REDESIGN OF MOTORCYCLE TOWING DEVICE FOR COMMERCIALIZATION

NIK AMIRUDIN ANAS BIN NIK HAK

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DECLARATION

I declare that this thesis entitled “Redesign of Motorcycle Towing Device For Commercialization” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : Nik Amirudin Anas Bin Nik Hak

Date : 19 May 2018

DEDICATION

I would like to dedicate this project to both of my parents, Nik Hak Bin Nik Mat and Roszaiyusnibinti Ibrahim who meant so much to me. This project also dedicated to my supervisor, Dr Shamsul Anuar bin Shamsudin since he has been my mentor during this project. Besides that, I would like to dedicate this project to my friends who helped me throughout this project.

ABSTRACT

Currently, there is no motorcycle to motorcycle towing device available in the market. Most of the motorcycle towing service uses a pick-up truck to pick up the motorcycle. Plus, the towing service price is quite unreasonable. This is because there is no standard price for the service and the service costly for the operator itself. 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.

ABSTRAK

Alatuntukmenundamotorsikalmasihtiada di pasaran. Tambahan pula, servismenunda motor yang sediaadatidakmenggunakanperalatanuntukmenunda motor tetapimerekamenggunakantrakuntukmengangkutmotorsikaltersebut. Hargauntukservismenundaini juga agak mahal. Hal ini kerana kos untukmelakukanservismenundabagipengendaliservisagak mahal. Selainitu, ada juga yang hanyamenggunakan kaki untukmenunda motor. Iniakanmembahayakanpenunggang dan jugakpenggunajalanraya. Matlamatprojekiniadalahuntukmenghasilkanproduk yang bolehdikomersialkan dan juga mampumenyelesaikanmasalahnya. Prototaiptelahdihasilkan dan difabrikasi. Prototaiptersebutberjayamenunda dan iniboleh di lihatapabilakepanjangananduhitubolehdipanjangkan dan akanditarikkembali.

ACKNOWLEDGEMENT

The achievement and ultimate result of this task required a great deal of direction and help from numerous individuals and I am to a great degree advantaged to have this up and down the fruition of my undertaking. All that I have done is just because of such supervision and help and I would not neglect to express gratitude toward them. I regard and express gratitude toward Dr Shamsul Anuar, for giving me a chance to enroll in this project and giving every one of us support and direction which made me finish the undertaking appropriately. I am to a great degree grateful to him for giving such a decent help and direction, in spite of the fact that he had occupied calendar dealing with the corporate issues. I would not neglect to recall both of my parents, for keep giving me motivation and support during this project.

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LIST OF ABBREVIATIONS

SYMBOLS	TITLE	PAGE
CAD	Computer Aided Drawing	6, 37, 43, 61, 62
CAM	Computer Aided Manufacturing	37
CAE	Computer Aided Engineering	37
PLM	Product Lifecycle Management	37
OEM	Original Equipment Manufacturer	37
PC	Personal Computer	37

LIST OF SYMBOLS

N	-	Newton
m	-	Mass

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

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 tractor-trailer combination and cargo or leisure vehicles coupled via trailer-hitches to smaller trucks and car as shown in Figure 1.1(a) and Figure 1.1(b).

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, analysing 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 of redesign 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.

Project also involves previous studies involving device for towing motorcycle. The study will cover all the method that suitable and related device that had been use for towing motorcycle. It involves the study of mechanism that commonly for towing device not only for motorcycle but also other vehicle. This will help to generate ideas to invent something new that can be applied into the product.

Having finished product testing and analyse 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 1.1(a): Truck-trailer combination from the source (Houston's Truck, 2015)

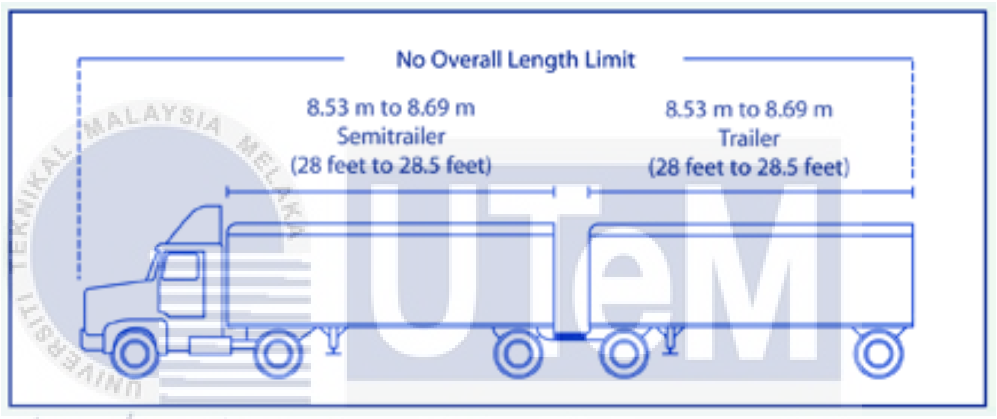


Figure 1.1(b): Trailer-hitcher (U.S. Department of Transportation, 2004)

1.2 PROBLEM STATEMENT

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 1.2. This towing is extremely dangerous and it neglects the safety of the both motorcyclist. Using a motorcycle as towing vehicle with proper attachment towing device can help to improve the method of towing motorcycle which is more affordable and efficient to the road user.

Figure 1.2:Foot as towing device

1.3 OBJECTIVE

The objectives of this project are as follows:

1. To redesign and to propose a new motorcycle towing device design for commercial use using CAD software.
2. To perform analysis on the new and improved design of the motorcycle towing device.
3. To fabricate the new and improved design of the motorcycle towing device.

1.4 SCOPE OF THE PROJECT

The scopes of this project are:

1. Focusing on designing a few improved designs based on the original design of the towing device by decrease the size, increase the portability and user friendliness.
2. Selecting the best design to meet the criteria of the commercial needs and analyzing the design.
3. Fabricating and testing the effectiveness of the device.

1.5 GENERAL METHODOLOGY

The actions that need to be carried out to achieve the objectives of this project are listed below:

1. Literature Review
    a. Journals, articles, or any materials regarding the project will be reviewed.

2. Conceptual Design
    a. Sketching a few improved designs from the original to meet the commercial criteria
3. Preliminary Design
    a. Choosing the best design of the sketches
    b. Drawing a 3D CAD full assembly model
4. Analyses
    a. Analyzing the structural force, stress and strain of the design
5. Prototyping
    a. Fabricate a prototype and test its effectiveness.
6. Final Design
    a. Improvements applied on the final drawing after the prototype testing.
    b. Finalized the drawing.
7. Fabricate The Final Design
    a. Fabricate the improved drawings into a working product.

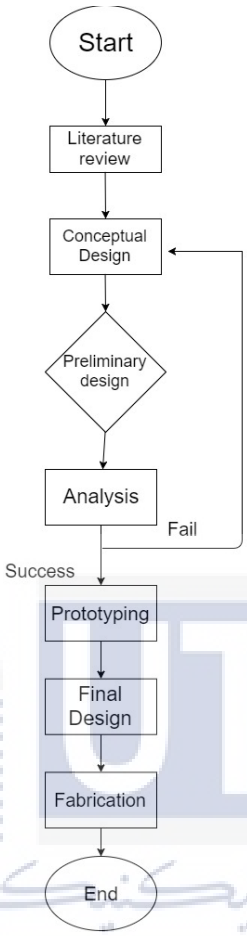


Figure 1.3: Project General Methodology

CHAPTER 2

LITERATURE REVIEW

2.1 PREVIOUS MOTORCYCLE TOWING DEVICE

2.1.1 PORTABLE TOWING SYSTEM FOR A MOTORCYCLE

A portable towing system for a bike or comparable vehicle, for example, a trike, theframe of which can be brought down to ground level to load the bike or comparable vehicle bypushing or riding the vehicle onto the frame without risking the vehicle tumbling off the ramp.The towing system might be reassembled, raised and brought down by a single person. Thetowing system came with a load box to store the casing when dismantled. The raising andbringing down of the casing is affected by a lifting and bringing down system is connected withwheel assemblies (Khoa, 2015).

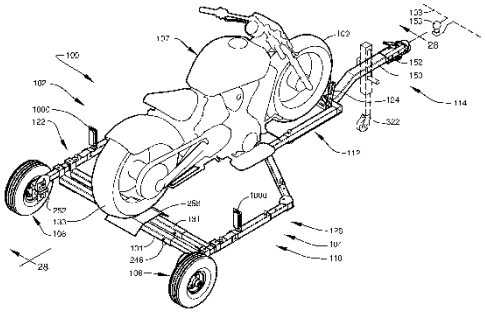


Figure 2.1: Diagram of portable towing system (Khoa, 2015)

2.1.2 TOWING APPARATUS

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 cradles and also three(Fred, 1969).

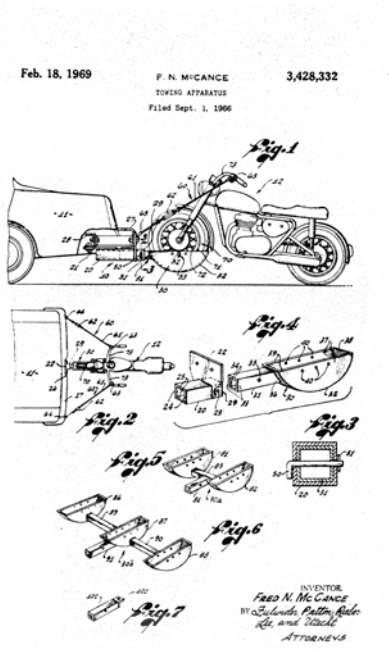


Figure 2.2: Diagram of the towing apparatus (Fred, 1969)

2.1.3 MOTORCYCLE TOWING DEVICE

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 (Ernest, 1993).

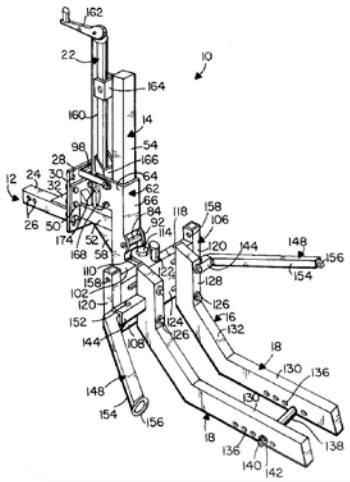


Figure 2.3: Diagram of motorcycle towing device (Ernest, 1993)

2.1.4 TOWING DEVICE BETWEEN TWO MOTORCYCLES

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 110 cc type of motorcycles only (Zharif, 2015).

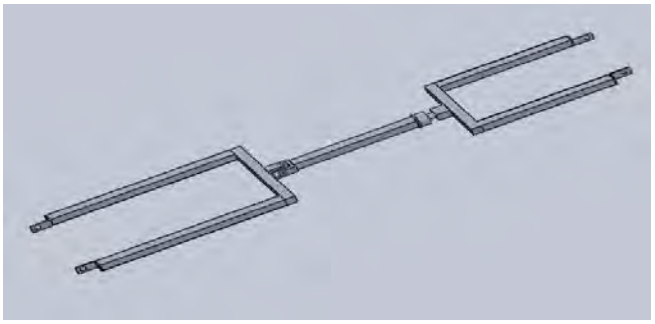


Figure 2.4: Towing device between two motorcycles (Zharif, 2015)

2.2 RELEVENT EXISTING DESIGN

2.2.1 BUMPER HITCH FOR TOWING MOTORCYCLES

A quick detachable bumper hitch for towing a motorcyclethat is manually operated to raise and bring down the front wheel of the motorcycle to keep itabove 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 wheelstraddling relationship to the depending sides of themotorcycle's steering fork (Lee, 1978).

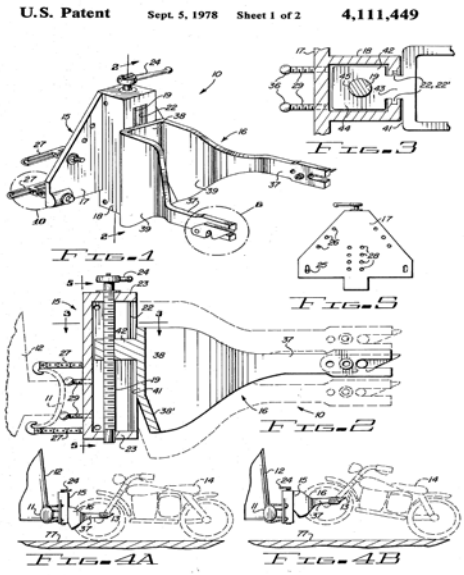


Figure 2.5: Diagram of bumper hitch for towing motorcycles (Lee, 1978)

2.2.2 TOW SLING

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 (Bernard H. Gertler, 1975).

Figure 2.6: Tow Sling (Ben-Mor, 2018)

2.2.3 WEBBING

Webbing is a solid woven texture discernible by its different material arrangements, quality contrasts, and widths. Showing up over various scope of uses and businesses, webbing can be found in military apparatus, climbing and outdoors rigging, for example, saddles, and car security highlights like safety belts. (Bally Ribbon Mills, 2016)

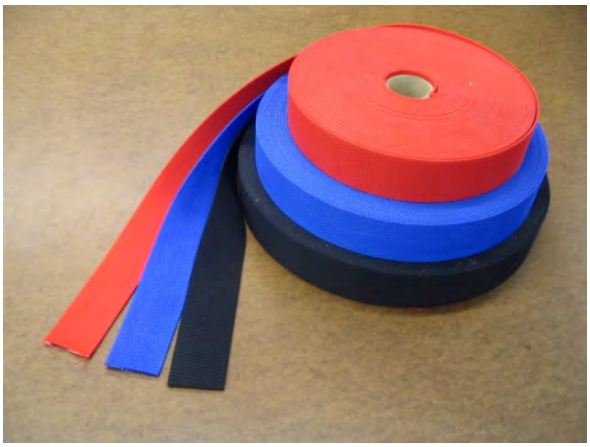


Figure 2.7: Webbing (Scottanon, 2006)

2.3 MECHANISM

It is a system of components that is in an orderly manner to transfer motion in a predetermined fashion.The word mechanism has numerous implications. In kinematics, a mechanism is a method for transmitting, controlling, or restrain relative movement (Hunt 1978). The focal topic for mechanisms is unbending bodies associated together by joints. A machine is a mix of unbending or safe bodies, framed and associated so they move with clear relative movements and transmit the force from the source. A machine has two capacities: transmitting movement and transmitting force. These capacities require quality and inflexibility to transmit the powers (Wendy, 2009). The term mechanism is connected to the blend of geometrical bodies which constitute a machine or part of a machine. A mechanism may in this way be characterized as a mix of inflexible or safe bodies, shaped and associated so they move with unmistakable relative movements as for each other (Ham et al, 1958).

2.3.1 KINEMATICS AND DYNAMICS OF MECHANISMS

Kinematics of mechanisms is worried about the motion of the parts without considering how the impacting factors (power and mass) influence the motion. Subsequently, kinematics manages the key ideas of room and time and the amounts speed and increasing speed got there from kinetics manages activity of powers on bodies. This is the place the impacts of gravity become an integral factor. Dynamics is the blend of kinematics and kinetics. Dynamics of mechanisms concerns the powers

that follow up on the parts - both adjusted and lopsided powers, considering the majority and increasing speeds of the parts and also the outside powers.

2.3.2 LINKAGE MECHANISM

A mechanism made from unbending bodies and lower pairs is known as a linkage (Hunt 1978).A pair is a joint between the surfaces of two inflexible bodies that keeps them in contact and moderately mobile.In planar (2D) mechanisms, there are two subcategories of lower pairs which are revolute pairs and prismatic sets, as appeared in Figures 2.8 and 2.9 below.

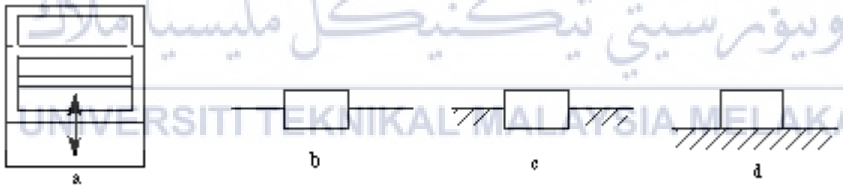


Figure 2.8: Prismatic Pairs (Carnegie Mellon University, 2010)

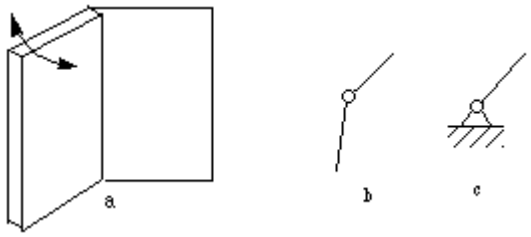


Figure 2.9: Revolute Pairs (Carnegie Mellon University, 2010**)**

The function of a link mechanism is to create pivoting, wavering, or responding movement from the revolution of a wrench or the other way around (Ham et al. 1958). Expressed even more particularly linkages might be utilized to change over a persistent pivot into nonstop revolution, with a consistent or variable rakish speed proportion,consistent turn into swaying or response (or the invert), with a steady or variable speed proportion and lastly swaying into wavering, or response into response, with a consistent or variable speed proportion. Linkages have various capacities, which can be characterized concurring on the essential objective of the mechanism which are capacity age as the relative movement between the links associated with the casing, the way age as the way of a tracer point, or movement age as the movement of the coupler link.

2.4 FACTOR AFFECTING THE TOWING DEVICE

2.4.1 WEIGHT OF MOTORCYCLE

Motorcycles have turned out to be one of the regular methods for transport today. They are quick and not at all like autos, can take you anyplace andvery convenient to utilize. There are a few types of motorcycles. Figure 2.8 below shows a few types of motorcycle.

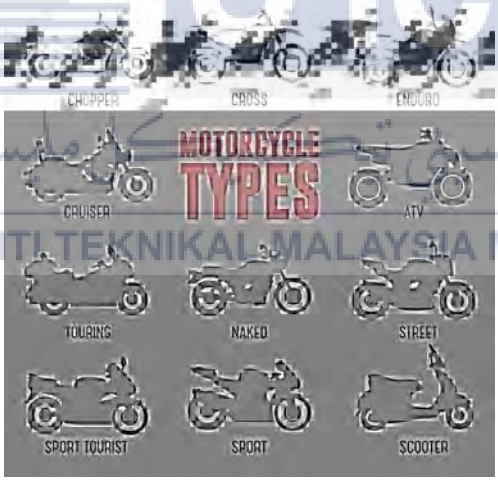


Figure 2.10: Motorcycle types (Peter, 2017)

All these types of motorcycle, they have been made according to their types and purpose by considering things like weight. The lightest sports bike would weigh

138 kg and its pre-2008 Kawasaki. That is when weighed while dry, but it also can go up to 150kg on street or wet. With regards to road legitimate bikes, the lightest is Yamaha XT225, and weighs around 108 kg, while dry. In all the bike models, the Harley-Davidson is by all accounts the heaviest. This super flow ships weighing 245 kg from the industrial facility while the Softail Heritage ships at around 331 kg. This affirms the prior said the way that bikes weight as indicated by the sorts and models. Averagely, a motorbike weighs between 90 to 320 kg, with varieties to things, for example when dry and wet weights put in place. (Peter, 2017)

2.4.2 MATERIALS OF THE DEVICE

Material of a product is very crucial in representing the product and to meet the standards and engineering characteristic. Material selection is very important because it will determine the quality of the product. These are the materials that will be used in this project:

2.4.2.1 Mild Steel

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 ascast 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.

2.4.2.2 NYLON

Nylon is a polymer a plastic with super-long, substantial particles developed of short, unendingly rehashing segments of iotas, much the same as an overwhelming metal chain is made of regularly rehashing joints. Nylon isnot really one, single substance yet the name given to an entire group of fundamentally the same as materials called polyamides.

Figure 2.11: Nylon Sling

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 moulds, bugs, and growths. It is also waterproof and quick drying because water particles cannot easily penetrate the outer surface.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter will explain about the methodology used to accomplish this project. In conducting a project, planning is required to avoid any problems during the research period. Therefore, several steps and procedure need to be assessed to ease the research process alongside getting the satisfied result such as designing process, House of Quality (HOQ), morphological chart, engineering design and analysis.

3.2 PROJECT REQUIREMENT

This task prerequisite is to develop a towing gadget between two motorcycles. The carefully and well planned for towing gadget between two bikes comprises of three fundamental parts. The first is outline part where it goes about as base that connection between those bikes. This part ought to be made by utilizing a flexible and rigid material keeping in mind the end goal to withstand heap of those two bikes. Second one, the frame should be light

weight and portable. Last but not least, the linkage mechanism must be properly chosen and universally compatible.

3.3 PROJECT FLOW CHART

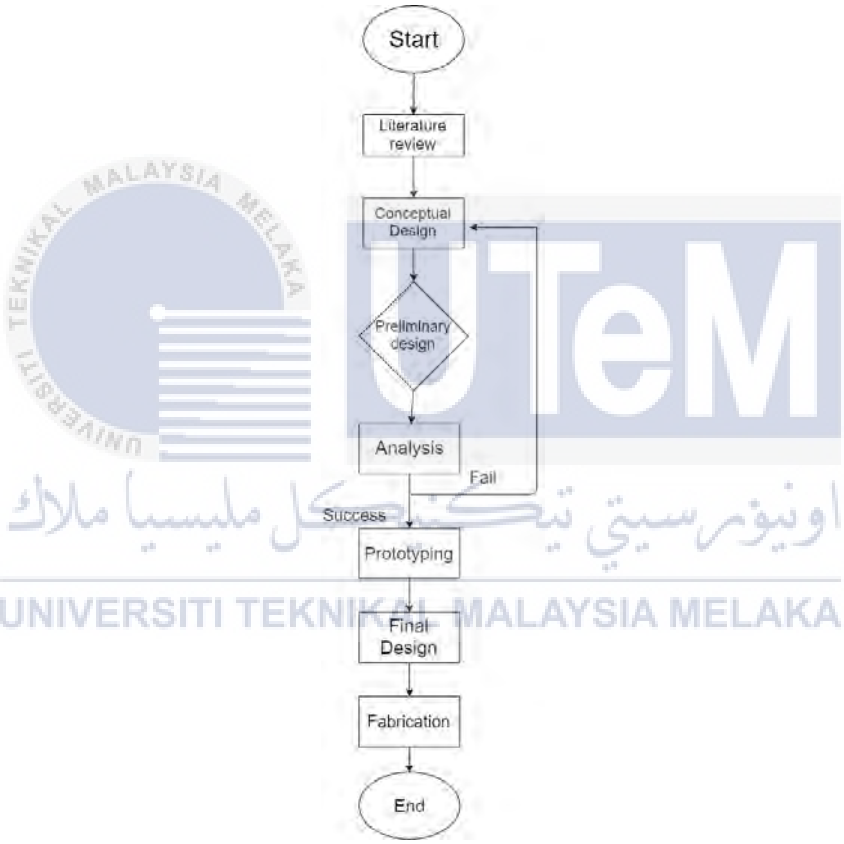


Figure 3.1 General Project Flow Chart

Figure 3.1 demonstrates the project flow chart. The task came with distinguishing problem statement, trailed by objectives and scopes of study. The objective and the scopes of

study are essential to decide project goals and cut off points for the task that need to be completed.

The project starts with a discussion about background study, idea and accessible system for towing gadgets will be expressed in the literature review part. This area clarifies all the previous towing device and designs that utilized for towing bike. Gadget for motorcycle towing that has been created or accessible in the market are recorded and disclosed to produce thought and idea with the end goal of the task. As such, this area is required for picking appropriate idea and mechanism for the towing gadget that need to be create.

The conceptual designs that have been draw will be pickand 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, analysed 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.

3.4 CONCEPTUAL DESIGN

In this segment, conceptual design technique is utilized to discussed on the best way to choose the best idea of the project. Conceptual design is the principal phase of the product design process, where illustrations and different outlines or models are utilized. It serves to give a depiction of the proposed product, as far as an arrangement of coordinated thoughts and ideas about what it ought to do, act and look like in a way that is reasonable for clients. It's grounded in more unique intuition until the point that a detailed design is prepared to be made. (Morten, 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.

3.4.1 DESIGN CONCEPT DEVELOPMENT

In this chapter, we will focus on concept development. Concept development is a stage that are done ahead of schedule in the engineering designmethod to gather and organize operational necessities and obstructions, create elective concepts to address the issues, and select a favored one as the reason for ability development and execution. The initial concept development process is imperative in light of the fact that a better design process prompts a better design result. Choices made amid the

beginning times of configuration firmly oblige future choices. It is assessed that 70% cost of anproduct is resolved in the initial 30% of the design cycle.

3.4.2 PRODUCT CONCEPT

Before continuing to other chapter, the concept of the towing gadget that need to be created must be set for easy to produce thought of the towing gadget. Based on the investigation of the concept of the towing device, the principal technique is decided for the towing device to be delivered. Thiswill includes connecting the device behind a moving bike. Other than that, the concept additionally considers the method for towing that utilized by a tow sling to interface both vehicle.From the perception of related device for bike, the mechanism is expected to give compatibility of the towing device. In this way, the component of mechanism, for example, linkage and joint is required for the towing device needs to be create.

3.4.3 MORPHOLOGICAL CHART

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 3.2. 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 3.1: Morphological Chart for Towing Device

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

3.4.4 CONCEPT SELECTION

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.

3.4.4.1 FIRST CONCEPT

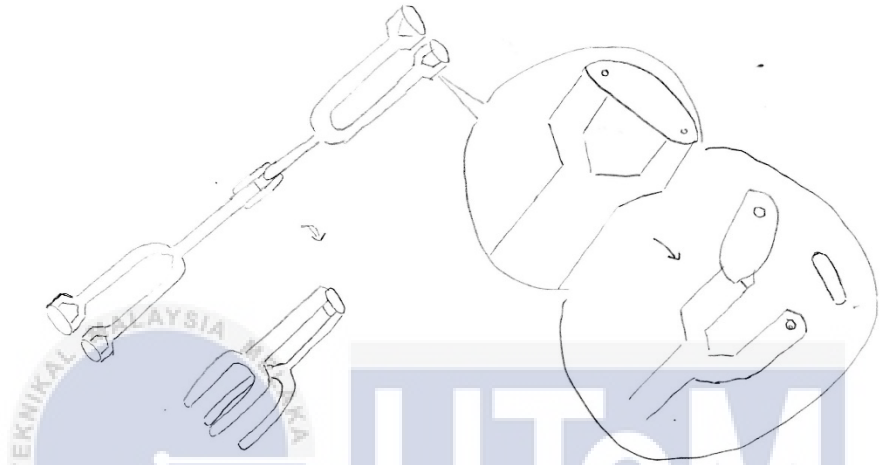


Figure 3.2: First concept for the towing device

As appeared in figure above, the first concept is demonstrating the design that utilizing inflexible shaft with a universal coupling as a joint. The bars are used to clamp the beam of the forks on both motorcycle. The benefit of this idea is the design is simple and it can be fold. The drawbacks of this device the size is quite big to carry around and it is look heavy.

3.4.4.2 SECOND CONCEPT

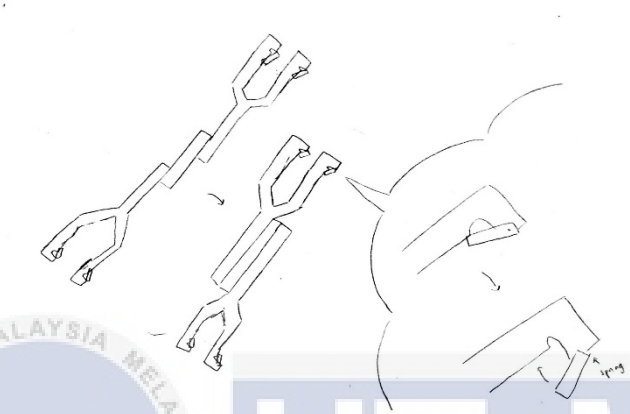


Figure 3.3: Second concept for the towing device

The second concept shows a quite complex design with hinge joint that connected both body frames. The body frames connect with the forks with quick releasing technology. It snaps into the bolts on the fork. This device can be fold into small square. The advantage of this design, it is easy to use and it is very portable. As the disadvantage of this device, the design is too complex, and the quick releasing technology is not very compatible with many motorcycles.

3.4.4.3 Third Concept

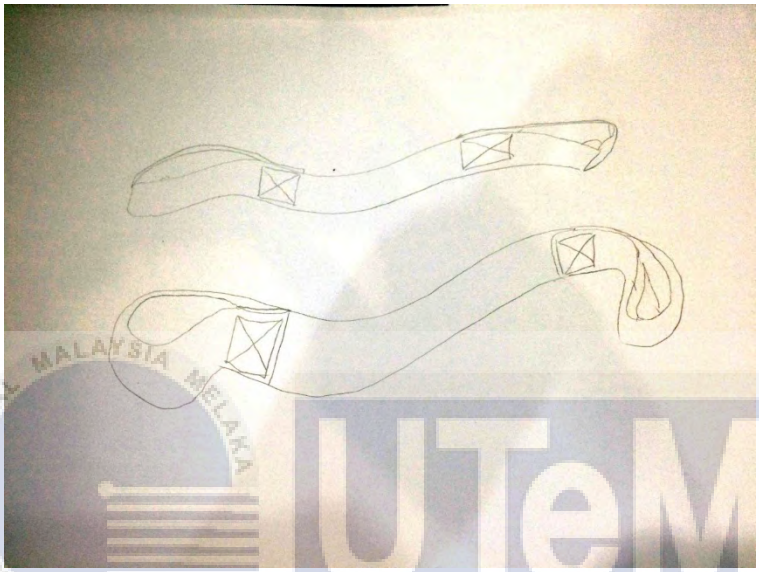


Figure 3.4: Third concept for the towing device

Third concept is a quite simple design. It utilizes two slings tow. One of the end of the sling will be tie on front forks of towed motorcycle and the other will be tie on the back of towing motorcycle. This device is user-friendly and very customizable. The advantage of this device is the device is lightweight, portable and small. On the other hand, this device come with many parts and it tends to tangle with the wheel of the towed motorcycle.

Table 3.2: Characteristics between conceptual designs

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

3.4.5 CONCEPT EVALUATION

Table 3.3: Pugh Table

	Design 1 (Datum)	**Design 2**	**Design 3**
CRITERIA			
Performance	0	+	+
Economy	0	-	0

Target production cost	0	-	+
Service life	0	-	+
Size	0	0	+
Weight	0	-	+
Ease of Material	0	+	-
Ergonomics	0	-	+
Safety	0	0	0
Design Time	0	0	0
Appearance	0	-	0
Evaluation			
∑+	-	2	6
∑-	-	6	1
∑0	-	3	4
Net Total	0	-4	5

Based on the result from the evaluation of Pugh table, design 1 is chosen as datum because the design is quite similar with the previous towing device. After all the decision have been taking into consideration in picking the most suitable design, the design 3 is chosen for preliminary design because it has the best result in comparison of criterion among the three conceptual designs.

3.5 DETAILED DESIGN

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 require in a project are isometric view, orthographic projection and solid models.

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, Solid Works and others.

For the detail design of the towing device, CATIAsoftware 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.

3.5.1 CATIA

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 organization 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 function. 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.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 RESULTS

The result of this task comprises of a few sections that are best conceptual design, detail design, testing of prototype and discussions related to the final product that has been fabricated.Before every one of the outcomes displayed, the item distinguishing proof of the towing device will be disclosed tosummarize the criteria of the item that required for the towing gadget that should be accomplish. Likewise, the investigation and testing result additionally will be talked about in this section.

4.1.1 PRODUCT IDENTIFICATION

The purpose of product identification is to decide the criteria that should be accomplished for designing a new product.The criteria that have been distinguished can be utilized asguideline in designing and developing the towing device. There are

two sorts of criteria that has been distinguish for this task which arethe product characteristic and functional design.

4.1.1.1Product Characteristic

Table 4.1: Product characteristic

No.	Criteria	Characteristic
1.	Concept design	The motorcycle towing device should be highly portable, light weight and the connection should be flexible.
2.	Aspect of safety	Safety of both bikers and the road user is the main concern while considering the connection between the bikes.
3.	Ergonomic	The user feels comfortable and assured of the integrity of the device.

4.1.1.2 Functional Design

Table 4.2: Functional Design

No.	Criteria	Characteristic
1.	Mechanism	Sling tow with shackles to secure the connection.
2.	Assembly and joining method	Assembly by using welding, riveting and sewing
3.	Material	Mild Steel for the structure frame, nylon for the connection.

4.1.2 BEST CONCEPTUAL DESIGN

The best conceptual design has been selected by using Pugh Method. Pugh Method is utilized to assess different options against a benchmark. Three conceptual designs that have been proposed for designing towing device between two bikes. The best conceptual design was picked by screening and looking at every aspect, to achieve the best product.

Among the threeconcept that have been proposed, third concept is selected. This concept is more practical or commercialize and it has best implementable design contrasted with the other reasonable outline. This idea comprises of flexible connection between the bike and the ergonomics of the device.

The chosen conceptual design will be modified to make sure the conceptual is the best concept and it can apply in the real world. The sling tow has the risk to tangled with front wheel of the towed bike or even also tangled with the rear wheel of the towing bike. The length of the sling tow affecting the safety of both bikers. This will be overcome with the seatbelt retractor. The retractor will pull back in the sling whenever the distance between decrease and it is also can be pull until it reaches it maximum length of the belt.

Figure 4.1: Sling tow and seatbelt retractor

4.1.3 DETAILED DESIGN

The third conceptual design have been chosen as preliminary design and the design also have been 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.

4.1.3.1 3D MODELLING

The improved conceptual drawing was generated using CATIA software by Dassault Systèmes. This drawing is to illustrate the device in 3D technical drawing or model which the scale and dimension of the device is

represented. This is important to make sure the device is well understood. The 3D drawing of this device will be a guidance during the fabricating process.

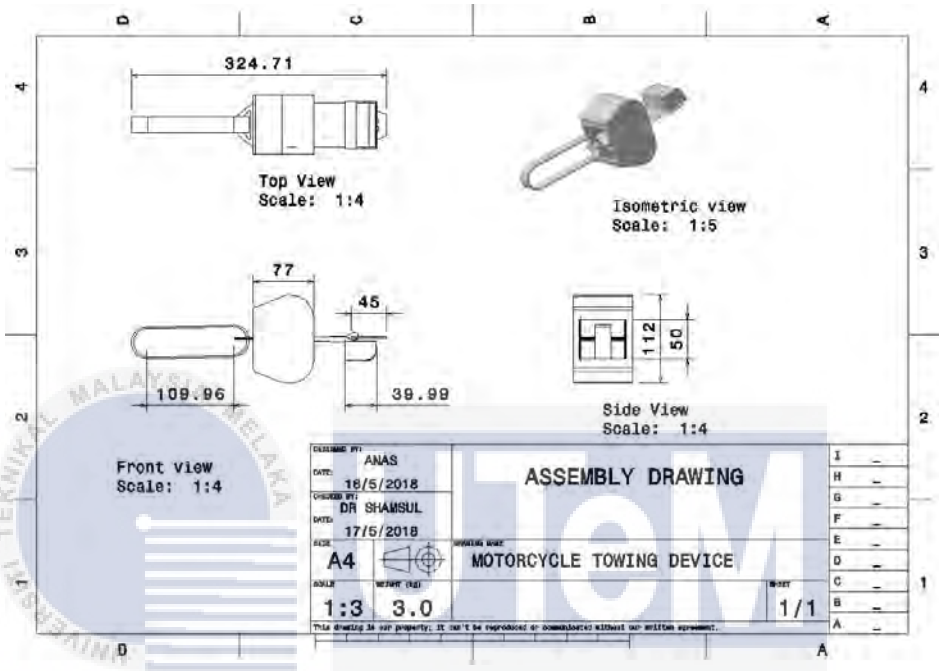


Figure 4.2: Assembly drawing for motorcycle towing device

Figure 4.2 shows 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.

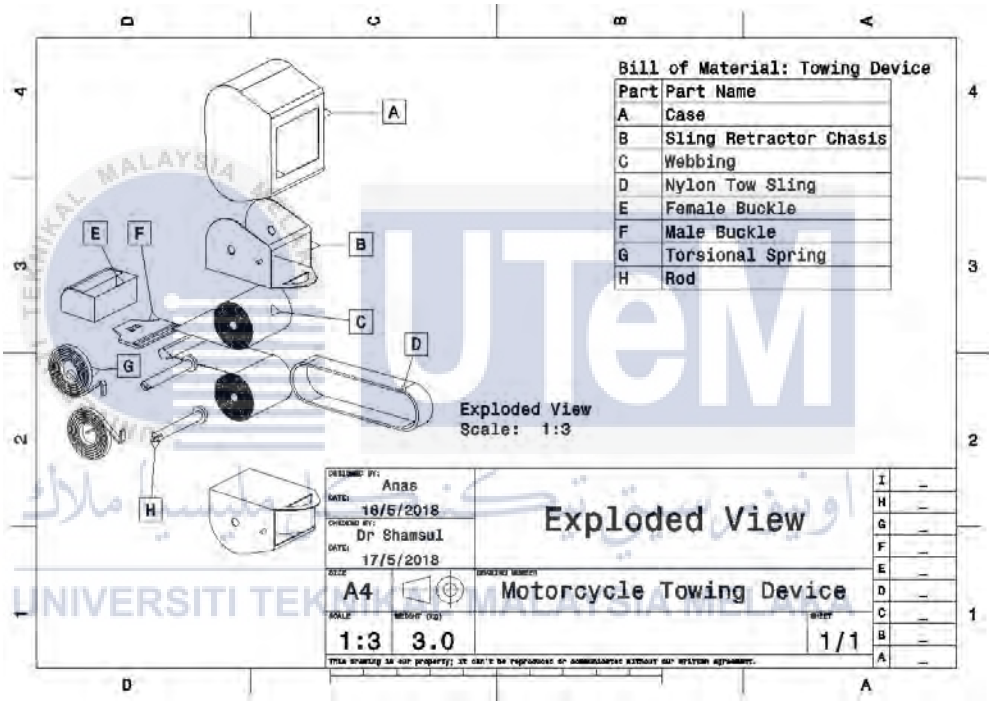
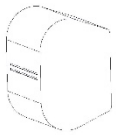
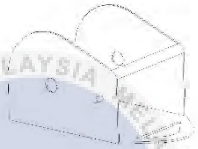
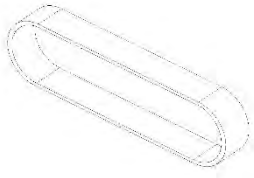
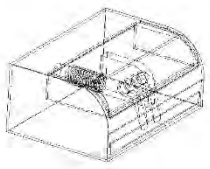


Figure 4.3:Exploded view of the device

The figures above show the exploded view of the device. The parts are labelled and named in the bill of material table. This drawing also provide checklist for the fabrication process.

Table 4.3 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 • Connected with the rod
 Rod	• To hold and to store the sling

4.2 DESIGN ANALYSIS

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-degree, single person towing and also with passenger. The motorcycles that have been used for this experiment was Yamaha LC 135 for the towing and Honda Wave for the towed bike, the motorcycles wet weight 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.

4.2.1 EXPERIMENT

Table 4.4 Experiment Result

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

Road		

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.

4.2.2 GENERATIVE STRUCTURAL ANALYSIS

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 25N and the force that acted on each rod openings on the chassis is 12.5N.

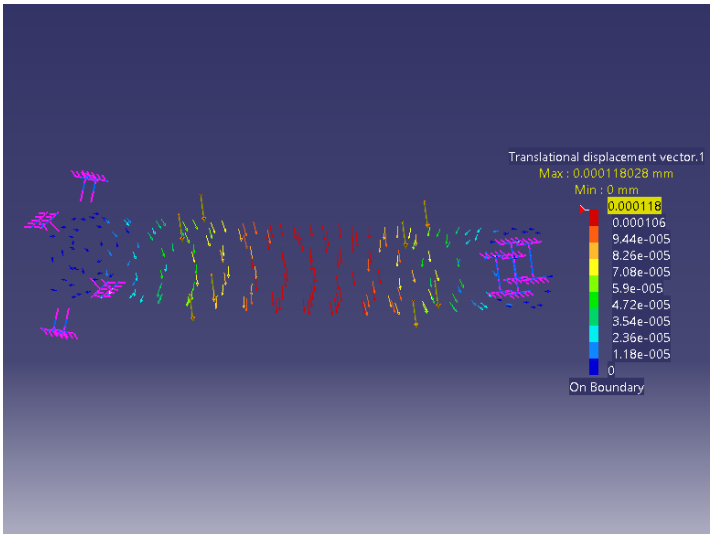


Figure 4.4: Transitional displacement of the rod

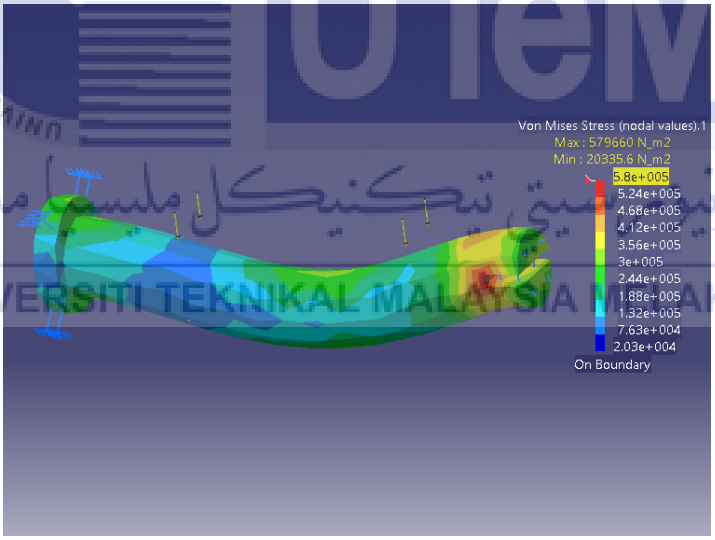


Figure 4.5: Von Misses Stress that act on the rod under the load

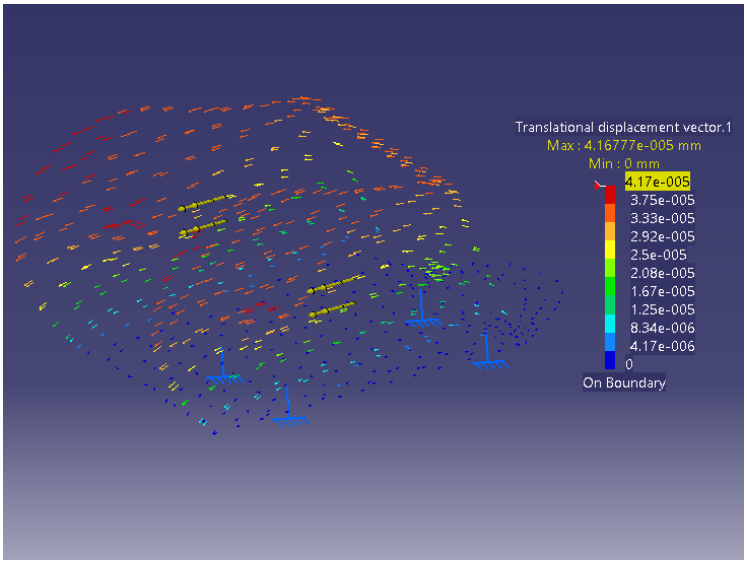


Figure 4.6: Translational displacement of the chassis

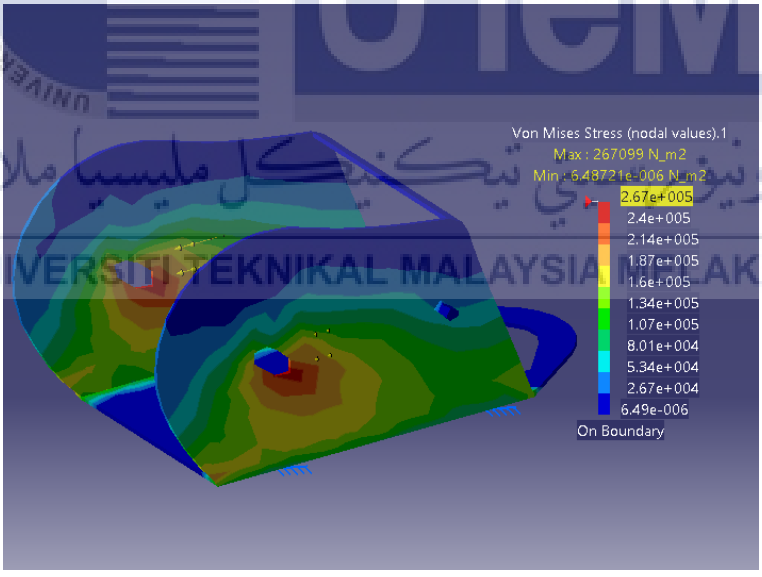


Figure 4.7: Von Misses Stress on the chassis

Figure 4.4 and 4.6 shown the transitional displacement of the parts under the load. This displacement is caused by the pulling sling that attached to the rod during the towing process. The maximum displacement of the rod under the load is 0.000118 mm and for the chassis is 4.1677 mm. Von misses stress result also produced in this structural analysis. Stress is produced on the rod when the load is pulled along the rodand also the stress affecting the chassis. Figure 4.5 and 4.7 showed that the stress heat map on the rod and chassis under the load. The maximum stress and displacement is marked with red and the minimum is blue. The maximum von misses stress on the rod under the load is 579660 $N/m^2$and the minimum is 20335.6 N/m^2 and the maximum stress at the rod openings is 267099 N/m^2 then for the minimum is 6.487 N/m^2.

4.2.3 CALCULATION

Factor of safety plays an important part in designing or producing a working product. Safety factor is a ratio between ultimate strength of the material or part to the actual working stress. Below is the calculation of this factor of safety. Each of the test will be calculated at the crucial parts of this device to find the factor of safety.

$$Actual\ Working\ Stress\ of\ the\ rod = \frac{Force\ (N)}{Area\ (m^2)}$$

$$Factor\ of\ Safety = \frac{Ultimate\ Strength}{Actual\ Working\ Stress}$$

$$Ultimate\ Strength\ for\ Rod = 579660\ N/m^2$$

$$Ultimate\ Strength\ for\ Chasis = 267099\ N/m^2$$

Table 4.5: Calculation Result for the Rod

Test	Actual Stress (N/m^2)	Factor of Safety
Normal road, single person towed.	9599.82	60.38
Normal road, two persons towed	10610.33	54.62
Elevated road, single person	10105.07	57.36
Elevated road, two persons towed	11368.21	50.98

Table 4.6: Calculation Result for the Chassis

Test	Actual Stress (N/m^2)	Factor of Safety
Normal road, single person towed.	151197.20	1.77
Normal road, two persons towed	167112.69	1.60
Elevated road, single person	159154.94	1.68
Elevated road, two persons towed	179049.31	1.49

Based on the table above, the minimum factor of safety is 50.98 and 1.49. Since the minimum safety factor is more than 1, thus can conclude that the rod is reliable enough to handle the load under those circumstances and the chassis is reliable to hold the rod.

4.3 PROTOTYPING

4.3.1 PROTOTYPE FABRICATION

The detailed design of motorcycle towing device is the fabricated. The device is fabricated according to the drawing that have been generated using CATIA software. The fabrication of this prototype has through several process such as cutting, welding, riveting, sewing, grinding, drilling and lastly finishing.

Figure 4.8: Motorcycle Towing Device Prototype

Figure 4.9: Seatbelt retractors

Figure 4.10: Light reflectors

The safety of using this prototype is added with light reflectors. The light reflectors are added to make the road users is aware of the towing process. The prototype is anything but difficult to fabricate in fact that it just includes straightforward and basic manufacture process. Besides, the items which made of material and part that simple to find in the market. The sling retractor is replaced with seatbelt retractor. This

preferred standpoint because the assembling expense of the item is low and modest, along these lines satisfy the client necessity that required a towing device which has sensible and moderate cost in the market.

4.3.2 PROTOTYPE TESTING

The fabricated prototype is then tested in real motorcycle towing, this is to ensure the device is not only working on paper but also in real situation. This testing also to test the reliability of device and the effectiveness of it. The prototype is then assembled on the towed motorcycle and also the towing motorcycle.

4.3.2.1 PROTOTYPE ASSEMBLY

Figure 4.11 Assembly of the device to the bikes

The nylon sling is first connected with the seat handle at the back of the towing motorcycle as shown as in Figure 4.11. Nylon sling and the seat handle connection should be secure and tight. The female and male buckle is then pulled and wrap around the neck of the towed motorcycle. Male buckle is then secured in the female with the click sound as shown in Figure 4.12. Both motorcycles are turned off before the assembly process. Figure 4.13 showed the towing motorcycle moved forward to increase the length of the sling until it tense. Finally, the device is ready for the towing.

Figure 4.12 Connection Between Handle and Nylon Sling

Figure 4.13 Female and male buckle are secured

Figure 4.14 The sling is tense and ready for towing

4.3.2.2 PROTOTYPE ON THE ROAD TEST

Figure 4.15Prototype Road Testing

The prototype is tested on real situation. 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.

4.3 DISCUSSION

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 it making the prototype is safe and could be fabricate. In addition, fabrication process with the guidance of the technical drawing was completed. Plus, a case that made from galvanised 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 intense it might cause the safety of the towed biker. These are the findings during the test observation.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

In conclusion, literature review is used to find the best pattern or design to be improvise. It is also as a guidance or a reference in redesigning a product.After that, conceptual design is where a few concepts are illustrated by following morphological chart then the concept is chosen using 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 CAD software which is CATIA. Afterwards, the detailed design helped through the fabrication process. 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. Based on the observation of the test, the prototype is having problem with jerking. The jerking will risk the prototype and most importantly the safety of the towed biker. During this project I had learn a lot from using CATIA, a CAD software in making designs of the device.Furthermore, I gained some skills in fabricating and also problem solving during this project.

5.2 RECOMMENDATION

Technically, there are still a few problems regarding this prototype such as jerking and the proper connection between towed motorcycle and the device. These problems can be solved in the future by using a removable extension at the neck. There will be a ball mount on the extension to make a proper connection. Besides that, a dampener will solve the jerking problem since the dampener will dampen the shock and making it more smooth towing.

Figure 5.1: Trailer Ball Mount

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