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An Ergonomics Study of UniKL MSI Perodua Eco-Challenge Race Car Cockpit

Khairul Akmal Shamsuddin[1], Ahmad Hazwan Ilyas[2], Mohd Nurhidayat[3], Khairul Shahril Shafee[4]
[1, 2, 3, 4]*(Mechanical Section, Universiti Kuala Lumpur (UniKL), Malaysian Spanish Institute (MSI), Malaysia*

ABSTRACT : This research will concern itself primarily with the ergonomics of motor vehicle specifically in race car especially for cockpit UniKL MSI Perodua Eco-Challenge Race Car. Motor racing is very popular sport around the world. There are several types of motorsport that has long existed, including the Formula 1 which is the sport's most prestigious motor racing category. UniKL MSI Perodua Eco-Challenge Race Car is an adaptation of the concept of single-seat racing cars similarly as Formula 1. The cockpit is one of the most important things in racing, including the race car in the UniKL MSI Perodua Eco-Challenge Race Car. In the cockpit, there are several components required by the driver such as steering, gear lever, accelerator pedal and brake pedal, and seat. These are basic components that should be in a cockpit. UniKL MSI Perodua Eco-Challenge Race Car has been completely built. However, this race car needs to go through some test and should be completely finalized before the competition. One of the major problems is about the driver cockpit. In order to obtain the best cockpit design, RULA analysis has been used to utilize the suitable cockpit design for UniKL MSI Perodua Eco-Challenge Race Car. The resulting of cockpit design is solved by using CATIA V5R16. From the analysis, it was found that design E is the best cockpit design in term of RULA analysis final score achieved when compared to the other designs.
KEYWORDS - Ergonomics, Ergonomic Software, Cockpit, Anthropometry

1. 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”.

In our present civilized world, ergonomics appear in many different forms such as general ergonomics, micro-ergonomics, and multitude of different consumer goods. The most important field of application is general ergonomics in technical systems such as mechanical engineering and road vehicle, aircraft, and marine vessel engineering. In principle, ergonomics is the study of people and their work. Objective of the ergonomics is to optimally match labor and the work environment to human being. This project will concern itself primarily with the ergonomics of motor vehicle specifically in race car especially for cockpit UniKL MSI Perodua Eco-Challenge Race Car.

Motor racing is very popular sport around the world. There are several types of motorsport that has long existed, including the Formula 1 which is the sport's most prestigious motor racing category. UniKL MSI Perodua Eco-Challenge Race Car is an adaptation of the concept of single-seat racing cars such as Formula 1.

The cockpit is one of the most important things in racing, including the race car in the UniKL MSI Perodua Eco-Challenge Race Car. Referring to cockpit definition, it can be such a lot of definition. Mostly, cockpit is well known as the compartment in a small aircraft in which the pilot, crew, and sometimes the passengers sit. However, in motorsport cockpit defined as the driver's compartment in a racing car. In the

cockpit, there are several components required by the driver of which are the steering, gear lever, accelerator pedal and brake pedal, and seat. These are basic components that should be in a cockpit.

UniKL MSI Perodua Eco-Challenge Race Car has been completely built. However, this race car needs to go through some test and should be completely finalized before the competition. One of the major problems is about the driver cockpit.

2. LITERATURE REVIEW

2.1 Ergonomics

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 [1].

2.2 Hierarchy Goal of Ergonomics

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 [3].

2.3 Anthropometric

Anthropometry literally meaning "measurement of humans", in physical anthropology, refers to the measurement of the human individual for the purposes of understanding human physical variation. Today, anthropometry plays an important role in industrial design, clothing design, ergonomics and architecture where statistical data about the distribution of body dimensions in the population are used to optimize products. Changes in life styles, nutrition and ethnic composition of populations lead to changes in the distribution of body dimensions, and require regular updating of anthropometric data collections [2].

2.4 Ergonomics Model

In ergonomics and human-factor engineering, the term model is often defined as a model is a mathematical or physical system that obeys specific rules and conditions and whose behavior is used to understand a real (physical, biological, human-technical, etc.) system to which it is analogous in certain respects to the real system.

2.5 Testable Hypothesis

A lack of rigor ergonomics studies has been reported by Heacock et al. (1997), who compiled a checklist that is useful both for planning experiment and for assessing past studies. Investigations of, and experiment with, human being and their performance must be carefully planned, executed, evaluated, and reported in order to test a theory or, more often, a hypothesis. The usual approach is to state a hypothesis and then determine whether it is true or false based on the experimental result.

Testing is commonly done in term of the null hypothesis. There is no difference between the outcomes of the test. Whether the null hypothesis is rejected or not is determined by statistical evaluation of the experimental data. Weimer (1995) discussed, in a down-to-earth manner, how to develop and carry out a research project. This is also a topic of many more theoretical treatises on methodological and statistical aspects in human-factors research. Through guide to the design of experiments and the analysis, the result have been compiled by Williges (1995) and Han et al. (1997), with the latter dealing with complex studies with multiple variables. A major aspect of their discussion is how to control individual differences among the subjects who participate in experiments [4].

2.6 Cockpit

Mostly, cockpit is well known as the compartment in a small aircraft in which the pilot, crew, and sometimes the passengers sit. However, in motorsport cockpit defined as the driver's compartment in a racing car [10].

2.7 Race Car

The control and instrumentation of race cars has changed dramatically since motor sport began early in the 20th century. A very simple vehicle design in the early years meant that the main control input came from the driver, and this hasn’t changed here at the start of the 21st century. However the driver’s job is made easier

by the greater inclusion of control and instrumentation systems. The use of control and instrumentation systems on modern racing cars is mainly dependent on the cash budget of a competing team. This section of the background investigation will analyze the cockpit design solutions utilized in three vehicles used in different motor-sport categories with differing annual budgets. The vehicles chosen are an Intercontinental Super kart, a Formula SAE, and a Formula One car. These vehicles were chosen as they represent the entire scope of motor sport categories while also including a sequential gear shift or similar and require similar characteristics of acceleration, braking and cornering performance, albeit at an elevated level, and the design solutions used could be directly applied to the UniKL MSI Perodua Eco-Challenge Race Car [9].

3. METHODOLOGY

3.1 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 [6][7].

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 [7].

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 [8].

3.2 Ergonomics Analysis in CATIA V5R16.

CATIA V5R16 was included with Ergonomics Design and Analysis (EDA) module. By implementing and using the ergonomics facilities, a CATProduct in CATIA is generated. The ergonomics design processes are defined by four sub modules which are:

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

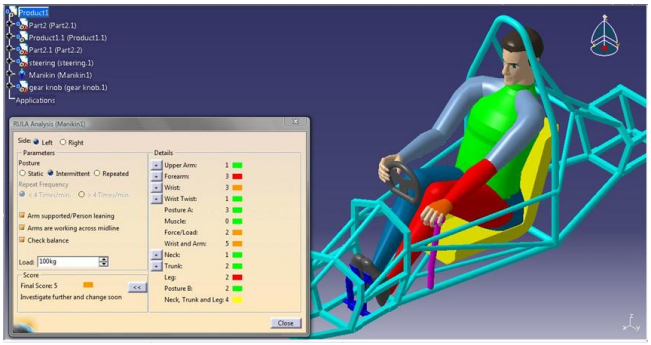


Figure 1: Example of RULA analysis in Catia using manikin.

3.3 The development of RULA

It can be divided into three stages and the example of RULA analysis interface in Catia using manikin as shown in Figure 1 above:

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

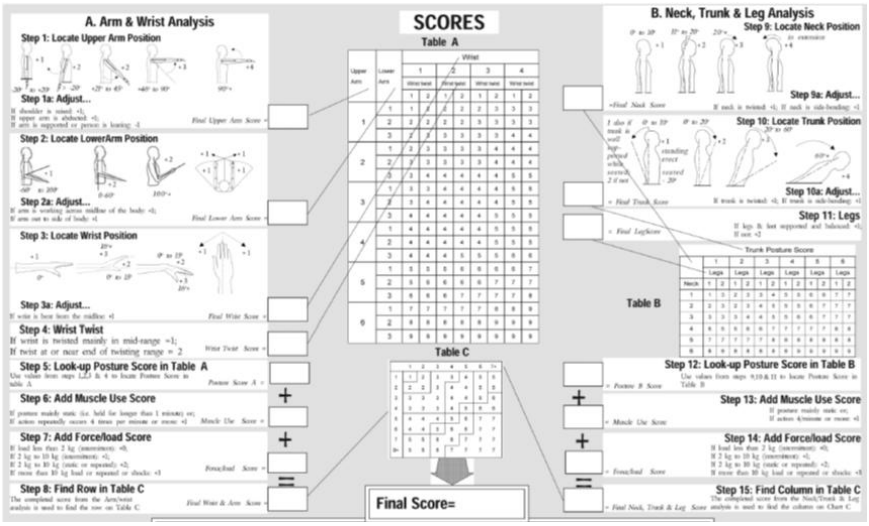


Figure 2: RULA worksheet (personal.health.usf.edu/tbernard/Hollow Hills/RULA)

3.4 Method of Design

3.4.1. Design Sketching

Sketching has proved to be the fastest way to define problem, explore ideas and develop. Sketch generally the meaning of a rough or unfinished drawing, and the activity to sketch for general outline of something. Benefit of sketching is that the mere acts of formulating a mental image in a concrete way possible for designer to reflect over the concept at once. Sketching is valuable activities such as brainstorming and concept evaluation [5].

3.4.2. Detail of Design

Detailed design is the process of developing a fully defined design from a clear set of requirement while creating deliverables and documentation appropriation. In this project, CATIA (Computer Aided Three-Dimensional Interactive Application) is use for the proper drawing.

3.4.3. Analysis of the Design

Design analysis had used for every type of design development and research effort imaginable. Design analysis can elucidate a wide range of development problems. In this research, RULA analysis was used for the analysis. These RULA analysis descriptions have been mention at the beginning of this research. The worksheet that was used to determine the RULA analysis is shown in Figure 2.

4. RESULT AND DISCUSSION

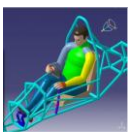
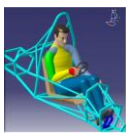
No.	Criteria	Concept Rating (0-7 as RULA analysis score)					
		Design A		Design B		Design C	
							
		Right	Left	Right	Left	Right	Left
1	Upper Arm	2	3	2	2	3	3
2	Forearm	2	2	2	2	2	2
3	Wrist	2	3	4	4	1	1
4	Wrist Twist	1	1	1	1	1	1
5	Posture A	3	4	4	4	3	3
6	Muscle	0	0	0	0	0	0
7	Wrist and Arm	3	4	4	4	3	3
8	Neck	2	2	1	1	1	1
9	Trunk	2	2	3	3	2	2
10	Leg	1	1	1	1	1	1
11	Posture B	2	2	2	2	1	1
12	Neck, Trunk and Leg	2	2	2	2	1	1
13	Final Score	3	3	3	3	3	3

Figure 3: Proposed design comparison in term of RULA analysis score

Based on the RULA analysis of the proposed design which is design A, B and C as shown in Figure 3 above, the acceptable score did not reach as per required. As a result, all of these designs can be accomplish as

unacceptable. At this point, this current chassis was not suitable to use as UniKL MSI Perodua Eco-Challenge Race Car because it will not be able to fulfil the ergonomics required for the driver.

		Concept Rating (0-7 as RULA analysis score)			
		Design D		Design E	
					
No.	Criteria	Right	Left	Right	Left
1	Upper Arm	2	1	1	1
2	Forearm	1	1	1	1
3	Wrist	2	1	2	1
4	Wrist Twist	1	1	1	1
5	Posture A	3	1	2	1
6	Muscle	0	0	0	0
7	Wrist and Arm	3	1	2	1
8	Neck	1	1	1	1
9	Trunk	1	1	1	1
10	Leg	1	1	1	1
11	Posture B	1	1	1	1
12	Neck, Trunk and Leg	1	1	1	1
13	Final Score	3	1	2	1

Figure 4: New proposed design using new chassis comparison in term of RULA analysis score

From the Figure 4 above shows that the comparison upon all three new proposed design using new chassis of the cockpit arrangement; design D and design E. According to the RULA analysis results, it can be conclude that the design E was selected proposed design based on the final score for each left and right side which 1 and 2, and it also stated 'acceptable' in the analysis which had been done.

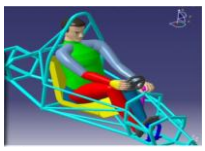
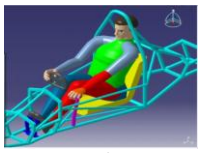
		Concept Rating (0-7 as RULA analysis score)			
		Existing Design		Selected Proposed Design	
					
No.	Criteria	Right	Left	Right	Left
1	Upper Arm	1	1	1	1
2	Forearm	3	3	1	1
3	Wrist	2	3	2	1
4	Wrist Twist	1	1	1	1
5	Posture A	3	3	2	1
6	Muscle	0	0	0	0
7	Wrist and Arm	5	5	2	1
8	Neck	1	1	1	1
9	Trunk	2	2	1	1
10	Leg	2	2	1	1
11	Posture B	2	2	1	1
12	Neck, Trunk and Leg	4	4	1	1
13	Final Score	5	5	2	1

Figure 5: Comparison between existing and selected proposed design

Presently, proposed design has been not selected yet. Hence, the selected and existing proposed design today is being compared in order to meet the final design which is suit with UniKL MSI Perodua Eco-Challenge Race Car. To begin with, both designs will be compared by using the score obtained from RULA analysis. Formerly, it needs to be compared based on requirement of basic component which will include in the cockpit that has been shown in Figure 5 above. At this moment, the selected proposed design had considerable improvement in ergonomics compared to the existing design. The greatest perceived improvement is using the new design of cockpit.

5. CONCLUSION

Based on the analysis that has been done, it can be determined that this research has a high prospect if continued. After going through the process of scientific research, nowadays known that the ergonomic been emphasized since the beginning of the automotive industry. Thus, progress in this area is growing regardless of the private car or racing engine. Consequently, this research refer to the ergonomic study on the UniKL MSI Perodua Eco-Challenge Race Car, an emphasis on ergonomics aspects involving cars is discovered. Among them are Formula 1, Formula SAE and Super kart which of the three categories were used as reference.

By referring to the objectives and scope, this research is now on the right track. The definition of ergonomics, cockpit layout of race cars, and also the way to conduct ergonomics analysis using the RULA analysis have been achieved in order to fulfill the resolutions.

New cockpit arrangements layouts have been design based from the original chassis design with a basic component in the cockpit. There are five new designs proposed; which are design A, B, C, D and E. RULA analysis has been well performed on all the new cockpit arrangement layout design. The results of each comparison for the new designs show that design E is the best among the other two proposed design. Whereas, the existing design need to be revised back in order to compare it again with the selected proposed design equally to final design which is the best suit with the UniKL MSI Perodua Eco-Challenge Race Car.

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