Ergonomic Design of Electric Car's Cockpit

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Abstract: Electric car competition has been well known lately in Indonesia. The car will be tested for its speed, break, and slalom ability. The electric car's cockpit is an important part of the car. Designing a comfortable cockpit will increase the driver's focus. Unfortunately, the ergonomic design of the cockpit has not been implemented in Enggang Evo, an electric car made by the students of Institut Teknologi Kalimantan. This research was conducted to gain a dimension for building an ergonomic apparatus based on anthropometrical data of ITK students. Calculation result using 95^{th} percentile male is the shoulder height in sitting position (D10) = 60.80 cm, Eye height minus shoulder height sitting (D9-D10) = 17.16 cm, Shoulder breadth (D17) = 42.66 cm, Hip breadth (D19) = 32.33 cm, Sole breadth (D31) = 10.07 cm, Body to steer (i) = 76.46 cm, and Hip to pedal (j) = 64.25 cm.

1. INTRODUCTION

Lately, fossil fuel has been a global issue for its availability and the number of pollutants it produces. Indonesian government trying to tackle this issue by holding an electric car competition. One of the famous electric car competition, held by Politeknik Negeri Bandung. In the competition, students from all around Indonesia will be competing in designing an electric car. Later, the electric car will be tested for its speed, its break, and slalom. Institut Teknologi Kalimantan (ITK) also joined the competition. Students from ITK had come out with the design of their electric car named Enggang Evo.

Car cockpit is the place where the driver will interact directly with all the components that are crucial to make the car work properly, such as accelerator pedal, brake, and also steering. The comfortable design of this cockpit will increase the performance of not only the driver but also the car because it will give easy access for the driver to operate the car comfortably (Z. Ahmad, 2017). The components of the electric car that are easy to reach will also minimize the driver's mistake due to it helps them to focus. An ergonomically designed cockpit is important to increase comfort in driving. In the previous study, the survey reveals that attributes like ease to reach steer, comfortable seat, and spacious cockpit were some attributes that customers care about (Soewardi, 2018). Body back pain was also reduced by designing a comfortable seat (I. Kamp., 2012).

Unfortunately, students making an electric car have less knowledge of how to ergonomically designed the car cockpit. Thus, this research is carried out to assess the design of the Enggang Evo's cockpit. In the previous research, a driving posture of the 95th percentile male has been known along with all the angles in the driving posture (Ahmad A., 2017). In this research, we only focus on gaining dimensions for the cockpit's ergonomic apparatus based on anthropometrical data of ITK students, for further usage to design Enggang Evo's cockpit.

2. METHODS

2.1 Anthropometric Data

Based on the Indonesian anthropometric data, there are thirty-six (36) dimensions that can be measured (D1-D36). In this research, based on the previous study (Ahmad A., et al., 2017), we only measured the dimension of D9-D10, D10, D14, D16, D17, D19, D22, D23, D30, and D31. All this dimension explained in table 1. Tools used to measure all of these dimensions are measuring tape, dial caliper, height measure, flexible curve, and L-square angle ruler. Taking into consideration that Enggang Evo

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Car designed for a male driver, the anthropometric data were obtained from 54 male students of ITK.

Table 1: Dimension measured

Dimension	Name	Part of the body measured
D9-D10	Eye height minus shoulder height sitting	The vertical distance from the acromion to the outer corner of the eye
D10	Shoulder height sitting	The vertical distance from a horizontal sitting surface to the acromion
D14	Buttock-popliteal length	The horizontal distance from the hollow of the knee to the rearmost point of the buttock
D16	Lower leg height	The vertical distance from the foot-rest surface to the lower surface of the thigh immediately behind the knee bent at a right angle
D17	Shoulder Breadth	The distance across the maximum lateral protrusions of the right and left deltoid muscles
D19	Hip breadth	The breadth of the body measured across the widest portion of the hips
D22	Elbow height	The vertical distance from the foot-rest surface to the lowest bony point of the elbow bent at a right angle with the forearm horizontal
D23	Elbow-length	The horizontal distance of the elbow bent at a right angle with the forearm horizontal
D30	Sole length	Length of the feet's sole measured from the lowest part of the sole to the longest finger
D31	Sole breadth	The breadth of the feet's sole measured across the widest portion of the hips

2.2 Statistic Test for Anthropometric Data

The anthropometric data obtained was tested statistically for normality and uniformity test. The normality test was carried out using SPSS with a value of $\propto = 0.05$. A normality test was carried out to ensure that the distribution of all the data was normal. Furthermore, the data will be tested for its uniformity. Uniformity test was carried out to ensure that there are no extreme data that will be the outlier of our overall data. It is also to ensure that all the data is not beyond the control limit.

All the calculation step was mentioned in the previous work, and will not be discussed deeply in this paper (Wignjosoebroto, 1989). If there are any outliers, the data will be neglected. In the end, after any outlier objected out, we will do a statistical test to ensure that our data was enough and presenting well the population sample, using data proficiency test. The data was count as sufficient if n-calculated < n-sample.

2.3 Data Analysis

Figure 1 shows all the dimensions which should be measured to produce an ergonomic apparatus for cockpit design (Ahmad A., 2017).

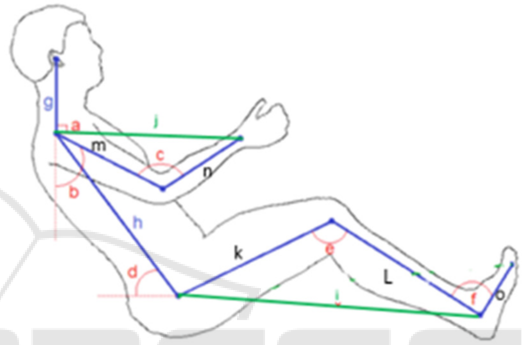

Figure 1: Driving posture dimension

In this research, we use the angle value of "a" to "f" from the previous work, as listed in table 2.

Tabel 2. Driving posture data (Ahmad A., 2017).

Variable	Dimension	Angle
a	neck	90°
b	shoulder	55°
c	elbow	116°
d	hip	50°
e	knee	120°
f	ankle	85°

In this research, the value of "g,h, k, l, m, n, and o" will be thoroughly analyzed with the help of SPSS 16.0 and Microsoft excel, based on the anthropometrical data obtained from the students in ITK. The data were analyzed to obtain minimum, maximum, mean, standard deviation, and 95th percentile. 95th percentile male is one kind of anthropometry principle that is designed for extreme individuals, which means all value obtained will still be suitable for the people beyond the average (Taifa, 2017). 95th percentile was chosen referred to as the previous work (Ahmad A., 2017). The dimension calculated using 95th percentile was calculated using well-known percentile formula as below:

$$P95 = \bar{X} - 1.645\sigma_X \quad (1)$$

2.4 Mathematic Calculation

The value of “i” and “j," as stated in figure 1, will be calculated using a well-known law of cosine.

3. RESULTS AND DISCUSSIONS

3.1 Normality Test

From figure 2 below, we can see that all the data were distributed normally.

One-Sample Kolmogorov-Smirnov Test

		D9_D10	D10	D14	D16	D17	D19	D22	D23	D30	D31
N		54	54	54	54	54	54	54	54	54	54
Normal Parameters[a]	Mean	15.5185	58.0833	43.6481	40.2111	40.8611	30.2870	34.1574	36.8333	23.9145	9.6134
	Std. Deviation	2.44749	4.04777	3.59065	3.35765	2.88014	3.04774	2.70384	4.35565	1.33488	.71434
Most Extreme Differences	Absolute	.101	.096	.090	.167	.182	.149	.118	.172	.137	.165
	Positive	.087	.096	.090	.167	.182	.149	.118	.172	.115	.165
	Negative	-.101	-.066	-.072	-.142	-.069	-.061	-.112	-.115	-.137	-.132
Kolmogorov-Smirnov Z		.744	.703	.662	1.231	1.334	1.092	.870	1.265	1.004	1.209
Asymp. Sig. (2-tailed)		.637	.706	.773	.097	.057	.184	.435	.081	.266	.107

a. Test distribution is Normal.

Figure 2: Normality test result

3.2 Uniformity Test

From figure 3 below, we can see that all the data (blue line) were between our control limit (orange line). There is no outliers, so all the 54 data were used.

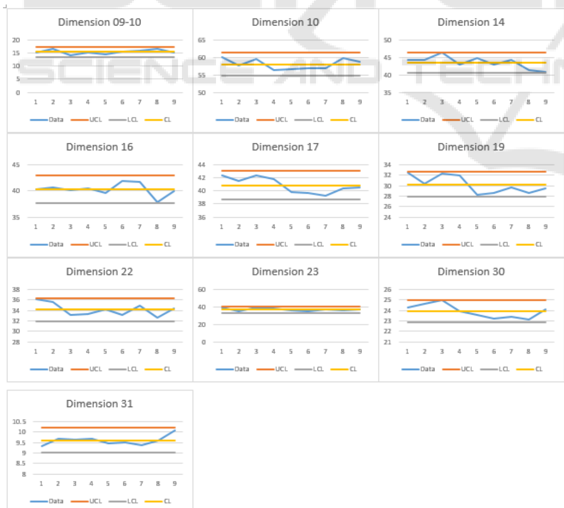

Figure 3: Uniformity test result

3.3 Data Proficiency Test

From figure 4 below, we can see that all the calculated n (n') for each dimension, were below the sample n (N). Thus, we can conclude that the data was sufficient.

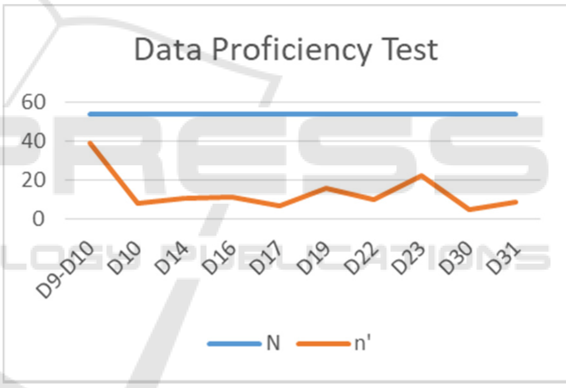

Figure 4: Data proficiency test result

3.4 Dimensions

After calculated using the 95th percentile, the dimension result can be seen in table 3.

Table 3: Dimension Results

Variable	Part of the body measured	Dimension
a	Neck	90°
b	shoulder	55°
c	elbow	116°
d	hip	50°
e	knee	120°
f	ankle	85°
g	D09-D10	17.16 cm
h	D10	60.8 cm
i	Body to steer	76.64 cm

Variable	Part of the body measured	Dimension
j	Hip to pedal	64.25 cm
k	D14	46 cm
L	D16	42.46 cm
m	D22	35.97 cm
n	D23	39.75 cm
o	D30	24.81 cm

4 CONCLUSIONS

In this design of the Enggang evo's cockpit, we can conclude that :

1. The shoulder height in sitting position (D10) = 60.80 cm.
2. Eye height minus shoulder height sitting (D9-D10) = 17.16 cm.
3. Shoulder breadth (D17) = 42.66 cm.
4. Hip breadth (D19) = 32.33 cm .
5. Sole breadth (D31) = 10.07 cm.
6. Body to steer (i) = 76.46 cm
7. Hip to pedal (j) = 64.25 cm.

All this data will be used for further research to design an ergonomic apparatus.

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