Development of a Practical Motorcycle Towing Device

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ABSTRACT

Motorcycle to motorcycle towing device is not readily available in the Malaysian market. Most of the motorcycle towing service uses a pick-up truck to pick up the motorcycle. Such towing or on-site service fee can be too expensive anyways. In addition, some of the towing process is done only using a foot to propel the towed motorcycle. The aim of this project to produce a product that can be commercialize and solve the problem. In this project, a prototype is produced after the fabrication process. The prototype seemed to function. The length of the sling successfully retracted for storing, thus the sling retractor is working accordingly.

KEYWORDS: *Motorcycle, towing, safety, design*

1.0 INTRODUCTION

Towing is an act of pulling or dragging a driven object that fastened behind another driver object and by coupling these two objects together it will keep these objects together while in motion. Source of towing can be range from the biggest aircraft to a cow. These may be coupled by a chain, rope, bar, hitch, three-point fifth wheel, coupling, drawbar, tow bar or other means of keeping the objects in motion. The first vehicle that use the application of towing is tow truck which is invented by German automotive pioneer Gottlieb Daimler who also the inventor of the first world gas-powered motorcycle. Towing varies widely in scale and type, on land, water and in the air. The most common form of towing is the transport of disabled vehicle by a tow truck. Other than that, are motorcycle-trailer combination and cargo or leisure vehicles coupled via trailer-hitches to smaller trucks and bike as shown in Figure 1.

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Nowadays, the application of towing is used in many types of field and industry especially vehicle recovery industry. Vehicle recovery is towing assistance given to any disabled or broken-down vehicle to place of interest with the help of recovery vehicle like a tow truck. Recovery operators are the people who undertake the recovery service. Early motorists were often capable of carrying out minor repairs themselves but as automobiles became more complicated, this became more difficult to carry out successfully. Thus, towing service is needed to transport the broken vehicle to auto repair shop.

This project was ventured to redesign the device that used for towing between two motorcycles. This project will involve redesigning, analyzing and testing process for the improved design of the device for towing motorcycle which is required to fulfil the objective of this project. This device may help users to tow motorcycle by using another motorcycle especially in emergency. As the title is development of a towing device between two motorcycles, the challenge is to redesign and produce an improve device with better mechanism and portability. This mechanism would help people especially for motorcycle user that has the probability to face towing situation of their motorcycle. Commonly, motorcyclist use the vehicle recovery service that use powered vehicle such as truck or trailer to tow their motorcycle which will burden them with the expensive service charge of the vehicle recovery service. Other than that, there is other method for towing motorcycle, but it is not suitable to perform and can cause harm not only to motorcyclist but also to other road users.

Having finished product testing and analyze process, conclusions and recommendations can be made. The conclusion of this project is based on research objectives. It is considered successful if all objectives are achieved. The proposal would involve improvements that can be made for the studies that have been done.

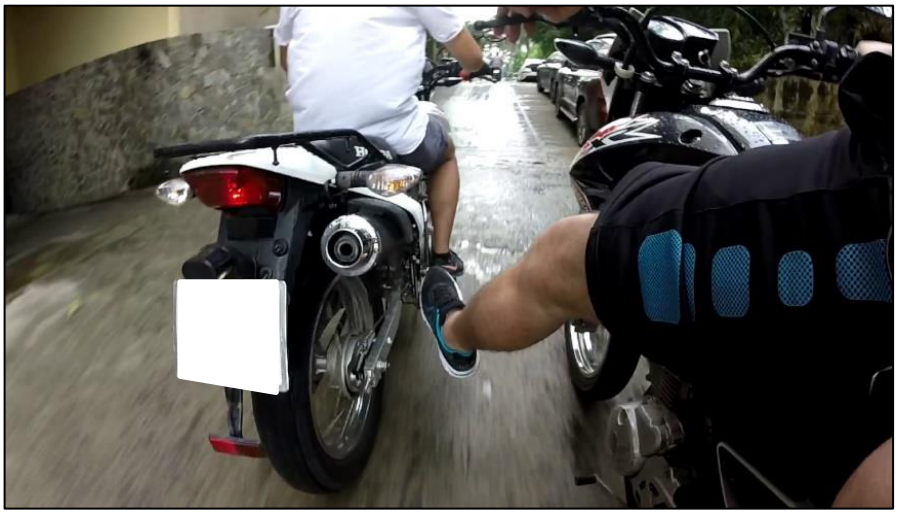
Figure 1. Trailer-hitcher for motorcycles (Tarakaner, 2014)

A towing apparatus for towing a two-wheeled vehicle, for example, a bike behind another vehicle, for example, a car. The apparatus incorporates a wheel bearer distinctly appended to the back of the towing vehicle by methods for a couple of keyed extending sleeves, one

of which stays joined to the towing vehicle. The bearer incorporates a support into which the significant controlling wheel of the towed vehicle rides. This apparatus needs two persons to connect the apparatus with the motorcycle. This apparatus came with optional cradles. There are single-cradle, two-cradle and also three (Fred, 1969).

Motorcyclist always have problem towing their motorcycle if their vehicle is broken down by the roadside or on the highway. They either call the highway operator, recovery operator or tow their motorcycle with the help of another motorcyclist. The problem when calling the highway operator or the recovery operator is an expensive service charge. Most of them will avoid calling those operators. They rather ask help from another motorcyclist to tow their motorcycle, but it may harm the motorcyclist and the other road users. It is harmful because the towing process involve physical help from human by using the human leg to push the broken motorcycle with the present of the motorcyclist controlling their driven motorcycle as shown in Figure 2. This push is extremely dangerous as it neglects the safety of both motorcyclists. Using a motorcycle as towing vehicle with proper attachment as a towing device can help to improve the method of towing motorcycle which is more affordable and efficient to the road user.

(a)



(b)

Figure 2. Using a foot in pushing another bike (a) in Malaysia and (b) Vietnam.

A motorcycle towing device incorporating a stage part with a front end for connection to the trailer hitch of a land vehicle. An upright part is oppositely joined to the backside of the stage part. A lift is specifically raised and brought down upon the upright part by methods for a jackscrew situated on the stage part. The lift has a head tube and a couple of turn orientation situated at the best and base of the head tube. The head tube conveys a rotate part. The rotate part has a carriage plate and a couple of turn arms expanding forwardly from the best and base thereof for significant engagement with the rotate direction. A couple of wheel engagement arms, for supporting a motorcycle wheel, expand rearwardly from the carriage plate (Cataldo, 2001).

This device consists of five main parts which are ball joint, universal coupling, connecting plate, connecting shaft and body frame. The body frame is to connect with both towing and towed motorcycle. The ball joint and universal coupling is to ensure the connection is flexible. The problem with this device is the size is very big and it is limited to only 110cc type of motorcycles only as shown in Figure 3 (Hasif, 2015).

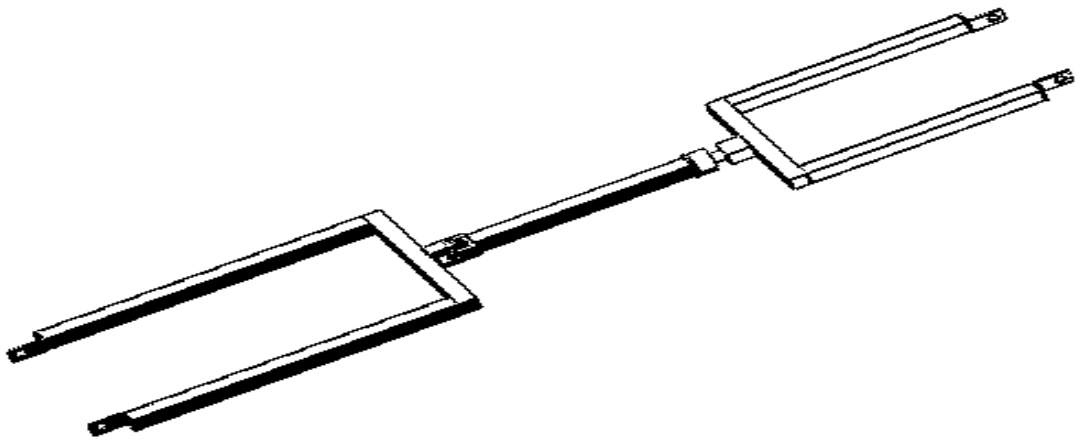


Figure 3. Towing device between two motorcycles (Hasif, 2015)

A quick detachable bumper hitch for towing a motorcycle that is manually operated to raise and bring down the front wheel of the motorcycle to keep it above the road surface on which the raise wheel of the cruiser is being bolstered. This device is particularly directed to a sturdy, lightweight bumper hitch for towing motorcycle. A hitch support portion which is detachably mounted on the vehicle's rear bumper and a rearwardly extending tow-bar portion detachably secured in wheel straddling relationship to the depending sides of the motorcycle's steering fork (Hancock, 1978).

The towing sling is one of the compact towing gadgets. This device is an easy to use towing link. It is an emergency towing device for a motorcycle or other vehicle for moving or towing the motorcycle from a one place to another. The compact normal for this gadget is reasonable for crisis reason while doing motorcycle activities, for example, cruiser escort or rally following exercises (Gertler, 1975).

Mild steel is a type of carbon steel with a low measure of carbon – it is also known as "low carbon steel." The measure of carbon ordinarily found in mild steel is 0.05% to 0.25% by weight, while higher carbon steels are regularly portrayed as having a carbon content from 0.30% to 2.0%. If any more carbon than that is included, the steel would be considered as cast iron. Less carbon means that mild steel is typically more ductile, machinable, and weldable than high carbon steel.

An advantage of the high carbon content which is championed by numerous fabricators is ductility, which makes mild steel greatly simple to cut, penetrate and weld to suit any extend. Not just a perfect decision of material for building move enclosures and edges, it is additionally hard sufficiently wearing to go about as an extremely viable edging material (Marc, 2013).

The absence of alloying components, for example, those found in stainless steels implies that the iron in mild steel is liable to oxidation (rust) if not legitimately covered. Be that as it may, the immaterial measure of alloying components likewise causes mild steel to be generally reasonable when contrasted and different steels. It is the affordability, weldability, and machinability that make it such a popular choice of steel for consumers.

Nylon is a sleek thermoplastic that is high strength, very durable and it is also elastic. Since it is a plastic, it is exceptionally impervious from such common nasties as molds, bugs, and growths. It is also waterproof and quick drying because water particles cannot easily penetrate the outer surface.

2.0 METHOD

The conceptual designs that have been draw will be pick and go a thorough inspecting process. At this stage a portion of the ideas will be exhibited and will be assessed in view of the criteria previously moving to the following procedure. The preliminary design will be choosing from the concepts using Pugh concept selection method. The chosen design which called the preliminary idea will be proceed to the following stage which is drawing the model by utilizing CATIA. Analysis will be made based on the drawing. If the result of the analysis is not as expected it turn to be it will go back to conceptual design and if succeed a model of prototype will be made. Testing of model is should have been led to ensure the model working admirably and safe to utilize.

Finally, a final modification will be made based on the testing on the prototype model result. The final design will be fabricated, analyzed and tested. All the findings and results of this project will be hold forth in the discussion part. Change that can be made on the towing device is expressed with the purpose of further research.

Conceptual design is the principal phase of the product design process, where illustrations and different outlines or models are utilized. This gives some initial ideas and sketches for easy communication with other people involved in this project that are based of many disciplines in engineering as explained in many sources like (Myszka, 2012), (Mills, 2016), (Hanson, 2017), (Hunt, 1978), (Ham, 1958) and (Dicker Jr. et al., 2016). There are a couple of things to be considered to design a product for example conceptual design, morphological chart, concept selection and preliminary design.

A morphological chart is a visual approach to catch the vital item usefulness and investigate elective means and mixes of accomplishing that usefulness. For every component of item work, there might be various conceivable arrangements. The chart empowers these answers for be communicated and gives a structure to thinking about option blends. This can empower the early thought of the item 'design' through the age and thought of various mixes of 'sub-arrangements' that have not already been distinguished. Utilized fittingly, it can energize a client driven way to deal with the age of potential arrangement.

There are three stages of this method. Right off the bat is the list the portrayal of the sub-function of the towing device that needs to be accomplished. The second step is to produce however many ideas as could be expected under the circumstances for each sub-work. In conclusion consolidate new ideas to the idea of people who meet every practical prerequisite.

Morphological chart for towing gadget between two bikes is appeared underneath in Table 1. There are two sub-function leaned to produce the possibilities of concept design. There are couple of discretionary ideas that identified with the sub-function that can be utilized as a part of request to get the best conceptual design.

Table 1. Morphological Chart for Towing Device (Nik Hak, 2018)

Sub-Function	Concept		
	A	B	C
Connection between motorcycles	Rigid Shaft	Ear Hook	Sling Tow
Joints	Coupling	Hook	Shackles

Concept selection is the way toward assessing concepts as for client needs and other criteria, looking at the relative qualities and shortcomings of the concepts, and choosing at least one concepts for advance research, testing, or improvement. In this stage, the assessed idea from morphological chart with the best characteristic will be pick. To make the selection easier, the concept design is visualized by sketching the concepts in order to give a clearer picture of the concept design. In view of the morphological chart, there are three ideas that can be produced. All the idea is the mix of the characteristic from morphological chart. Toward the finish of this stage, the best idea determination will be pick before continuing to detail design. Table 2 explains the general characteristics of the product that would form the product specifications.

Detailed design is where the design is refined, and plans, specifications and estimates are made. Detailed design can incorporate yields, for example, 2D and 3D models, cost develop gauges, acquisition designs and so on. This stage is the place the full cost of the venture is distinguished by and large. Detailed design is such a crucial need to makers that it exists at the convergence of numerous item improvement forms. Detail design is the last design activity to finish design process before advancement starts.

At the point when a project undertaking fabrication process, detail drawing which incorporates all the data about item or model is required as reference when led fabrication process. Other than that, detail drawing is required for drawing documentation for this project to give the clear picture of this product. Typically, the illustrations that are required in a project are isometric views, orthographic projections and solid models.

Table 2. Characteristics between conceptual designs (Nik Hak, 2018)

Characteristics	**Design 1**	**Design 2**	**Design 3**
Performance	This design has a flexible joint and highly portable.	Quick releasing technology to connect with the towed motorcycle front tire bolt.	It has a very high tensile strength and a very lightweight device.
Economy	Low manufacturing and material cost	High manufacturing and low material cost	Low manufacturing and material cost
Target production cost	RM 70	RM 100	RM60
Service life	1 year	1 year	3 years
Size	Width: 0.4m Height: 0.2m Length: 1.2m	Width: 0.4m Height: 0.2m Length: 1.2m	Width: 0.04m Thickness: 0.005m Length: 1.2m
Weight	5 kg	5 kg	2 kg
Material	Mild steel	Mild steel	Nylon
Ergonomics	Only compatible with certain motorcycle	Only compatible with certain motorcycle	Compatible with most motorcycle
Safety	A meter of distance between the motorcycle	A meter of distance between the motorcycle	A meter of distance between the motorcycle
Design Time	0.5 weeks	1 weeks	0.5 weeks
Appearance	Simple design	Complex Design	Simple Design

There are numerous techniques for producing drawing has revolt throughout the years. Prior to the innovation were developed, specialized illustration is utilized by engineers to produce drawing for some reasons. The aptitude of specialized illustration is profoundly required as the illustration is physically draft by the engineer and designer. As of late, PCs for all intents and purposes kill the specialized illustration as there are various PC helped outline programming, for example, AutoCAD, CATIA, SolidWorks and others.

For the detail design of the towing device, CATIA software is utilized to create the illustration that required for this project. The drawing incorporates all parts of the model drawing and assembly drawing of the model. CATIA (an acronym of computer aided three-dimensional interactive application) is a multi-platform software suite for computer-aided design (CAD), computer-aided manufacturing (CAM), computer-aided engineering (CAE), product lifecycle management (PLM) and 3D, created by the French-based corporation *Dassault Systèmes*. CATIA is the main item advancement answer for all assembling associations, from OEMs, through their supply chains, to little free makers. The scope of CATIA abilities enables it to be connected in a wide assortment of businesses, for example, aviation, car, modern hardware, electrical, gadgets, shipbuilding, plant outline, and purchaser merchandise, including plan for such different items as gems and apparel.

CATIA is used to create 3D drawing for this project. CATIA empower the production of 3D sections where it conquers the answer for shape, styling, expelling, alter and numerous different functions. Strong demonstrating with this product gives clearer photo of the first idea that has been chosen. Strong Works additionally empower to produce orthographic projection from strong displaying that will give diverse perspective of the of the illustration protest, for example, top plane, side plane and front plane.

4.0 RESULTS AND DISCUSSION

Through the use of screening and scoring selection processes, the third conceptual design was chosen as preliminary design and the design was modified to make it safer to use. This conceptual drawing is then drawn using computer aided design software. The design that was generated from the CAD software consist of assembly of the device and exploded view of the device.

Figure 4 displays the assembly drawing of the improved conceptual design that have been generated using CATIA software. The general dimensioning of the device also has been specified. The part drawings are assembled in the software to form the drawing. The exploded view will graphically explain what the parts in the device are.

Next, Figure 5 shows the exploded view of the device. The parts are labeled and named in the Bill of Materials table. This drawing also provide checklist for the fabrication process. Table 3 further describes each part in this towing system.

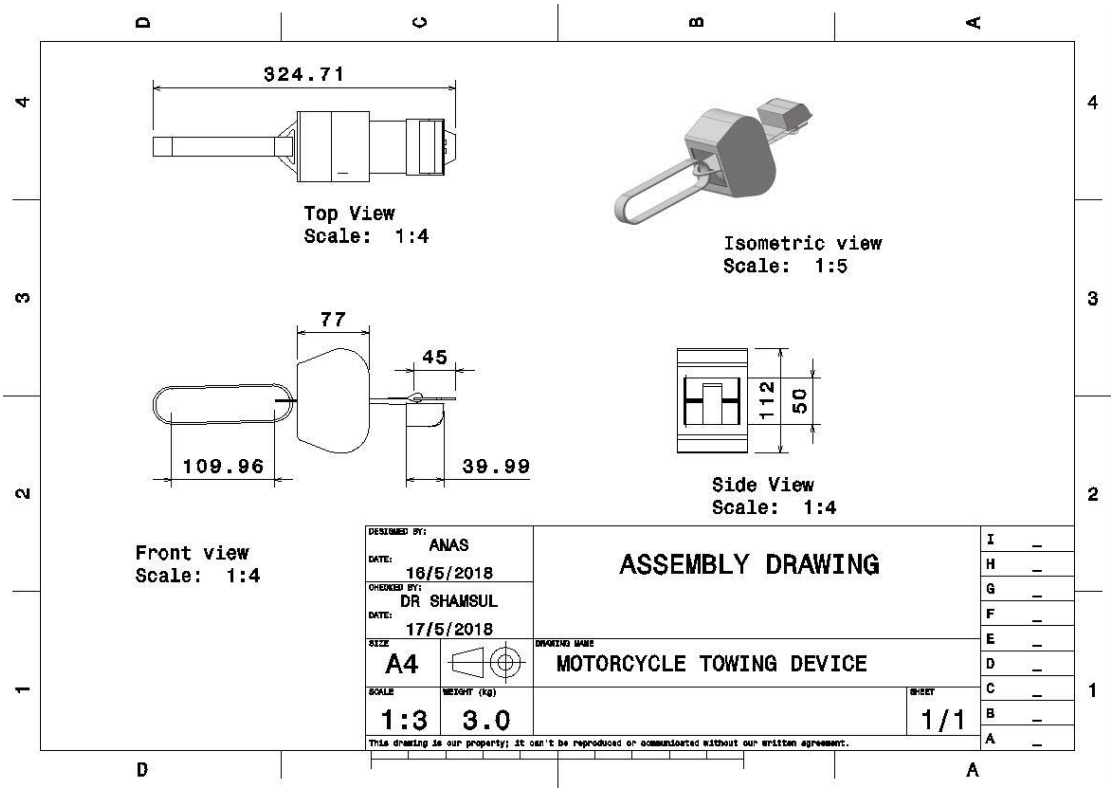


Figure 4. Assembly drawing for motorcycle towing device

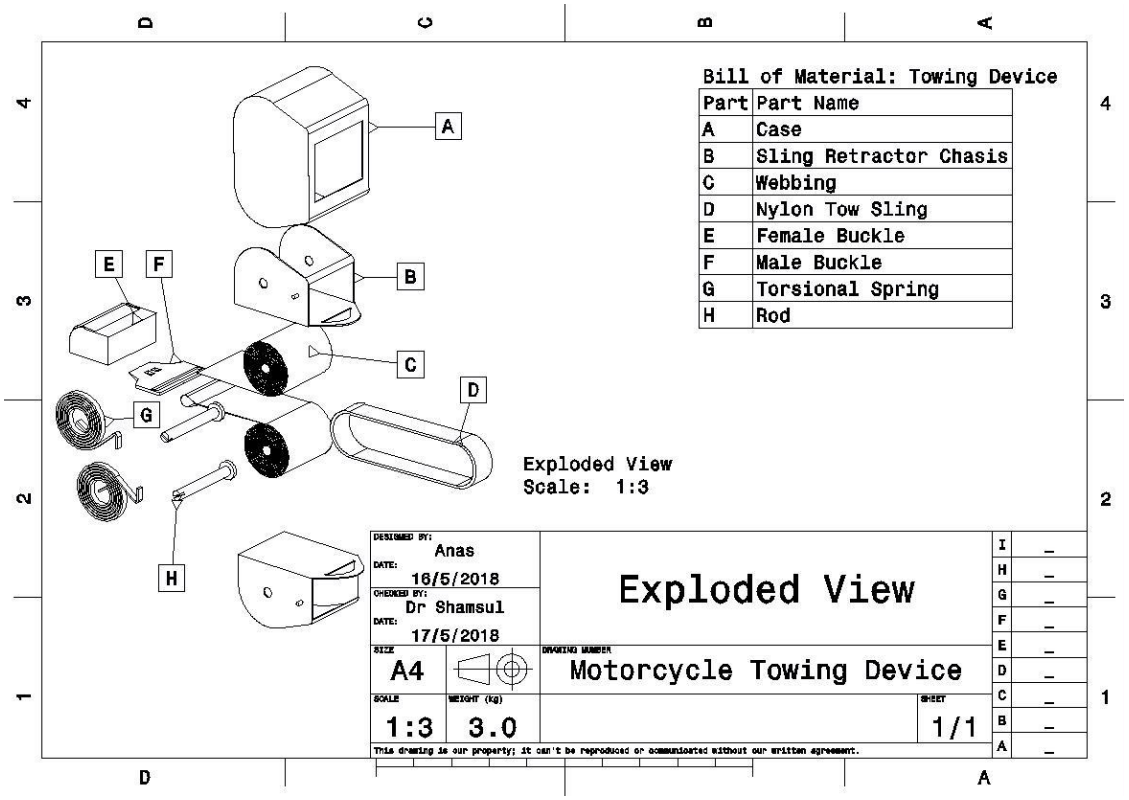


Figure 5. Exploded view of the device

Table 3. Parts and Description

Parts	**Descriptions**
Case	• To protect the chassis and the moving parts of the device • Aesthetic value
Chassis	• As the body frame of the device • To hold the rod in place
Sling	• As the connection between the towed motorcycle to the device • Maximum length for the sling is 0.65m
Nylon Sling Tow	• To connect the device with the towing bike • 0.3m in length
Female Buckle	• As a locking mechanism to lock the male buckle
Male Buckle	• To lock into the female buckle and secure the connection while towing process
Torsional Spring	• To help the process of retraction • It stores potential energy
Rod	• Connected with the rod • To hold and to store the sling

After the design is chosen and generated in the software. An experiment has been conducted to determine the towing force between the motorcycle from stationary to move on normal road. elevated roads up to 25° slope, single person towing (a rider on the troubled motorcycle) and also with a pillion rider. The motorcycles that have been used for this experiment were Yamaha LC 135 for the towing and Honda Wave for the towed bike, with the motorcycle wet weights of 110 kg and 105 kg, respectively. The data has been recorded. The rod which is the crucial part in securing the webbing with the chassis was run through Generative Structural Analysis using CATIA using the data in the experiment.

The pull force needed are reported in Table 4 below. The experiment was conducted to determine the towing force. Spring balance was used as a tool to measure the force taken by the towed bike to start moving. The spring balance was tied in between the sling connection. After that, the towing motorcycle will make sure the sling is tense between the bike. The towing motorcycle then will move forward as it slowly pulling the towed bike, the reading is then recorded. Each type of test ran five times to make sure less risk of error.

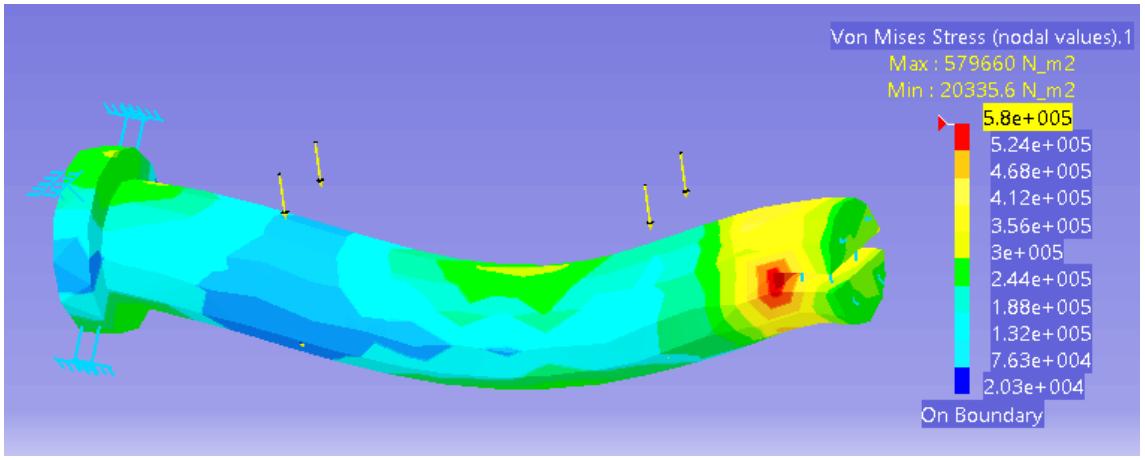
Table 4. Experiment Pull Force Results

Test	Average Towing Force (N)	
	Single Person	Passenger (Pillion Rider)
Normal Road	38	42
25-degree Elevated Road	40	45

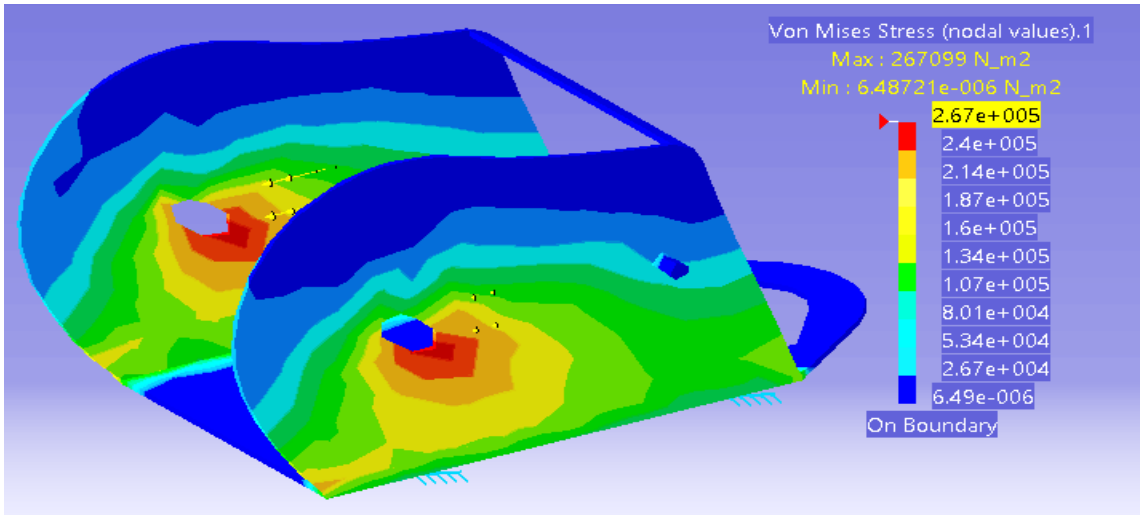
Generative structural analysis is an analysis that provided in CATIA software. This analysis will simulate the force that acted on the part and generate translational

displacement and Von Misses stress. The force that acted on the rod is 25 N and the force that acted on each rod openings on the chassis is 12.5 N.

Figure 6 show the distribution of stress of some parts under the load. The displacement is caused by the pulling sling that attached to the rod during the towing process. The maximum displacement (not shown) of the rod under the load is 0.000118 mm and for the chassis is 4.1677 mm. Von Mises stress result also produced in this structural analysis. Stress is produced on the rod when the load is pulled along the rod and also the stress affecting the chassis. The maximum stress is marked with red and the minimum is blue. The maximum von misses stress on the rod under the load is 579660 Pa and the minimum is 20335.6 Pa and the maximum stress at the rod openings is 267099 Pa then for the minimum is 6.487 MPa. These values are relatively low and further in-depth tests or simulation would be done to verify them.



(a)



(b)

Figure 6. Von Mises stress distribution on (a) rod pin and (b) chassis.

5.0 ON-ROAD TESTING

The prototype is tested on real situation at a maintained speed of between 30 to 40 km/h.

Two motorcycles are needed for this test, the towed motorcycle is Honda Wave 125 and towing motorcycle is Yamaha LC 135. The prototype is assembled and ready for the test. The test was observed, and the important data has been collected. The towing process was successful, and the prototype worked accordingly. Furthermore, sling retractor did pull the sling into the chassis to keep the connection away from the front wheel of towed motorcycle. Thus, the safety of both bikers and bike are well kept.

The result of this project has shown that the conceptual design has been successfully generated using CAD software, CATIA. Besides that, analysis also shown a good result in proceeding to fabrication process. The factor of safety is more than 1, thus making the prototype safe and could be fabricate. In addition, fabrication process with the guidance of the technical drawing was completed. Plus, a case that made from galvanized steel 0.5 mm was made to protect both sling retractors.

Moreover, the prototype keeps the connection away from the risk of tangling and successfully towed the motorcycle, but it tends to jerk the towed motorcycle when the webbing is retract then suddenly pulled to its maximum length. This jerking will affect the sling retractor rod integrity and if the jerking is too high, it might cause the safety of the towed biker. Figure 7 show the application of the towing device during the test.

(a)

(b)

(c)

Figure 7. Application of the device on both vehicles for road test.

6.0 CONCLUSION

A study was done to redesign a towing device for use between two motorcycles. Some concepts were generated by following morphological chart, then the developed concept was selected using a derivative of Pugh concept selection method. Then, data and result are achieved. In addition, this section helped me in improving the selected concept and will also help improve the design as the design description without disobeying the engineering characteristic before it proceeds to detailed design. Next, the detailed design is generated using CATIA. Finally, the prototype is tested in the real situation. The prototype solved the problems of previous device which is being rigid and big in size.

7.0 ACKNOWLEDGEMENT

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