An ergonomics prototype of adjustable chin stands aid for visual mechanical inspection at electronic manufacturing-based company in Kuantan, Malaysia

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Abstract. Chin stands aid is a device designed to reduce fatigue on the chin during the Visual Mechanical Inspection (VMI) task for operators in TT Electronic Sdn Bhd, Kuantan, Malaysia. It is also used to reduce cycle time and also improve employee well-being in terms of comfort. In this project, a 3D model of chin stands aid with an ergonomics approach is created using SOLIDWORKS software. Two different concepts were designed and the best one is chosen based on the Pugh concept selection method, concept screening and also concept scoring. After the selection of concepts is done, a prototype of chin stands aid will be developed and a simulation of the prototype is performed. The simulation has been executed by using Workbench ANSYS software as a tool. Stress analysis, deformation analysis, and fatigue analysis have been done to know the strength and lifespan of the product. The prototype also has been tested to know the functionality and also comfortability for the user to use the chin stands aid.

1. Introduction

Ergonomics is an interdisciplinary field of study that seeks to design tools and equipment for optimizing the interface between humans and systems [1]. Ergonomics is also known as the process of understanding and improving human communications with types of products, equipment, environments, and systems. Ergonomics principles are used to improve the "fit" between the worker and the workplace. Targets for ergonomics improvement are divided into two broad categories which are physical issues, such as reaches and exertion, and cognitive issues, such as mental overload and confusing displays [2].

Many theories, principles, methods, and data relevant to the workstation design have been generated through ergonomics research over the years. Poor workstation design can lead to fatigued, frustrated, and hurting workers [3]. As a result, the productivity of the product and quality will decrease [4].

Often in an industry, the workstation is designed in an arbitrary manner [1], giving little consideration to the anthropometric measurements of the anticipated user. Small changes in workstation dimension can have a considerable impact on worker productivity, and occupational health and safety. Inadequate posture from an improperly designed workstation causes static muscle efforts and then eventually resulting in acute localized muscle fatigue, and consequently in decreased

performance and productivity, and in an enhanced possibility of operator-related health hazards [5]. Therefore, workstation design plays an important role to improve productivity and safety.

In the process that mostly required the ergonomics workstation design are cropping process, laser marking process and also Visual Mechanical Inspection (VMI). VMI refers to the simple examination of a component for detects using the human eyes and is aided by artificial tools. VMI is usually used because it is simple, easy to apply and quickly carried out, but good eyesight, concentration and also illumination. However, TT Electronic Sdn Bhd, which located in Kuantan, Malaysia has some problem with VMI. At VMI, the major problem that occurred is an inappropriate workspace that can increase fatigue to the workers, especially on the chin part.

So, for this project, a prototype of adjustable chin stands aid will be proposed to reduce fatigue on the chin during VMI task for operators in TT Electronic Sdn Bhd, Kuantan, Malaysia. At the same time, employees can be more productive to reduce cycle time and also improve employee well-being in terms of comfort. As a result, human well-being can be improved, increased efficiency, produced a defect-free product and also improved profits for the company.

2. Method
The drawing is divided into three steps. The first step is sketching. All the ideas for the chin stand aid sketch on the paper to generated design for idea selection after the design is being chosen. Then, the sketch will be evaluated to set the new concept of the product. The last step is to draw the selected sketch by using SOLIDWORKS software.

2.1. Design
Generally, the chin stands aid can be divided into two main mechanisms which are supported mechanism and also lifting mechanism. For the first design, scissor lift is chosen as the lifting mechanism and rubber chin support for the support mechanism. For the second design, screw lift is chosen as the lifting mechanism and silicone pad for the support mechanism. Figure 1(a) and Figure 1(b) shows the sketching design and the mechanism of the concepts.
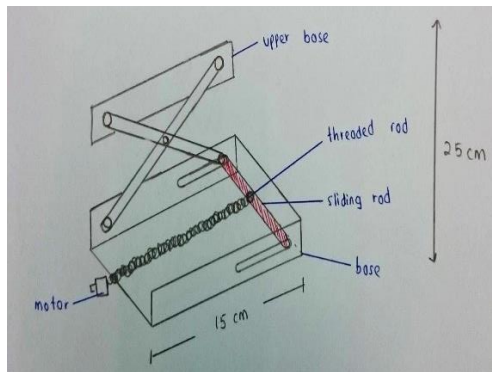

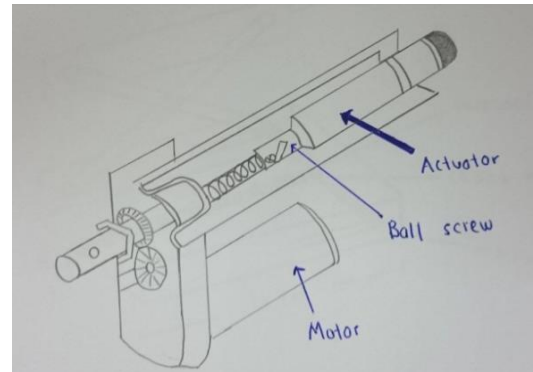**Figure 1(a).** Concept A. Scissor lifts as a lifting mechanism.

Figure 1(b). Concept B. Linear actuator as a lifting mechanism.

2.2. Concept generation and evaluation
From the two concepts, the best one should be decided as it will be the design of this project. Three sets of evaluation will be used to compare the design. The one design with the best specification will be built. The three sets of evaluation include a Pugh concept selection method [6], concept screening and concept scoring [7].

From the Table 1, the advantages and disadvantages of the design can be outlined. The criteria or the characteristics of the product to be fabricated are the important things to be considered before

fabrication process. According to the table, a study of the concept selection shows the concept B scores highest positive signs. So the concept B is the best selection to fabricate.

Table 1. Pugh Concept Selection Method.

	Concept	
Selection criteria	A	B
Safety	-	+
Load capacity	-	+
Adjustable height	+	+
Durability	-	+
Stability	-	+
Manufacturing cost	+	-
Ease of handling	+	+
Ease to manufacture	+	+
Lightweight	+	-
High strength	-	+
$\sum +$	5	8
$\sum -$	5	2
Net score	0	6
Ranking	2	1

Notes: '+' is for better, '-' is for worse

Table 2 shows the result concept screening. The result is evaluated from the two concept design. All the character that has for the concept is inserted in the table to see the concepts that have the characteristic needed for the chin stands aid.

Table 2. Concept Screening.

Concept	Height adjustable	Longevity	Automatic	Cost	Size
A	√		√	√	
B	√	√	√		√

Table 3 shows the result of the concept scoring. The marks are given based on the concept idea. The products that have the best characteristics are given 9 marks, the second best is given 6 and the worse is given 3 marks. The concept products that have the highest mark will proceed to produce and it will add to the character of other product that will improve the quality of the product.

Table 3. Concept Scoring.

Concept	Flexible Use	Ergonomics	Total weight	Appearance	Safety	Total marks	Rankings
A	6	6	9	6	3	30	2
B	6	9	6	6	9	36	1

Notes: '3' is for worse, '6' is for medium, '9' is for good

From the comparison between concepts, Concept B is chosen as the finalize design. It is because the load capacity is more than Concept A. Although the stroke length of Concept A is more than Concept B, screw lift easier to have a stable linear path when moving compared to the scissor lift. Besides that, screw lift has been using the available product while scissor lift has not been used.

2.3. Finalize product
Figure 2(a) shows the image of the chin stands aid that is generated from the SOLIDWORKS. It shows the complete parts of the design that assembled in the SOLIDWORKS software. The prototype consists of lifting and support mechanism. Screws are used to connect the support and lifting mechanism. The material and the size chosen are referred to the average anthropometric from workers at VMI station and the characteristics of the material itself.
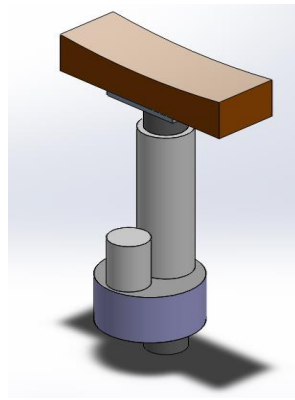

Figure 2(a). Isometric view of chin stands aid using SOLIDWORKS software.

Figure 2(b). A prototype of chin stands aid.

After completing the fabrication process, the prototype as shown in Figure 2(b) must be going through the analysis process. At this stage, all data about the product is gathered. It is important to classify the product before it enters a market.

3. Performance analysis of proposed prototype
After completing the fabrication process, the prototype must be going through the analysis process. At this stage, all data about the product is gathered. It is important to classify the product before it enters the market.

3.1. Experimentation and testing of prototype
The chin stands aid is safe for the user. Figure 3 shows the chin stands aid that been tested by one of the operators at TT Electronic Sdn Bhd. Figure 3 (a) is the front view of the chin stands aid. It shows how the operator used the prototype during working while Figure 3 (b) shows the side view of the chin stands aid.
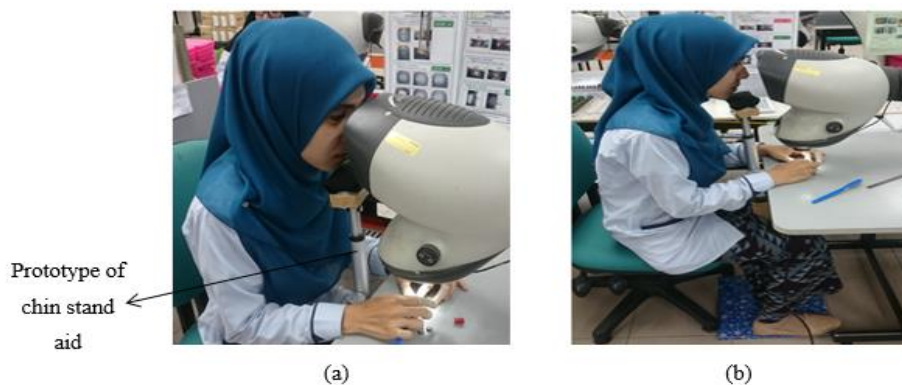

Figure 3. Testing the prototype.

The chin stands aid also have been used by the operators in VMI station to test the comfortability of the product and also measure the parameters such as time taken to adjust the product, strength and also the functionality of the chin stands aid. Table 4 shows the result of the experiment.

Table 4. Result from testing of prototype.

	Age	Height (cm)	Mass of chin (kg)	Time is taken to adjust the chin stands aid (second)	Comfortability
Operator 1	30	160	4.9	6.92	YES
Operator 2	26	156	2.3	5.10	YES
Operator 3	49	164	4.5	7.21	YES
Operator 4	35	157	3.9	6.94	YES
Operator 5	47	155	5.1	7.05	YES

From the result, it is proved that the chin stands aid is user-friendly because of it suitable to use for every age ranges. The height of the chin stands aid is adjustable. Therefore, it can fix with user height so that the users feel more comfortable when using the product. The maximum load (mass of chin) that has been tested is 5.1kg. So, for the analysis, this value will be used to know the lifespan of the chin stands aid. Besides that, the average time taken to adjust the prototype is only less than 8 seconds. So the operators will not waste time to wait for the chin support to be lifted. The maximum time taken is only 7.21seconds. For the comfortability, all the operator agreed that the product is comfortable to use and can reduce fatigue, especially on the chin during VMI process.

3.2. Simulation analysis
Import the drawing of chin stand aid into the ANSYS software to make failure and structural analysis. Stress life type of failure analysis is used for this analysis. Stress life is based on S-N curves (Stress – Cycle curves). Stress life is concerned with total life and does not distinguish between initiation and propagation [8]. In terms of cycles, stress life typically deals with a relatively high number of cycles. A high number of cycles refer to more than 105 (100,000) cycles [9]. Stress life traditionally deals with relatively high numbers of cycles [10] and therefore addresses High Cycle Fatigue (HCF), greater than 105 cycles inclusive of infinite life. For the loading type, constant amplitude (zero-based), proportional loading is used because this loading is of constant amplitude because only one set of FE stress results along with a loading ratio is required to calculate the alternating and mean values. And for the mean stress correction (stress life), Goodman theory is used [11].

In the fatigue analysis, a lifespan of the chin stand aid can be known. When subjected to millions of small repeated loads, a structure may have a slow growth of surface cracks that can cause material strength degradation and sudden failure [12]. Therefore, it is important to know the lifespan of the chin stand aid in maintaining the safety. The result of the fatigue life analysis can be seen in Figure 4. The minimum life for the chin stand aid is 100 months.

Figure 4. Detail of fatigue life from ANSYS software.

4. Conclusion

In this work, the prototype which has been proposed meets the objective of the project. This is because after done some analysis like stress analysis and so on, it is proved that the prototype has high strength and also can support certain weight capacity. So this prototype can help operators in VMI station to reduce the fatigue on the chin, especially when working. Other than that, the concept of the product can help them effectively in order to fulfill their need to have chin stands aid that can help to do VMI on product smoothly. In the nutshell, using Concept B for the chin stands aid is better and safe than Concept A.

Acknowledgements

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