A new development of the clove harvest safety tool for farmers

H Soewardi¹ and R Sujono²

¹,²Industrial Engineering Department, Faculty of Industrial Technology
Islamic University of Indonesia Yogyakarta – Indonesia

E-mail: ¹hartomo@ui.ac.id; ²mamad2101@gmail.com

Abstract - Clove harvest safety tool is a tool to assist the clove farmers to move at high altitudes while harvesting cloves. In addition to being a vital tool for user safety, it helps farmers ease the clove harvest activities. Currently, many users are complaining about the safety of the existing clove harvest tool available in the market. This indicates the shortcomings in the existing tool design. Some of these complaints include difficulty to use, less convenient shape, and the expensive price in the market. These shortcomings have made users reluctant to use the safety tool while moving at an altitude of clove trees. The purpose of this study is to develop a new design of safety tools for clove farmers using the User-Centered Design as a concept to determine the design parameters of safety tools. The survey was conducted to identify the criteria and the use of statistical analysis to test hypotheses developed. This research results in the design parameters of safety tools that can represent the user demand as well as the farmers’ safety and activity. These criteria include strong design, durability, flexibility, multifunctionality and comfort.

1. Introduction

Clove farmers in Kebonharjo village, Samigaluh Sub-District, Kulonprogo District of Yogyakarta are very good at taking cloves without using safety equipment even though the average clove tree is above 5 meters high. Just by relying on courage and experience, farmers can harvest the cloves regardless of their own safety while moving at the top of the clove tree. Based on the interviews with resource persons, it was noted that from 2012 to 2015 in Samigaluh Sub-district, there were several incidents of clove farmers who fell from the clove tree. They stated that in the last four years, there were twelve fallen victims, who died after falling from the height of clove trees. Meanwhile, there were twenty to twenty-five people have dislocated legs as they slipped from the top of the clove tree.

In 2007, Indonesia was ranked second after China in an accident of falling from above the altitude with seven deaths per day. Based on data from [1], working at an altitude is an activity categorized as "First Class Risk Activities", based on the UK Labor Force Survey (LFS2) report. One of the causes of workplace accidents affecting serious injury and death is falling from above (31%) that is mostly experienced by construction workers (11%).

User Centered Design (UCD) is a concept in design of products that focuses on users. It involves users to actively take part in the design process from the beginning until the product is ready to use. Hence, the products can be understood and suit with the users’ demand [2] [3].

Several previous studies have started to use UCD in designing products, such as motorcycle tire dismounting tool design for one-handed user [4], design of robotic devices for upper limb stroke
rehabilitation [5], design of hair washing assistive device for users with shoulder mobility restriction [6], intelligent wheel chair design [7], design of coconut fiber tablet case [8], and innovative design of wheel chair [9].

The purpose of this research is to redesign the safety tools and to add transport cargo tools that can meet user needs to reduce complaints by using UCD approach.

2. Research Method

2.1. Survey
A survey was divided into three stages. The first stage was to identify the attribute of Safety Harness that user desire. The second stage was to determine the design parameters. The last stage was to validate the proposed design. 80 users participated in answering some questions of the distributed questionnaires. They are males whose age is from 20 up to 45 years old.

2.2. Mapping Process with Axiomatic Design Method
Axiomatic design is a theory that was created and developed by [10]. This method provides a general framework for designing a product at all levels [10].

2.3. Statistical Analysis Method
Descriptive non parametric statistical analysis was used in this study using Cronbach’s Alpha to test the reliability and Spearman’s rank correlation to test the validity of customer attribute [12]. Statistical test was also conducted by using the marginal homogeneity method. This test was used to prove the hypothesis that is conformity between developed design and consumer need [12].

3. Result and Discussion

3.1. Result of Survey
Table 1 presents survey results about the design attributes that customer require. These attributes identified is used as a basis to develop an innovative and ergonomic tool for harvesting cloves safely to support farmer’s activities efficiently and effectively.
Table 1. Customer Attribute of Safety Tool Design

| No | Customer Attribute |
|----|--------------------|
| 1  | Robust             |
| 2  | Durable            |
| 3  | Flexible           |
| 4  | Multifunction      |
| 5  | Comfortable        |

Robust attribute indicates that the tool has a resistance level to sustain the user's body mass. It means that user requires that the harness should not be easily damaged and cracked. Meanwhile, durability means that the tool should have a lightweight material component and waterproof. Then, flexible attribute means that the tool's size should be easily adjusted for ease of usage and the design of compact bag. Multifunction attribute means that the tool has some additional functions aside from its main function to provide safety for users. The last attributes, comfort indicates that user wants the safety tools and activity for clove farmers design to be more comfortable when it is used without causing any pain.

3.2. Design Parameter of the Safety Tool

Table 2, Table 3, Table 4, Table 5 and Table 6 show the design parameter of safety tools developed as a result from mapping process satisfying the customer attribute. Table 2 presents the design parameters generated through the mapping process as raw materials made of 20 mm thick rubber pads (DP 1.1.1) with 22 cm long rubber bearing with 5 cm width for the thigh area (DP 1.1.1.1), length of rubber cushion of 40 cm with width of 5 cm for hip area (DP 1.1.1.2) each area covered with Vinyl fabric (DP 1.1.2), webbing rope with 25 mm width (DP 1.1.3), buckle use on hip belt connection with 25 mm size (DP 1.2.1), the use of polyester knit yarn (DP 1.2.2) using carabiner (DP 1.2.3) with a maximum load strength of 600 kg (DP 1.2.3.1) with screw gate protection & (DP 1.2.3.1). Table 3 defines that the material used on buckle is solid plastic material (DP 2.1.1) and parachute material in harvest bag (DP 2.1.2). Those design parameters are applied in order that the tool developed can be able support user's body mass and the number of cloves that are harvested with providing a strong connection. And also it is able to be used for a long period of time in an extreme weather.

Meanwhile, Table 4 defines that the design parameter of bag length is of 65 cm (DP 3.1.1) with diameter of 25 cm (3.1.2), and solid plastic material in adjuster is measuring 25 mm (DP 3.2.1). As for Table 5, it defines the position of the bag. It is on the right side and left belt hip (DP 4.1.1). Table 6 presents the design using the largest percentile of p95 on the dimensions of the circumference of stomach with size of 78.8 cm (DP 5.1.1.1). The largest use of percentiles is in the dimensions of the width of the belt thigh with the size of 44 cm (DP 5.2.1.1). The use of the average percentile p50 is on the dimensions of high space standing upright with size of 94.4 cm (DP 5.3.1.1). The maximum load of hip area is at the limit of 16 kilogram ergonomic tolerance (DP 5.4.1.1), while the design of carrying load is of 10 kilograms with upright moving position (DP 5.4.2.2). These design parameters are to support flexibility in use in which the tool can be used by more than one user and easy to access to use of bag as well as provides ease in loosening, tightening and folding rope. In addition the tool can also provide an additional function besides the main function. And use of the user’s anthropometric data provides comfort in use by also limiting capacity of bag.
| Code | Customer Attribute | Code (FR) | Functional requirement | Code (DP) | Design Parameter |
|------|--------------------|-----------|------------------------|-----------|-----------------|
| 1    | Robust             | 1         | Able to sustain user's mass | 1         | Robust Design   |
| 1.1  |                     | 1.1       | Structured seat belt components | 1.1       | have strong components in each media harness |
| 1.1.1|                     | 1.1.1     | bearing frame on strong belt base | 1.1.1     | specification of rubber bearing with thickness of 20mm |
| 1.1.1.1|                   | 1.1.1.1   | size of use of bearings for thigh belts | 1.1.1.1   | length of rubber cushion of 22 cm with width of 5 cm |
| 1.1.1.2|                   | 1.1.1.2   | bearing usage size for hip belt | 1.1.1.2   | Length of rubber cushion of 40 cm with width of 5 cm |
| 1.1.2 |                     | 1.1.2     | strong rubber bearing cover frame | 1.1.2     | coats rubber pads with vinyl fabric specifications |
| 1.1.3 |                     | 1.1.3     | Strong harness string | 1.1.3     | woven straps with 25mm width |
| 1.2  |                     | 1.2       | provides a strong connection | 1.2       | connection to adjust to the diameter of the construction |
| 1.2.1|                     | 1.2.1     | connection on portable hip belt and thigh connection on | 1.2.1     | Buckle use of 25mm in size |
| 1.2.2|                     | 1.2.2     | harvest bag to permanent harness | 1.2.2     | floor construction belt sewn with polyester knitting yarn |
| 1.2.3|                     | 1.2.3     | specification of thigh belt to belt hip portable | 1.2.3     | specification of alluminum alloy / Carabiner |
| 1.2.3.1|                   | 1.2.3.1   | Maximum Carabiner Strength | 1.2.3.1   | specification of 600 kilogram of attraction |
| 1.2.3.2|                   | 1.2.3.2   | input straps of removable carabiners | 1.2.3.2   | Screw Gate threaded use |
| 1.2.4|                     | 1.2.4     | thigh belt connection to a portable hip belt | 1.2.4     | woven straps sewn on the thigh and use of a 25mm buckle on the hip belt |
### Table 3. Durable Design Parameter of the Safety Tool

| Code | Customer Attribute | Code (FR) | Functional requirement | Code (DP) | Design Parameter |
|------|--------------------|-----------|------------------------|-----------|------------------|
| 2    | Durable            | 2         | Extreme weather resistant design lightweight components and can be used repeatedly | 2         | components that are tough and can be used continuously |
| 2.1  |                    | 2.1       | application of plastic material components to safety harness | 2.1       | the use of waterproof material specifications |
| CA2  |                    | 2.1.1     | waterproof material is applied to the harvesting bag components of fast drying material and protected from ultra violet rays | 2.1.1     | solid plastic material on buckle component |
|      |                    | 2.1.2     |                           | 2.1.2     | parachute material |
|      |                    | 2.1.3     |                           | 2.1.3     | fiber vinyl fabric on the pelt hip and thigh cover |

### Table 4. Flexible Design Parameter of the Safety Tool

| Code | Customer Attribute | Code (FR) | Functional requirement | Code (DP) | Design Parameter |
|------|--------------------|-----------|------------------------|-----------|------------------|
| 3    | Flexible           | 3         | Design that can be used more than one user Flexible access to use of harvesting bags specification of flexible harvesting pouch | 3         | Movable component design |
| 3.1  |                    | 3.1       |                         | 3.1       | Adjustment Design sizes and harvesting bags can be rolled |
| 3.1.1|                    | 3.1.1     | flexible harvesting pouch Specification of the width of a flexible harvesting bag provides ease in loosening, tightening and folding rope | 3.1.1     | length of 65 cm of harvested bag |
| CA3  |                    | 3.1.2     | The width of the harvested pouch is 25 cm | 3.1.2     | The width of the harvested pouch is 25 cm |
| 3.2  |                    | 3.2       | use of adjuster attached to the side of the webbing strap | 3.2       | use of adjuster attached to the side of the webbing strap |
| 3.2.1| Material of Adjuster | 3.2.1     | solid plastic material size of 25mm | 3.2.1     | solid plastic material size of 25mm |
### Table 5. Multifunctional Design Parameter of the Safety Tool

| Code | Customer Attribute | Code (FR) | Functional requirement | Code (DP) | Design Parameter |
|------|--------------------|-----------|------------------------|-----------|------------------|
| 4    | Multifunctional    | CA4       | Provides additional functionality besides the main function | 4         | additional functions for usability |
| 4.1  |                    |           | provides a suitable layout of the standard | 4.1       | where the placement of the pockets is stable |
| 4.1.1|                    |           | position where the bag is based on the belt harness | 4.1.1     | Pouch is on the right and left side of Belt hip |
| 4.2  |                    |           | bags have a compact design | 4.2       | The entire component can fit into one bag |

### Table 6. Comfortable Design Parameter of the Safety Tool

| Code | Customer Attribute | Code (FR) | Functional requirement | Code (DP) | Design Parameter |
|------|--------------------|-----------|------------------------|-----------|------------------|
| 5    | Comfortable        | CA5       | Provide a comfortable harness design when used | 5         | Harness design based on user anthropometry data |
| 5.1  |                    |           | Designs on the width of the hip belt | 5.1       | dimensions of the body standing upright |
| 5.1.1|                    |           | dimension of abdominal normal breathing | 5.1.1     | dimension of the largest percentile |
| 5.1.1.1| p95 men       |           | 78.8 cm |
| 5.2  |                    |           | Design on the width of the thigh belt | 5.2       | dimensional thigh stands upright |
| 5.2.1|                    |           | dimension of thigh thickness | 5.2.1     | largest percentile dimension |
| 5.2.1.1| p95 men       |           | 44 cm |
| 5.3  |                    |           | The design of the harvesting bag does not touch the ground high space dimension stands tall | 5.3       | dimensions of the hips standing upright |
| 5.3.1|                    |           | dimension of the average percentile | 5.3.1     | |
| 5.3.1.1| p50 men       |           | 94.4 cm |
| 5.4  |                    |           | The design of the sac remains comfortable when it is loaded with a heavy load weight where the load lies on the vertical line of gravity of the body | 5.4       | maximum haul load according to ergonomic tolerance |
| 5.4.1|                    |           | the maximum haul load on the hip area | 5.4.1     | |
| 5.4.1.1| maximum load weight of user hip area | 16 kilogram with administrative procedure |
| 5.4.1.2| Design of proposed maximum load weight | 10 kilogram with upright position moving and does not require administrative procedures |
3.3. Conceptual Design of the Safety Tool Developed

![Conceptual Design Safety Tool]

Figure 2. Conceptual Design Safety Tool

3.4. Result of Statistical Analysis

Table 7 presents the result of marginal homogeneity test. This test is to verify or to validate the developed safety tool to user.

| User's Requirements | Z values |
|---------------------|----------|
| Robust              | 0.683    |
| Durable             | 0.670    |
| Flexible            | 0.371    |
| Multifunctional     | 0.491    |
| Comfort             | 0.491    |

The result in Table 7 shows that attributes of the proposed safety tool design is valid to conform the user requirement at 5% or 0.05 of significant level. It means that the design developed is robust, more durable, flexible in use, having more than one function as well as comfortable in use.
4. Conclusion
It is possible to draw the following conclusions:
1. Attributes the user wants for safety assistance and farmer activity are tough, durable, flexible, multifunctional and comfortable.
2. Design parameters for robust attribute is a rubber material with 20 mm of belt thickness, 22 cm of rubber bearing length and 5 cm in width for thigh area, 40 cm of rubber bearing length and 4 cm width for hip area with each rubber pad area covered with vinyl fabric. It uses polyester stitching, 25 cm webbing straps for seat belts, 25 mm buckles for connecting or removing ropes to become more portable, and a carabiner with a maximum load of 600 kg for durable attributes such as solid. It also uses plastic material on the buckle, parachute material in an additional sac. For flexible rollable bag attributes, bag sizes is 65 cm in diameter and 25 cm, with 25 mm adjusters. For multifunctional attributes, the position of the sac is placed on the right and left side of the hip belt, so that the entire component can fit into a single pocket, and its attributes are comfortable with the use of the largest percentile in the dimensions of the stomach circumference of 78.8 cm.
3. Based on the validation test, the design meets the customer criteria and applies with a significant level of 5%.

References
[1] Kurniawan, Andry (2014). Working at Height.. [Online]. Available: http://andryzafer.blogspot.com/2014/02/bekerja-di-atas-ketinggian-working-at.html
[2] D. A. Norman, The design of everyday things. New York: COinS, 2002.
[3] K. Vredenburg, S. Isensee, C. Righi, User-Centered Design; An Integrated Approach. NJ: Prentice-Hall, 2002.
[4] M.N. Sudin, “User-Centered Design Approach In Designing Motorcycle Tire Dismounting Tool for One-Handed User,” IJET, vol. 5, pp. 3588-3595, 2013.
[5] E.C. Lu, R. Wang, R.Huq, D. Gardner, P. Karam, K. Zabjek, D. Hebert, J. Boger, A. Mihailidis, “Development Of A Robotic Device For Upper Limb Stroke Rehabilitation: A User-Centered Design Approach,” JBR, vol. 2, pp. 176-184, 2011.
[6] F.-G. Wu, M.-Y. Ma, R.-H. Chang, “A new user-centered design approach: A hair washing assistive device design,” Applied Ergonomics 40 , pp. 878–886, 2009.
[7] M. R. Petry, B.M. Faria, L.P. Reis, “Intellwheels: Intelligent Wheelchair With User-Centered Design,” JRRD, pp. 1061-1076, 2011.
[8] H. Soewardi, O. Achkadi, “Multifunctional Design Of Coconut Fiber Tablet Case By Using User Centered Design Approach,” BissTech, 2014.
[9] H. Soewardi, B.T. Ajie, A. Djalal, “Innovative Design Of Wheelchair By Using User Centered Design Approach,” ISSN: 1978-774X, 2015
[10] S. N. Pyo, “Ergonomics, Axiomatic Design and Complexity Theory,” Theoretical Issues in Ergonomics Science, 8(2): 101-121, 2007.
[11] Z. Zhang, “Research On Product Design Based On The Axiomatic Design,” In IEEE 10th International Conference Of Computer Aided Industrial Design & Conceptual Design, pp. 408-411, 2009.
[12] D.J. Sheskin, Handbook of Parametric and Non Parametric Statistical Procedures Third Edition. Washington: Chapman & Hall/CRC, 2004.

Author Biographies

Hartomo Soewardi is a senior lecturer of Industrial Engineering Department, Faculty of Industrial Technology, Islamic University of Indonesia, Yogyakarta. Currently he is Ph.D in Engineering Design
and Manufacture. His teaching and research interest are industrial ergonomic design, product design, management and quality design. His email address is hartomo@uii.ac.id

**Rachmad Sujono** is a final student of Industrial Engineering Department, Faculty of Industrial Technology, Islamic University of Indonesia, Yogyakarta. His email address is mamad2101@gmail.com