UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPLIED ANTHROPOMETRIC STUDY ON LIGHT VEHICLE DESIGN AND PROTOTYPE

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Manufacturing Engineering Technology (Product Design) with Honours.

by

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FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING TECHNOLOGY

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BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

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ABSTRAK

Projek ini adalah projek yang memberi tumpuan dalam menghasilkan kerusi kereta ringan untuk kereta sukan berdasarkan persentil 95 penduduk di Malaysia. Ia direka bentuk dalam bentuk prototaip percetakan 3d untuk memasuki pertandingan Shell Eco-marathon. Kerusi kereta yag dihasilkan mestilah bersifat ringan yang mengikut tema dalam menghasikan kenderaan ringan. Terdapat beberapa panduan yang digunakan untuk menghasilkan kerusi kereta termasuk faktor ergonomik dan kajian antropometrik yang digunakan di tempat duduk. Selepas kajian teori dan data dilakukan,pengukuran kedudukan pemandu dibuat menggunakan manikin di CATIA V5R21. Data akan dimasukkan berdasarkan peratus ke-95 orang dewasa Asia untuk menentukan kedudukan pemandu menggunakan data kenderaan sebenar. Kemudian, tempat duduk itu akan direka bentuk daripada manikin menggunakan perisian CATIA V5R21. Analisis RULA akan dilakukan untuk menggambarkan aspek ergonomik reka bentuk tempat duduk dan skor akan diberikan untuk memperoleh nilai risiko MSD. Selepas itu, simulasi analisis digunakan untuk menentukan ia boleh menjadi kejayaan atau tidak apabila kerusi selesai menggunakan perisian SIMSOLID. Sekiranya berjaya, ia boleh dicetak menggunakan mesin Laser Selektif Sintering tetapi jika tidak berjaya, ia mesti mengubah reka bentuk kerusi sehingga ia dapat meneruskan proses seterusnya.

ABSTRACT

This project is a project that focuses is on producing car seats lightweight for a sports car based on 95th percentile of population in Malaysia. It is designed in the form of a 3d printing prototype to enter the Shell Eco-marathon competition. The car seat must be lightweight according to the theme of the lightweight vehicle. There is some guide used to produce car seats including ergonomic factors and anthropometric study applied on the seat. After the theories study and data were done, the driver's position measurement was made using a manikin in CATIA V5R21. Data will be included based on the 95th percentile of Asian adults to determine the driver's position using actual vehicle data. Then, the seat will be designed from the manikin using CATIA V5R21 software. RULA Analysis will be performed to illustrate the ergonomic aspects of the seat design and the score will be given to obtaining MSD risk values. After that, the analysis simulation is used to determine it can be a success or not when the design seat is finished using SIMSOLID software. If successful, it can be printed using the Selective Laser Sintering (SLS) machine but if unsuccessful, it must change the design of the seat until it can continue the next process.

DEDICATION

This study is whole-heartedly dedicated to my beloved parents, Mr. Hamzah bin Md Daim and Mrs. Nina binti Mohd Walli who became the source of inspiration and strengthened me to continue this project. To siblings, friends, and classmates who share the words of advice and encouragement to complete this study. Thanks to my supervisor En Hassan bin Attan for guidance, encouragement, and patience to fulfill my inspiration in completing this project.

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LIST OF SYMBOLS

CAD	-	Computer-Aided Design
CAE	-	Computer-Aided Engineering
cm	-	Centimetre
kg	-	Kilogram
mm	-	Millimetre
Sd	-	Standard Deviation

CHAPTER 1

INTRODUCTION

1.0 Introduction

The first chapter will explain the introduction of the project. It consists of project background, problem statement, objective, significance study, and scope.

1.1 Background of study

Shell Eco-marathon is a program that covers science, technology, engineering that makes teams compete to produce the most energy-efficient cars, and then take them on track (Al-saffar & Duwail, n.d.). Therefore, need to produce a car that meets the standards to ensure better energy efficiency than other vehicle. In addition, car interior design also plays an important role in producing a car that meets the standards and satisfies the driver. Good car seat design is a key factor in this project to ensure good car interior design. Car seat plays a significant role in improving the comfort of professional drivers (Jhinkwan & Singh, 2014). Car seats closely related to anthropometric and ergonomic data in the car seat production process. For this project, the focus is on producing car seats lightweight for a sports car based on 95th percentile of population in Malaysia. With proper car seat posture, it can provide a good ergonomic effect as it sees good side mirrors, comfortable movements, and the front view of the mirror is clear.

The car seat is designed as a prototype to enter the Shell Eco-marathon competition. The prototype was scanned using 3D Printing and the seat was printed using the Selective

Laser Sintering (SLS) machine. The design process is obtained using a design software called CATIA V5R21. The material and weight of the seat must consider getting to meet the goals of producing seat lightweight on light vehicles. The car seat is designed using selected concepts and applies using ergonomics elements. If the car seat does not follow the correct ergonomic factors, the accident may occur at any time. Characteristics of seating such as surface shape, cushion type, lumbar support, location control (steering and pedal), the field of view and height of the head may affect driving posture if not followed properly (Sukadarin,2016).

1.2 Problem Statement

Anthropometric and ergonomic factors play an important role in creating the best and most comfortable car seats for drivers. Therefore, there are several problems faced that need to concerned.

I. How anthropometric studies can be applied in producing car seats?
II. What is a suitable posture for sports cars to the driver?
III. What are the material used to make lightweight seats in light vehicles??

Therefore, the anthropometric and ergonomics factors of the seat must be studied to overcome this problem. Furthermore, by referring to the RULA Analysis, the posture body can be configured and the model seat can use a design software called CATIA V5R21.

1.3 Objective of study

The objectives of this project are:

1) To design the car seat prototype of the Shell Eco-Marathon Urban car.
2) To find a suitable posture for sports cars to the driver
3) To apply the light material for the car seat prototype in producing the light vehicle.

1.4 Significant of study

The significant of study is to study the posture of the driver for the appropriate. This study helps design teams improve posture driver that is related to ergonomics to improve occupants ' comfort.

1.5 Scope

There has a several scopes of work and limitation which will be followed to complete this project. The work scope of this project is outlined as below:

1) To design car seat of Shell Eco Marathon Urban Car concept that suitable for 95 percentile Asian male according to The Society of Automotive Engineer (SAE) Standard.
2) To analyse the suitable posture that will created by using RULA Analysis.
3) To produce lightweight seat for prototype car seats using 3D Printing.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Chapter 2 will be some discussion on the background of research related to the project. This chapter also discusses journals made as references and good examples from other sources related to the project.

2.1 Shell Eco-Marathon Competition

The Shell Eco-marathon international competition organized by the Shell Company focuses on reducing vehicle fuel consumption. The event enables the presentation of original vehicle construction and combustion engine innovations. This car body is designed with 3D modeling using the CATIA V5R21 CAD system. The experimental vehicle's 3D model was designed aerodynamically with airflow simulation. The car body is based on the application of carbon fiber to optimize aerodynamics by simulating airflow to significantly reduce weight. Part of the construction of accessory vehicles is based on the use of carbon fiber which significantly reduces the weight of the vehicle. Some components of accessory vehicles (such as rear mirrors) are made using the rapid prototyping methodology using 3D printers. Others are used in the CAD engineering car body design process in a propensity to smooth the car body shape (Fabian et al., 2018)

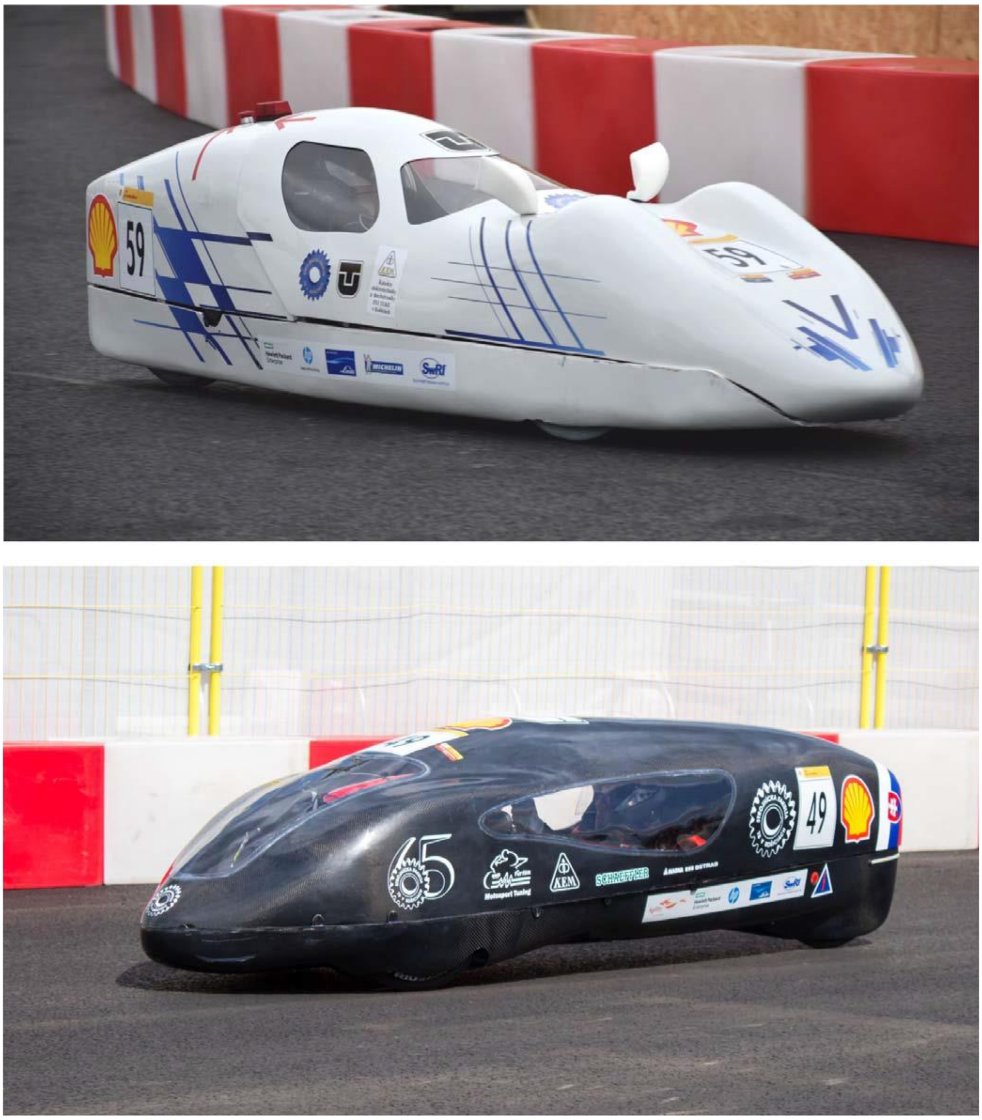

Figure 2.1: Shell Eco-Marathon Vehicle construction (Fabian et al., 2018)

2.2 Anthropometry Measurement

Anthropometry is a study of the human body in terms of bone, muscle, and adipose (fat) tissue dimensions. The word “anthropometry” is come from the Greek word “anthropo” meaning “human” and the Greek word “metron” meaning “measure” (Ulajaszek, 1994). The field of anthropometry covers a variety of human body sizes. Examples of anthropometric measurements are weight, stature (standing height), recumbent length, skinfold thicknesses, circumferences (head, waist, and limb), limb lengths, and breadths (shoulder, wrist) (CDC, 2013).

There is a related between anthropometric measurements and car seat design. Regarding the differences in driver anthropometric measurements, it is sometimes a problem to adjust the car seat and safety belt. This problem occurs when using the airbag if the driver's body deviates from the standard size of the anthropometry cause the driver's head comes out of the airbag. It occurs if the driver is very tall or short. The seat can be mostly adjusted by pulling it for-/backwards. The seat height cannot be adjusted, so the short driver's head position is lower than that of the high driver. The short driver was in an unexpected position, not only because of poor visibility but also because of the possibility that safety belts and airbags are not operating efficiently, as the body can be more easily released in time of the accident and get injured (Kovačević, Vučinić, Kirin, & Pejnović, 2010).

2.2.1 Anthropometry and its Uses in Ergonomics

Anthropometric data is a relevant parameter for determining comfortable car seat design and usually are taken between the 5th percentile female to 95th percentile male dimensions will accommodate 95% of people. This principle is called the parameters of fitting the seat and is significant for drivers to be comfortable. Usually, the arrangement of interior packages and seating designs restricts the current driver's position in the car. The driver’s car seat designer needs to incorporate users’ population anthropometric data to increase drivers’ safety and comfort rate. Short-term effects of seats on the human body with the comfort of a driver's seat (Sukadarin, 2016).

Anthropometry is very important in ergonomics for user convenience, especially for car seats. For those with long legs or vice versa, special feature considerations should be taken for them and do not meet one's average height (Ciro Romelio Rodriguez-Añez, 2001).

2.2.2 Anthropometric Survey

Based on measurements of 146 men and 168 female participants (18-45 years) were established as an anthropometric database for sitting and standing dimensions for Malaysian operators. Then, three selected Asian countries compared anthropometric data, focusing on sitting and standing measurements. The 36 anthropometric measurements were chosen for comparison based on general accessibility between the four nations. The results show that Indonesians highest (male: 172 cm, female: 159 cm) among the four countries, while the Philippines is the shortest both male and female (male: 167 cm, female: 153.9 cm) (Izzah et al., 2018).

Philippines and Malaysia data are very similar and appears to have the smallest values for eye height (male: 155 cm, female: 143 cm) and elbow height (male: 104 cm, female: 96 cm) (Izzah et al., 2018). Knowledge of population variance is useful in designing car seats that are convenient and suitable.

The sample population, consisting of students and workers, is in offices and factories in general. The number of subjects is estimated according to the equation given in Appendix A ISO 15535: 2003.

General requirements for establishing anthropometric databases based on 95% confidence intervals and 5th and 95th percentiles:

$$n \geq \left(3.006 \times \frac{CV}{\alpha}\right)^2$$

where n is the sample size, CV is the coefficient of variation and α is the percentage of relative accuracy desired. The sample size was calculated based on the assumption that the 5th and 95th percentiles and the empirical CV value of 25 are sufficient for a relative accuracy of 10 percent. The minimum sample size for this analysis was found to be 112 (56 subjects per gender). Thus the number of subjects for this study, with the total number of 314 subjects, is sufficient (Izzah et al., 2018). The figure 2.2 below shows anthropometric data for Malaysian males (all dimensions in cm, body weight in kg).

No.	Anthropometric measurement	Mean	SD	1%tile	5%tile	50%tile	95%tile	99%tile
1	Weight	68.4	13.4	44.0	53.0	66.0	94.8	104.5
2	Stature	168.1	12.9	143.0	158.3	168.5	179.3	181.5
3	Standing eye height	155.5	14.1	116.3	146.9	156.1	167.9	171.6
4	Standing shoulder height	138.5	11.5	107.2	130.5	139.0	150.5	152.8
5	Standing elbow height	103.7	9.4	81.0	96.1	103.7	112.6	132.4
6	Waist height	99.1	9.7	68.2	91.6	99.8	109.1	111.0
7	Crotch height	78.8	6.7	60.9	70.1	79.0	88.1	93.3
8	Kneecap height	47.0	3.5	40.4	41.9	46.8	52.3	55.4
9	Coat height, standing	68.8	9.5	49.8	56.0	68.0	81.8	85.4
10	Span	169.9	15.5	117.4	158.4	170.5	184.2	189.8
11	Elbow span	85.9	9.3	66.7	75.6	86.5	96.3	105.9
12	Hip breadth, standing	37.2	38.1	25.8	28.8	32.5	37.5	150.8
13	Interscye breadth	30.8	3.3	24.2	25.8	30.5	36.1	38.1
14	Back waist length	46.6	4.7	36.6	38.2	46.5	54.7	59.3
15	Sleeve inseam	45.9	8.2	35.6	37.5	44.4	65.7	72.6
16	Shoulder breadth	40.0	5.0	29.5	31.4	41.0	47.1	49.5
17	Hip breadth, sitting	34.3	3.9	24.5	29.1	34.1	40.8	45.3
18	Forearm–hand length	39.5	9.5	23.1	24.0	44.4	49.0	50.6
19	Buttock–knee length	54.4	3.6	46.0	48.2	54.4	59.7	61.7
20	Buttock–popliteal length	43.0	3.8	34.0	36.5	43.3	49.1	50.3
21	Shoulder–elbow length	34.9	3.2	28.4	30.3	34.8	38.7	42.4
22	Thigh clearance	13.1	2.1	8.3	10.5	12.8	16.5	18.0
23	Arm reach forwards	80.9	8.5	68.7	70.4	81.0	93.4	104.7
24	Arm reach upwards	149.6	180.9	115.8	120.4	128.0	139.0	583.0
25	Sitting height	87.7	4.5	76.6	80.8	87.4	95.2	97.4
26	Sitting eye height	76.3	4.3	63.8	69.9	76.0	83.5	86.7
27	Sitting shoulder height	59.3	3.8	51.6	53.8	59.1	66.1	68.3
28	Sitting elbow height	23.1	3.7	15.5	17.4	23.1	29.9	30.4
29	Knee height	50.4	4.9	42.6	44.6	50.7	56.6	59.2
30	Popliteal height	42.4	4.4	34.9	37.9	42.8	46.8	49.7
31	Head length	19.1	3.9	15.9	16.3	18.1	25.7	33.2
32	Head breadth	15.2	1.0	12.7	13.8	15.4	16.8	17.1
33	Hand length	18.3	1.1	15.7	16.5	18.2	19.9	20.5
34	Hand breadth	8.1	0.8	6.6	7.0	8.1	9.6	10.4
35	Foot length	24.7	1.3	21.9	22.8	24.7	26.7	27.5
36	Foot breadth	9.6	0.7	7.9	8.4	9.6	10.6	11.3

Figure 2.2: Anthropometric data for Malaysian males (all dimensions in cm, body weight in kg) (Izzah et al., 2018).