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INVESTIGATION OF ERGONOMICS DESIGN FOR THE VEHICLE DOOR HANDLE FOR PROTON (BLM) AND PERODUA (VIVA)

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ABSTRACT

Automotive ergonomics is the study of how automotive can be designed better for human use. The human factor aspect of designing automobile is first considered in designing good door handle. This study is to correlate car door handle dimensions to comfort factors by means of measuring and surveys as well as using ergonomics software. This document has been prepared to provide the reader with information about ergonomics in designing a car door handle and its location base from the anthropometry of human body. Ergonomic provide an ultimate comfort in workplace to eliminate or at least to reduce musculoskeletal disorders.

Biomechanical study of car occupant posture is one of the most referenced aspects for the ergonomic design process of the whole vehicle. The aim of this work is to study customer satisfaction as the car passenger or the driver, to compare car door handle dimensions to comfort factors by means of measuring and survey as well as using ergonomic software and to recommend the best dimension of occupant seat in aspect of anthropometric data percentile.

The human factor aspect of designing automobiles is considered for the car door handle dimension and location. It is a method to provide comfort and effective working space for the driver and the occupant. Other purposes are to provide alternative solutions and proposals, to ensure the legal requirements are met and to ensure all domestic requirements are met. This study is to correlate car door handle dimensions to comfort factors by means of measuring and survey as well as using ergonomic software. Two cars are compared to achieve this objective, which is the Proton (BLM) and Perodua (Viva). From the result, it can be seen that dimension factors of interior affects the car ergonomic factors.

KEYWORDS: Ergonomics, Ergonomic Software, Door Handle, Anthropometry, Anthropometric Percentile.

INTRODUCTION

Ergonomics is the application of scientific principles, methods, and data drawn from a variety of disciplines to the development of the engineering systems in which people play a significant role. Among the basic disciplines are psychology, cognitive science, physiology, biomechanics, applied physical anthropometry, and industrial systems engineering. The engineering systems to be developed range from the use of a simple tool by a consumer to a multiperson, sociotechnical systems.

There is a hierarchy of goals in ergonomics. The fundamental task is to generate “tolerable” working conditions that do not pose known dangers to human life or health. When this basic requirement is assured, the next goal is to generate “acceptable” conditions upon which the people involved can voluntarily agree, according to current scientific knowledge and under given sociological, technological, and organizational circumstances. The final goal is to generate “optimal” conditions which are so well adapted to human characteristics, capabilities, and desires, that physical, mental, and social well-being is achieved. The multitude of different consumer goods which we encounter in our daily lives, safe and comprehensible operation is also included under “ergonomics”.

LITERATURE REVIEW

Ergonomics

Ergonomics **(**or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a systems, and the professional that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance [1].

Anthropometric

Anthropometry is the science that measures the range of body sizes in a population. When designing products it is important to remember that people come in many sizes and shapes. Anthropometric data varies considerably between regional populations [2]. The Figure 1 below shows common body measurement that use in industrial design.

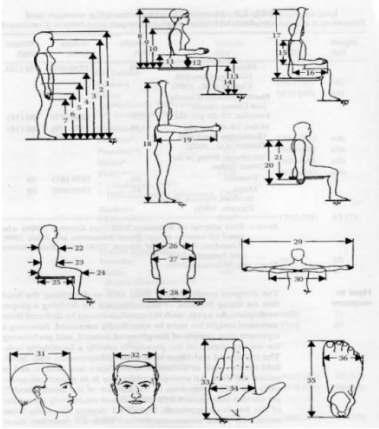

Figure 1: Illustration of measured body dimension (Adapted from Kroemer, K.H.E.,Kroemer, H.J., and Kroemer-Elbert, K.E (1997). Engineering Physiology. Bases of Human Factor/ Ergonomics. New York: Willey

METHODOLOGY

In order to meet the objective, two passenger cars are selected to be measured in order to investigate for the dimension parameters that contributed to automotive ergonomics consideration. Car selected are Proton BLM (1.6) and Perodua VIVA (660). Cars users input will be taken into account from questionnaires that are intended to seek user's preference in term of ergonomics. Through dimension measurement and CAD data will be analyzed. Virtual comfort measurement will be made to use for comfort and clearance study to 95 % men and 5 % women population [3]. The end result will discussing on the findings from surveys, measurement, and analysis. The process flow of the research can be refer to the figure 2 below.

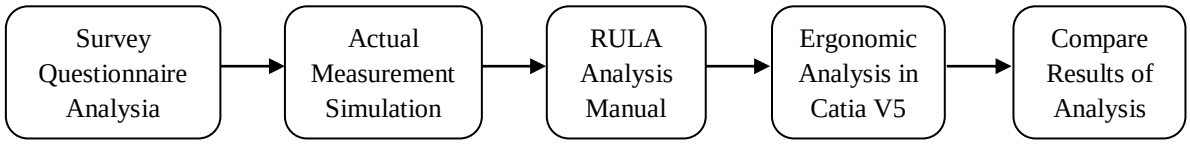

Figure 2: Process flow of the project

Surveys Questionnaires

From the surveys result, the answer are divided into 5 categories from scale 1 to 5 which consist very comfort, comfort, moderate, discomfort, and very discomfort. The surveys was evaluated by 100 respondents. The surveys was meant to get the general idea of satisfaction for each car door handle. Only general question could be asked to make it easier for them to answer all question. Mean of respondent's rating that has been calculated using SPSS Statistics Software are in the Table 1.

SPSS Statistics Software

SPSS is a Windows based program that can be used to perform data entry and analysis and to create tables and graphs. SPSS is capable of handling large amounts of data and can perform all of the analysis covered in the text and much more. The Table 1 below shows the mean and Cronbach's Alpha for both interior and exterior using SPSS statistics software. The value of Cronbach's Alpha can be refer to the Table 2 below.

Table 1: Mean and cronbach's alpha of respondent rating using SPSS Statistics Software.

	Proton (blm)		Perodua (viva)	
	Mean	Cronbach's alpha	Mean	Cronbach's alpha
EXTERIOR				
Handle height from ground	3.74		3.74	
Handle width	3.82		3.82	
Handle heigh	3.64	0.847	3.64	0.859
handle location at doort	3.52		3.52	
INTERIOR				
Handle height from bottom frame	3.80		3.80	
Handle width	3.78	0.776	3.78	0.782
Handle height	3.82		3.82	
Handle location at door	3.86		3.86	

Table 2: Cronbach's Alpha value rating (Cronbach LJ (1951). "Coefficient alpha and the internal structure of tests". Psychometrika)

Cronbach's alpha	Internal consistency
$\alpha \geq 0.9$	Excellent (High-Stakes testing)
$0.7 \leq \alpha < 0.9$	Good (Low-Stakes testing)
$0.6 \leq \alpha < 0.7$	Acceptable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

In statistics, Cronbach's (alpha) is a coefficient of internal consistency. It is commonly used as an estimate of the reliability of apsychometric test for a sample of examinees. The Table 1 above shows that the result of cronbach's alpha based on the surveys questionnaire that have been made for respondent rating. As the result, it shows that the Cronbach's Alpha for both exterior handle door is 0.847 while for interior handle door is 0.776. For that reason, the results for both condition are good and it represent the surveys questionnaires shall be accepted.

Rula Analysis

RULA (rapid upper limb assessment) is a survey method developed for use in ergonomics investigations of workplaces where work-related upper limb disorders are reported. This tool requires no special equipment in providing a quick assessment of the postures of the neck, trunk and upper limbs along with muscle function and the external loads experienced by the body. A coding system is used to generate an action list which indicates the level of intervention required to reduce the risks of injury due to physical loading on the operator. It is of particular assistance in fulfilling the assessment requirements of both the European Community Directive (90/270/EEC) on the

minimum safety and health requirements for work with display screen equipment and the UK Guidelines on the prevention of work-related upper limb disorders[4] [5].

RULA was developed to investigate the exposure of individual workers to risk factors associated with work related upper limb disorders. Part of the development took place in the garment-making industry, where assessment was made of operators who performed tasks including cutting while standing at a cutting block, machining using one of a variety of sewing machines, clipping, inspection operations, and packing. RULA was also developed through the evaluation of the postures adopted, forces required and muscle actions [5]. The Figure 3 below shows the example of RULA Analysis in Catia using manikin.

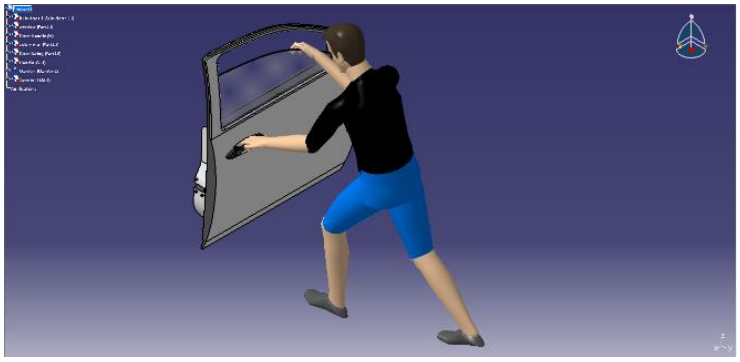

Figure 3 : Example of RULA Analysis in Catia using manikin.

RULA was developed without the need for special equipment. This provided the opportunity for a number of investigators to be trained in doing the assessments without additional equipment expenditure. As the investigator only requires a clipboard and pen, RULA assessments can be done in confined workplaces without disruption to the workforce. Those who are trained to use it do not need previous skills in observation techniques although this would be an advantage [6].

Ergonomics Analysis in CATIA V5R21

CATIA V5R21 was included with Ergonomics Design and Analysis (EDA) module. By implementing and using the ergonomics facilities, a CAT Product in CATIA is generated. The ergonomics design processes are defined by 4 sub modules which are:

i. Human Builder
ii. Human Measurements Editor
iii. Human Posture Analysis
iv. Human Activity Analysis

The development of RULA

It can be divided into three stages:

STAGE 1: The development of the method for recording working postures
STAGE 2: Development of the system for grouping the body part posture scores
STAGE 3: Development of the grand score and action list

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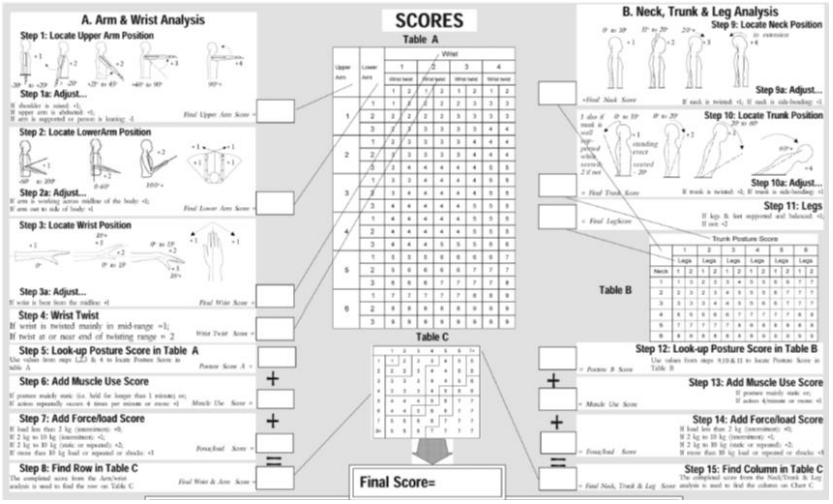

Figure 4 : RULA worksheet (personal.health.usf.edu/tbernard/Hollow Hills/RULA)

No	Criteria	*Concept Rating (0 – 7 as RULA analysis score)*			
		Proton BLM 1.3		Perodua Viva 660	
		Exterior	Interior	Exterior	Interior
1	Upper Arm	3	4	4	4
2	Forearm	2	3	2	3
3	Wrist	3	4	3	4
4	Wrist Twist	1	1	3	2
5	Posture A	4	6	4	6
6	Muscle	1	1	1	1
7	Wrist and Arm	1	1	1	2
8	Neck	2	3	3	3
9	Trunk	2	2	2	2
10	Leg	1	1	1	1
11	Posture B	2	3	3	3
12	Neck, Trunk and Leg	4	5	5	5
13	Final Score	6	6	5	7

Final Score Range	*Action*
1 or 2	Acceptable
3 or 4	Investigate Further
5 or 6	Investigate Further and Change Soon
7	Investigate and Change Immediately

Table 3: RULA Analysis Final score range (personal.health.usf.edu/tbernard/Hollow Hills/RULA)

The result of the manual calculation of interior and exterior for both car using RULA Employee Assessment Worksheet has been shown in Table 3. Whereas, for the final score range, it can be refer to Figure 5 as references.

Ergonomics software analysis

a) Comfort Rating

A vehicle ergonomics software (RULA Analysis) will be used to evaluate gripping position for both cars. The evaluation will find level of discomfort at specified gripping and handle location. So the value of less discomfort is preferred. Final score range for RULA analysis in catia can be refer to table 4.

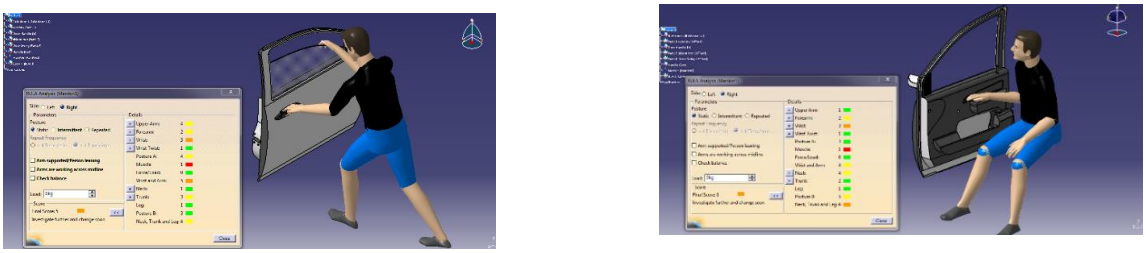

Figure 5: Result of RULA analysis in Catia for exterior and interior for Proton (BLM)

Figure 6: Result of RULA analysis in Catia for exterior and interior for Perodua (VIVA)

RESULT AND DISCUSSION

Comparing between result of surveys and result of measurement in table 3 and RULA analysis in figure 5 and 6 will show the correlation between the two. Surveys was taken to identify the driver's perception in car evaluation standarts. Measurements were done to identify the dimensions involved and then ergonomics software was applied to analyze the dimensions involved. Since the surveys does not take into account the anthropometrics of respondents, it cannot tell in terms of people size that gives such answer. The result can be compute from the discomfort assessment using RULA Analysis in the worksheet and Catia V5R21.

Calculation of the percentage error have been made to see the difference between the RULA Assessment using Worksheet and the RULA Analysis using Catia V5R21. Percent error is used when comparing the result to a known or accepted value. It is the absolute value of the difference of the values divided by the accepted value, and written as a percentage. In most cases, a percent error or difference of less than 10% will be acceptable. If comparison shows a difference of more than 10%, there is a great likelihood that some mistake has occurred.The result are mostly quite close between both of analysis. Survey was taken to identify driver's perception towards the two cars in term of aspects that are often seen in car evaluation standards. Measurements were done to recognize the dimensions which are involved and afterwards ergonomic software (RULA Analysis in Catia V5R21) applied to analyze the dimension involved. For the driver's comfort factor, the survey questionnaire analyzed by the discomfort factor that majority respond by the students experiences the comfort level for both interior and exterior car door handle.

The questionnaire that distributed to all of the students are based on their understanding level in aspect of the language and the scientific term for the front and rear seat section. SPSS Tool This step was also done to ensure high face validity of the survey and produced an assured result to be analysed. From the survey result, the answer are

divided into five categories of scale 1 to 5 which represent very comfort, comfort, moderate, discomfort and very discomfort. From 100, there are 53 mark for Proton (BLM 1.3) and 47 mark for Perodua (Viva 660). The survey was meant to get the general idea of satisfaction of each car driver and passengers. Based on the survey questionnaire analysis, the study for customer current satisfaction of Proton (BLM 1.3) and Perodua (Viva 660) are not as high as expected.

Actual Measurement Simulation progress in this investigation is an important factor that need to be consider to proceed for the RULA Analysis in Catia V5R21 the measurement are accurate to produce a reliable and valid result. Based on the exterior and interior for both of the two cars, the overall dimension for Proton (BLM 1.3) are more comfort for taller compare to Perodua (VIVA 660). In order to ruminate the selection of car door handle for anthropometry studies, it is virtuous to select the 95^{th} percentile so as to fit the majority of human size.

CONCLUSION

The main objective of the study presented in this paper was to investigate and possibly to improve the comfortable of car door handle. The investigation focused on four critical handle dimension; height of handle from the ground, handle height, handle width, and location of the handle. Since some questions were not clear to respondent, the answer may as well be uncertain. Also the external factor such as time, environment may have been effects their answers. Measurement and comparison will give a better understanding of how a car door handle contributes to automotive ergonomics. There were multiple relevant anthropometric dimensions the method of principal component analysis was applied to reduce the problem to two dimensions and hence make possible the graphical representation of data and the selection of cases.

The validity and reliability of the survey analysis using SPSS Tool conclude that the customer does not meet the satisfaction for both Proton BLM 1.3 and Perodua Viva 660. The satisfaction has no limit and base on the result from SPSS Analysis, focusing more on which part of the most unsatisfactory of the part of the car door handle design are necessary. In this circumstance, before improvement will be done, it need to identify the least or the lowest Means of the part of the car door handle design. The comfort factor for that can be compare in the research are based on the car door handle design. Thus, the different anthropometry data of different sizes of human being will provide a different comfort factor to the research that have been done.

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