



DESIGN AND SIMULATION OF COCONUT TREE CLIMBING TOOL FOR COCONUT FARMERS IN LOMBOK SANGATTA BAY, EAST KUTAI

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ABSTRACT

Great potentiality of coconut cannot be separated from the method of coconut harvest which still draw a lot of problems in. Until now, coconut farmers still use climber service in coconut harvesting. The process of coconut tree climbing is usually done without tools. This is very risky for the harvesters. Since the utilization of animal service (monkeys) have already prohibited from commercial activities, human service in coconut tree climbing becomes the alternative for the farmers. For this reason, the aim of this study is to design a tool for coconut tree climbing that will help coconut harvesters in Lombok Sangatta Bay, East Kutai, by considering climber's characteristics. Furthermore, the tool is made in form of design, which then being simulated to determine the tools' safety level, stress level and the ability which is designed by using SolidWorks 2018 software. The result for the proposed design of coconut tree climbing tool for coconut harvester in Lombok Sangatta Bay, East Kutai, is to use 20 mm x 20 mm x 2 mm of hollow profile with AISI 1020 material built, which is declared safe for 80 kg capacity. The highest score of stress is 223.04 Mpa on body holder, 4.68 mm deflection, 1.6 in factor of safety, and 17.08 kg for tool's overall weight.

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I. INTRODUCTION

Coconut tree which known as the tree of life has become one of the most popular plants in the world (Elevitch, 2006). Coconut trees grow in more than 98 countries which covers the area around 12 million hectares (Arulandoo et al., 2017). In 2013, coconut held the record as the type of plant with the largest cultivated area in the world, with the average production rate of 62.45 million tons, and Indonesia is one of the countries that produced the most coconuts (Arulandoo et al., 2017). When compared to other types of plants, coconut is a versatile plant because almost all parts of this plant are providing benefits for humans, i.e. green coconut water which contains micromineralised and nutrients which is essential for health (DebMandal and Mandal, 2011; Susilo, 2015).

Coconut plays an important role in the economy of Indonesian people, including the people in Lombok Sangatta Bay, East Kutai. However, the current process of coconut harvest still uses conventional methods. Coconut harvesters are climbing the trees without tools, or by using monkeys. The monkeys used for the harvesting process have been trained so that they able to harvest the proper fruits. With the limited number and high cost of monkey services, as well as the prohibition on exploiting animals as stated in the Constitution no. 41 year 2014, resulting in the option of using human services (Suwandi et al., 2017).

In doing their work, coconut harvester must have good instincts in choosing ready-to-harvest coconuts, reach for the fond, and can survive high altitude (Abraham et al., 2014). Since coconut trees can reach tens of meters in height, harvester will face huge and serious risks (Mani and Jothilingam, 2014). The conditions bring difficulties for coconut farmers to find human harvester because they are aware of the risks involved, especially because the wages are not worth the risk. Based on a series of observations, coconut harvesters have equipped themselves with coconut climbing tools. However, different methods of climbing coconut trees in each area makes it difficult for them to adjust themselves with the tool. As what happened among coconut harvester in Lombok Sangatta Bay, East Kutai, they finally choose to work without climbing tools.

Several studies related to the design of coconut tree climbing tools were found, such as Sardino et al. (2018) that designed a portable

coconut tree climbing tool which worked on rope effect on coconut tree and equipped with safety rope. Suwandi et al. (2017) designed a coconut tree climbing tool by using the French method and Design for Manufacturing and Assembly (DFMA). Azizah (2018) designed a microcontroller-based green coconut fruit harvesting system. Handoko (2013) made a tool for coconut trees climbing in southern coastal areas. The weakness of previous studies was that they did not consider the elements of climbing method differences in each region in Indonesia. For this reason, the purpose of this study is to design a special climbing tool for coconut tree harvesters in Lombok Sangatta Bay, East Kutai. The tool will be made by taking harvester's characteristics, material quality, strength and capacity of the designed tool into consideration. The tool is in form of design, then being simulated to aim the information regarding its safety level, stress level, and ability. Thus, this tool can increase the productivity of coconut harvest and give the sense of security for coconut harvester.

II. RESEARCH METHOD

A. Equipment

The equipment used to design a coconut tree climbing tool were 1 unit of measuring tape to measure the dimensions of coconut tree trunk and harvester's body; 1 unit of computer with Windows 10 operating system, equipped with SolidWorks 2018 software to design and simulate the design results.

B. Data Collection Methods

There were 3 stages of data collection methods in this study, they are: (1) identified the means or method of coconut trees climbing in Lombok Sangatta Bay, East Kutai; (2) measured the dimensions of coconut trees and harvester's body; (3) designed the tools using SolidWorks 2018 software by considering the type of material, the strength of the joints and the stresses in the holder parts.

C. Data Processing Methods

The result of problem identification that had been obtained then converted into a tool design. Considering that the research only aimed to design a suitable tool for particular method of coconut tree climbing in Lombok Sangatta Bay, East Kutai, the designed tool was adjusted to the obtained identification results. Solidworks 2018 software was used to design this proposed tool. Furthermore, after obtained the 3D design, it was

then being simulated to determine the tool design capabilities, the level of safety, and the level of stress.

III. RESULTS AND DISCUSSIONS

A. Design Concept

The concept of designing a device for coconut tree climbing followed the characteristics

of the means or method of coconut trees climbing in Lombok Sangatta region, East Kutai. During the process, harvesters support their body with both hands and feet so that their body kept in balanced position. From the observations, the researchers tried to design the tool by considering that particular method. The design results can be seen in Figure 1 below.



Figure 1 Design concept for coconut tree climbing tool

B. Design Result's Working Principles

The coconut tree climbing tool was designed in two parts, consisted of the top part as the seat (body holder) and the bottom part as footrest (foot holder). First, those two parts were attached to the targeted coconut tree, then the harvester sat on the body holder and placed his feet in foot holder. The harvester should be fully seated in body holder and made sure the tool well attached to the coconut tree trunk. The same thing was done for the foot holder; the harvester's feet were attached to that part to the point that he could stand on the foot holder. Body holder then slowly pushed upward followed by foot holder. Furthermore, the process for descending operation was in the opposite. Thus, foot holder moved before body holder.

C. Design Result's Simulations

The simulation was a type of static simulation, to find out whether the parts could withstand the loads of 80 kg or 800 N. Stress analysis output, displacement (deflection) and the factor of safety for parts that had been made were 2)

created by using Solidworks 2018 software. The simulation was based on the analysis of tool's design concept and its working principle. When the external load was given, gravity was added by 9.81 m/s^2 so that the simulation generated a real result.

1) Body Holder: The simulation results on body holder showed the adductions of external load by $80 \text{ kg} \times 9.81 \text{ m/s}^2 = 784.8 \text{ N}$ which rounded up to 800 N, plus the mass of the object itself by 10 kg (100 N) which added up the weight into 900 N. The number then added 9.81 m/s^2 of gravity and fixed geometry at all four ends of frame. The highest stress analysis simulation result showed 223.04 KPa which was smaller than the yield strength of AISI 1020 material (351.57 KPa). The biggest result of displacement test was 4.68 mm and the factor of safety on body holder frame was 1.6. Thus could be said that the frame of body holder considered safe to use. The results of body holder simulation shown in Figure 2 below.

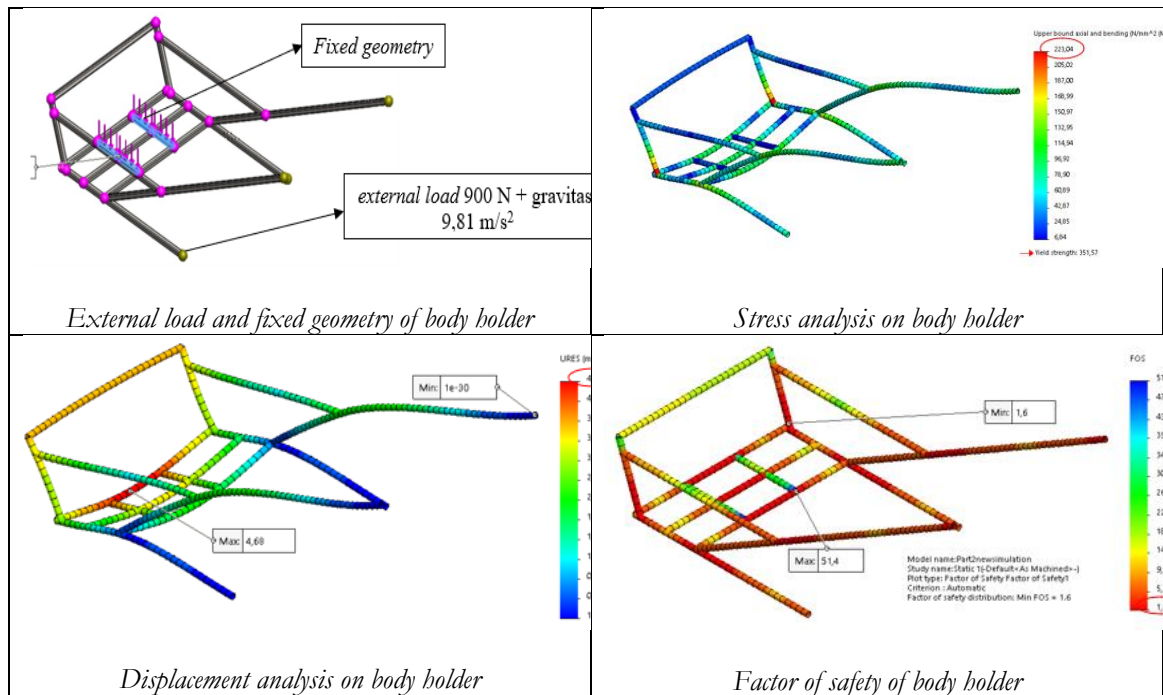


Fig 2 Simulation result of *body holder*

2) Arm Holder: The bolts were given external load, and the part that in direct contact with coconut tree which the smallest diameter was 40 cm on average. Arm holder was connected by 2 bolts, thus 900 N was divided by 2 into 450 N. The highest simulation results of stress

analysis on arm holder was 181.55 MPa, smaller than the yield strength material. The highest deflection in arm holder was 0.431 mm. Meanwhile, factor of safety of arm holder was 1.9. Arm holder simulation results can be seen in Figure 3 below.

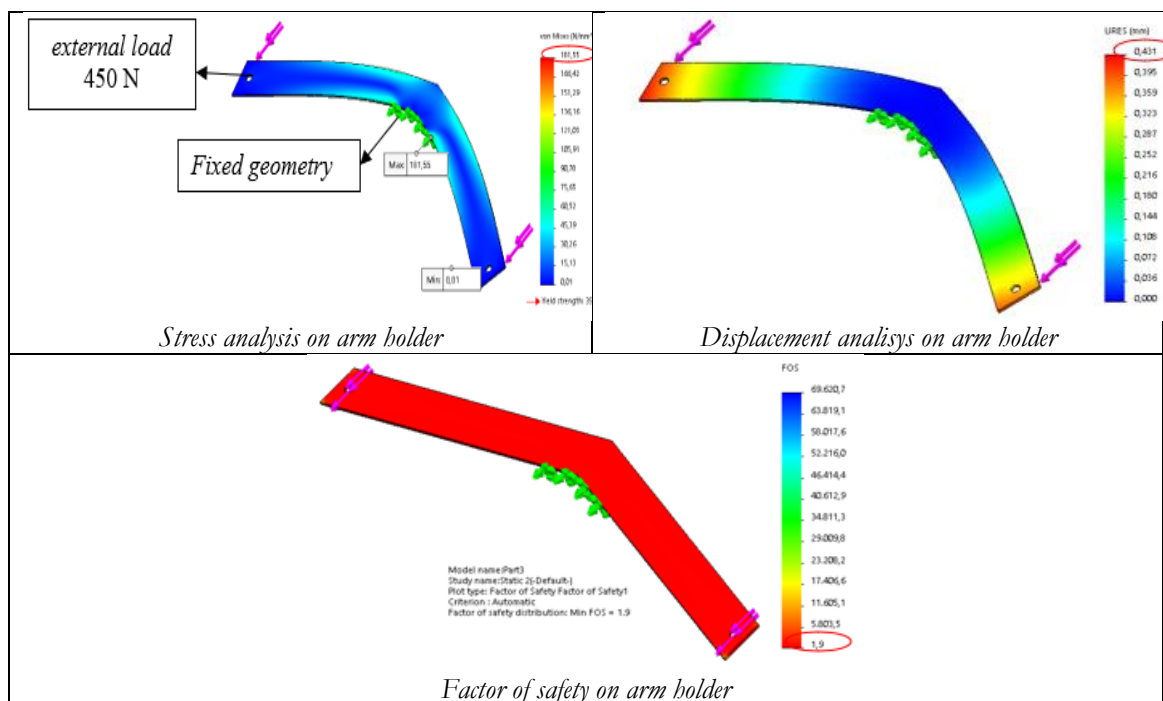


Fig 3 Simulation results on *arm holder*

3) Lower Holder: The threaded holes parts were given external load and the part which in contact with the coconut tree was given fixed geometry. Because the lower holder was connected with 2 bolts, it became 450 N each. The highest result of stress analysis test for lower holder was 154.36 MPa, smaller than the yield strength of AISI 1020 material, while

displacement analysis value was 0.173 mm. Meanwhile, the factor of safety for lower holder part was 2.3. It meant that the lower holder components were categorized as safe when connected with the main tool. Lower holder simulation results can be seen in Figure 4 below.

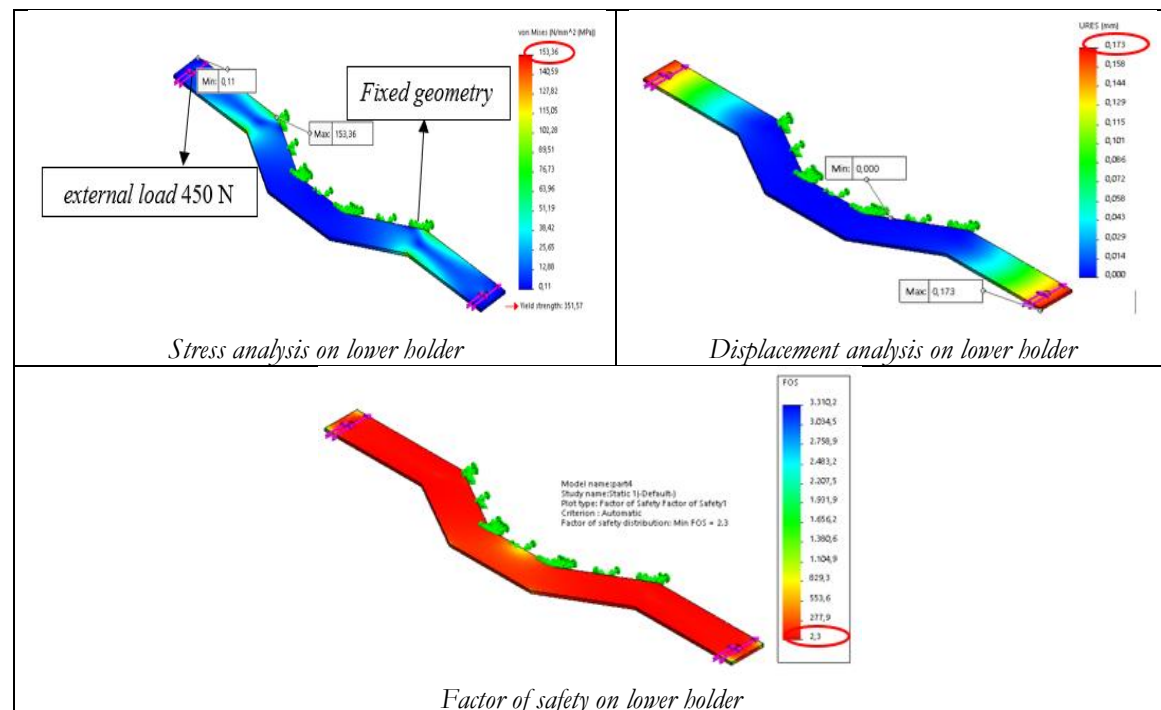
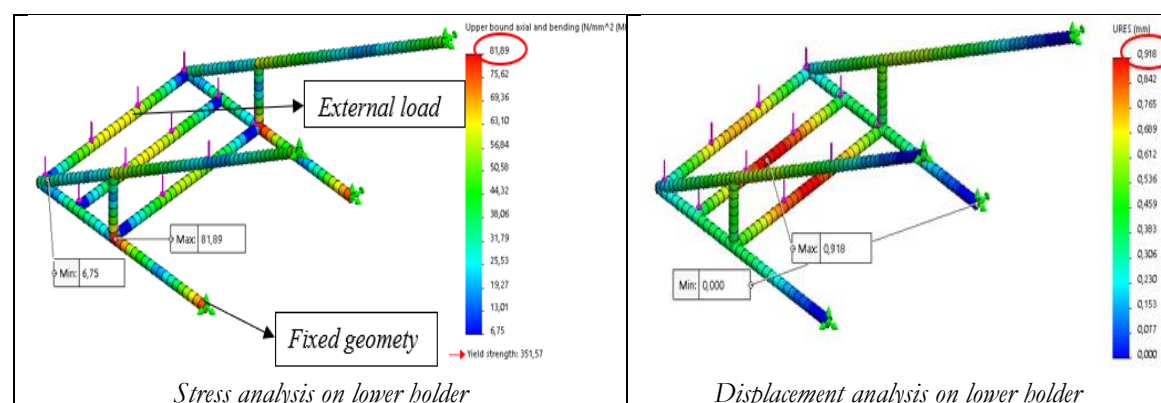


Fig 4 Simulation results on *lower holder*

4) Foot Holder: The simulation results showed that the highest stress analysis value on lower holder was 81.89 MPa, smaller than yield strength of AISI 1020 material, while the highest

deflection in arm holder was 0.918 mm. Then, the factor of safety of this part was 4.3. The results of foot holder simulation can be seen in Figure 5 below.



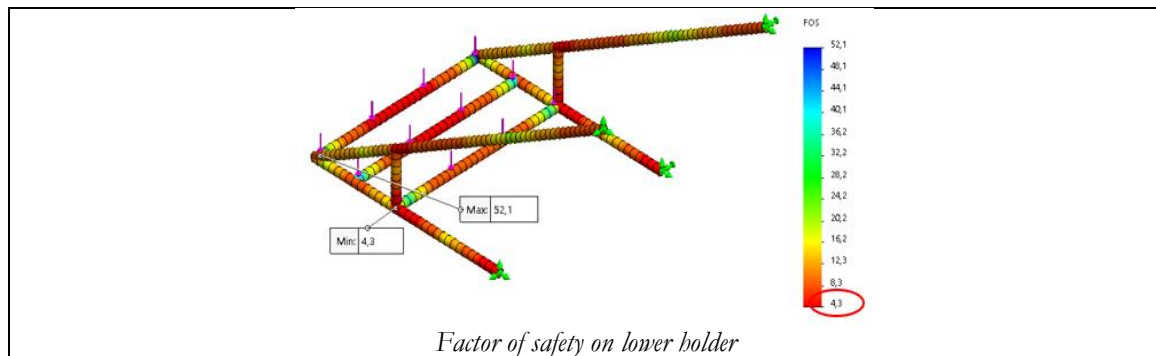


Fig 5 Simulation results on *foot holder*

4. Overall Equipment Weight

To find out overall weight of the equipment that had been made could be performed by using "Evaluate" feature in Solidworks 2018, then select the option "Mass properties". From the calculation results, total weight of body holder assembly were 10.91 kg, while the total weight of foot holder assembly were 6.17 kg.

IV. CONCLUSION

The conclusion of this research is the design of coconut tree climbing tools for coconut harvesters in Lombok Sangatta Bay, East Kutai. The tool capacity is 80 kg, using 20 mm x 20 mm x 2 mm hollow profile of AISI 1020 material, which is safe to use. The highest stress value is 223.04 Mpa on body holder, the deflection is 4.68 mm, the factor of safety is 1.6, and the overall weight is 17.08 kg. It means that the proposed tool is feasible to be made and used by coconut harvesters who work for coconut farmers in Lombok Sangatta Bay, East Kutai. Thus, the productivity of coconut harvesting will increase and also reduce the risks faced by coconut harvester.

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