Available online at www.sciencedirect.com

ScienceDirect

Procedia Manufacturing 3 (2015) 2581 – 2588

Procedia MANUFACTURING

6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015) and the Affiliated Conferences, AHFE 2015

The Motorcycle Design Parameter Database (MDPD) for different motorcycle models

M. I. N. Ma'arof[a,]*, A. R. Omar[a], I. N. Ahmad[a], R. Jaafar[a], W. M. S. W. Fauzi[a], A. A. Rahim[a], H. Rashid[a], Z. Mahmud[b]

[a]*Motorcycle Engineering Technology Lab (METAL), Faculty of Mechanical Enginering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia*

[b]*Faculty of Computer & Mathematical Sciences, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia*

Abstract

Globally, motorcycle road accidents are increasing annually. Among the efforts in overcoming this dire scenario, motorcycle simulators were developed. The Postura Motergo™ which was developed by researchers at the Motorcycle Engineering Technology Lab (METAL) is an example of such simulators. The Postura Motergo™ has a unique capability in replicating various riding postures according to the Riding Posture Classification (RIPOC) system. However, there is the need for a novel database that gives information on the workstation design parameters of various motorcycles. Hence, a specifically built mannequin (the D5EM110N) was developed as a tool to measure various workstation dimensions on actual motorcycles. As of April 2015, the mannequin's design is being filed for an intellectual property (IP) protection. The motorcycles' design parameters which were collected via the D5EM110N mannequin was then tabulated into the Motorcycle Design Parameter Database (MDPD). The database is then could be utilized to set up the Postura Motergo™ to accurately replicate the desired motorcycle model's workstation design parameters. This is vital in ensuring that the motorcycle simulator could accurately simulate an immersive user experience to the subject in utilizing the desired motorcycle model. By having this novel database and mannequin design, researchers have greater opportunity in conducting various studies in a controlled laboratory setting with respect to motorcycle workstation designs and its possible connection with road accidents.

Peer-review under responsibility of AHFE Conference

Keywords: Motorcycle; Ergonomics; Accident; Mannequin; Database

* Corresponding author. Tel.: +06-013-636-891.
E-mail address: muhammad.izzat87@gmail.com

Peer-review under responsibility of AHFE Conference
doi:10.1016/j.promfg.2015.07.575

1. Introduction

Motorcycle road accidents is a global transportation safety issue [1]. In Colombia, motorcycle represented 39% of the deaths from road crashes in 2010, and rose to 42% in 2012 [2]. Meanwhile, in Taipei, among 94 fatalities caused by the road accidents, 53.2% were involving motorcyclist [3]. Fig. 1 shows the fatal and non-fatal injury rates by year from 2001 to 2008 recorded in United States, involving the motorcyclist and pillions rider. From 2001 to 2008, motorcycle fatalities increased to 55% (1.12 per 100,000 persons in 2001 to 1.74 per 100,000 persons in 2008). In 2001, the numbers of motorcyclist increased, from 120,000 injuries to 175,000 between the years 2001 to 2008 [4]. This increasing number of fatal injury rate shows that many motorcyclists get involved in tragic accident because of rider's negligence itself and riders that push their motorcycle exceeding their limit [5]. This statistics justifies the need for continuous preventive actions and investigations in regards to minimizing motorcycle road accidents.

Annually, road accidents that occur in Malaysia are exceeding 400,000 cases and within this statistics, 7000 deaths were reported [6]. Statistically, it is documented that Malaysia is the top country within the ASEAN region based on the road fatality contingency per 100,000 of the country's population [7]. Road fatalities have shown a steady increase of 4% per year in the last 7 years, rising to 6745 in 2009 [7]. In contrast to other fatalities cases among the road users, since the year 1999, motorcyclist are leading the statistical list by 4070 cases [7]. From the statistical investigation in Malaysia [8], there are several items which were evidence. Firstly, the numbers of motorcycles registered annually coincides with the increase in the country's population. Secondly, as shown in Fig. 2, it was evidence within a 20 year period (1990-2010) that the increase in the number of motorcycle accidents is directly proportional with the increment of motorcycles being registered. Furthermore, Fig. 3 shows that at 60%, the risk of death involving motorcyclists is the highest in comparison to car 22%, followed by pedestrian 9%, bicycle and lorry both 3% and 1% for van, bus, and others road users [7]. These statistics clearly show the differences in road accidents ratio and mortality rates between motorcyclist and other road users in Malaysia.

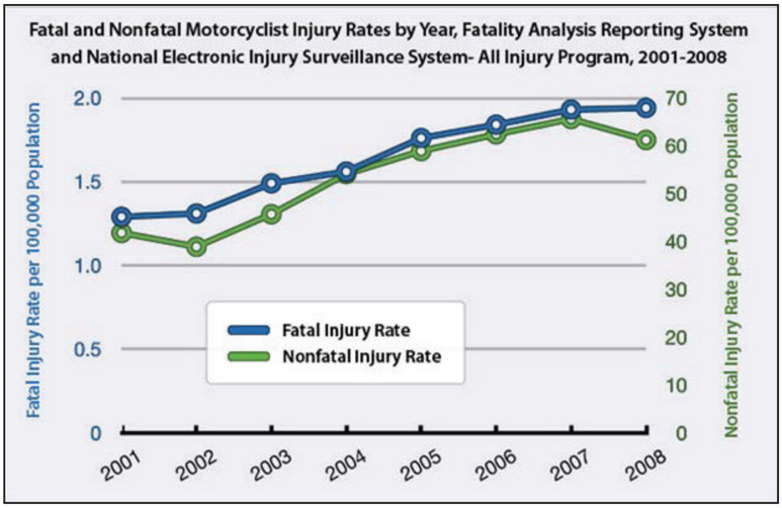

Fig. 1. Motorcyclist injury and death by year recorded in United States [4].

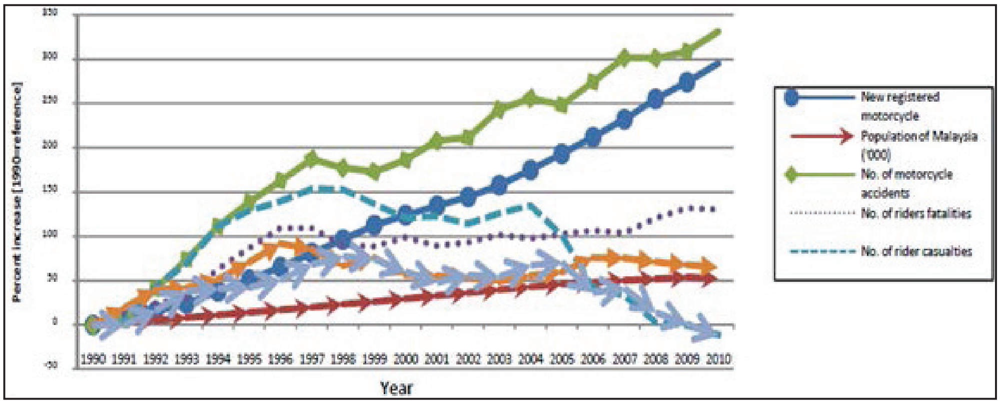

Fig. 2. Graphs of New Registered Motorcycle, Population of Malaysia, Fatalities and Casualties [8].

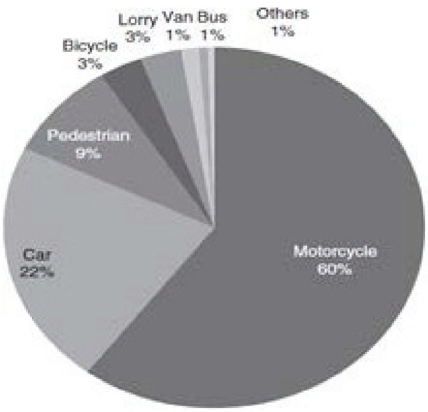

Fig. 3. Pie chart of the fatality distribution by transport's mode [7].

The main cause of the motorcycle crashes is extremely difficult to be specifically concluded. From behavioral aspects to rider's error, there is no one specific factor that could be singled out to directly contribute to motorcycling accident [4]. Henceforth, various studies have been conducted in order to gather greater information on motorcycling accident with the goal in minimizing the dire global phenomenon. One of the research methods performed is via the use of motorcycle simulators which could replicate the real world motorcycling conditions (albeit placing the test subject to any forms of danger) within a controlled laboratory setting [7]. This research method overcomes the risk (e.g. mortality risk) and difficulties (such as the attachment of measuring tools on the subjects, e.g. the use of surface electromyography) which are present in real world assessments [7]. Currently, there are several motorcycle test rigs have been established. Examples of these motorcycle simulators are the Honda SMARTrainer Motorcyle Simulator [9], MORIS Motorcycle Simulator [10], and the University of 3 Padova Motorcycle Simulator (UNIPD) [11]. The Honda SMARTrainer is assigned to be used as an educational training tool, while for the other two simulators were estanlished for research purposes. Fig. 4 shows the Honda SMARTrainer Motorcycle Simulator, MORIS Motorcycle Simulator, and University of Padova Motorcycle Simulator (UNIPD) respectively.

Fig. 4. Examples of established motorcycle simulators: (a) Honda SMARTrainerMotorcyle Simulator [9]; (b) MORIS Motorcycle Simulator [10]; (c) University of Padova Motorcycle Simulator (UNIPD) [11].

Based on the Riding Posture Classification (RIPOC™) system [12], a research project in establishing a low-cost motorcycle simulator was conducted in the year 2014 by the researchers of the Motorcycle Engineering Technology Lab (METAL) of the Faculty of Mechanical Engineering in Universiti Teknologi MARA (UiTM), Shah Alam, Malaysia. The newly established motorcycle simulator was named the Postura Motergo™ [13, 14]. The Postura Motergo™ with its adjustability features can replicate various types of riding postures as outlined by the RIPOC™ system [12]. This patented motorcycle simulator is currently available at Motorcycle Engineering Technology Lab (METAL) in UiTM Shah Alam, Malaysia. Fig. 5 shows the Postura Motergo™ test rig.

However, in reviewing the unique adjustability package of the Postura Motergo™, it was foreseen that there would be an issue in providing an immersive riding experience via the simulator with respect to the available motorcycle models in the market. This was because, prior to this study, the initial design feature of the Postura Motergo™ could only be adjusted with respect to the riding posture which is wanted to be assessed (adjusted according to the guidelines given by RIPOC™ system). In short, the initial setup was limited to assessment with respect to the human operator (the motorcycling riding postures). Assessment from the perspective of the motorcycle (the workstation) such as the effects of the tank/body design and shape of the handlebar could not be scientifically precise. Thus, there was a research gap with respect to the variation of research perspectives that could be conducted in utilizing the Postura Motergo™. In order to conduct research from the perspective of the motorcycle i.e. workstation design (design parameters), the Postura Motergo™ has to be able to be adjusted to accurately replicate various motorcycle model's workstation design parameters. In order to achieve this goal, a novel database that has the information on various motorcycle model's workstation design parameters is needed. This novel database of motorcycle design parameters will enables the Postura Motergo™ to be setup according to the workstation designs of motorcycles which are available in the market. The aim of this study was to establish a novel motorcycle design parameters database. In establishing this database, design parameters' measurements of various motorcycles which are available in the market have to be firstly taken. The tool used in capturing the motorcycle model's workstation design parameters was a specifically designed motorcycle's template mannequin.

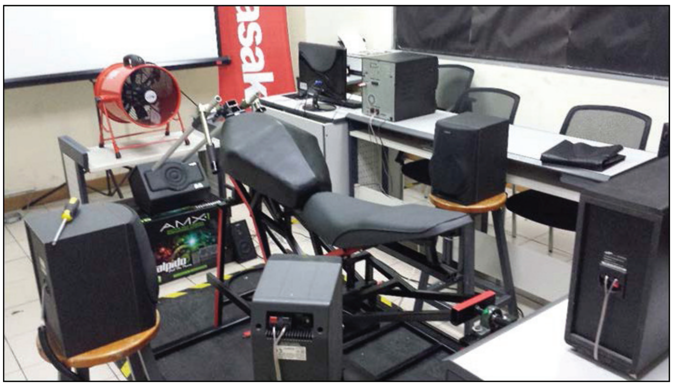

Fig. 5. The Postura Motergo™.

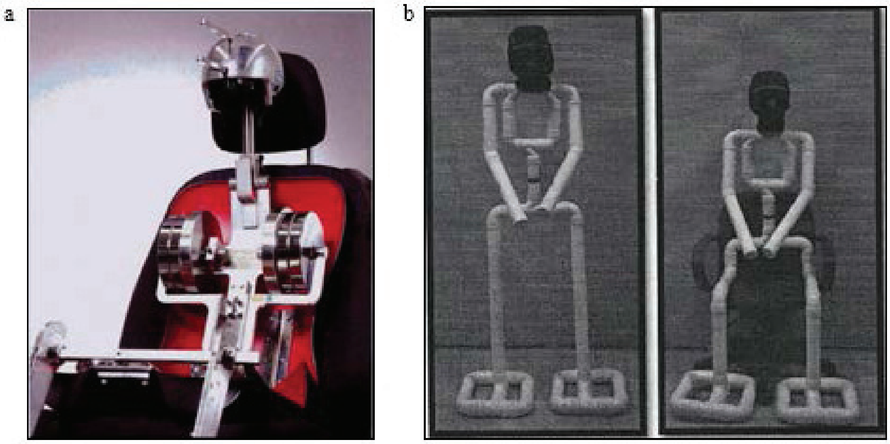

Fig. 6. (a) The Tier One; (b) The Welder mannequin.

1.1. Review on the use of mannequins in literature

Mannequin is imitation dolls used by the merchant to display their products which can introduce their latest product to the customer without bugging them during selling [15]. Basically, there are several types of mannequins which are abstract, headless, realistic, tailors, and display mannequin. The example of mannequin is shown in Fig. 6. Besides in the tailoring field, mannequin is also utilized in both the industry and research field. The mannequins of interest are: (i) The Tier One, and (ii) the welder mannequin, as shown in Fig. 6.

The Johnson Controls company has created a universal, hip-point and very accurate precision mannequin called The Tier One [16]. It meets the most three important specifications which are SAE, Euro NCAP, and VDA [16]. Apart from that, the mannequin is also being used for the medical education purposes. Furthermore, this mannequin was constructed from carbon fiber material [16]. The Tier One is a great example of a highly advanced mannequin. Nevertheless, in the respect of fabricating a highly advance mannequin from high quality materials, several issues are anticipated. Firstly, fabricating a highly advance mannequin will be a challenging task. Secondly, via the use of complex design and high quality material, the production cost for such mannequin is estimated to be considerably high. Finally, the involvement of high number of man-power in ensuring the success of such project is also expected. Henceforth, due to these anticipated issues, tediously planning and calculation at every stage of such project are advised to be mandatory.

A study has been established by Industrial Environment Research Group (IERG) in Faculty of Mechanical and Manufacturing Engineering from Universiti Tun Hussein Onn Malaysia. The researcher established a mannequin that is capable in replicating common body postures during welding works [17]. The mannequin was fabricated by using PVC hollow pipe fastened by metal plate and PVC connecter [17]. Additionally, it was noted that the spine is adjustable and its posture can be adjusted from standing to sitting or vice versa by reassembling the leg. Furthermore, the advantages presented by this dummy such as detachability, lightweight, water resistant, and can stand up to a certain stress were also described. Upon reviewing this dummy, it is agreed that this dummy can be set as one of the datum. Specifically was because the researchers had selected Malaysian anthropometry measurement to construct the dummy. This is essential since this study was also with respect to the Malaysian demographic. However, based on the mechanism integrated into this mannequin, in following similar steps taken by this group of researchers for a study on motorcycling, the following concerns are addressed.

Firstly, the joining which are utilized at the arms, knee, and torso cannot move freely and no measuring device that can compute its movement. In reviewing the mechanism used, it is anticipated that the mannequin's arms cannot move up and sideways as to follow the position of the handlebars of the motorcycle. Thus, the desired riding posture parameters dimension cannot be accurately captured via the mannequin. Secondly, the shape and measurement of the feet of the said mannequin are not suitable for the placement on the motorcycle's foot-pegs.

This square-shape foot are perhaps only suitable in ensuring that the mannequin could be set up to stand erected. For motorcycling research purposes (or at least in the respect of this study), only the sitting posture is assessed. Indeed, the RIPOC^{TM} system documented several types of riding postures for motorcycling. Even so, the reported postures are on the variation of the sitting posture. Henceforth, the important aspect here is the placement of the mannequin's feet on motorcycle's foot-pegs. At best, the mannequin's feet are designed to be similar with the human's feet. Finally, it is apparent that the welder mannequin is not equipped with hands. For study within the scope of assessing the working posture, it might not be an issue if the mannequin is not equipped with hands. However, for this study, it is highly critical that the mannequin has hands that are able to reach and grip the motorcycle handlebars. For only then the measurement of the desired measurements of the parameters could be taken.

In summary, the currently used mannequin in both the industry and research field are great references. Mannequins have been utilized in various industries, henceforth, having a specialized mannequin that is specific to cater for the need of motorcycling research purposes is essential. With respect to this study, in acquiring design parameters' measurements of various motorcycles which are available in the market a unique mannequin were designed and fabricated. The mannequin was named as the D5EM110N. The mannequin will provide the measurements of selected motorcycle workstation design parameters i.e. the workstation template, by placing the mannequin on the respective motorcycles' cockpits (location where the human operator would usually be seated). The mannequin was then adjusted to 'fit' into the respective motorcycles' cockpits. By 'fitting' the mannequin into a particular motorcycle's cockpit, the template for the particular motorcycle workstation design parameters could be obtained. This information was then transferred into a motorcycle design parameters database. The database was named the Motorcycle Design Parameter Database (MDPD). However, certain issues have to be taken into considerations – mainly on functionality design and overall fabrication cost.

2. Research methodology

The research methodology was separated into two stages. The stages were as follow:

2.1. Stage 1: The Design and fabrication the mannequin using established design parameters as proof-of-concept

The research methods used in this stage were:

2.1.1. Literature assessment

Literature assessment was performed in acquiring the information on the anthropometric attributes of the Malaysian male. Furthermore, the mannequin designs previously used by researchers in the industry and academic field alike were reviewed and served as design reference. The literature was obtained from the UiTM Online Library database and ergonomics books.

2.1.2. Computer-Aided Design/Computer-Aided Engineering (CAD/CAM)

The D5EM110N mannequin was design was developed extensively using DS CATIA V7. The selected CAD/CAM provides accurate 3D depiction of the mannequin which ease the design process.

2.2. Stage 2: The establishment of the Motorcycle Design Parameter Database (MDPD)

The research methods used in this stage were:

2.2.1. Field study

A field study was performed in gathering the workstation design templates of several selected motorcycle models in the market. The motorcycles tested were 2009 Kawasaki ZX10R, 2012 Kawasaki ZX2R, 2012 Yamaha 135 LC, 2012 Yamaha FZ 150, 1998 Kawasaki Vulcan 800 and 1997 Honda Magna 740. The information gathered in this stage was essential in the development of the Motorcycle Design Parameter Database (MDPD).

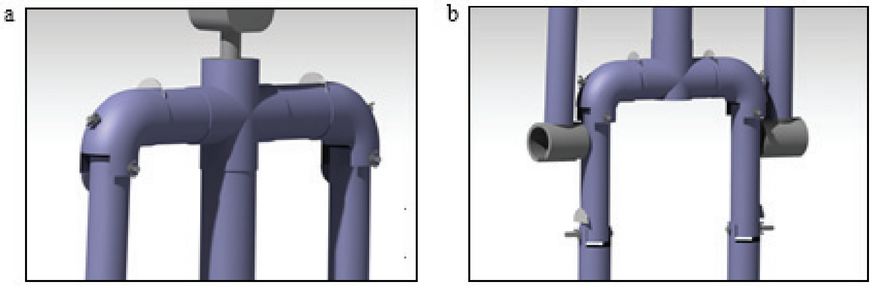

Fig. 7. (a) Adjustable shoulder; (b) Adjustable legs for the mannequin.

2.2.2. Software development

The Motorcycle Design Parameter Database (MDPD) was preliminary generated via Microsoft Excel.

3. Result

Fig. 7 shows the 3D model of the D5EM110N mannequin. The D5EM110N features the necessary adjustability in order to 'fit' seamlessly onto a motorcycle as a real human operator would be.

Table 1 shows the preliminary database developed in Microsoft Excel for the Motorcycle Design Parameter Database (MDPD). The database provided the information on several workstation designs templates for several motorcycles. The information was then be able to be transferred into the necessary adjustment language of the Postura Motergo™ motorcycle simulator.

Table 1. Preliminary database of MDPD.

Motorcycle models	D5EM110N					Postura Motergo™		
	a^0	b^0	c^0	d^0	e^0	x, m	y, m	z, m
2009 Kawasaki ZX10R								
2012 Kawasaki ZX2R								
2012 Yamaha 135 LC								
2012 Yamaha FZ 150								
1998 Kawasaki Vulcan 800								
1997 Honda Magna 740								

4. Discussion

The aim of this study was for the establishment of a novel database that gives accurate dimensioning (design parameters) of various motorcycles. In achieving this objective, a specifically built mannequin was developed as a tool to measure various workstation dimensions on actual motorcycles. The mannequin was named as the D5EM110N – a homage to the engineer who was responsible in the establishment of the Postura Motergo™ motorcycle simulator. The D5EM110N mannequin was built towards functionality engineering with sufficient aesthetic attributes. The mannequin has 5 degree of freedoms in order to be able to 'fit' into a motorcycle similar to a human operator would be. Henceforth, successfully provide a template 'fit' of several motorcycle models. The D5EM110N was also designed based on the anthropometric attributes of the average Malaysian male. The information captured via the D5EM110N was then utilized in the establishment of the Motorcycle Design Parameter Database (MDPD).

The Motorcycle Design Parameter Database (MDPD) is a database that provides information on several motorcycle models which are available in the market. In order to successfully capture the riding experience provided on different motorcycle models, the information provided by the MDPD is then translated to the Postura Motergo^{TM} motorcycle simulator. This enables for the motorcycle simulator to be adjusted accordingly. As of April 2015, the MDPD has 6 number of motorcycle models in the database. More data on various motorcycle models are currently gathered.

5. Conclusion

Conclusively, the D5EM110N mannequin was successfully fabricated. The particular mannequin serves as a vital tool in capturing the workstation design templates for several motorcycle models. The information captured via the D5EM110N was then utilized in the establishment of the Motorcycle Design Parameter Database (MDPD). By having this novel database and mannequin design, researchers have greater opportunity in conducting various studies in a controlled laboratory setting with respect to motorcycle workstation designs and its possible contribution/connection with road accidents. The use of the adjustable Postura Motergo^{TM} motorcycle simulator eliminates the need for preparing various real motorcycles during such assessment.

Acknowledgements

The authors would like to express their utmost gratitude to the Ministry of Education (MOE) Malaysia for providing the research fund for this study through the Fundamental Research Grant Scheme (FRGS/1/2014/TK01/UITM/02/3) and Universiti Teknologi MARA Malaysia for the Research Entity Initiative (REI) Grant Scheme. Special thanks also to Mohd Saiful Arif bin Bakeri, all members of the Motorcycle Engineering Technology Lab (METAL), the staff of the Faculty of Mechanical Engineering and the Institute of Graduate Studies in Universiti Teknologi MARA and the Human Factors and Ergonomics Society Malaysia who have, directly or indirectly, contributed to this research.

References

[1] L. I. C. Sàrl and Villars-sous-Yens, "Global Status Report on Road Safety," Switzerland2013.
[2] A. Jimenez, J. P. Bocarejo, R. Zarama, and J. Yerpez, "A case study analysis to examine motorcycle crashes in Bogota, Colombia," Journal of Safety Research, vol. 52, pp. 29-38, 2// 2015.
[3] J.-F. Tsai, C.-P. Chu, and S.-R. Hu, "Road pricing for congestion and accident externalities for mixed traffic of motorcycles and automobiles," Transportation Research Part A: Policy and Practice, vol. 71, pp. 153-166, 1// 2015.
[4] C. f. D. C. a. Prevention. (2012, 12/11/2013). Motorcycle Crash-Related Data. Available: http://www.cdc.gov/features/dsMotorcycleSafety/
[5] J. Adler. (13/11/2013). Common Causes Of Motorcycle Accidents. Available: Lawcore.com.htm
[6] Azhad. (2007). Statistik Kemalangan Jalan Raya. Available: http://blog.azhad.com/2007/11/statistik-kemalangan-jalanraya.html
[7] M. M. Abdul Manan and A. Várhelyi, "Motorcycle fatalities in Malaysia," IATSS Research, vol. 36, pp. 30-39, 7// 2012.
[8] N. Nasaruddin, Y. B. Wah, W. S. Voon, and M. A. Lazim, "Fatality Prediction Model for Motorcycle Accidents in Malaysia," 2012.
[9] J. Buchanan. (2008, 30 November). Honda SMARTrainer. Available: http://www.motorcycle.com/how-to/honda-smartrainer-86756.html
[10] D. Ferrazzin, F. Salsedo, F. Barbagli, C. Avizzano, G. Di Pietro, A. Brogni, et al., "The Moris Motorcycle Simulator: An Overview," SAE Technical Paper2001.
[11] S. Consortium. (2013, 30 November). Riding Simulator in Padova. Available: http://www.saferider-eu.org/demonstrators.html
[12] M. I. N. Ma'arof and I. N. Ahmad, "Proposed standard method for motorcycle nomenclature system," in Network of Ergonomics Societies Conference (SEANES), 2012 Southeast Asian, 2012, pp. 1-6.
[13] M. Hafizudin, "Thesis : An Ergonomic Motorcycle Test Rig based on Motorcyclist Riding Posture Classification (RIPOC) System," Bachelor of Engineering (Hons) (Mechanical), Mechanical Engineering, Universiti Teknologi Mara (UiTM), 2014.
[14] W. M. S. b. W. Fauzi, "Thesis : Integrating Human-Machine-Environment Interface (HMEI) Elements into an Ergonomic Motorcycle Test Rig to Replicate Near-To-Real Riding Scenario," Bachelor of Engineering (Hons) (Mechanical), Mechanical Engineering, Universiti Teknologi Mara (UiTM), 2014.
[15] M. S. Guide. (2013, 19 November). What are Mannequins? Purpose and its Importance in Retail Industry. Available: http://managementstudyguide.com/what-is-mannequin.htm
[16] (2013) Johnson Controls helps you to get straight to the point. Automotive Engineer. 41.
[17] A. Hariri, A. M. Leman, and M. Z. M. Yusof, "Application of Malaysian Anthropometric Data in Dummy Welder Design," iDECON 2012 - International Conference on Design and Concurrent Engineering pp. 20-24, 15-16 October 2012 2012.