

ERGONOMIC DESIGN OF THE CORN SHELLER MACHINE FOR IMPROVING PRODUCTIVITY USING AXIOMATIC DESIGN

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Abstract

The common problems in post harvesting the corn is to split it safely, comfortably and effectively. This is indicated that 90% of workers experience discomfort at hands, back and legs when splitting a corn. And also they complained difficulties in using the existing Sheller machine such that a target cannot be achieved on time. It results in decreasing of productivity. Thus it is important to improve a tool. The purpose of this study is to design the corn Sheller machine to improve comfort ability and productivity of workers. Survey was conducted to identify user attributes by distributing questionnaires. Anthropometric data is used to design. And design parameter will be developed by using axiomatic design method with mapping process from user attributes and functional requirement. Statistical analysis was conducted to validate the proposed design. Result of this study is an ergonomic design of the corn Sheller machine that satisfying user criteria namely adjustable, durable, multifunction, comfortable, and interesting design. This purposed design is also valid to improve 60% of work productivity and reduce of complaint/discomfort.

Keywords: Ergonomic; Corn Sheller Machine; Axiomatic design; Anthropometry; Multifunction

1.0 INTRODUCTION

Corn sheller machine has become a substantial tool for splitting seeds of corn. It because of the tool can contribute a farmer to carry out the job fastly. However the existing tool still indicate ineffectiveness and discomfort in use. Ineffective can be seen from the length of time of process and a machine still produces the remaining corn grain. Discomfort can be seen from the various complaint work environment is an important component in affecting productivity. Good conditions will of workers. According to

preliminary study, it is demonstrated than 78% workers stated less innovative. It is demonstrated that machine is still traditional use such that causing 72% workers experience less comfortable and the remaining material is fragile. This discomfort is indicated some workers getting multiple injuries on hand, back, legs and neck. They occurred because using poor posture and longer operation with unsteady motion. Not speak of the operation manufacture's fragile product. It is critical to improve

such machine in order to more effective and comfortable. The discomfort posture may cause WDMS. Work-related musculoskeletal disorders (WMSD) are disorders of musculoskeletal that encompasses cumulative trauma disorders or repetitive strain injuries on tissues [1].

This ergonomis problem may cause injuries in different part of the body such as intersection syndrome, DeQuervain's Tenosynovitis, Carpal Tunnel syndrome, etc Axiomatic design is used as a method to develop the product. This Method is very useful for mapping the customer attributes and functional requirements to design parameter [2].

2.0 METHOD

Survey

The paper based survey was conducted to identify musculoskeletal disorders and some attribute of corn sheller machine that user requires by distributing questionnaires to 15 farmers (12 male and 3 female). Their ages is in range 36 to 50 years.

Apparatus

Questionnaire was developed. It consists of two parts. The first part contains questions to identify disorders on farmers and the second is to attribute of machine. Anthropometry was used to measure human dimension.

Solid Work

Solid Works is an application software to design a virtual model of the purposed design [3]. This application should be installed in the latest version of computer with windows operating system.

Axiomatic Design

Axiomatic design is a method to design product, process and system by mapping process from customer requirement to design parameter that have certain function [4]. The sequence of mapping is from the customer domain to the functional domain, then to the physical, and finally to the process domain. The basic postulate of the axiomatic approach to design is that there are fundamental axioms that govern the design process. The first axiom is called the independence axiom. It states that the independence of FRs must always be maintained, where FRs are defined as the minimum set of independent requirements that characterize the design goals. The second axiom is called the information axiom, and it states that among those designs that satisfy the independence axiom, the

design that has the smallest information content is the best design [5]. Figure 1 presents a diagram of mapping process.

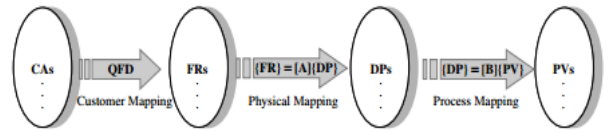


Fig. 1. Design Mapping Process [6]

Statistical Analysis Method

This study implements non parametric statistical analysis. Cronbach's Alpha was used to test reability of customer voice. An spearman's correlation to test of homogeneity. Wilcoxon Signed-rank test was used to test the validity of customer attribute [7].

3.0 RESULTS

Result of Survey

Table 1 show the result of survy about attribute of corn sheller macine that customer requires

Table 1. Customer Attribute

Customer No	Attribute
1	Adjustable
2	Durability
3	Multifunction
4	Comfortable
5	Attractive design

adjustable attribute is one of user's need to easier in making height ajustmant of machine. Durable is an attribute of machine that user requires for longer duration in use. While multifunction attribut explains that the sheller machine have more than one function. And comfortable attribute was required by user to ensure no negative effect happen on hand. Attractive design of sheller machine constitutes an attribute to make a good impression for customer.

The Proposed Design of Corn Sheller Machine

Table 2, Table 3, Table 4, Table 5 and Table 6 shows the result of mapping process from customer attribute to design parameter. Table 2 shows the

result of design parameter for adjustable height of machine (DP1.1.1.1; DP1.1.1.2; DP1.1.1.3) that satisfying FR1: ease to operate and CA1: adjustable. It means the machine design is easier to operate so that it can improve the comfort and productivity. While Table 3 explains the design parameters of sheller machine to satisfy the durable criteria (CA2). It means that the raw material is from irons (DP2.2.1; DP2.2.2; DP2.2.3) so that the machine can be run for longer duration. Table 4 explains the design parameter (DP3.1; DP3.2) to satisfy the multifunction criteria (CA3). The machine have more than one function. They are to cut hump corn (FR3.1) and to split corn (FR3.2).

Table 5 explains the design parameter (FR4.1) of sheller machine to satisfy the comfortable criteria (CA4). Corn sheller machine with the proposed engine design can reduce the complaints of farmers on hands (DP4.1). And Table 6 explains the design parameter of sheller machine to satisfy the Attractive design (CA5). Attractive design of the machine sheller is a variation of colors for the bodywork, handle and leg machines (DP5). Where color is selected (DP5.1.2; DP5.1.4; DP5.1.6) for the bodywork been navy blue color, for handling machines have green and to the leg of the machine been black.

Code	Customer Attributes	Code	FRs	Code	DPs
		FR1	Providing easeness to operate	DP1	Adjustable work palce Design
		FR1.1	Providing conformation function	DP1.1	Adjustable heighth of machine
		FR1.1.1	Providing low size until high	DP1.1.1	3levels of height conformation
CA1	Adjustable	FR1.1.1.1	Providing the size of brace dimension on drinking machine for 5% percentile	D.P1.1.1.1	The machine height with P5% is 94.3 cm
		FR1.1.1.2	Providing the size of brace dimension on drinking machine for 50% percentile	DP1.1.1.2	The machine height with P50% is 106.6 cm
		FR1.1.1.3	Providing the size of brace dimension on drinking machine for 95% percentile	DP1.1.1.3	The machine height with P95% is 118.8 cm

Table 2. Result of Mapping Process for Adjustable

Code	Customer Attributes	Code	FRs	Code	DPs
		FR2	Provides a durable machine	DP2	Maximize time usage
		FR2.1	Material component materials capable of withstanding the load	DP2.1	Material that is not easy porous materials
		FR2.2	Material Specification	DP2.2	Material engine and handling
CA2	Durability	FR2.2.1	Material specification machine	D.P2.2.1	Material from iron machine
		FR2.2.2	Material specification machine foot	DP2.2.2	Material from the machine foot iron
		FR2.2.3	Specification material handling	DP2.2.3	Material handling of iron

Table 3. Result of Mapping Process for Durability

Code	Customer Attributes	Code	FRs	Code	DPs
CA3	Multifunction	FR3	Provides more than one function other than as a corn sheller machine	DP3	Multiple use design
		FR3.1	To cut hump corn	DP3.1	Design cutting tools
		FR3.2	To splitt corns	DP3.2	Design splitting tools

Table 4. Result of Mapping Process for Multifunction

Code	Customer Attributes	Code	FRs	Code	DPs
CA4	Comfortable	FR4	Minimize complaints of farmers	DP4	The ergonomic machine design sheller
		FR4.1	Giving dimensional machine handle that minimizes user complaints to accommodate 95%	DP4.1	Dimension machine handle with P50 percentile anthropometry size is 22.6 cm
		FR4.1.1	Specifications Material Handle comfortable	DP4.1.1	Handle material of iron
		FR4.1.2	Provide machine size (a capacity of) the appropriate standard	D.P4.1.2	The length, width and height
		FR4.1.3	Provides a measure of length machine (place capacity) according to the standard	DP4.1.3	The length of the machine (a place to accommodate) 80 cm
		FR4.1.4	Giving width machine (place capacity) according to the standard	DP4.1.4	The width of the machine (a place to accommodate) 40 cm
		FR4.1.5	Giving width machine (place capacity) according to the standard	DP4.1.5	High-machine (place accommodating) 40 cm
		FR4.2	Providing dimensions sheller machine foot according to the characteristics of farmers	DP4.2	Sheller machine foot design with a high measure of elbow stand
		FR4.2.1	Providing dimensions sheller machine foot minimum to 5% percentile	DP4.2.1	High size machines P5 is 94.3 cm
		FR4.2.2	Providing dimensions sheller machine foot minimum to percentile 50%	DP4.2.2	High size P50 engine is a106,6 cm
FR4.2.3	Providing dimensions sheller machine foot minimum to percentile 50%	DP4.2.3	Size P95 engine height is 118.8 cm		

Table 5. Result of Mapping Process for Comfortable

Code	Customer Attributes	Code	FRs	Code	DPs
CA5	Color Attractive Design	FR5	Increase the interest of farmers to use	DP5	Variations in color design
		FR5.1	Providing a nice color variation	DP5.1	RGB and luminescent appropriate
		FR5.1.1	Choosing the proper RGB on the bodywork	DP5.1.1	Navy Blue(0, 0, 160)
		FR5.1.2	Set the corresponding luminescent element	DP5.1.2	Navy blue (75)
		FR5.1.3	Choosing the proper RGB on handling	DP5.1.3	Green (0, 225, 64)
		FR5.1.4	Set the corresponding luminescent element	DP5.1.4	Green (120)
		FR5.1.5	RGB Selecting the right foot machine	DP5.1.5	Black (0, 0, 0)
FR5.1.6	Selecting the right foot machine	DP5.1.6	Black (0)		
		FR5.1.6	Set the corresponding luminescent element	DP5.1.6	Black (0)

Table 6. Mapping Process for Color Attractive Design

Result of Validation

The validation of corn sheller machine design used Stuart Maxwell test of marginal homogeneity. The table below presented the result of the test at 5% significance level :

Table 7. Test of Homogeneity Result

attribute	Asymp. Sig. (2-tailed)
adjustable	.130
durability	.283
multifunction	.684
comfortable	.397
attractive_design	.670

Hypothesis

H0: There is no significant difference between the needs of users and corn sheller machine design proposals.

H1: There are significant differences between user needs and design proposals corn sheller machine. Table 7 is the result of marginal homogeneity test with significance between 0.130 to 0.670. This means that the null hypothesis can be accepted for $z > 0.05$. Thus, the design of the machine corn sheller in accordance with the needs of users (farmers).

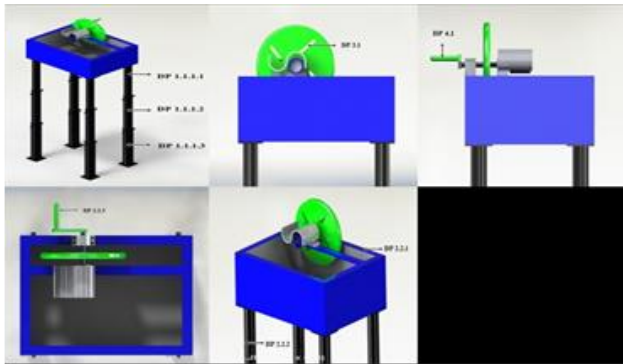


Fig 2. The Virtual Prototype of the Proposed Design

4.0 DISCUSSION

Analysis of the Proposed Design Parameter

In this study, attributes corn growers are adjustable sheller machine design, durability, multifunctional, comfortable and Attractive Design. Fig.2 presents a virtual prototype machine of foot high corn sheller

machine (DP 1.1.1.1) is 94.3 cm for p 5 (DP 1.1.1.2) to P50 is 106.6 cm, (DP 1.1.1.3) to P95 is 118.8 cm, adjustments can be adjusted by sliding hinge. The slope of the board can also adjust the slope of 3 level. Design of Prototype adjustments can provide ease of change. So that it can meet Adjustabel attributes.

Bodywork, handling and legs machine leg material made of iron (DP2.2.1; DP2.2.2; DP2.2.3), so as to maximize machine usage time. So that it can meet Durable attributes.

Sheller machine has more than one function. Multifunction of the machine is cutting corn hump (FR3.1) and other function to split corn (FR3.2). So that it can meet multifunction attributes.

Handling machine designed is to provide hand move easily when using corn sheller. As for handle dimension is 22,6 cm (DP4.1).So that it can meet comfortable attribute.

The color is navy blue bodywork (DP 5.1,2), green color (DP5.1.2) for handling the machine. And black colors selected for the feet, for an interesting picture of a corn sheller machine so that it can meet Attractive design attributes.

Analysis of Hypothesis Test

At 5% of levers that are significant for the results of the homogeneity test the null hypothesis is accepted. This means that there is no difference between the proposed design parameters for developing a corn sheller machine and multifunction needs of farmers, including adjustable, durability, multifunctional, comfortable and attractive. Thus this design can be used by farmers to complete a turnaround using corn sheller machine

5.0 CONCLUSION

It is concluded that the proposed design of corn sheller machine is valid to meet customer requirements that is adjustable, durable, multifunctional, comfortable and attractive design at 5% of signifinat level. Where the design parameters are as follow:

- a. Adjustable height of machine is in between 94,3cm to 118,8 cm.
- b. Diameter of handle is 22,6 cm.
- c. Raw material is from iron.

- d. Machine have more then one function that is to cut hump corn and to split corn.
- e. Colour of machine is Black, Blue and Green

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