Design of the Portable Motorcycle Cover

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Abstract. As fuel cost increases, majority of road users in Malaysia turns to motorcycle as an economical method of transportation. Unfortunately, the weather condition in this country is unpredictable especially with sudden rainy season. Due to this reason, the idea of a portable motorcycle cover has been developed. The objective of this project is to design a motorcycle cover, which can protect the user from rain and other weather condition. Currently, we are focusing the usage in a non-mobile (static) mode. The design shall focus on workability and ease of installation, followed by the affordability factor. This design was generated with the aid of CATIA software as the design tools. FEA simulation was performed in order to validate the performance. Result shows that the safety factor of the most critical section (rear compartment) is around 7.15, which is within safety range. Performance check on the prototype shows reliable result. In near future, more improvement shall be made towards the design to enhance the function and performance factor.

1. Introduction

Based from statistics obtained from the official website of Road Transport Department of Malaysia (JPJ) in 2014, the total number of motorcycle registration have increased to 1.16 million, coincides with the increase of population in this country [1]. This means that more than 46% of Malaysian road users are motorcyclists. One of the main reasons is the increase of fuel cost, which largely effects the low and averaged income users.

In general, majority of user prefer to use their motorcycle as the daily transport as it can save their budget, since any type of four wheeled vehicles shall consumes more fuel. In addition, the heavy traffic condition in most cities, especially during festive seasons is one of the culprits. Unfortunately, most common motorcycle does not provide any type of shelter or roofing to their user. This becomes a problem, due to the location of this country within the equatorial region, which contributes to the unpredictable heavy rainy season [2].

Statistically, motorcyclists are more exposed to critical accidents compared to other method of transportation [3]. The choice to continue the journey even during bad weather condition further increases this possibility. Result from a case study performed in Malaysia between 2010 and 2012, shows that the time of day and weather conditions contributes to fatal crash cases [4]. In rainy day for example, we can observe the behavior of most motorcyclists to drive in a high-risk driving pattern. They are exposed to risks such as by riding fast on slippery road or rushing to find shelter on unnecessary area. From here, we can conclude that the main factor that contributes to motorcycle crashes is the behavior of the motorcyclists themselves [5]. For these reason, we are aiming to support the motorcyclist
community, by providing a simple yet affordable solution. A portable motorcycle cover is seen as the most suitable option to solve this problem.

2. Literature Review
In this segment, we shall discuss on the main factors, which must be considered in designing the portable motorcycle cover. This includes market study of current motorcycle cover, the study on Malaysia’s climate condition, basic design specification and more.

2.1. Review on Current Product
Based from market study performed, our observation result shows that the number of product with similar concept is very minimum. In addition, these products also have a very limited number of users. Each product has their own advantages and disadvantages. Below are the summary of three related products, in terms of its features, specification plus other contents; with visuals shown in Table 1.

i) The fabric outdoor motorcycle cover
The weight of this motorcycle cover is around 0.45 kg, which is very light. The general idea of the product is to cover the motorcycle during storage. It is suitable for 125-155 cc motorcycles with rear box; which means that the maximum dimension covered is around 1.05 x 1.25 x 2.45-meter length (WxHxL). It also has a storage bag, with anti-theft lock hole and buckle strap design. This can prevent the motorcycle cover from being blow away by the wind [6].

Pros: Portable, lightweight & easy to use
Cons: Only able to cover the motorcycle (during storage mode) and does not protect the motorcyclist.

ii) The biker raincoat type
This product features a full body and rear mirror covered design. The weight of this motorcycle cover is around 1.0 kg with thickness of 0.24 mm. The maximum dimension that can be covered is 1.45 m for open length, 1.0 m for rear width, 1.2 m for front width and 0.3 m for header part height [7].

Pros: Portable, lightweight & easy to use
Cons: The motorcycle cover is easy to blow away by the wind. It also has a low aesthetic value (the design is too simple). The safety measures (anti-theft) is also not provided.

iii) The mobility scooter umbrella type
Finally, we have a product with most similar concept. The size of this motorcycle cover is around 1.4 x 0.5 m (Length and width). The overall weight is around 1.05 kg.

Pros: Portable and can be used in motion (but within limited speed limit)
Cons: Parachute effect may occur if over speed. Also, it needs more time to assemble and dismantle.

A concept score matrix was summarised based from these products. The score was made based from the engineering specifications and customer requirement. This includes certain criteria such as size, weight, reliability, assemble and disassemble factor, safety and cost. The score matrix was defined from 1~5 incremental range, with the highest number representing excellent value vice versa. As a result, the fabric outdoor motorcycle cover and mobility scooter umbrella gain the highest score. However, as the fabric outdoor motorcycle cover concept is more towards storage purposes, we shall focus more on the mobility scooter umbrella as the main benchmark instead.
Table 1. Concept Flow Matrix.

|                      | Fabric Outdoor Motorcycle Cover | Biker Raincoat | Mobility Scooter Umbrella |
|----------------------|---------------------------------|----------------|---------------------------|
| **Size**             | 3                               | 3              | 3                         |
| **Weight**           | 4                               | 4              | 4                         |
| **Reliability**      | 1                               | 1              | 3                         |
| **Ease of use**      | 2                               | 3              | 2                         |
| **Safety**           | 2                               | 1              | 1                         |
| **Cost**             | 3                               | 3              | 4                         |
| **Availability**     | 4                               | 3              | 2                         |
| **TOTAL SCORE**      | **19**                          | **18**         | **19**                    |

2.2. Main Issues of Current Product
The application of currently available motorcycle covers is quite complex. A cover which can protect both motorcycle and motorcyclist usually cannot be portable. It needs to be permanent installed or requires too much time to set up. Normally, a motorcyclist will ride as far as possible before they coming to a halt, either due to bad weather such as heavy rain or due to fatigue. Therefore, a simple assembly operation is required.

Another problem is space. In order to produce a good convertible or foldable motorcycle cover, space is needed to act as storage and mounting. However, most motorcycles have limited space. Therefore, the selection of space is one the main priority as it will effect the space consumption. The comparison of safety, reliability and ease to use factors need to be considered during the selection. In addition, the coverage area of the cover when opened must be optimized.

2.3. Malaysian Climate
Uniform temperature, high humidity and copious rainfall are the main characteristic of Malaysian climate. In general, the weather is changing from time to time in a single year, where the wind over the country is generally light and variable with some uniform periodic changes in the wind flow patterns. This wind flow patterns can be classified as the northeast monsoon, southwest monsoon and two shorter periods’ inter-monsoon seasons. The northeast monsoon commonly has winds of 10 to 30 knots, southeast monsoon has prevailing wind flow that below 15 knots and inter-monsoon winds are generally light and variable [2]. Since 1 knot is equal to 0.514 m/s, so the highest prevailing wind flow is around 15.433 m/s. Since the maximum wind velocity is around 16 m/s, so the approximation of wind load is around 154 Pa or equivalent [8].

3. Methodology

3.1. The Engineering Design Process
The development of this product can be divided into three major categories, which are the conceptual design stage, the design stage and the manufacturing stage. The flow process of this motorcycle cover shall be using Deming Cycle method, which involves ‘plan-do-check-action’ (Refer Fig. 1).
At the beginning, identifying the problems is done by performing study on the requirement of motorcycle cover and by comparing to products that is available in the market. The process is done after thorough discussions with designers and colleagues, product benchmarking process, by reviewing of related journals, patents and other documents. At the Plan stage, a Gantt chart is made to schedule this project, after having deep understanding of the problem statements. Since the period to complete this project has been decided, optimization of time is important.

Next stage is the Do stage. It consists of literature review, conceptual design, preliminary design and detail design parts. During literature review, the data or information is gathered to initiate possible solutions from earlier problems. Accumulation of information related to this theme such as road safety regulations, design safety factors, benchmark study of existing motorcycle cover, general summary of motorcycle type and its dimension, the weather condition in Malaysia and others. The source of this information is either from reference books, general observation, websites, journals and articles.

**Figure 1.** The design process flow
The conceptual design is the process where suitable concept is identified for this motorcycle cover design such as its shape and materials used. Aluminum has been chosen as the main material in order to reduce overall weight. This also includes consideration of overall size of the product. The final conceptual design is selected using Pugh chart. In addition, the 3D design of the product shall be made via CATIA during the preliminary design stage.

The next step is to analyze the design. This is where the evaluation process begins, where confirmation of material used, specific dimension and shape of the motorcycle cover obtained during the preliminary and detail design phase. The engineering detail drawing shall be made for each component, sub-assembly and assembly. In addition, the final drawing of this product shall reflect on the main information about it such as its dimensions, fabrication process, material type and more. One of the expected result is to reduce the assembly and disassembly time of the motorcycle cover.

Check stage is a phase after gaining the feedback from designer or potential user, either from meetings or discussion. It is important as the fabrication of the prototype for a motorcycle cover can be done if the final adjustment is made.

Finally, the Act stage is the final phase where fabrication of a tangible prototype for a motorcycle cover will take place. Machines shall be used during fabrication, which includes milling, cutter and column drill. Next, inspection shall be made on the product including the evaluation on dimensions, material specifications, manufacturing details and others; before proceed to the documentation stage where the overall report shall be made. Performance check is done during testing and inspection. As for this product, several design revision is expected in order to come out with the best reliable output. Reason given, the final product shall be used in a harsh and unpredictable open-environment. The design must passes through severe checking before it can be used. In this study, we shall focus on the first design cycle, which we define under the initial preliminary phase.

3.2. FBD (Free Body Diagram) analysis of the motorcycle cover

The objective of this calculation is to estimate the load and stresses, which is experienced by the motorcycle cover and indirectly the motorcycle itself. Next, suitable material shall be selected based on their properties.

At first, considering that the height and the width of the front windshield section is around 0.6 m and 0.4 m, resulting in affected area of \( A = 0.24 \text{ m}^2 \). As for the incoming wind speed, the average wind speed in Malaysia is considered around 20 [m/s] with allowable operating speed of vehicle around 40 [km/h]. The combination of both factor shall resulting in the maximum velocity of \( V_{\text{max}} = 31.11 \text{ m/s} \).

\[
\Delta P = \frac{1}{2} \rho v^2 \quad (1)
\]

\[
F = PA \quad (2)
\]

As for the convertible cover, the front windshield section shall receive direct load from upcoming wind. The dynamic pressure can be viewed from (1) which resulting in \( \Delta P = 604.9 \text{ Pa} \) (using \( \rho=1.25 \text{ [kg/m}^3] \)). Referring to (2), considering both affected area \( (A) \) and dynamic pressure, shall resulting in concentrated force of \( F=145.18 \text{ N} \).

From Fig. 2, we can see the free body diagram of the motorcycle cover from side view, where line AB represents the front windshield section, line BC represents the top cover and finally line CD represents the mainframe section. Through the calculation of equilibrium, we are able to define the loading at each critical position by considering the calculated force \( F \) as a distributed force applied at windshield area AB. As a result, the resultant force acting on point A, moving towards the vertical direction (upwards) is around \( F_{AY} = 111.34 \text{ N} \), whereas the horizontal load also at point A (moving to the left) is around \( F_{AX} = 43.66 \text{ N} \). Finally, the resultant load at point D is around \( F_{DY} = 15.34 \text{ N} \), which considered for vertical load only. This is because the rear position is fixed. From the calculation, we can conclude that the most critical area is the front lower portion. However, in the FEA simulation, we shall be focusing on the reliability of the rear compartment area. Reason given, our plan is to use a standard polycarbonate based front windshield as support, which is more reliable and firm. Whereas the rear
compartment needs to be more robust, as it support the load during storage and also during assembled mode.

![Figure 2. FBD of the motorcycle cover (from side view).](image)

4. Result and Discussion

4.1. FEA result
As informed previously, the rear compartment or the monorack has been selected for FEA analysis, since majority of the load of the product is concentrated on the rear side. From Fig. 3, the maximum deflection of the product is 0.172 mm, which is occurring at the rear side of the monorack, whereas the von Mises stress is around 11.6 MPa. Considering the yield strength of aluminum is 83 MPa, which brings to the safety factor of 7.15. Although the safety factor is within the safety range, we must take caution that this simulation was performed in static condition. A more thorough study needs to be performed towards the prototype before detailed design improvement can be made. We are expected to proceed with the dynamic analysis in near future.

![Figure 3. FEA analysis result of the rack (a) von Mises stress and (b) displacement.](image)
4.2. Validation of prototype

Referring to Fig. 4, we can simulate the prototype during folded mode and fully-opened mode. Basically, the estimated time to set up (open) the product to use is less than 4 minutes. To simplify the fabrication process and to reduce the part cost, the front windshield segment was made using thin plastic sheet. As we are focusing current usage in static mode, this condition able to serve the purpose. In future, we shall replace the design of the front windshield using permanent polycarbonate based.

![Figure 4. Final condition of the product in (a) folded-mode and (b) fully-open mode.](image)

The main frame was fabricated using extendable stainless steel mechanism. The main purpose is to monitor the mechanism during opening and closing state. When fully closed, majority of the parts including mainframe and top cover shall be situated on the monorack section behind passenger seat. Currently, the enclosed box design is still in progress. In future, the stainless steel mechanism shall be replaced by aluminum material in order to reduce the weight. Overall, the design of all parts especially rear structure section shall be polished and improved.

4.3. Workability and physical test

Several inspections and testing have been performed towards the prototype. The first one is the physical inspection on the product, including the evaluation of its dimensions, material specifications and manufacturing details. Basically, the structure and position of the cover frame needs to be symmetrical. Next, the prototype also undergoes a simple weather testing (in non-mobile or static mode). As the portable motorcycle cover is fully installed on the motorcycle and being set up (open), the spray water is applied at 3 positions (front, side and rear) as a simple rain simulation (Refer Fig. 5(a)). The main purpose of this test is to monitor the area coverage during rain. As a result, the product was able to cover up the minimum number of area. However, more consideration needs to be made to increase the coverage in case of side wind. Also, we are able to test the durability of the cover, as there was no water leakage coming through the fabric during test.

In addition, we also proceed with another additional test, which was to conduct an on-road test during maximum velocity of 40 km/h (Refer Fig. 5(b)). This was to experience the actual feel of the user, at the same time to monitor the stability of the motorcycle with cover attached during use. The test was conducted on a closed road section without any bystanders nearby. This is to ensure the safety of the user as well as the surroundings. The speed was increased gradually before reaching the maximum speed. As a result, the product maintained attached even during maximum velocity.

However, displacement still occurs especially at the front position due to upcoming wind. As informed previously, we shall replace the design of the front windshield using permanent polycarbonate based, as this will increase the stability during motion. Also, there was no parachute-effect experienced
during motion. Considering the preliminary design target, which was to confirm the reliability during static mode, we can consider this on-road test result as success.

![Image](a) ![Image](b)

Figure 5. Physical testing during (a) water splash/rain test and (b) on road test.

5. Conclusion
As the fabrication of the motorcycle cover mock-up design has been completed, the goal of this project has been successfully met. The basic calculation and simulation has been performed to monitor the performance of the critical region. An actual on-road test was performed to validate the reliability and performance of the product. In future, a wind tunnel test shall be conducted, as the velocity from the wind can be fully controlled and monitored, producing a better output.

We can also conclude that motorcyclists should be given more option to protect themselves from incoming weather via a more robust product such as the portable motorcycle cover. In term of safety, we are hoping that this motorcycle cover can ease the traveling journey, preventing from fatigue and possible accidents.

In future, further improvement towards the design is positively viewed. Consideration of a mobile mode is required as the current design is limited to static or non-moving condition. To ensure that the product can be used widely and legally, the study on the stability factor of the motorcycle should be improved. A more detail simulation on the design could be added in order to improve its reliability and performance. Finally, reduction of the overall part cost shall be made after considering the final design concept.

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References
[1] Laporan tahunan. (2014). Malaysia. Retrieved from www.jpj.gov.my/documents/10157/cc6788cf-fe2d-48ed-80ac-a121675665b6
[2] Malaysian Meteorological Department. (2013). Malaysian Meteorological Department. Climate General Information Malaysia _Retrieved October 1, 2017, from http://www.met.gov.my/en/web/metmalaysia. 1-21
[3] MIROS. (2016). Official Website of Malaysian Institute of Road Safety Research (MIROS). Malaysia. Retrieved from https://www.miros.gov.my.1-2
[4] Abdul Manan, M. M., Várhelyi, A., Çelik, A. K., & Hashim, H. H. (2017). Road characteristics and environment factors associated with motorcycle fatal crashes in Malaysia. IATSS Research, (risk factors contributing to traffic crashes in 9,176 fatal cases involving motorcycle in Malaysia between 2010 and 2012), 1–4.
[5] Ibrahim, M. K. A.-H., Nor, S. M. M., Mohamad, N. A., & Yusoff, M. F. M. (2012). A Case Study on Risk-taking Behaviour Among Motorcyclists. A Case Study on Risk-taking Behaviour Among Motorcyclists in Klang Valley, Malaysia (MRR 07/201). Klang Valley. 1-26

[6] "BA020 Motorcycle Cover 190T Waterproof", https://www.lelong.com.my/ba020-motorcyclecover-190t-waterproof-dustproof-uv-protection-cover-happyestore-I5784092C2007-01Sale-1.htm, Accessed on 1st Nov 201

[7] “Biker Raincoat Full Body Cover Moto”, https://www.lelong.com.my/biker-raincoat-full-bodycover-motorcycle-slicker-baju-hujan-motor-kavenneoh-I5786220-2007-01-Sale-1.htm, Accessed on 1st Nov 2017

[8] “Universal Motor Scooter Umbrella Mobility Sunshade & Rain Cover Waterproof Sale”, https://www.banggood.com/Universal-Motor-Scooter-Umbrella-Mobility-Sun-Shade-Rain-Cover-Waterproof-p-1194234.html?cur_warehouse=CNLaporan tahunan. (2014). Malaysia. Retrieved from www.jpj.gov.my/documents/10157/cc6788cf-fe2d-48ed-80ac-a121675665b6