upper portion)

Maximum principal strain analysis has been carried out, load has been given as 1470N. the strain of maximum 0.69371mm and minimum of 2.9898mm has occurred on the application of load. This ensures very minimum strain and concludes that the aid is safe for use until the applied weight is 150kg. The below image shows the complete maximum principal strain analysis with respect to the color coding.

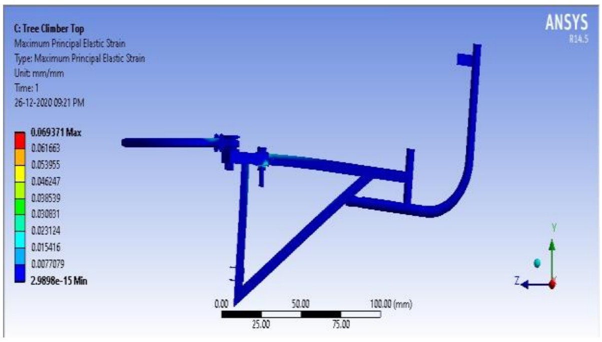

Fig. No 7 – ANSYS Results

Maximum principle strain analysis has been carried out using ANSYS by providing the load of 1470N.

12. Total deformation (Lower portion)

Maximum principle strain analysis has been carried out, load has been given as 1470N. the deformation of maximum 0.001 mm and minimum of 0mm has occurred on the appilication of load at the end where the support is not fixed and the human weight is to be applied. This ensures very minimum deformation and concludes that the aid is safe for use until the applied weight is 150kg. The below image shows the complete deformation analysis with respect to the color coding.

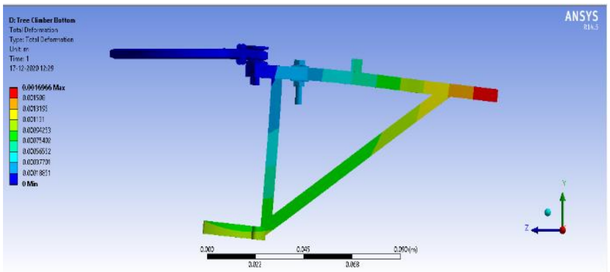

Fig. No 8 ANSYS Results

Total deformation analysis has been carried out using ANSYS by providing the load of 1470N.

13. Total Deformation (upper portion)

Maximum principle strain analysis has been carried out, load has been given as 1470N. The deformation of maximum 0.004 mm and minimum of 0mm has occurred on the application of load at the end where the support is not fixed and the human weight is to be applied. This ensures very minimum deformation and concludes that the aid is safe for use until the applied weight is 150kg. The below image shows the complete deformation analysis with respect to the color coding.

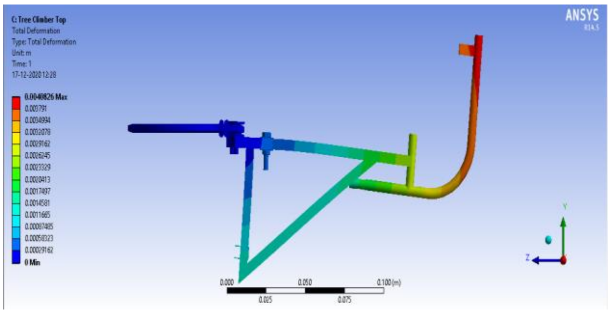

Fig. No 9 – ANSYS Results

Total deformation analysis has been carried out using ANSYS by providing the load of 1470N.

14. Design and Fabrication

The coconut palm climbing device type seating consists of two units called the upper and lower units. The following details of its components as shown the figure 1


Fig. No 10 – Testing the Climbing Aid in Coconut tree

1. Approach sections of the climbing aid:-

It is one of the most significant components of the coconut climbing system for sitting. It was made from a MS hollow square pipe with a 16 mm square cross-section with a thickness of 2 mm and a length of 280 mm. To allow the sliding of the telescopic pipe over it, seven holes with a diameter of 8 mm were drilled at a distance of 25mm. With the assistance of a complete M6-50 mm threaded bolt, one end of the pipe was intended to be attached to the junction. All four approach sections have the same approach portion.

2. Junction (For Upper Unit and Lower Unit):-

The system formed a total of two junctions, namely the upper junction (at the upper unit) and the lower junction (at lower unit)

The upper junction helps to join the seat support pipe approach section for the upper unit, while the lower junction helps to join the foot rest approach section. The dimensions of both junctions are the same. Firstly, MS hollow rectangular pipe with an internal dimension 67 mm and a thickness of 1.5 mm and a length of 50 mm was cut wisely and welded to a MS square pipe with a short side of 38 mm internal dimension with a thickness of 1.5 mm and a length of 50 mm as shown in the complete threaded M6-50 mm bolts were intended to link the approach section with the junction

3. Face Plate With Base Pipe Gripping (For Upper Unit And Lower Unit)

Gripping face plate offers grip with trunk during service, as its name implies. Gripping face plate 6 mm MS flat with a 210 mm length was used. At the end of the MS flat, two holes with a diameter of 8 mm were then drilled at a distance of 20 mm from the outer end. At a radius of 25 mm, it bent. Then two completely threaded M6-50 mm bolts were taken and their heads were machined up to 2 mm with the unit

4. Telescopic pipe of the climbing aid:-

The telescopic pipe is used to fit various coconut palm girths to the system and also carries a 6 mm thick metal rope. The metal rope had been twisted before. A 22-22 mm MS square pipe with a thickness of 1.5 mm and a length of 40 mm was made of telescopic pipes. Two M6-20 mm full threaded bolts were welded to the MS pipe from its head by maintaining a gap of 20 mm between them. Between these two bolts, the metal rope was then attached. After that, these bolts were fixed through the holes with the aid of two 6 mm hexagonal nuts. To regulate the sliding movement of the telescopic pipe, a key was made. It was formed over the approach section by a washer welded at the head of M6-50 mm full threaded bolt slides. A total of four telescopic pipes of the same dimensions were made, two (top telescopic pipe) for the upper unit and two (bottom telescopic pipe) for the lower unit.

5. Seat of the climbing aid:-

The heart shaped bicycle seat accessible to the operator was used to provide the sitting facility. The seat was attached to a seat support pipe (29-29 mm MS square pipe with a thickness of 1.5 mm and a length of 4355 mm). First of all a 20×6 mm MS flat having length of 140 mm was selected to provide base for seat. Holes of 8 mm diameter were drilled at both ends of MS flat with the distance of 20 mm from near end. On it seat was fitted. Overall seat size is 210×180 mm.

6. Foot rest of the climbing aid:-

Feet rest is the component of the lower unit of the device. A 29×29 mm MS square pipe with 1.5 mm thickness and the length of 260 mm was taken. On it at one side three holes of 8 mm diameter were drilled at the spacing of 25 mm from each other that provide facility to slide inside the junction

Then four MS square pipes (16-16 mm) with a thickness of 2 mm and a length of 140 mm were welded to the 29-29 mm pipe in such a way that the front pipe was raised by the toe and the rear pipe was pushed by the heel. To give comfort, the Rubber grips for operators are given

15. Performance Evaluation

This performance evaluation was done in real time by using the climbing aid in the coconut trees. Here different real tree climbers used this climbing aid to climb the trees and the parameters such as heart rate, pulse counts weight of the climber was recorded and tabulated below.

Particulars	Permissible range	Climbing Device
Heart rate beats min $^{-1}$	130-150	120.1
Energy Expenditure, KJ min^{-1}	24-50	28.7
Work Pulse, beats min^{-1}	50-60	49.4
Allowable Work load	Out of 100	55.6
Limit of continuous Performance	Out of 100	47.8
Overall Discomfort Rating	Out of 10	6.3
Overall Safety Rating (OSR)	Out of 10	7.6
Ease of Operation Rating(OER)	Out of 10	7.2
Body part Discomfort Score	Out of 100	37

Table No 1 – Comparison of Ergonomic Parameters

Conclusion

Two portions upper and lower are designed and lower portion is fabricated and analysis is carried out using ANSYS, where maximum principal elastic strain and total deformation is found out using static analysis for both top and bottom portion of the climbing aid. The two metal wire ropes locked to the tree operate on the timely grasping and release of the tree. This is a safe aid to use for the unskilled people. The structure is capable of holding a load of 160 kg.

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