UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS ◆

JUDUL: DESIGN AND DEVELOPMENT OF SINGLE SEATER ELECTRIC SCOOTER FOR SHORT DISTANCE APPLICATION

SESI PENGAJIAN: 2008/2009

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DESIGN AND DEVELOPMENT OF SINGLE SEATER ELECTRIC SCOOTER FOR SHORT DISTANCE APPLICATION

ABDUL HAFIZ BIN RAMLI

A report submitted in partial fulfillment of the requirements
For the award of the degree of
Bachelor of Mechanical Engineering with Automotive engineering

Faculty of Mechanical Engineering
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SUPERVISOR DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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STUDENT'S DECLARATION

I declare that this final year project report entitled "*Design and Development of Single Seater Electric Scooter for Short Distance Application"* is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……..……...
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ACKNOLEDGEMENTS

First of all I would like to express my grateful to Allah s.w.t. as for the blessing can give that I can finish my project.

In preparing this paper, I have engaged with many people in helping me to completing this project. I would like to take this opportunity to express my sincere gratitude and appreciation especially to my supervisor, Mr. Gan Leong Ming for his constant guidance, invaluable knowledge, and constructive idea in leading me to accomplish this project.

I would also like to thanks to all of university staffs especially from Mechanical Engineering Faculty which is Mr. Mohd Fazli Ismail and Mr. Mohd Rizal for being co operative, nice, and very helpful. I appreciate very much to them due to the idea, information given and tech me to handle mechanical laboratories equipment very well.

Last but not least I acknowledgements without endless love and relentless support from my family and not forgetting to all my fellow friends, lecturers and other in giving me helping, advices and sincere supported.

Thank you very much.

ABSTRACT

This project is to design and develop of single seater electric scooter. It is rear wheel drive and operates by DC motor which takes energy from dual rechargeable batteries. The conceptual design of this model is comes from mantis behaviors which fold its hand to eat. From that, the conceptual design of this scooter makes to be foldable. Rear arm and handle bar recognize to be fold due to component attach on it Dimension of the scooter model comes from real human model. Handle height, seat and foot rest location is based on Malaysian normal human size. By using 3D software, the part of model started to sketch. Part by part create before assemble together to see the model how comes out. Modification on part done to makes it join perfectly. The strain stress of model then is analyzed by using CAE software. Modification by attach support is to make structure more strong at critical point. In materials using, mild steel is choose as a main structure and joining by welded. It covers by aluminum from 6000 series with 2.5mm thickness. These materials also for rear arm main structure. Rivet at certain part is use to join this materials to steel plate and main structure. Component of model attach by bolt and nat. For the transmission, it use gearing to change rotational of DC motor. Power from that then transfer to rear wheel by sprocket and chain. From technical drawing and conceptual design, component of model being fabricate using FKM laboratory tools. Part by part create then be fabricate together. Several parts being in refinement process to make sure it can be joining very well. At the end of the project, the model tested by several person and their comment then being record. This model can work properly after all work done.

ABSTRAK

Projek ini adalah untuk menghasilkan dan membangunkan sekuter elektrik satu tempat duduk. Ia adalah pacuan belakang, digerakkan oleh motor arus terus yang mendapat tenaga dari dua buah bateri boleh cas semula. Rekabentuk model ini diperolehi berdasarkan pemerhatian pada kelakuan mentadak dimana ia melipatkan tangan untuk kaedah pemakananya. Daripada situ, konsep rekabentuk boleh lipat dipilih untuk model ini. Bahagian lengan belakang dan pemegang tangan dikenalpasti untuk direka bagi membolehkan ianya dilipat. Saiz skuter ini berdasarkan model manusia sebenar. Tinggi pemegang tangan, tempat duduk dan tempat pemijak kaki adalah diukur dengan menggunakan saiz biasa warga Malaysia. Dengan menggunakan perisian 3 Dimensi, bahagian-bahagian komponen yang diperlukan dilukis besertakan ukurannya. Komponen seterusnya dicantumkan untuk melihat gambaran sebenar model yang akan dihasilkan. Pengubahsuaian pada lukisan dilakukan bagi mendapatkan sambunagn yang tepat. Ketegangan dan tekanan pada model dianalisis dengan mengguakan perisian CAE. Pengubahsuaian dilakukan dengan menambah penyokong untuk memastikan struktur lebih kukuh pada titik yang menerima tekanan tinggi. Bahan yang digunakan adalah *mild steel* untuk kerangka utama yang disambungkan secara pematerian arka. Ia dilitupi oleh aluminium dari keluarga 6000 series berketebalan 2.5mm. bahan ini juga digunakan untuk struktur lengan belakang. Pencantuman kaedah rivet digunakan untuk menyambungkan aluminium ini dengan plate besi dan kerangka utama. Komponen model diikat dengan menggunakan bolt dan nat. untuk Sistem penghantaran kuasa, ia menggunakan gear untuk menukar gerakan motor. Kuasa seterusnya di hantar ke roda belakang dengan menggunakan rangkaian rantai dan spoket. Daripada lukisan teknikal dan konsep rekabentuk, komponen model ini dibuat dengan meggunakan alatan yang terdapat dalam makmal kejuruteraan mekanikal. Bahagian-bahagian yang dihasilkan seterusnya dipasang dan pengubahsiuaian untuk membolehkan komponen dipasang dengan baik dilakukan. Diakhir projek, model skuter ini diuji oleh beberapa orang dan komen mereka direkodkan Model berfungsi dengan baik setelah semua kerja selesai.

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CHAPTER 1

INTRODUCTION

1.1 AN ELECTRIC SCOOTER

An electric scooter is a battery-operated one-person capacity vehicle that is specially designed for people with low mobility. It is generally used by those who have difficulty walking or standing for long periods of time. Scooters are available in three common designs, those intended for indoor use, those for outdoor use, and those that are used for both. An electric scooter is different from a motorized wheelchair, in that the wheelchair is generally intended for indoor use and usually costs a great deal more.

An electric scooter may have three wheels or four. Since it runs on battery power, it does not create pollution. A typical electric scooter requires a pair of batteries, but the batteries are rechargeable. The length of time an electric scooter can run on each charge depends significantly on its battery's type and capacity. The most common batteries are advertised to run for about eight hours, and between 20-30 miles, before needs to be charged.

Some people are a little wary of purchasing an electric scooter because they fear it will be difficult to operate. In fact, the control console makes it quite simple once a person gets the feel for it. Electric scooters are also equipped with advanced brake systems, so stopping is simple and comfortable. The brake begins to engage as soon as the operator lets off the throttle, so there is little chance for abrupt or jarring stops. Most scooters also have a parking brake to keep the electric scooter from rolling when parked.

1.2 PROBLEM STATEMENT

Nowadays, small scooter becomes popular especially during recreation time, relaxing and for human exercise after they had faced their office job. There is a lot of scooter type around us like have seated or stand while riding the scooter. Most of that is operation by motor electric or just using our leg to move scooter like playing skate board.

The problem is, most of that scooter is not flexible although it is already small. Even though some manufacturer make it can be flip, but there is just only a few part to be that like seat, handle, and sometime arm bar. Most of flip small scooter are operate by swinging rider leg to move it. Some of the scooter looked not so ergonomic and cannot be use for a long time.

Even for an electric scooter, most of that can't be flip. Usually just their seat and handle can be up and down to flip. Sometime this will cause a lot of space for storage and difficult to bring far from house like to put it into the car and so on.

1.3 OBJECTIVES

i. Fabrication model development of single seater electric scooter.
ii. CAE analysis on main structure and rear arm of the electric scooter fabrication model.

1.4 SCOPE OF WORK

The following studies are including in the design and development of single seater electric scooter:

i. Literature study
ii. Conceptual design
iii. CAE analysis
iv. Fabrication model refinement

v. Materials selection
vi. Prototyping Development
vii. Running
viii. Report preparation

1.5 METHODOLOGY

i. Literature study
- Make review on other model and focusing on how to make it simple and relevance to the project title.

ii. Conceptual design
- Sketching several type of design based on concept that being choose.
- State the dimension for all part.
- Draw the sketching model using SOLIDWORKS software

iii. Computer Aided Engineering (CAE) analysis
- Analysis the design for strain stress structure by using ALGOR.
- Define critical point.

iv. Fabrication model refinement
- Fabricate the scooter according to the design.
- Refinement at several part of joining and sharp edge.

v. Materials selection
- Selected the true material based on model design and criteria.
- Light, easy to joining and easy to manufacture.

vi. Prototyping Development
- Assemble all the part to the design.

vii. Testing

- Run the model

viii. Documentation

- Preparing a report for the project.

1.6 PROJECT FLOW CHART

As shown in Figure 1.1

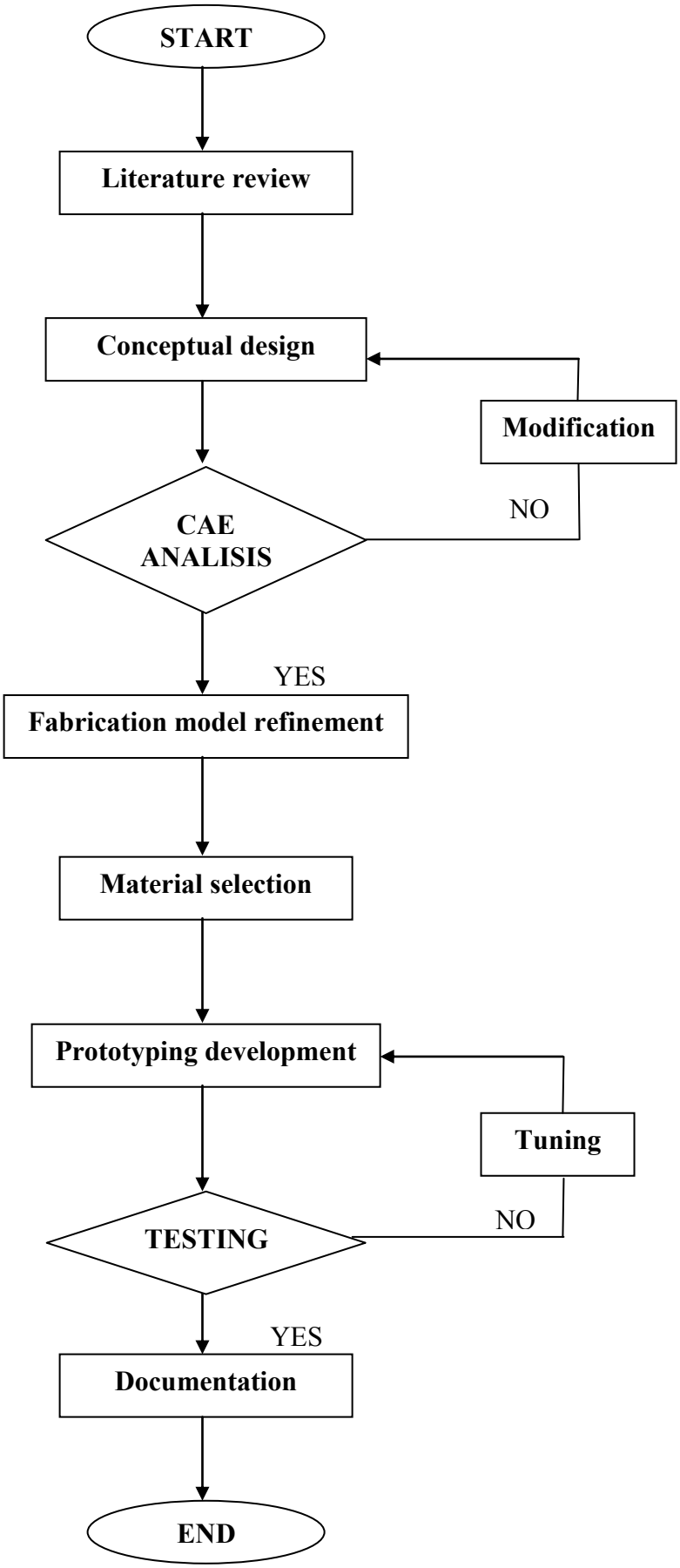


Figure 1.1: Project flow chart

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION OF SCOOTER

Scooters are a subclass of motorcycles and are very popular as urban and rural means of transportation. There are several types of scooters that we will find zooming up and down the highways and city streets.

A scooter includes a main frame, a tread board, a one-way bearing, and a linkage. Thus, the user can tread the pedal of the tread board successively to move the scooter forward, and the user's two feet need not to leave the main frame of the scooter, thereby facilitating the user operating the scooter.

2.2 SCOOTER OPERATION

Generally, there is several type of scooter operation. The way how to produce power for this kind of transport is depend on its want to use. High power scoter usually use small engine with gasoline. Another type is using electric motor operation whether dc or ac motor. This kind of bike usually use in small area and for recreation. The rest is more being use by children is kick power scooter. This is kick power scooter is cheaper, light and easy to manufacture.

2.2.1 Engine Powered Scooter

This type of scooter usually use small capacity engine. Normally around 40 to 60 cubic capacities (cc). This kind of engine can be found whether four-stroke or two stroke engine. This small engine scooter usually looks like small super bike. It can speed up until 50 to 60 km/h. Safety clothes should be use for precaution safety while ride this type of bike. This kind of scooter usually can be found at place which already has their club track. The sound of this bike is little bit noise but it looks very nice. Figure 2.1 and Figure 2.2 show engine powered scooter.

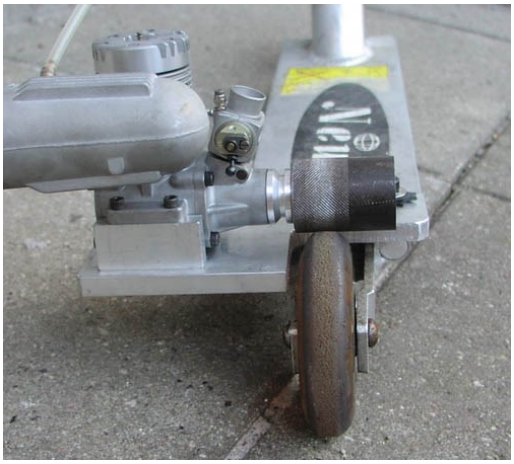


Figure 2.1: Rear look engine

Figure 2.2: Small engine on scooter

Source: http://www.webx.dk/rc/scooter/scooter.htm

2.2.2 Electric Motor Scooter

Generally, the source of power for the electric motor has been batteries, but development in fuel cell technology has created several prototypes. Some examples are: the ENV from Intelligent Energy, Honda's scooter using the Honda FC Stack, and the Yamaha FC-AQEL. Also, petroleum hybrid-electric motorcycles are under development. Some examples are the E-cycle, and Yamaha's Gen-RYU. Figure 2.3 is example of scooter using electric motor with stand riding operation.

Figure 2.3: Electric scooter stand riding

Source: *http://salestores1.com/hehcelscmo20.html*

2.2.3 Kick Scooter (foot-power)

A kick scooter or push scooter is a small platform with two or more wheels that is propelled by a rider pushing off the ground. The most common scooters have two hard small wheels, are made primarily of aluminiums and for children, and fold for convenience. Some kick scooters have 3 or 4 wheels, or are made of plastic, or are large, or do not fold. Figure 2.4 shows kick scooter.

Figure 2.4: Kick Scooter

Source:
http://www.extremekites.co.uk/jd_bug_scooter/images/jdbug_scooter_medium.jpg

2.3 TYPE OF SCOOTER

There are lots of scooter types**.** Table 2.1 shows the type of scooter and description of that.

Table 2.1: Type of scooter and description

	**i. Gas Scooter** The speed of these scooters can be stepped up to levels that cannot be achieved in case of other types of scooters. These scooters are also available in different sizes and weights depending on the gas tank
	ii. Electric **Scooters** An electric scooter is a battery-operated one-person capacity vehicle. Usually, it used DC electric motor for its operation. The battery can be recharge and certain design can be foldable. It may have three wheels or four and also does not create pollution.
	**ii. Mobility Scooter** This is a modified version of the electric scooter and is made for special people like the disabled and the aged people. These scooters are extremely stable, as they have more than two wheels. Some even have four wheels

 	**v. Foldable Scooter** This kind of scooter made to be small space storage and easy to bring from another place to another place. Either use electric source or kick power moving.
	**v. Utility Scooter** The utility scooters are extremely handy and are used for a wide range of purposes. This variety serves multiple purposes.
	**vi. Retro Scooter** Based on modification from classic scooter like Vespa. It refers to how much a design adheres to the original Vespa.
	**vii. Chopper Scooter** Many scooters available come in bodywork that rests on a tubular frame. Because of this, it is relatively easy to modify and give the appearance of small Harley chopper motorcycles. Because of their appearance, it is called chopper scooters

2.4 DESIGN CRITERIA

In this project, the work is focusing on design and development of single seater electric scooter which can be foldable and powered by DC electric motor. Below are design criteria for the scooter to be creating.

i. Type : Single seat electric scooter
ii. Operation : DC Electric motor
iii. Motor power : 3000W, 24V
iv. Batteries : 2 X 12 volt
v. Overall dimension : 150 x 220 x 889 mm (foldable)
vi. Drivetrain : Gearing, chain and sprocket
vii. Accessories : Lamp and horn required

Sketching for the design is based on mantis look like. This is because this insect can be fold up their hand to eat. Based on that principle, several part of model created to be fold up. Then, location for component will be determined with it true size and tolerance need. After that, sketching will be draw into engineering software.

2.5 SOFTWARE USING FOR MODELING PROJECT

To modeling and look overall of design and part location, the several software being use. Modification of part can be done in this engineering drawing. This is also one way to reduce cost manufacturing. By drawing the model in this program, the true size can be determine and easy to proceed to another process. 3D Software use in this project is Solidworks 2007 for drawing and CAE analysis which is ALGOR version 16 used for strain stress analysis.

2.6 COMPONENT FOR THE SCOOTER MODEL

The component for modeling the single seater electric scooter is divided by three main parts which is mechanical component, transmission systems and electrical component. Combination of the task is to make sure the model can be run properly.

2.6.1 Mechanical Component

i. Structure

- The primary requirements for structures are safety, strength, economy, stiffness, durability, robustness, esthetics, and ductility. The safety of the structure is paramount, and it is achieved by adhering to rules of design contained in standards and codes, as well as in exercising strict quality control over all phases of planning, design, and construction. The structure is designed to be strong enough to support loads due to its own weight, to human activity, and to the environment. Aluminium use is show in Figure 2.5.

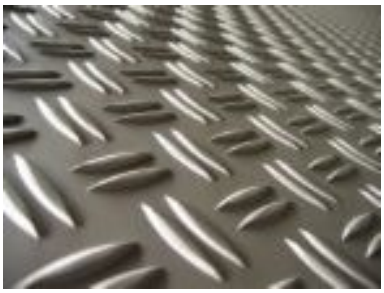


Figure 2.5: Aluminium structure

ii. Wheels

- Wheel is a solid disk or a rigid circular ring connected by spokes to a hub, designed to turn around an axle passed through the center. Wheel is use to easy move object from other to another place. Figure 2.6 shows the heavy duty tire using to build this model.

Figure 2.6: Heavy duty wheel

iii. Bushing

- Bushing is use to hold movement object like sprocket and gearing and to maintain location on part rotating. It also can transfer load at joining support part. Figure 2.7 shows examples of bushing.

Figure 2.7: Bushing

iv. Seat

- Place in which one may sit. Comfortable seat is made by soft sponge and tidy its design. Figure 2.8 show example of comfortable single seat for driving.

Figure 2.8: Single seat

v. Cover

- Cover use to close part that do not looking by anyone. Sometimes, cover use to close sharp edge and to avoid from injury. Cover can be made by cloth, thin zink, soft steel, aluminum, rubber, PVC leather and so on. Figure 2.9 shows PVC leather for seat cover.

Figure 2.9: PVC leather for seat cover

vi. Bracket

- Bracket is part to hold the component. In this project, bracket made to hold DC motor and support for joining left and right side rear arm structure. Figure 2.10 is example of bracket.

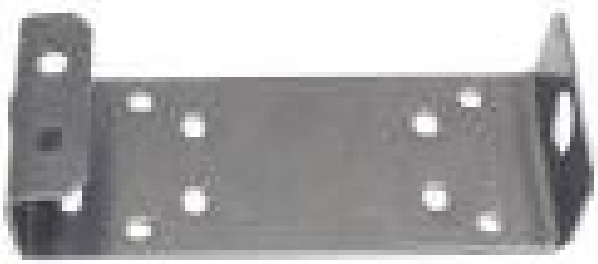


Figure 2.10: Bracket

vii. Suspension

- Suspension is tools that use to absorb vibration from road surface and give rider more comfortable while riding. Figure 2.11 show one of the suspension type.

Figure 2.11: Coil rear suspension shock

2.6.2 Transmission Systems

i. Shaft

- Shaft is a long bar steel that use to transfer force of rotation from source power. By using this type, chain, sprocket and gearing do not be use. If the shaft is too long, support will be

attach o hold this shaft from moving out. Sometimes, lock key will be attached to hold the shaft from missing twist.

ii. Gearing

- Pinion gear is use in this project. It is to transfer rotation of motoring from horizontally rotation to vertically. Figure 2.12 is pinion gear meshing.

Figure 2.12: Pinion Gear

iii. Chain and sprocket

- Chain is use to transfer force from driven sprocket to driver sprocket. Reduction gear to get torque usually can be at different sizes gear using. Figure 2.13 is joining of chain and sprocket

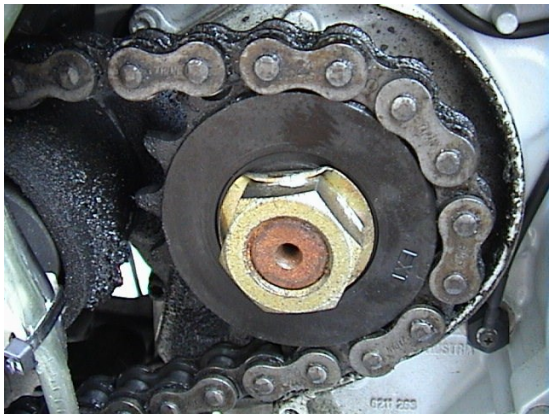


Figure 2.13: Chain and sprocket joining

2.6.3 Electrical Components

i. Brushless Direct Current Motor (DC Motor)

- This type of motor widely use in applications**.** A DC motor works by converting electric power into mechanical work. This is accomplished by forcing current through a coil and producing a magnetic field that spins the motor. The simplest DC motor is a single coil apparatus, used here to discuss the DC motor theory. Brushless DC motors use a rotating permanent magnet in the rotor, and stationary electrical magnets on the motor housing. A motor controller converts DC to AC. This design is simpler than that of brushed motors because it eliminates the complication of transferring power from outside the motor to the spinning rotor. Advantages of brushless motors include long life span, little or no maintenance, and high efficiency. Disadvantages include high initial cost, and more complicated motor speed controllers. Figure 2.14 shows disassemble of DC brushless motor.

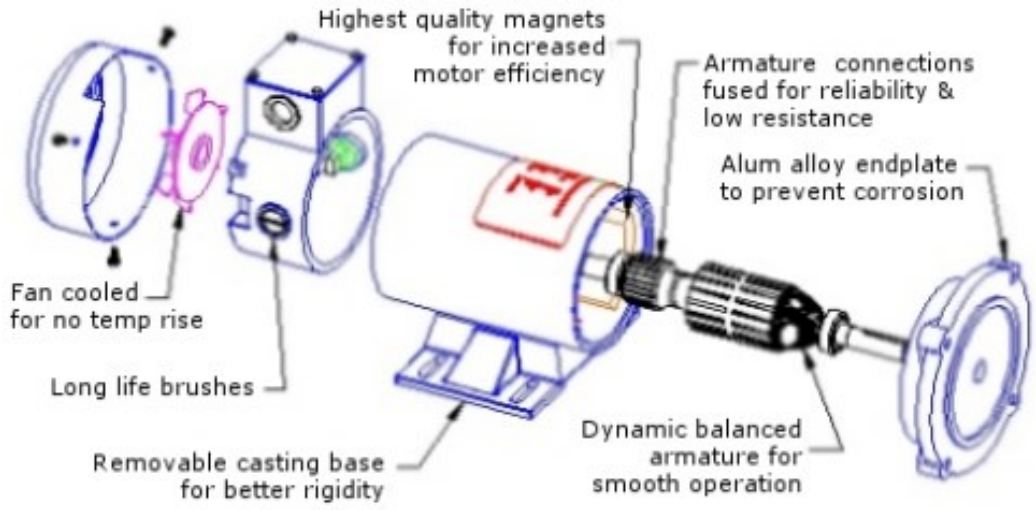


Figure 2.14: DC brushless motor disassemble

Source: *http://www.joliettech.com/permanent_magnet_dc_motors.htm*

ii. Battery

- An electrochemical device that stores chemical energy which can be converted into electrical energy, thereby providing a direct-current voltage source. Figure 2.15 is dry cell rechargeable battery.

Figure 2.15: Dry cell rechargeable battery

iii. DC motor electric controller

- The main controller for operate the motor. Source from batteries will detect here first before it distribute to motor how much it need to run the motor. Figure 2.16 is **b**rushless DC Motor Controller tcp1000-01A

Figure 2.16: Brushless DC Motor Controller tcp1000-01A

Source: *http://www.cprmotor.com/products_img/2007816154065.jpg*

iv. Light Emitting Diode LED

- A diode is the simplest sort of semiconductor device. Broadly speaking, a semiconductor is a material with a varying ability to conduct electrical current. Lighting emitting diode shows in Figure 2.17.

Figure 2.17: 3Volt lighting emitting diode

v. Switches

- Switch is devices that use to control current flow in electric circuit. An electrical switch is any device used to interrupt the flow of electrons in a circuit. Switches are essentially binary devices: they are either completely on (“closed”) or completely off (“open”) It can be stop, run, on and off the circuit. There are a lot of switch type like push stop switch, two way switch, single pole, double pole, three way, four way, toggle switch, pushbutton switch, selected switch, joystick switch, level actuator switch, proximity switch, pressure switch and speed switch. Most of that has their own function. Figure 2.18 **is d**ouble pole toggle switch.

Figure 2.18: Double pole toggle switch

2.7 PURPOSE OF SINGLE SEATER ELECTRIC SCOOTER

2.7.1 Using For Personal Needs

- This scooter can be use to where the owners want. This can give the person ability to be self-dependent.

2.7.2 Using To Visit Friend

- Another usage of this kind of scooter is to meet with friend. It can be more enjoyable time when the group will play together, round with this bike.

2.7.3 Reduce Walking Time

- By using the scooter, time to move from place to another place can be reducing the walking. Worker can be more aggressive and productive to do the work.

2.7.4 Relaxing Riding

- This purpose is for rider who take deep feel of using this bike. They will be proud to ride scooter and the rest will see how the scooter nice looking.

2.7.5 Increase Productivity

- Worker can reduce their time to move from one place to another place. They will faster to moving and transfer data compare to walking which need mere energy.

2.8 ADVANTAGES AND DISADVANTAGES OF ELECTRIC SCOOTER

Whatever model or product being done, it cannot be run from problem. Advantages and disadvantages are normal cases will face for the product. Below is the list of advantages and disadvantages of design and development of single seater electric scooter.

2.8.1 Advantages

i. Environment free from pollutant
ii. Time walking to another place can be reduce
iii. More productivity of worker
iv. Low maintenance cost
v. Nearly silent environment
vi. Small space storage

2.8.2 Disadvantages

i. Heavy. Due to its component such as batteries and dc electric motor
ii. Long time to recharging
iii. Easy to be stolen
iv. Cannot be use at roughness road surface. Due to the small and hard wheel.

CHAPTER 3

METHODOLOGY

Based on literature review, planning to modeling the single seater electric scooter then will be proceed with the way how to crate it. By using the budget given and selection of material, the project begins with conceptual design. Free sketches are makes before transfer into 3D software with dimension. Then it will be analyze at main structure and rear arm, which is suspect part to receive higher force while riding. From here, design create will be fabricate and refinement at certain part which is needs to modify will be done. After the assemblies, model is ready to run around.

3.1 CONCEPTUAL DESIGN

Based on the mantis concept, free sketches make to see how the model will be creates and comes out. Overall dimensions and component then roughly defined. Type of joining being use and materials also be determine here.

After free sketches on paper, the design is drawn into solid model using CAD software. In this project, Solidworks is used to model the design. The model is drawn according to actual dimension. In this stage, the design is redesign to simplification. It is important to make sure the design can easily to manufacture. Some of part is modified to make sure it is easy to fabricate.

The model will be creates part by part which is fitness with component. That part then will be assembling together to see how the shape will come out. Modification on part will do if there is any missing dimension occurs. This 3D software can show how the model will expected look in real view.

The first design of sketch is X-shape design 1. Then second model also still X-shape, but at the front support that being change by reduce the boxes to hold the handle. So, small supports being attach to change the boxes that take out. Third shape is base on mantis look like. It is more futuristic stile and look so compact when be fold. All of these three designs can be foldable, same dimension when fold and same materials use. Table 3.1 shows summarize of design created.

Table 3.1: Summarize of design created

Conceptual design	Description	Advantages	Disadvantages
X-Shape Design 1	• Boxes look • Drivetrain of gearing, chain and sprocket. • Long handle	• Large storage for things compartment	• Long space storage due to long handle • Sharp edge • Heavy
X-Shape Design 2	• using universal join with small handle support • Drivetrain of gearing, chain and sprocket. • More short handle being use. • Can separate handle component	• Less material use. • Reduce the weight due to small handle support • Part of the handle can separate and keep in the body. • Small space storage	• Looks complicated at their universal join. • Support not strong enough • More shape should be build
Design 3	• Simple looks design • Drivetrain of gearing, chain and sprocket. • Frame as main structure.	• Strong structure due to it frame • Small space storage • No flip seater • Not complicated design	• Handle joined not so smooth

3.2 DESIGN CONSIDERATIONS

Based on conceptual design creates, some considerations made to make sure model is safety and friendly user. This scooter model is for adult user, so their operations, way to handling and control button is depend on normal adult body size. Below are list of consideration on making this model:

i.	Safety cover	- No other human could reach the operating electrical and mechanical components.
ii.	Emergency switch	- to cut off electric current to DC motor and stop motor operation if it is out of the control.
iii.	Foot rest	- More stability on riding and easy to handle and take cornering.
iv.	Horn	- To warn front object of moving scooter. Due to quiet operations.
v.	Size	- Normal human body size.
vi.	Lamp	- can be riding in dark condition.
vii.	Ventilation system	- to avoid over heat on batteries and motor while recharging and operating conditions.
viii.	Battery lock	- to hold batteries and can avoid from short circuit.
ix.	Tidy wiring	- to avoid short circuit and easy to maintenance.
x.	Light	- Light structure, but strong enough to support load and easy to bring anywhere.
xi.	Space storage	- Due to objective, this model create to be easy to foldable and small space storage need

3.3 ENGINEERING SOFTWARE USING

In this design and development of single seater electric scooter, two engineering software are use to modeling the design and another one to analyze on structure. Solidworks 2007 is using to modeling the design while CAE software is use to do analysis on structure.

3.3.1 Solidworks Software

Solidworks is a parasolid-based solid modeler, and utilizes a parametric feature-based approach to creating models and assemblies. Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Parameters can be either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, and so on. Numeric parameters can be associated with each other through the use of relations, which allow them to capture design intent.

Building a model in Solidworks usually starts with a 2D sketch. Features refer to the building blocks of the part. They are the shapes and operations that construct the part. Shape-based features typically begin with a 2D or 3D sketch of shapes such as bosses, holes, slots, and other. This shape is then extruded or cut to add or remove material from the part. Operation-based features are not sketch-based, and include features such fillets, chamfers, shells, applying draft to the faces of a part, and extras.

3.3.2 Computer Aided Engineering (CAE) Software

To do the analysis on the model, ALGOR V16 is use. This software can show the value of strain stress, mechanical contact, thermal conductivity, fluid dynamic and couple and uncouple multiphysics. Usually color contour will show the comparison of part to be broken and which part will receive high force.

This software provides cost-effective solutions for design, analysis and simulation and enables engineers to virtually test and predict real-world behavior of new and existing product designs

3.4 ENGINEERING DRAWING

After the design phase and materials selection, this information then transform into engineering language- Technical Drawing. It is use to store the design information into hardcopy and this is the easier way to communicate with manufacturer.

3.4.1 Training of Advance Skill in Engineering Drawing

Engineering drawing is very important aspect in engineering. Without good engineering drawing, failure could happen during fabrication process and more worst than that is when the system is failure during operation cause in reading error in reading engineering drawing. Week engineering drawing also can cause losses to an organization because it can crate large error in manufacturing process.

Thus to avoid this from occur, a training in advance engineering drawing is held before real engineering drawing is drawn. It have several phase such as making good drawing blocks, drawn simple but compact, standardize font, arrows, and features in drawing.

3.4.2 Engineering Drawing Block

Function of this engineering block is for verify the drafter, the material, tolerance, scale and many more tat state the initial configuration of the drawing. All this detail must be state on a simple block. The most important factors about creating a good engineering block is to verify the drawing as an intellectual properties and to make sure initial configuration of the drawing is completely receive if the drawing hand to others. The detail engineering drawing block of this project is in Appendix B.

3.4.3 Complete Engineering Block

After training engineering drawing block, next process is completing all parts engineering drawing. In this process, the simplest part is drawn first and then followed by complex geometry parts..The drawing is use third angle view. It is consist front, side and top view, the drawing also include isometric view of the parts. All the part is carefully dimensional to make sure the drawing easy to read and all the info to fabricate the parts is stated.

After done all part created, it will be assemble together. This will show how the model will come out. If there is any miss matching and poor looks, refinement on the model and part will be done.

3.5 CAE ANALYSIS

In this analysis, software of ALGOR Version 16 is use to predict how strong material chosen and how tough the model can be loaded. Stress Analysis with Linear Material Models is test here to improved contact along edges and improved calculation of out-of-plane shear effects for thick composite elements.

Main part like body structure and rear arm structure will be analysis. Data show the maximum force that structure can hold before it collapses and break. The force will attach on the rear seat with first load is 700N. At front, which is handle hold support will be fixed. The force then will be increase to 800N, 900N and 1000N. The force of 700N is choosing because this is normal weight of Malaysian humans. This force shows that person who have weight in range 71.36kg to 101.94kg still can ride this foldable scooter or not.

Equation 3.1 is use to change Newton to kilogram units.

- $700\ N / 9.81\ ms^{-2} = 71.36\ kg$ (3.1)

Although this software cannot show how it broke, but it still can be determine by compare maximum stress and strain with tensile of materials using. This software

will show located that will receive more force and which part will safe and unsafe by contrast of color.

Figure 3.1 shows force applied at rear main frame structure which is part rider sit. Fixed point at front frame is due to its static point at fork location.

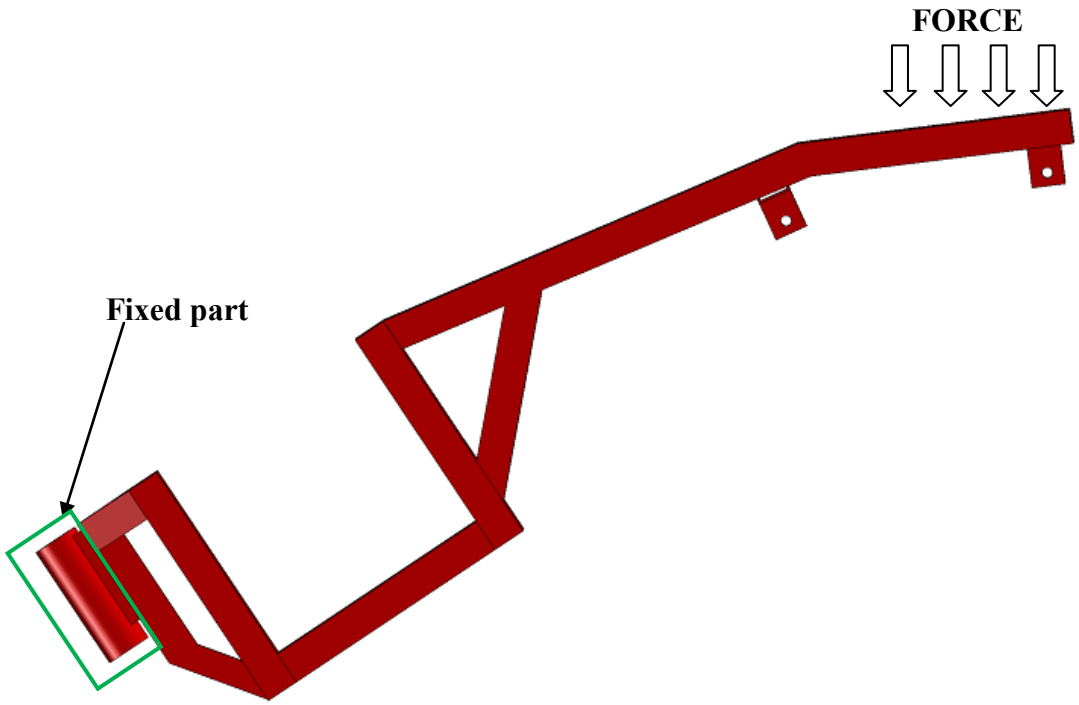


Figure 3.1: Main structure analysis applying force and fixed part

Source: *Sketching from Solidworks software*

3.5.1 Meshing Setting

From the 3D drawing, file saves into IGES format. This format is use when analysis using ALGOR. For the design scenario, single analysis and static stress with linear materials model is choose. Figure 3.2 shows design scenario menu.

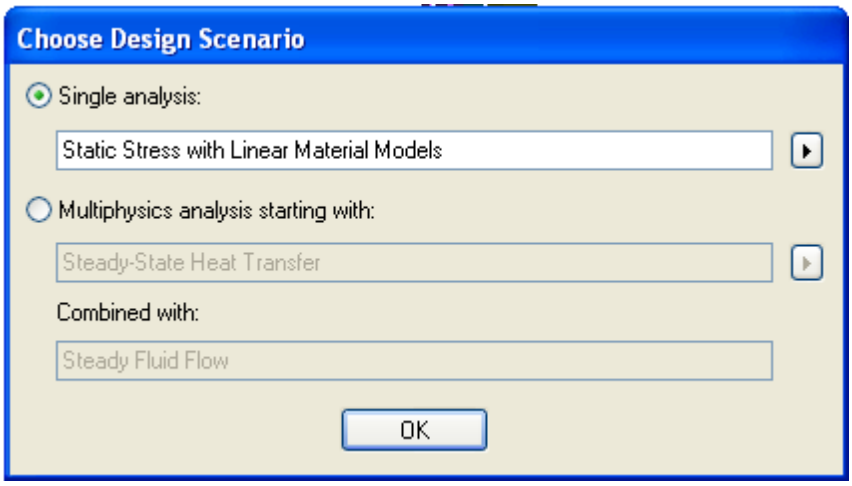


Figure 3.2: Design scenario menu

Figure 3.3 is model mesh setting. Analysis will do on surface structure and meshing size is 100%. Meshing type is solid and meshing size is middle between coarse and fine. Meshing level is important because it will influence the final result. Figure 3.4 shows meshing type. Figure 3.5 show meshing in progress.

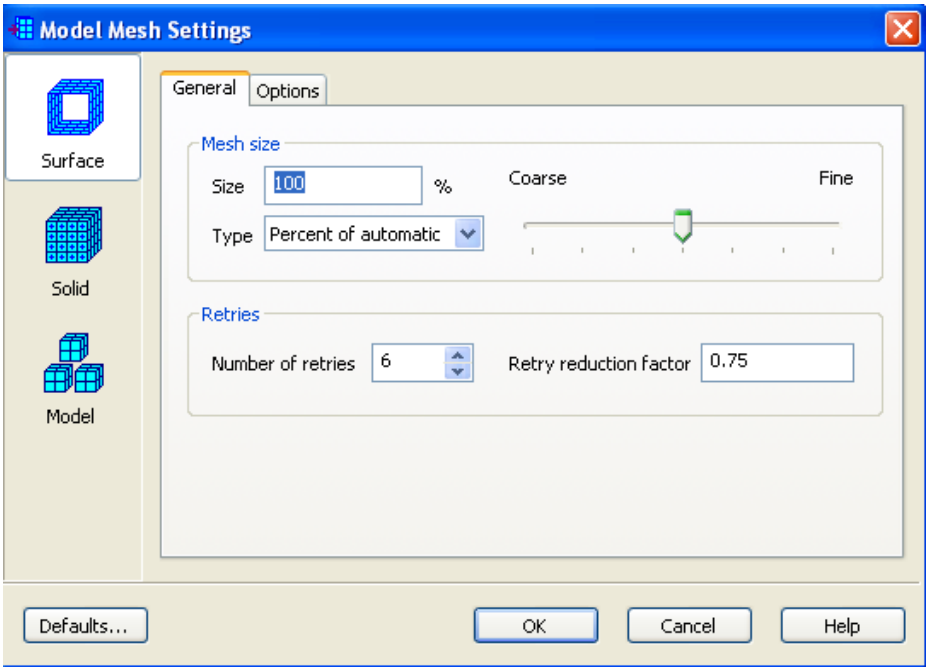


Figure 3.3: Model mesh setting

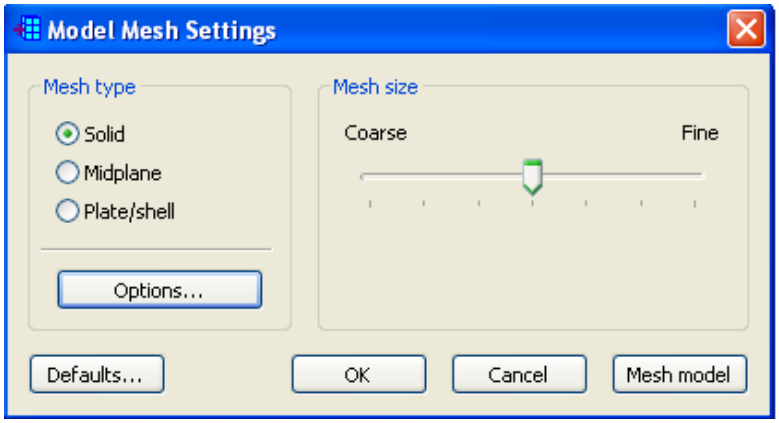


Figure 3.4: Meshing type

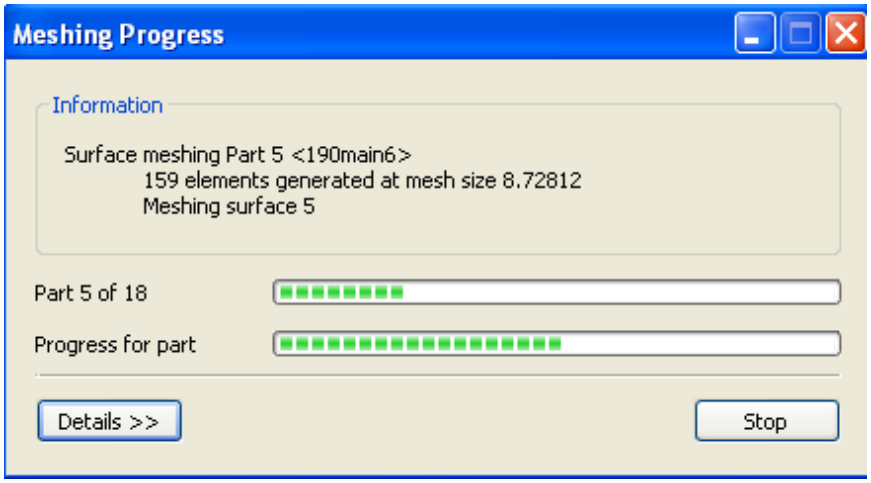


Figure 3.5: Meshing in progress

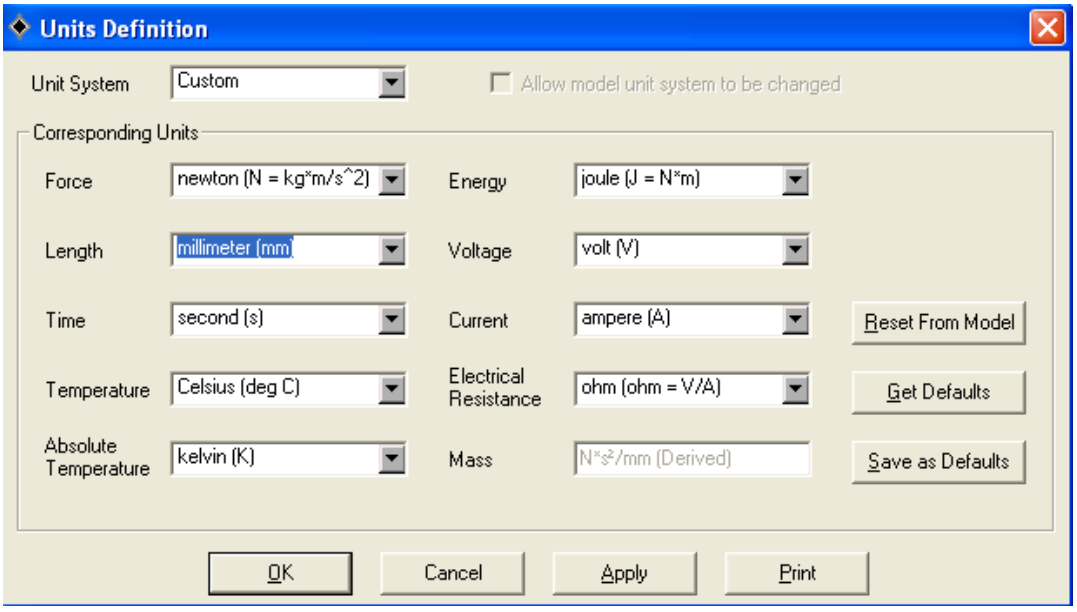


Figure 3.6: Unit definition setting

After mashing process, this analysis will move to FEA editor. Here unit for analysis will be determined to standard imperials (SI) unit and change at length to be millimeter unit. Figure 3.6 shows unit definition. In this FEA editor, material for analysis is steel AISI 4130, element type is brick and boundary condition setting will be set before proceed with analysis. Figure 3.7 shows meshing on main frame structure to do analysis while Figure 3.8 shows the meshing on rear arm structure.

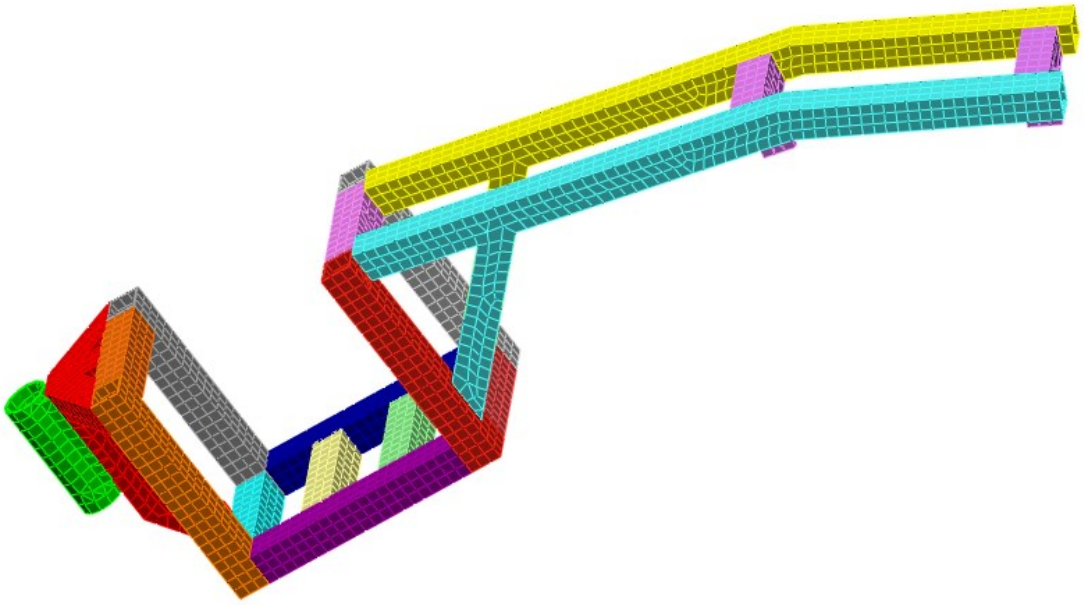


Figure 3.7: Meshing the model on main frame structure to do analysis

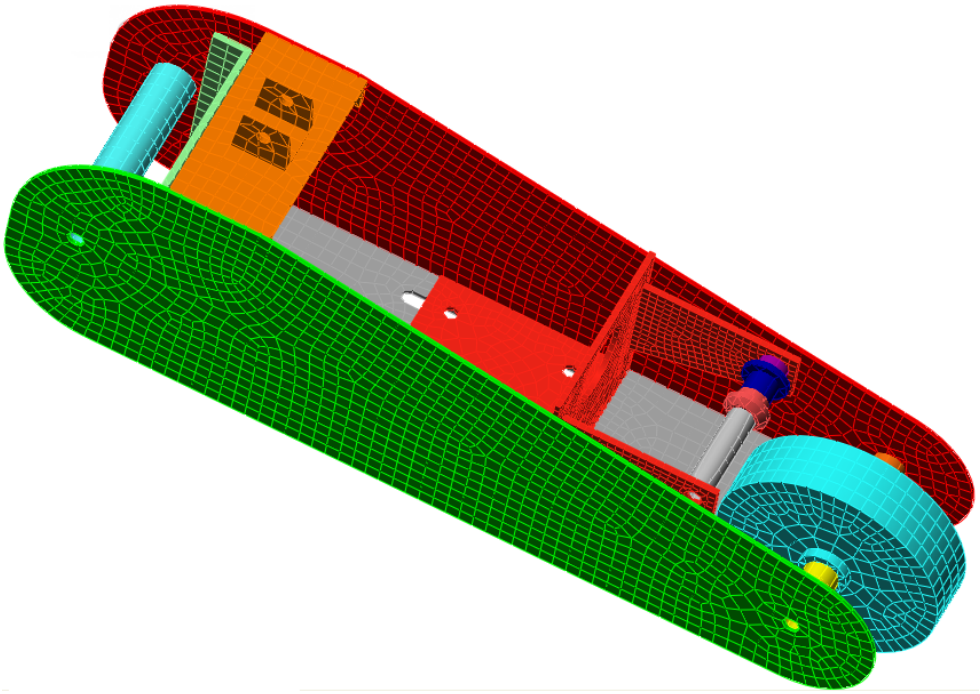


Figure 3.8: Meshing the model on rear arm structure to do analysis

3.5.2 Boundary Condition Setting

Figure 3.9 show menu for boundary condition setting. Front part, handle located is defined to be fixed from all direction force. Due to static part, no load applied, the front area is assumed free from any force.

Figure 3.10 is nodal force setting. Due to load on structure from human force is applied at rear main frame structure. This is the part where load attach. Rider will seat there and force attached on it refer to the force of main structure should support. By selecting seat surface area, setting to the force applied with convert human weight in kilogram to Newton is done. The force apply is start with 700N for the first analysis. It will increase until 1100N test. Figure 3.11 and Figure 3.12 shows boundary condition setting on main frame and rear arm structure

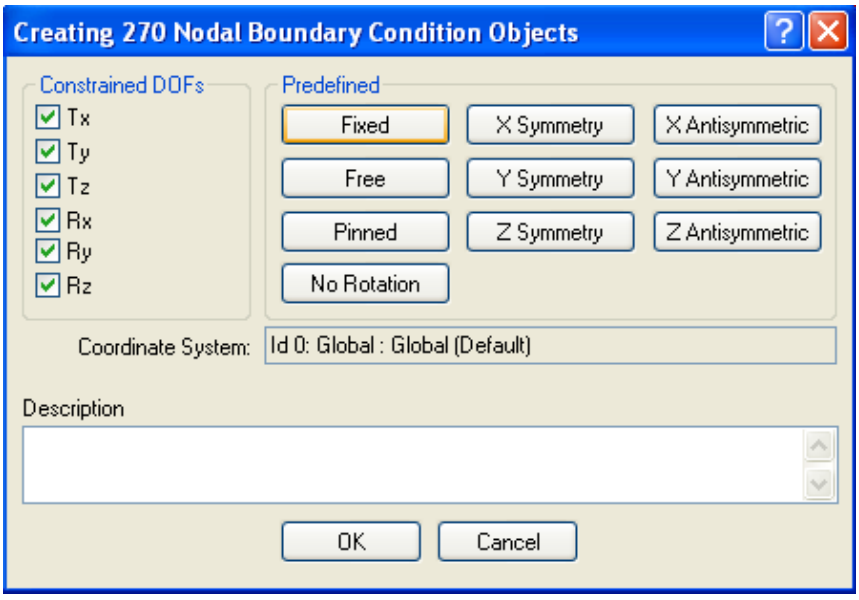


Figure 3.9: Menu for boundary condition setting

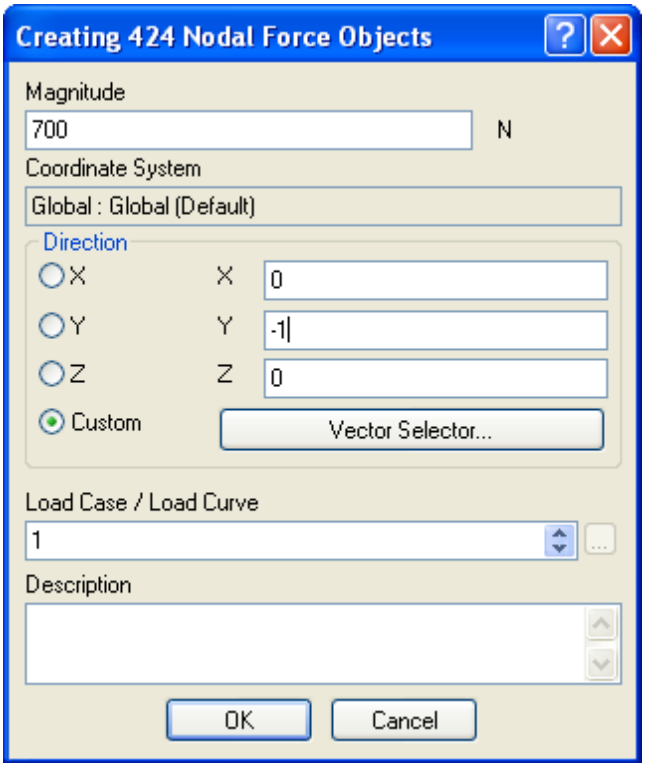


Figure 3.10: Nodal force setting

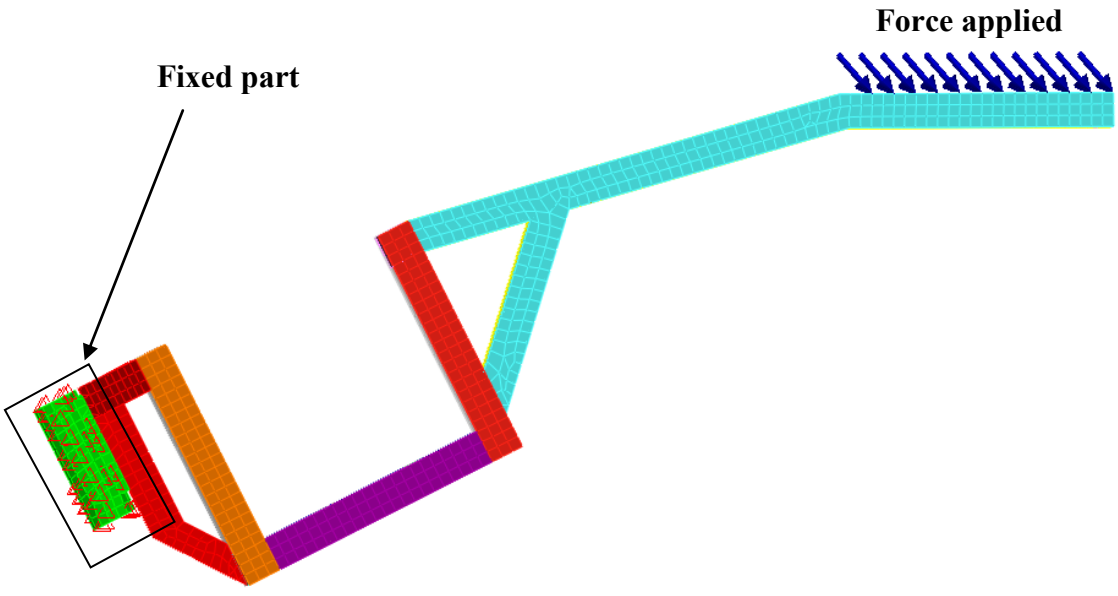


Figure 3.11: Boundary condition setting on main frame structure

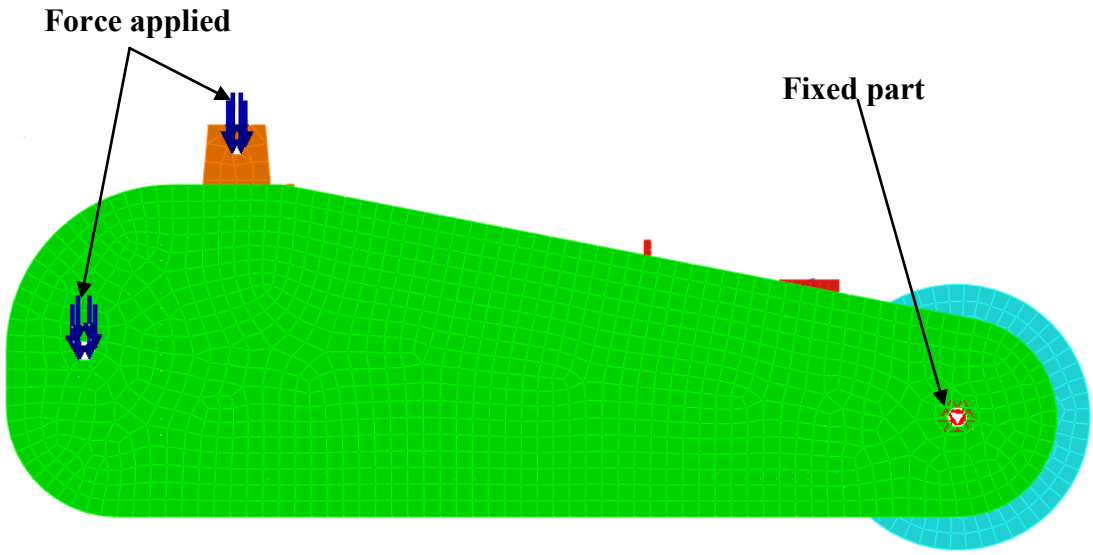


Figure 3.12: Boundary condition setting on rear arm structure

Source: ALGOR *software*

3.5.3 Materials Selection for Analysis

Materials to be using for analysis are takes from ALGOR library which is the main parameter should be considering to do analysis. Figure 3.13 shows the element types that already have in ALGOR library. For the main structure, steel AISI 4130 is choose while for rear arm main structure, aluminum from 6000 series is take out to do the analysis.

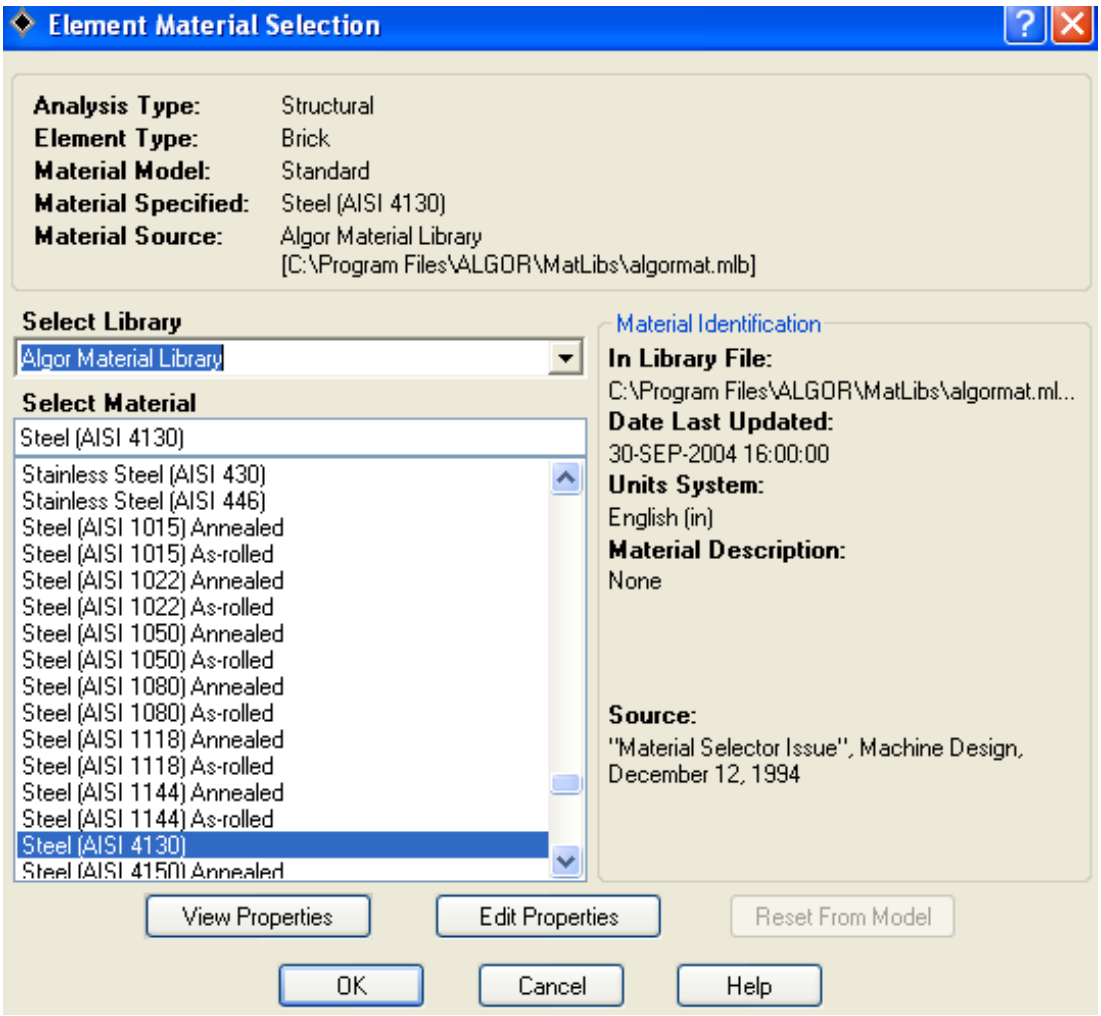


Figure 3.13: Material selection from ALGOR library

Source: *ALGOR selection materials library*

3.5.4 Analysis Process

After all parameter is set, analysis will perform to see how structure will looked after receive load. A Figure 3.14 shows the analysis perform icon and Figure 3.15 is analysis in process.

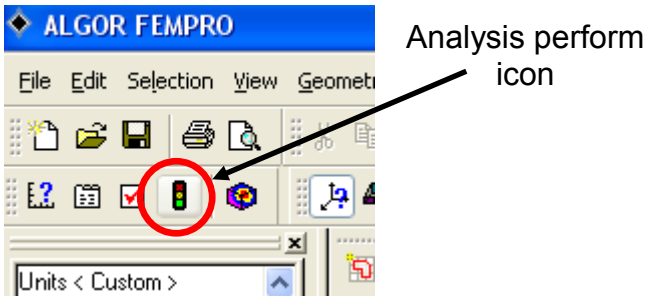


Figure 3.14: Analysis perform icon

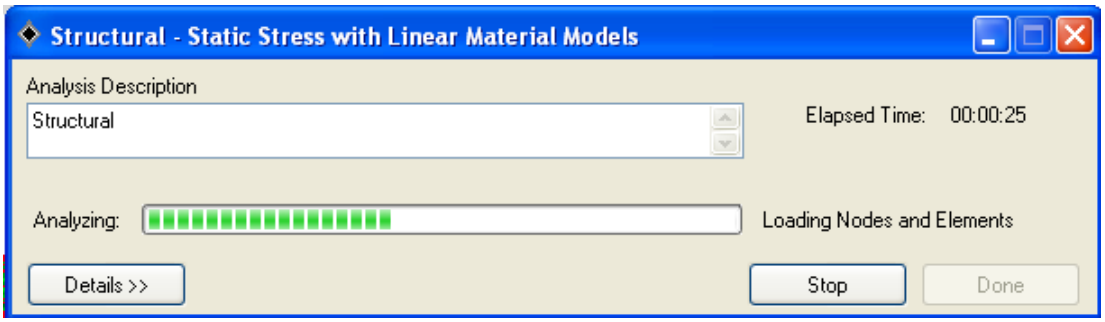


Figure 3.15: Analysis in process

By using this CAE software, result of the analysis will show in contour of color. The dark color (blue) shows that the structure is safe, while the bright color (red) shows that the point will receive high force. Some modification should be done to reduce brightness color. In the result of Stress Analysis with Linear Material Models, it will show the value of minimum and maximum stress strain, displacement of structure and also deformation shape.

From the data tested, comparison to the real modulus elasticity characteristic of materials should be done. This is to compare maximum load structure can support before it break.

3.6 MATERIALS SELECTION FOR SCOOTER MODEL

Based on conceptual, design consideration and done of analysis on structure, process to fabricate this project start with find materials in market. Price, type, size and materials using then will buy and which is suitable will be use to create the model.

Material that being chosen for this project is should be light, strong, and look attractive for its cover. Hollow bar steel with size 1" x 1" (24.5mm x 24.5mm) and thickness of 1.2mm, aluminum 2.5mm thickness and sheet metal 1.2 mm are use in this project. These plates choose because of it light, strong with melding joining and easy to bend. Table 3.2 shows about type of materials selection and justification of materials selection.

For the main structure, hollow bar steel is use. This steel is light and strong to support load from rider and component of scooter. This steel chooses due to it is easy to cutting and joining process by MIG welding.

For the rear arm, there is several parts to be joined. Main part is aluminium as main structure and steel plate as support to attach both side aluminium plates. This steel plate will be strong enough when bends at their edge. It is also easy to bend by bending machine that already has in laboratories. Due to lightweight, this sheet metal attach to the aluminium by rivet joining.

For control this bike, handle bar is made from hollow bar steel. This steel is light and simple structure and also a normal shape of handle. This metal will reduce weight of model, easy to assemble and easy to handle the bike.

Back to the main frame structure, that part is a seat located. Made by sponge for comfortability while base from plywood, it is easy to attach sponge on it and screw plywood on main structure. PVC lather will covered all this sponge and plywood to make it tidy, comfort, and good water protection.

As a drivetrain of this model, it used gearing, sprocket and chain from grass cutter and small engine. Gearing ratio of 1:1 is suitable to transfer higher torque from DC motor to wheel. By using this gearing, it also produce quiet operation because of helical teeth and the small size make it easy to join with DC shaft. For the chain and sprocket, it comes from small engine timing gear and sprocket. This material is small size and very light. Furthermore, small chain and gear will make good contact to transmit DC power and can reduce slip compare to using belting.

The power from mashing gearing and sprocket will finally reach to rear wheel. This part will move on the model. Heavy duty wheel with no air pressure require is choose as a wheel of this scooter. Due to usage, available in various sizes in market and low maintenance, this wheel is suitable for model creates. This wheel also long life durable and can be use either on rough or smooth road surface.

Another component buy from market is foot rest and hand grip. Made by aluminium, this foot rest already can be fold and low cost to buy. It is also easy to assemble and strong enough to support human leg. For the hand grip, it is sponge made and comes from bicycle hand grip. With low cost and easy to get in market, this material just only go and buy.

For the electrical component, all this part is buys from electronic shop and just connection of circuit is made in laboratories. LED, buzzer, switch, circuit board and wire are gets from that shop. This entire component is for accessories and controller system.

Table 3.2: Material selection for single seater electric scooter

Types of material	Justification
Al alloy 6000 series	• Light and ensure lower cg. • Able to withstand the designed load
1.5 mm steel plate	• easy to bend • Strong when bending. • Easy to rivet and welding. • Light
1mm zinc plate	• Light
1.2 mm steel plate with 5mm diameter punch hole	• Strong • Light
Hollow steel bar 1" x 1" 1mm thick	• To make sure body strong • Light frame • MIG welded to join each other
Hollow steel bar 1" diameter	• Light • Easy to fabricate • Normal type for handle
Al alloy 5000 series	• Light • Strong to support human leg
Sponge PVC lather Plywood	• Water protection • Comfort seat
High density rubber No air pressure required	• Long life durable wheel • Can be use either on rough surface road or smooth road • Easy to maintenance
Mild steel bar 25 mm	• To support each side of rear arm joined • To joined between motor shaft with gearing location • To maintain gearing and wheel at their location

3.7 BILLS OFMATERIALS SELECTION (BOM)

Bill of materials is use to know the overall cost and materials using to build or do anything work. This can be measure by research from market supplier and project requirements. Besides that, this is the most important part should be consider for manufacture to produce product with price and product that can be accept by customers. Appendix D shows overall bills of materials for design and development of single seater electric scooter model.

3.8 FABRICATION PROCESS

Fabrication of the scooter model start after finishing analysis and selecting all materials needs. Before fabrication, the equipment should be finds and selected suitable with tools.

Based on the technical drawing, part of the scooter model start to creates. Firstly, project started with create main frame structure. Hollow bar steel (24.5mm x 24.5 mm) is cut through dimension drawing by cutter machine. Angle for joining also cut by that machine and finished with grinding to remove sharp edges and get nearly angle needs. Figure 3.16 shows cutting angle of material.

Figure 3.16: Cutting angle on steel bar

For the joining process, jig is made by nail and wood due to real dimension to make sure the welding process will accurate with true size. This is also to avoid bar

move while joining process. This cutting steel then will be joining by using MIG welding. Figure 3.17 shows MIG welding process for joining main structure frame.

Figure 3.17: MIG welding joining process

After finish making main frame structure, process proceeds with making cover main frame structure. This materials using is aluminum 2.5mm thickness. Real dimension on technical drawing printed by plotter and that paper is glue on aluminum surface. By using jigsaw hand machine, the materials cut follow up shape of drawing. Sharp edge of this aluminum is removed by pile.

At front and middle of this sheet metal will be bending by bending machine. Due to thickness it is hard to bend by human energy. Precaution to using this machine is do not hold metal too tight and put hand too closed with machine. Part to be bend and size are shown in Appendix B.

Next process is making handle, front fork and fork holder. For the fork holder, it comes from real unusable bike. That part is just cut at their neck before welded to main frame structure. Some modification on based of the holder is makes to support and give strong structure on it. Figure 3.18 shows the bicycle part taken. For the fork, its make by bending process of plate sheet metal 1.5mm thickness. Two holes makes at both side of plate with 10mm diameter.

Figure 3.18: Handle bar holder takes from unusable bicycle

From the front fork, it joined to handle by 25mm diameter hollow bar which attach at center of fork. Handle is takes from damage foot power scooter. Figure 3.19 shows the handle taken.

Figure 3.19: Handle from unusable foot power scooter

The process then continued on making rear arm of scooter model. For the rear arm, project started with making rear arm structure. It is made by aluminum plate of 2.5mm thickness. Drill machine and jigsaw hand are use for making this plate. Shape of plate cut by jigsaw hand follow up dimension makes. Then sharp edge is removed by pile and two holes makes. One is at front; joining part between rear arm and main cover structure, while another holes is at the rear; to hold rear wheel. 12mm diameter holes at front and 10mm at rear wheel.

This two side aluminum attach by three bending plate. A long plate is for based of structure. It holds along rear arm bottom and also a DC motor basement. To maintain floor and side structure in 90 degree angle, one vertical plate attach at front DC motor location which is near joining main cover structure part. Another plate is place at top of rear arm structure. This plate also base for suspension. Top plate attach by bolt and nat 8mm size while bottom and vertical plate joining by rivet 4mm size.

Another part of rear arm is bracket for hold DC motor and gearing. This bracket makes by steel plate of 1.2mm thickness. Appendix B shows the dimension of this bracket. It makes part by part before joining by MIG welding follow up shape makes.

Bush and shaft makes to hold gearing maintain at their position. Mild steel is use as materials and lathe machine use to manufacture this shaft. Basic operation of lathe machine with low speed is use to make this shaft. Next shaft making is at rear wheel and front rear arm; joining arm and main structure. This shaft is use for transmission system.

Gearing for this scooter is takes from grass cutter machine. So that, some modification done to makes this component can be use for transferring rotation of gear. This gearing welded to the shaft and joined to DC motor shaft by lock nat. another gear hold by shaft and locate horizontally with DC motor bracket.

For rider seat, it makes from plywood 15mm thick and double layer of 20mm sponge. The based is made by wood sizes 120mm x 200mm x 50mm. This seat is rectangular. Sponge attach on wood and another sponge by glue. Top sponge cut to be round shape. Whole this assembly is covered by red color leather. It is glue and stapler at bottom; plywood surface.

3.9 EQUIPMENT FOR FABRICATING PROCESS

Whole part making above is done by several type of equipment that have in mechanical laboratory of Universiti Malaysia Pahang. For the cutting materials, hand grinder, cutter machine, jigsaw hand and shearing machine use. Figure 3.20, 3.21, 3.22 shows the equipment being use to cut materials.

Figure 3.20: Cutter machine

Figure 3.21: Hand grinding

Source: FKM laboratories tools

Figure 3.22: Shearing machine

Source: Wuxi Shenchong Forging Machine CO., Ltd

Besides that, another machine to create part use is lathe machine to create shaft, pillar and hand drill to makes holes. Parts that have been making then finished by tools like pile, stand grinder and sand paper. For the joining part, tools used are MIG welding, and rivet. Figure 3.23 is pillar drill which is use to make holes.

Figure 3.23: Pillar drill in UMP laboratories

From the explanation of tools using, Tables 3.3 is the summary of the laboratory equipments utilization.

Table 3.3: The summary of the laboratory equipments utilization

Equipment	Fabrication part	Justification
Horizontal bend saw	• Raw material cutting	• Accurate material cutting • Fast clean and easy raw material cutting
Cutting and grinding tools	• Raw materials cutting of hollow bar steel • Surface finishing of main frame structure	• Can obtain good surface finish • Essential to get good surface finish • For closed fitting purposes
Lathe Machine	• Main shaft • Gearing shaft • Wheel bush • Gearing bush	• To support each side of rear arm joined • To joined between motor shaft with gearing location • To maintain gearing and wheel at their location
Belt grinder	• Surface finishing	• For last finishing process to get smooth and accurate surface
Pillar and hand drill	• Making hole, tapping holes	• Simple operation
Jig saw machine	• Cutting aluminuim	• Easy to cut by following shape drawing
MIG welding	• Main structure frame joining	• Strong joining • Good joining compare with arc welding
Rivet	• Rear arm joined between plate sheet metal and aluminium. • Main part structure joined with aluminium cover • Rear frame cover	• Less work to do • Strong joining and can be easily to remove. • Easy joining process
Thread maker	• Shaft which connect DC motor to gearing	• Small screw attachment • Hold the shaft from slip
NC shearing machine model 6131	• Plate steel cutter	• Good surface cutter compare with metal scissor • Accurate cutting dimension
Bending machine	• Aluminium cover	• Band the materials through the dimension and angle needed • For thick bending process which is hard to do by hand.

3.10 CONTROL SYSTEM

This model is control by electronic switches. All switches for running is place at center of the handle bar. Only one switch for connect both batteries is locate under main frame structure while for charging system, the crocodile clip is locate under seat. Connection of DC motor controller is shown in Appendix C.

Switch controller box made by plastic and all switch is lock to this box by screw. This box then screw at middle of the handle bar. Wire form switch in control box will twist and go along handle bar to the bottom. From bottom side, it will take out and direct connect to the bar connection which is locate above battery. From that connection bar, wire then connected to DC motor controller. This DC controller screw on main frame bar. Figure 3.24 show the electric circuit of scooter model operation.

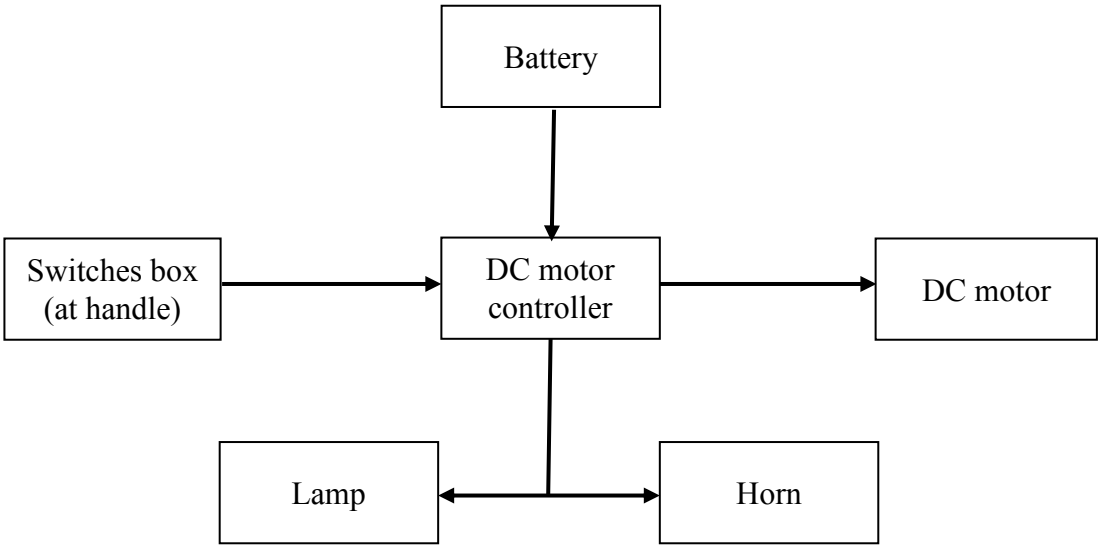


Figure 3.24: Electric circuit of scooter model operation

3.11 FINISHING PROCESS

Before assemble part create, finishing work should be done to makes assembles can be easy fit. The finishing process includes the separate component from work piece, abrasive, polishing and make a hole and threading. This is because

dimensional accuracy and surface finished is important to make sure each component can be assembles with ease and have good tolerance.

Another finishing done in this model are spray paint and decoration with sticker. Paint is spray to avoid structure from rust and can be use for long time and also to make it look more attractive.

3.12 ASSEMBLIES

After done all part making, the component start to assemble. Model start with assemble main frame structure with aluminum cover. It attached by rivet 4mm sizes. The holes make by hand drill. Next, the process is assembles of DC motor to their bracket and gearing joining. This DC motor will put in the rear arm structure and lock by bolt and nat that already welded at bottom of bracket. Rear wheel and sprocket assemble and the chain connects between sprocket at bracket and rear wheel then being adjusts.

In the main frame structure, there is located of batteries and other electronic component like main DC electric motor controller, controller board of switches and wiring. Batteries are placed side by side at bottom of other component. It is lock by bracket. At top back is dc motor controller. It is hanging to bar structure by screw. While board of switch controller is attach at edge of dc board controller by small screw. After wiring connected, model start to free running.

3.13 FABRICATION MODEL REFINEMENT

Refinement on model is done to make sure joining can be perfectly, good and safety product create. Some of refinement is done on this project such as discuss below.

3.13.1 Attachment Support to Make Structure Strong

After fabricate the model it being refinement at certain part to make the structure more tough and strong enough to bring load. Supported will be put on the main body which is located between vertical bar and rear main frame.

For bottom arm structure, there is no frame structure. Aluminum was use as main structure and joined with other side by long steel plate at their bottom and small plate at the top. Suspension will attach on this small sheet metal to the main frame structure. This structure joined by rivet at certain part.

3.13.2 Removes Sharp Edge

Aluminum sheet metal will attach on main frame by rivet. Sharp shape of aluminum edge will be trim to be smooth and not injury rider by pile. Another component that trims is steel plate and front fork. The front fork makes round shape at their bottom.

Besides that, basement for hold DC motor also being trim. This is because the rear wheel too closed with that plate and hit the plate while it moving. By using hand grinder, it trims to be curve follow up rear wheel shape.

3.13.3 Small Modification

At main cover, there is some modified done. A little bit part is pull out to able rear arm can place under main frame structure while in foldable condition. This is because rear arm bolt is outside of dimension that being determine before fabrication process.

3.13.4 Surface Finishing

Welding part which look poor and at contact surface between aluminum and main frame will be grinding fist until it look flat. This is to make sure closed joining

between these two materials. Besides that, poor welded being grinding to make it looks smooth and clean.

3.13.5 Major Modification

Major modification is makes on angle of front wheel handle. Due to hard control in the first running time, it was being development again. Whole part and scooter component was takes out during this modification. The front handle holder be cut again and trim back. Their base is design with new one. After all design done, the part makes is welded back using MIG welding. Then all components are assembles again.

3.14 RUNNING

In this running, gearing meshing, chain and sprocket and rear wheel holder is set to not be so tight. Chain and sprocket is adjuster by four nat at bottom of dc motor bracket. Then gearing is release and tightened by bolt an gnat hold the gearing while for rear wheel, double nat are attach to control their tightened. One nat is for locking and another nat for adjust suitable clearance.

All electronic circuit and switch is tested in this running condition. This is to make sure all of the component can work properly and give good respond on each switch button pushed. Wiring of this circuit is seal by tape and arranges to be looking tidy. When the wiring is done, it will cover with flat rubber to avoid from human touch electric circuit. There also some structure to support this rubber layer.

After free running, this model then being run with load applied. This mean it runs by rider. Human will seat on rear seat, put leg on footrest and hand hold handle bar while finger is set to reach button switch. Operation of the model start with connected main switch under batteries. Then center red button push to closed circuit. Toggle switch which is side of red button then switches on. This button also act as emergency switches if there is out of control. This switch can stop motor operation. Slowly started twist acceleration knob to move scooter. To accelerate more, twist this

knob larger. Riding this bike is same like handling bicycle or motorcycle. Different is only at acceleration knob. To slow the scooter, slowly reduce acceleration knob.

To storage this model, make sure all switch is on. Disconnect batteries connection and make sure terminal is seal back. Then take out lock nat at rear suspension and handle joining. Fold down this part and lock it back. Keep it in the safe place.

In this running condition also, the model will be done for several experiments which is how fast it can go, load it can carry, flexibility to use, how long life of the battery, rechargeable time, and stability to handle. This task will be discussed in next chapter.

CHAPTER 4

RESULT AND DISCUSSION

4.1 SKETCHING MODEL

After get conceptual of design that wants to be creates, model from free sketching is drawn in engineering drawing. After had been study how to using 3D software, the model than draw and purpose into real model. The model started sketches with part by part. After all part done; it will be assembling with this software to see how the model will comes out before fabricating process. Solidworks is software use in modeling this scooter. Table 4.1 shows the result of sketching in solidworks.

Table 4.1: Parts of design 3 sketching by Solidworks software

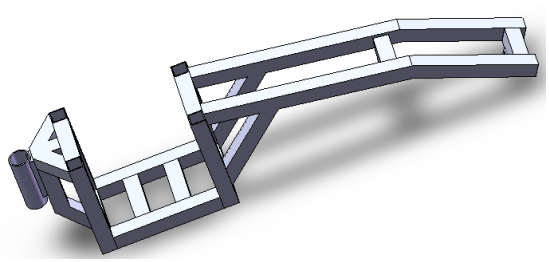
Part	Descriptions
i. Main frame structure 	This main structure consists of seat, electronic controller and batteries compartment. Front body has hollow shape for fork guide. Made by mild steel (24.5mm x 24.5mm) hollow bar.

Table 4.1: Continued

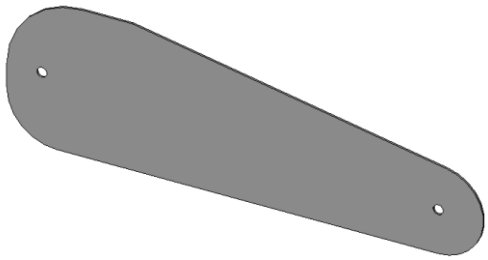
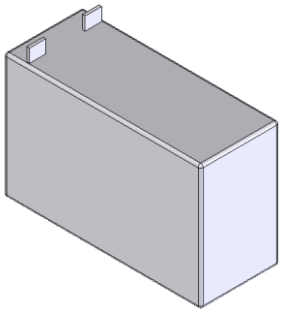
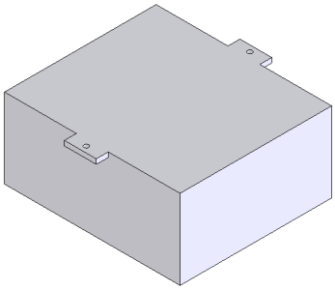
ii. Rear arm side 	This arm is dc motor and drive train system location. Rear wheel will attach at two forks. The upper us for suspension basement. Front hole for joining with main frame cover while rear hole is for rear wheel attachment.
iii. Battery 	Main energy source for operate scooter
iv. Dc motor controller 	This controller is to manage how much current should be distributes to motor. It is main controller for bike moving.
v. Handle shaft 	This shaft will connect handle bar with the front fork. It use lock key to join both of component.

Table 4.1: Continued

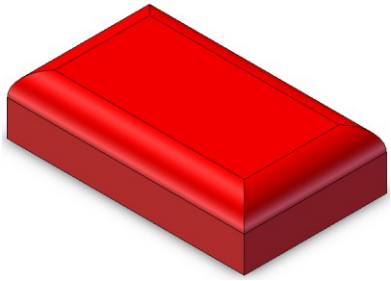
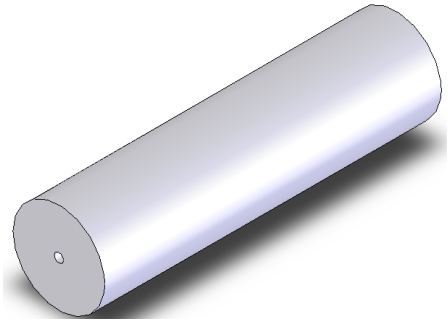
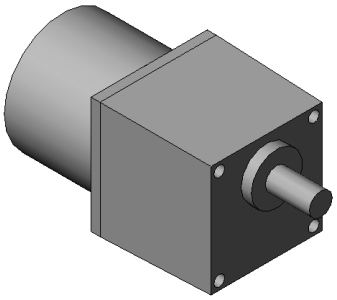
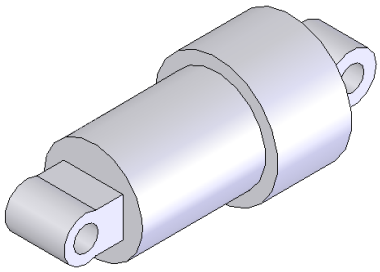
vi.	Seat	
		Part for rider sit. Attach on rear main frame structure.
vii.	Handle grooves	
		This handle groove use to grip hand while riding scooter.
viii.	dc electric motor	
		This component is to moving scooter. Energy from battery will generate rotation of this motor shaft and moving on the bikes.
ix.	Suspension	
		Locate between rear arm and at rear main structure. Use to absorb road surface vibration and give comfortable for rider.

Table 4.1: Continued

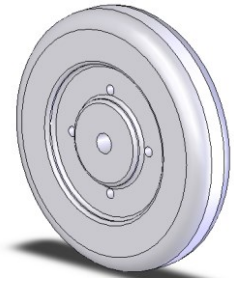
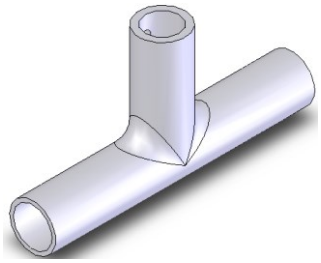
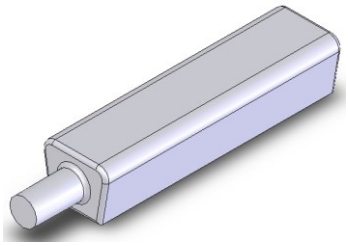
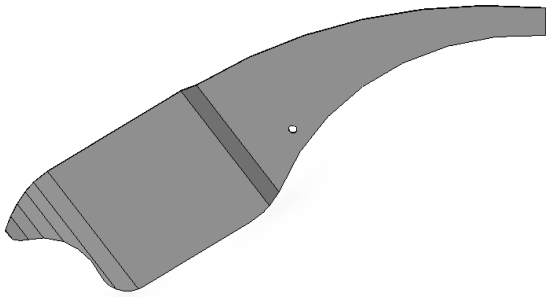
x.	Wheel	
		To move the scooter front or backward.
xi.	Handle bar	
		To control the scooter and hand placed while riding.
xii.	Stand	
		To rest the leg when riding the scooter and get more stability in handling.
xiii.	Side rear arm cover	
		This cover is for closed electronic component and main structure from outside looking. This also will introduce image of scooter shape.

Table 4.1: Continued

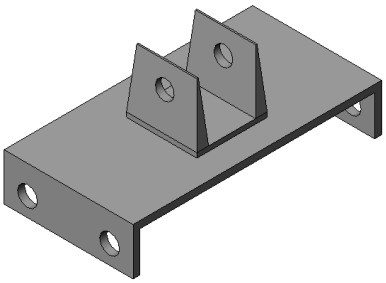
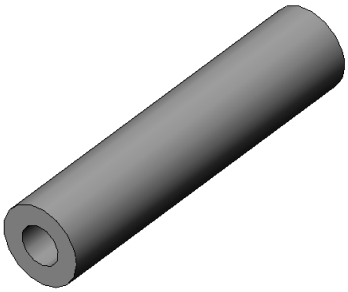
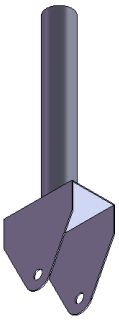
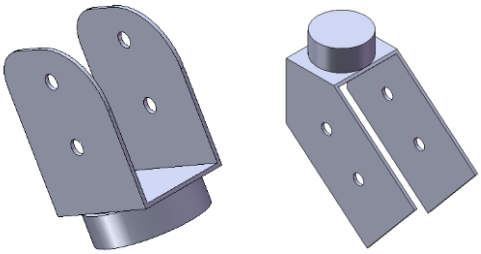
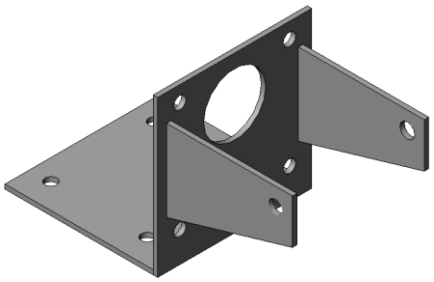
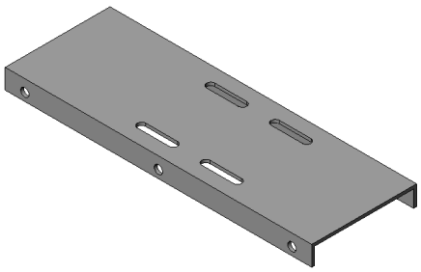
xiv.	Top bracket 	To hold both side of rear arm structure. It also based for suspension.
xv.	Hub 	To support joined between rear arm and side cover of main frame.
xvi.	Front fork 	To joined between front wheel and handle bar. It also to hold front wheel and for cornering handling.
xvii.	Handle bar joining 	This joining is use to hold handle bar. At the same time, it is also flip part for handle.

Table 4.1: Continued

xviii. DC motor bracket 	This bracket is to hold DC motor and make adjustment of chain tensioned.
xix. Basement of rear arm 	To hold structure between two side of aluminum rear arm plate. It also base for DC motor bracket and has long hole for adjusted chain.

From the sketches of component above, the assemblies of all component becomes as Figure 4.1. The Figure 4.1 (a) show overall view of design 3 in unfoldable while Figure 4.1 (b) show overall view in foldable condition. Figure 4.2 show part of component located. Some part will be trim and modification to get good assemblies and best match.

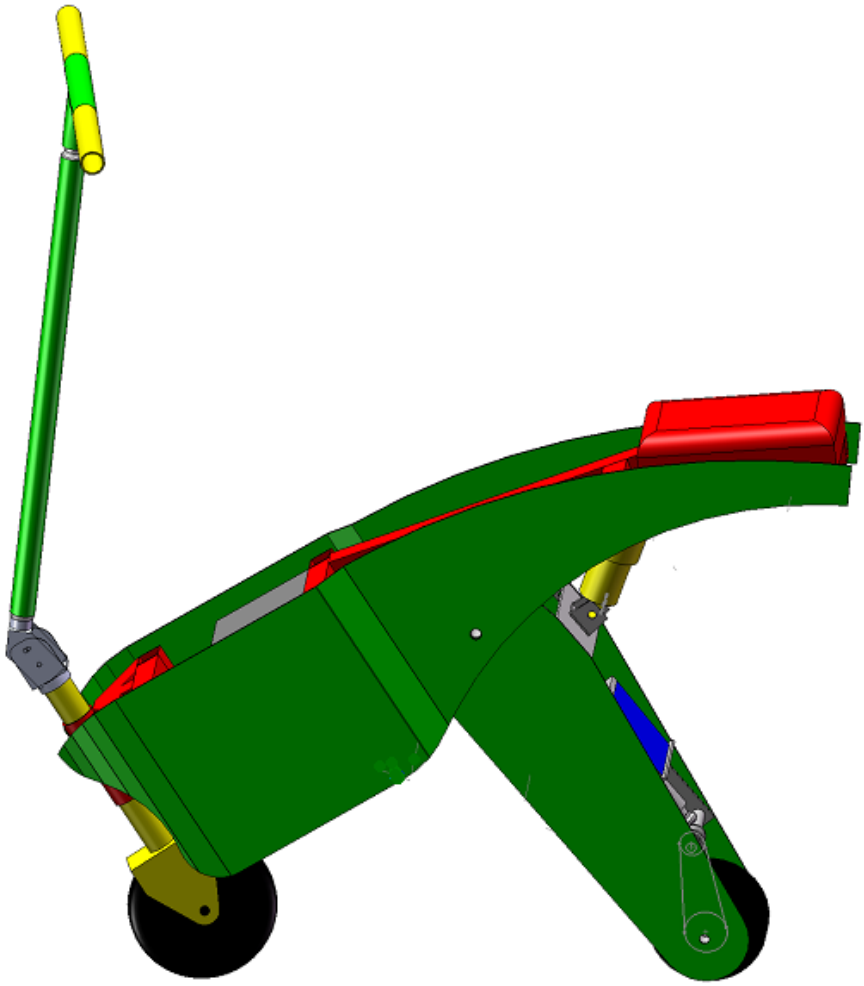


Figure 4.1 (a): Unfoldable of design 3

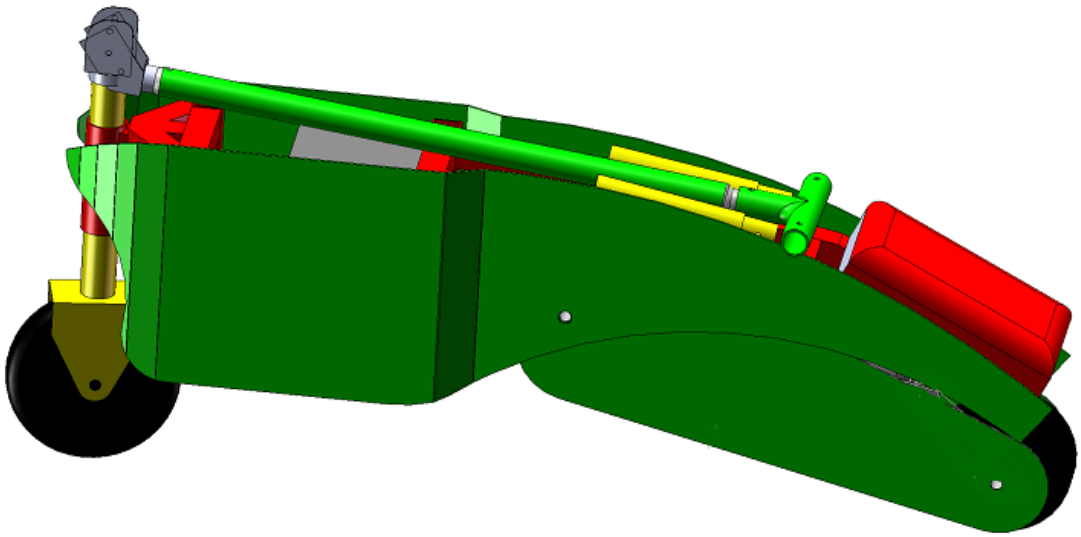


Figure 4.1 (b): Foldable of design 3

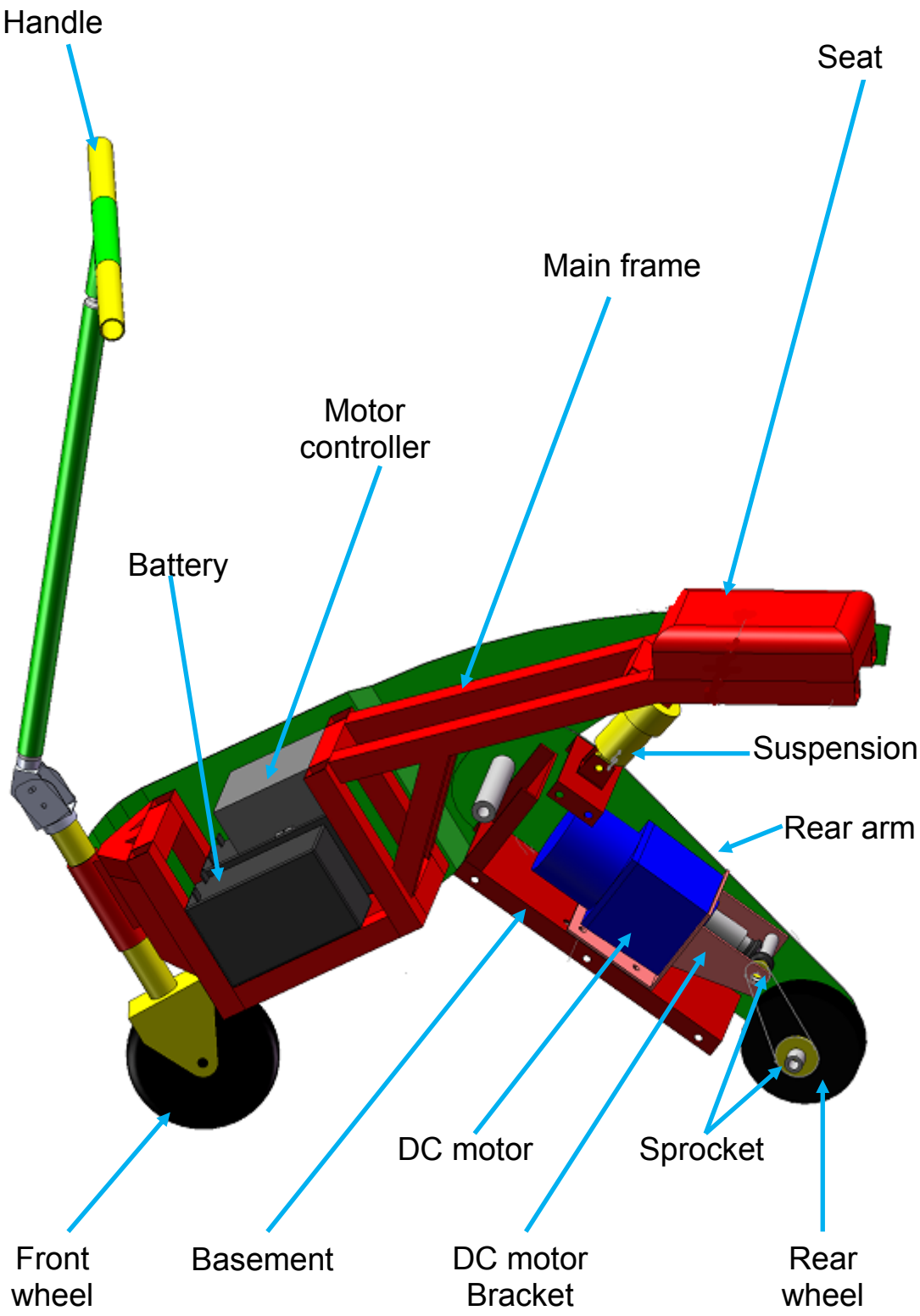


Figure 4.2: Overall look and part of component located

Source: Sketching from solidworks software

4.2 MATERIALS SELECTION

Materials choose for this project is light, strong and for its cover, it wills looks attractive. Hollow bar steel with size 1" x 1" (24.5mm x 24.5mm) and thickness of 1.2mm and aluminum 2.5mm thickness are use in this project for main structure and its cover. This type of Aluminium also uses as main structure for rear arm. Plates 1.2 and 1.5 mm chooses because of light, easy to rivet joining and bending process. This plate is use at basement of DC motor, motor bracket and support plate between rear arm side and also base of suspension bolt. Table 4.2 shows about type of materials selection and application of materials selection.

Table 4.2: Type of material and application for single seater electric scooter

Types of material	Application
Al alloy 6000 series	• Main frame cover • Main structure for rear arm
1.5 mm steel plate	• joined plate between two rear arm aluminum structure • base for dc motor • bracket for gearing • based for suspension
1mm zinc plate	• Rear cover
1.2 mm steel plate with 5mm diameter punch hole	• Based of dc motor
Hollow steel bar 1" x 1" 1mm thick	• Main frame structure • Batteries based
Hollow steel bar 1" diameter	• Handle
Al alloy 5000 series	• Foot rest
Sponge PVC lather Plywood	• Seat

Table 4.2: Continued

High density rubber No air pressure required	• Wheel
Mild steel bar 25 mm	• Main shaft • Gearing shaft • Wheel bush • Gearing bush

4.3 STRUCTURE ANALYSIS

In design criteria, analysis is very important process that must be done before create something. It is one way to measure how strong enough model can be create and what is the best material should be use to make the design that can achieve the objective. Nowadays, there are many software can be used to do the test and analysis on model that want fabricate. It will reduce manufacturing cost, can define materials should use and save time.

From the part sketches in 3D software, analysis can do by using CAE software. In this project, software that use to analysis structure is ALGOR version 16. This CAE analysis will focus on two main parts which is main frame and rear arm structure.

4.3.1 Main Structure Analysis

By using this CAE software, result of the analysis will show in contour of color. The dark color (blue) shows that the structure is safe, while the bright color (red) shows that the point will receive high stress and first part to be break. Some modification should be done to reduce brightness color. In the result of Stress Analysis with Linear Material Models, it will show the value of minimum and maximum stress strain, displacement of structure and also deformation shape. Figure 4.4 show the result of stress after the analysis.

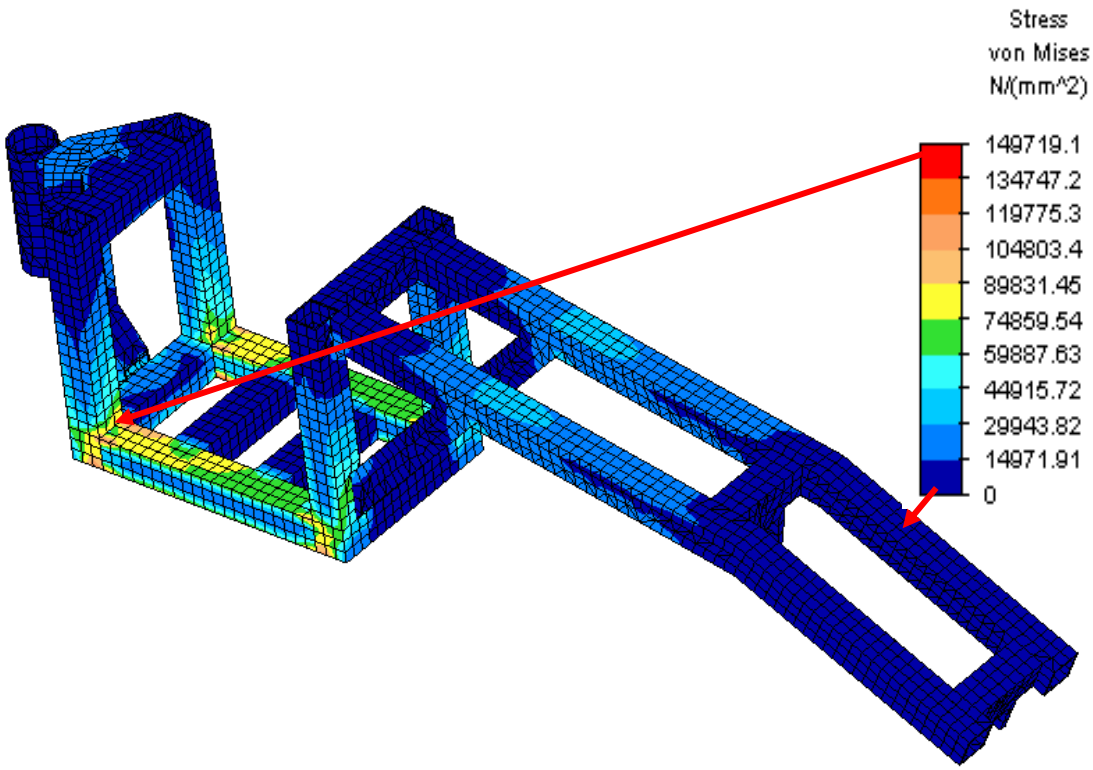


Figure 4.3: Von Mises result of stress analysis on main frame structure

Based on structure analysis and comparison of tensile for steel AISI 4130, the main frame structure actually just only can support load until 85kg or 833.83kN/m. So that, person who weight over than load 85kg, cannot ride this scooter. Figure 4.3 shows result of stress analysis on main frame structure and Figure 4.4 is closed view of high stress part.

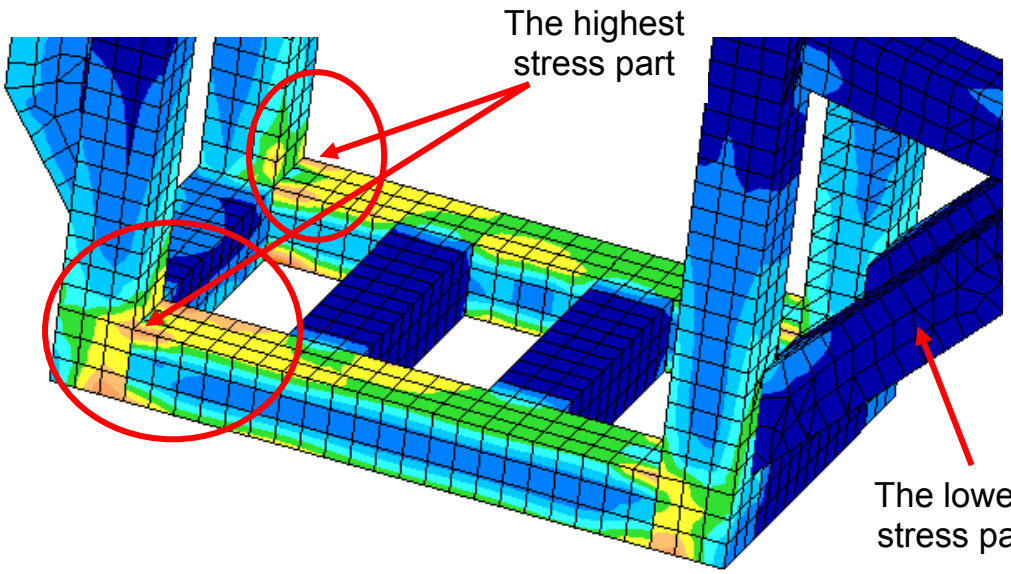


Figure 4.4: Large view of high stress on main structure

From the analysis, can been see that part of battery base will receive high stress and strain. Figure 4.4 shows closed view of main frame critical part. This point is first location of creaking or failure will occur. Due high stress and strain, this model can be support load until 833.83kN/m. Failure at that point occurs because of design structure and joining of 90 degree. Different of color more occur at front bottom face and these values can be determined by compare it with indicator contour color with color on main frame structure such as Figure 4.3. This high value occur because of the downwards angle between font and force at rear (seat). More bright (orange to red) color show the high force attach and first part to be crack. Dark (blue) color shows that the structure is strong and this usually occur at force given and receive minimize stress. Furthermore, there is no support beam attach at top side between front and rear vertical structure. However, this situation can be avoided by add support beam at top of structure. At rear of structure, stress and strain approximately zero value due to this part is load apply and low stress on structure. In Table 4.3, there is result of analysis done with several load given. Start with 700N, maximum stress value is 149.719 kN/mm^2 and maximum strain value is 0.94099. For the last value test is 1100N, stress and strain shows value of 213.491kN/mm^2 and 1.47598. For all test, minimum value of stress strain are nearly to zero. This value is safe for structure. Test value in range of 700N to 1100N is choosing due to normal weight of adult.

Table 4.3: Load comparison of strain stress analysis for main frame structure

Load (N)	**Stress (kN/mm^2)**		**Strain**	
	min	**max**	**min**	**max**
700	0	149.719	0	0.94099
800	0	171.063	0	1.07514
900	0	192.496	0	1.20985
1000	0	213.491	0	1.3418
1100	0	234.840	0	1.47598

Figure 4.5 shows deformation on main frame structure. This situation occurs inside of material. Can be seen at the support member, deformation more occur at middle rear beam and support structure. These two parts deform due to pressure given on that frame and this structure need to hold it. Figure 4.6 shows closed view of deformation shape on support member and middle rear main structure.

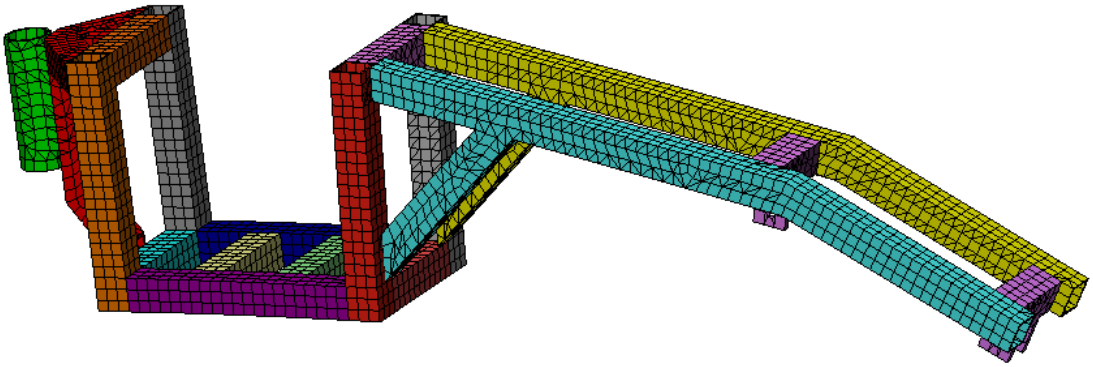


Figure 4.5: Deformation shape on main structure

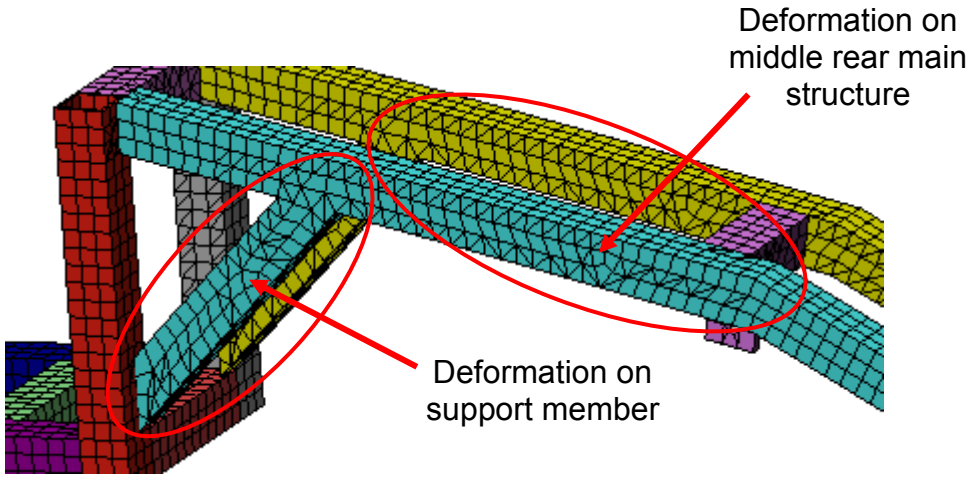


Figure 4.6: Deformation shape on support member and middle rear main structure

Another result of the analysis done is displacement on structure. Figure 4.7 shows the deflection occurs at main frame structure. The high value of displacement is at rear frame which is seat part. This is because force attach at seat will transform shape of beam. It is small deflection and cannot be seen clearly. But in long time, effect of this deflect can been by failure on structure. Table 4.4 shows value of displacement and testing force.

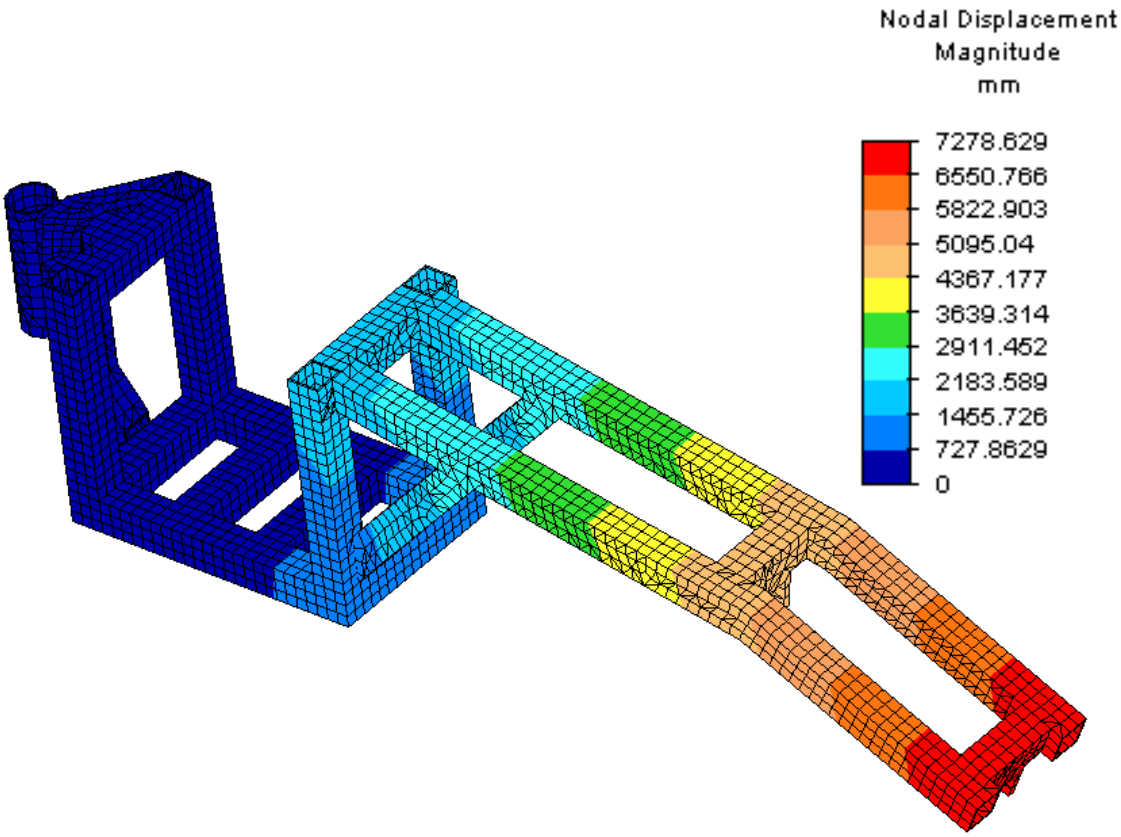


Figure 4.7: Deflection on main frame structure

Table 4.4: Result of displacement and testing force on main structure

Load (N)	**Displacement (mm)**	
	min	**max**
700	0	7278.70
800	0	8316.32
900	0	9358.24
1000	0	10367.25
1100	0	11403.98

4.3.2 Rear Arm Analysis

For the aluminum, the modulus elasticity for this kind of material is very high. It still can support load that being test. However, this is only a part of aluminum using, materials attach on the aluminum, joining stile and material joining should be in this analysis consideration. It can hold the load, but the other materials cannot. In this case, load that should be added or can be support by this material is depends on plate sheet metal. So, it is also same with maximum load can be support by main frame structure.

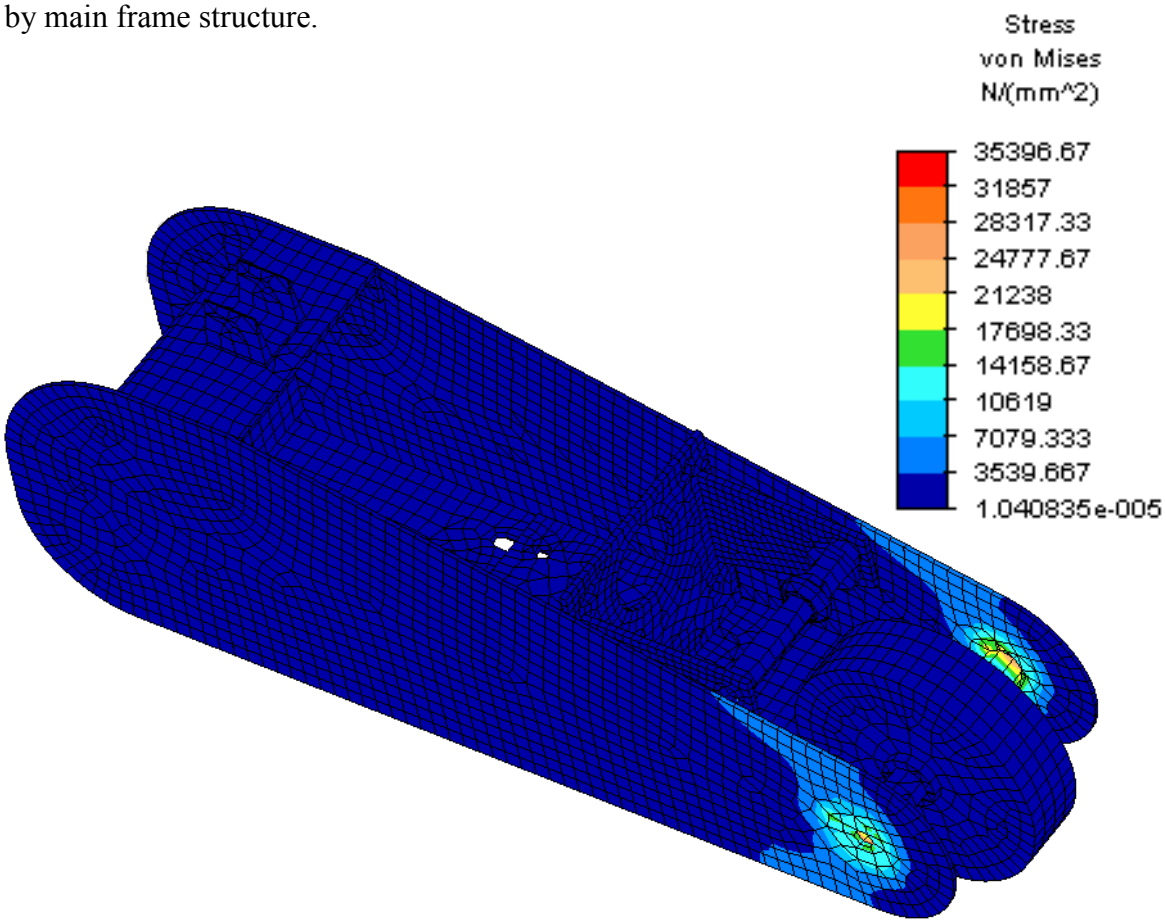


Figure 4.8: Von Mises result of rear arm analysis

From the analysis, stress only occurs at side aluminium of rear wheel bolt and nut. Figure 4.8 shows part stress at side structure and little bit at shaft and wheel bush. This part deflect due to force that should it support of whole model structure. Rider leg also attach near deflection area. Figure 4.9 will shows more closed at stress environment. Maximum stress value of 700N is 35396.67N/mm^2 and minimum value is 1.041e-005N/mm^2. Table 4.5 shows comparison force testing.

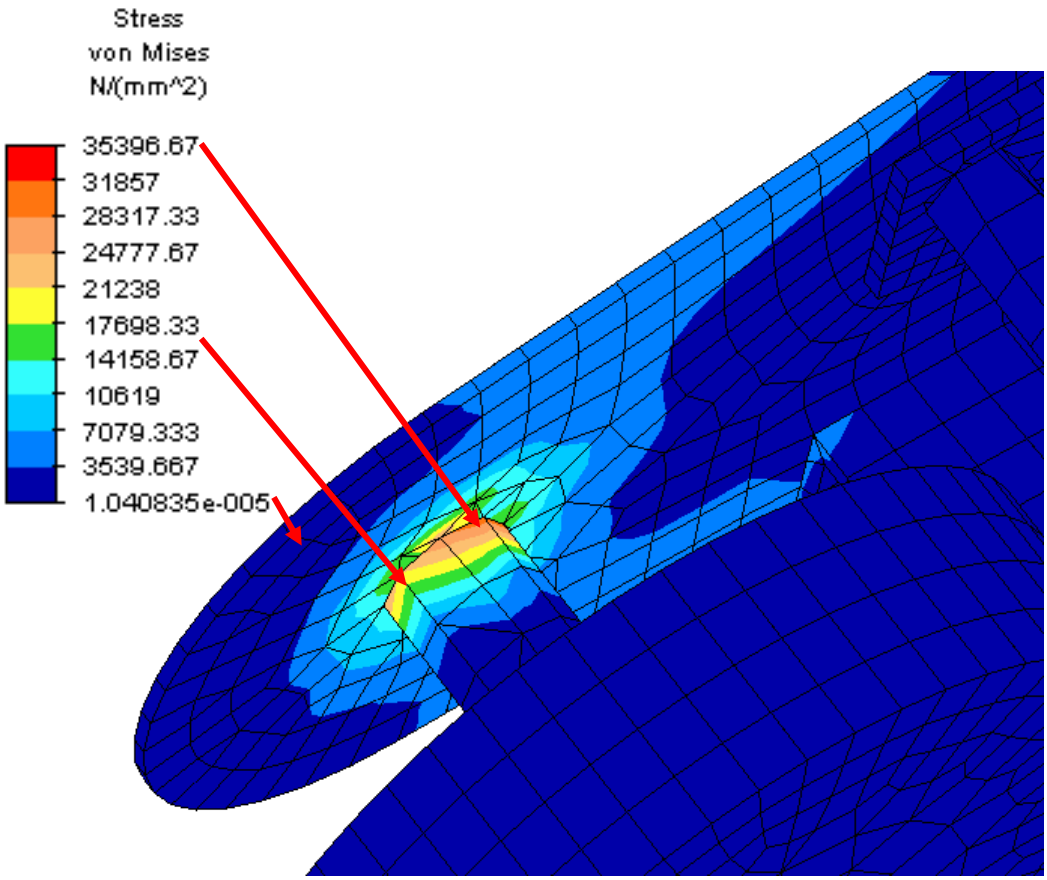


Figure 4.9: Closed view on stress area

Table 4.5: Load comparison of strain stress analysis for rear arm structure

Load (N)	**Stress (N/mm^2)**		**Strain**	
	min	max	min	max
700	1.0408e-005	35396.67	5.0949e-009	0.4875
800	1.1895e-005	40453.33	5.8228e-009	0.5571
900	1.3388e-005	45510	6.5506e-009	0.6267
1000	1.4869e-005	50566.7	7.2785e-009	0.6964
1100	1.6356e-005	55623.3	8.0063e-009	0.7661

Similarly to stress, the strain region is at same point with maximum value of 0.4875 and minimum value is 5.0949e-009 for 700N analysis. Table 4.5 shows the strain value and force applied. Strain has same character with stress. The region and shape of strain act also same as stress.

Figure 4.10 shows deformation on rear arm structure. This situation occurs inside of material. Can be seen at the deformation occur at basement, front hole, rear wheel bolt, DC motor bracket and a little bit at suspension base. These parts deform due to pressure given on that frame and this structure need to hold it. Figure 4.11 (a), 4.11 (b) and 4.11 (c) shows closed view of deformation shape at part mention above.

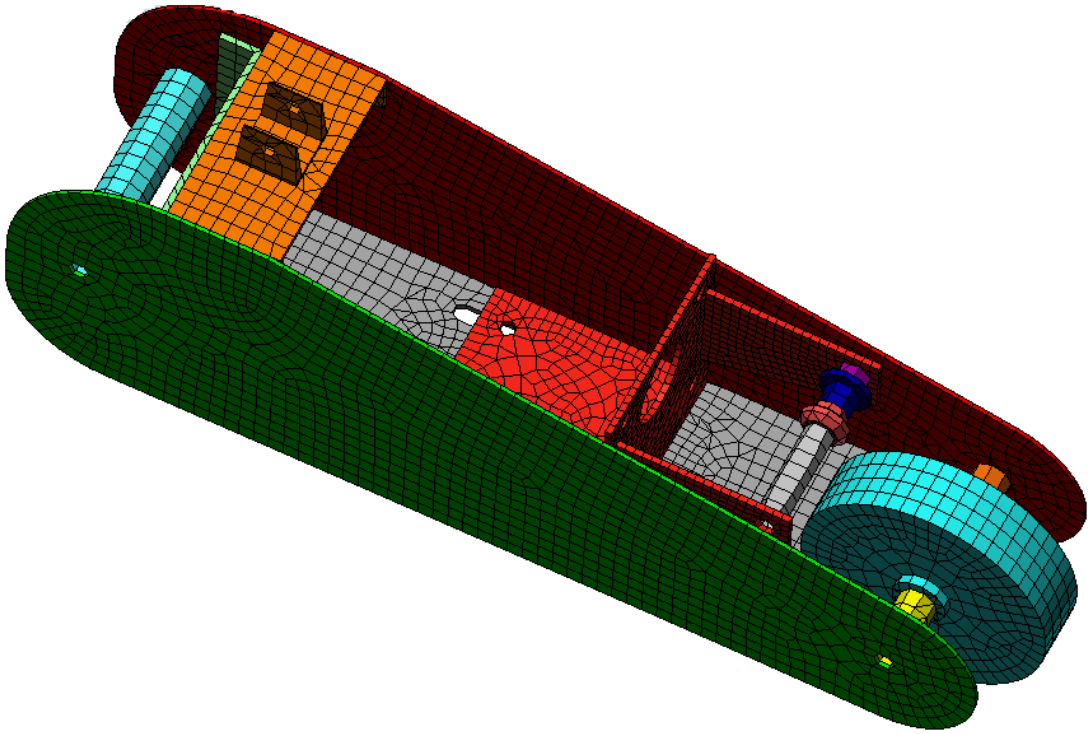
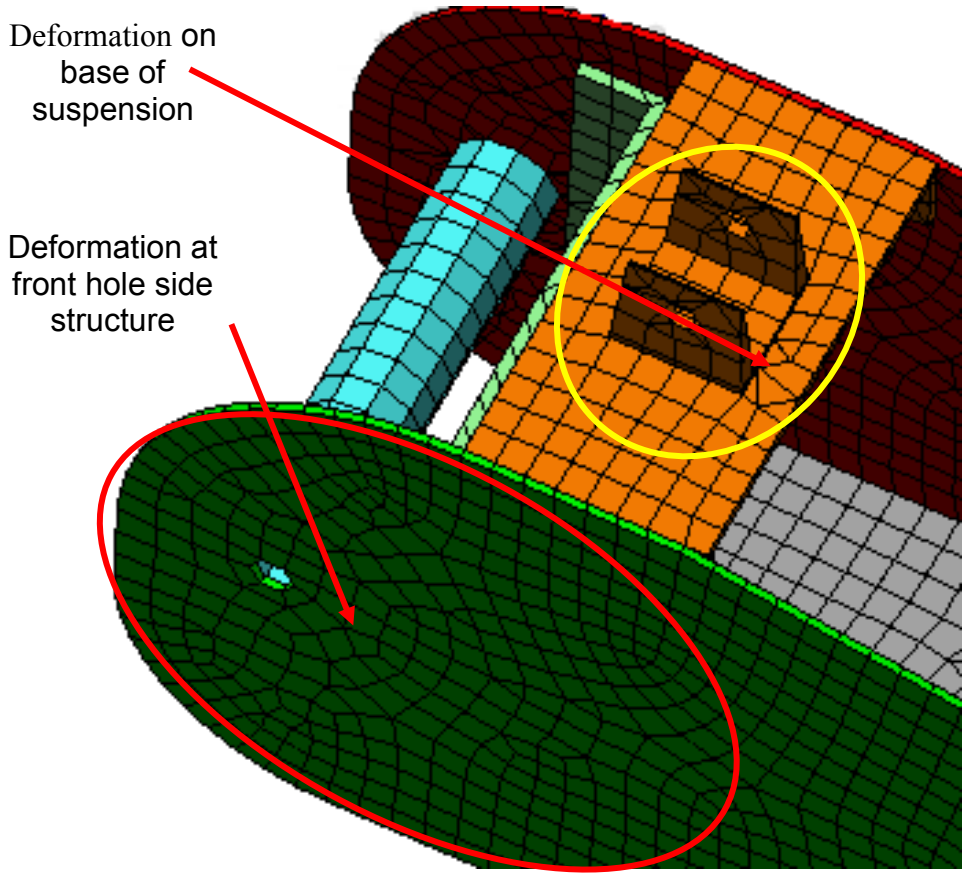
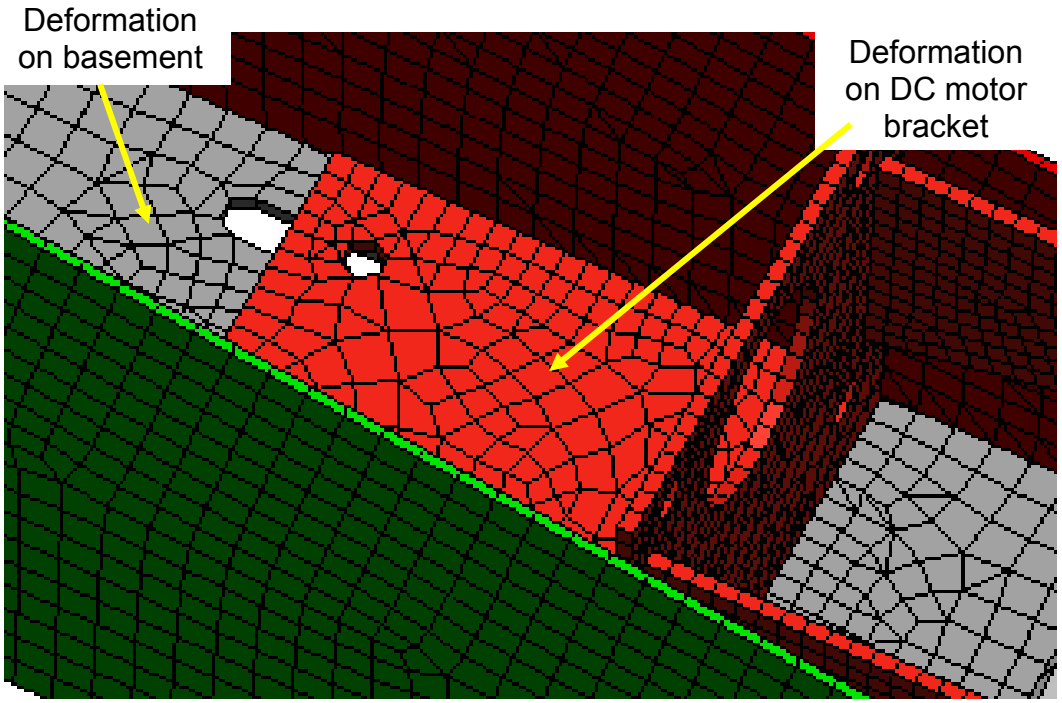


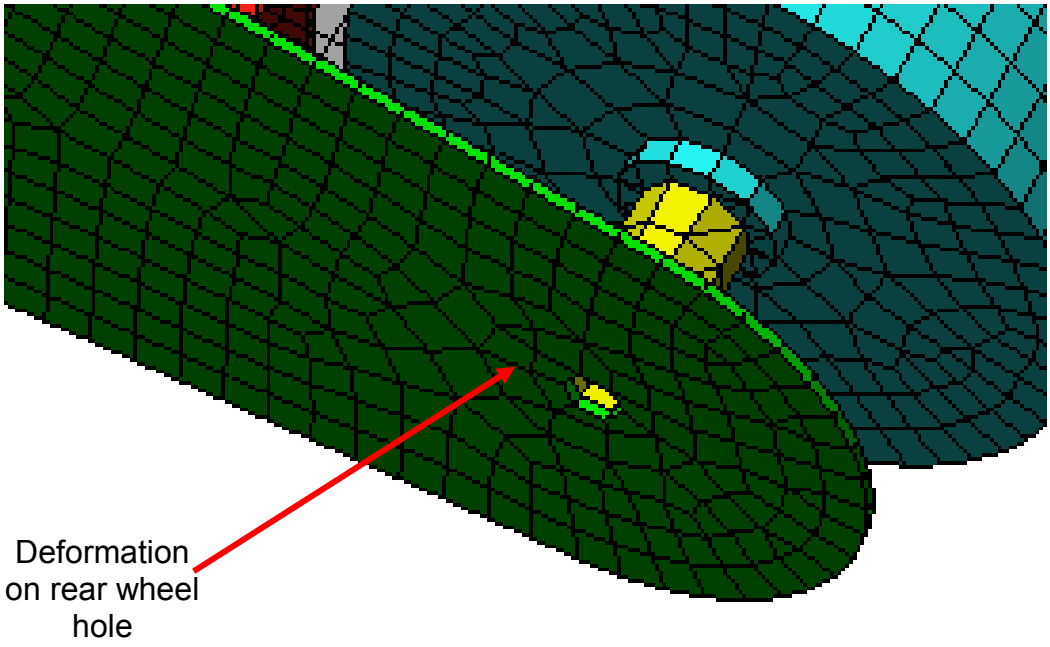
Figure 4.10: Deformation on rear arm structure



(a) Deformation on side structure and base of suspension



(b) Deformation on DC motor bracket and basement



(c) Deformation on rear wheel hole

Figure 4.11: Closed view of deformation shape at rear arm

Another result of the analysis done is displacement on structure. Figure 4.12 shows the deflection occurs at rear arm structure. The high value of displacement is at font rear arm which is near which is near joined part between rear arm and main structure frame. This is because force attach from main frame transmit to rear arm at this contact area first. Force attach on contact area will transform shape of rear arm structure. It is small deflection and cannot be seen clearly. But in long time, effect of this deflect can been by failure on structure. Table 4.6 shows value of displacement and testing force.

In this project, analysis also did not depend on CAE analysis only. Some other method is use to analyze this model based on their capability. One of that is use human to know how comfortable riding this model is, and real condition it can operate.

Table 4.6: Result of displacement and testing force on rear arm

Load (N)	Displacement (mm)	
	min	**max**
700	0	221.717
800	0	253.391
900	0	285.064
1000	0	316.738
1100	0	348.412

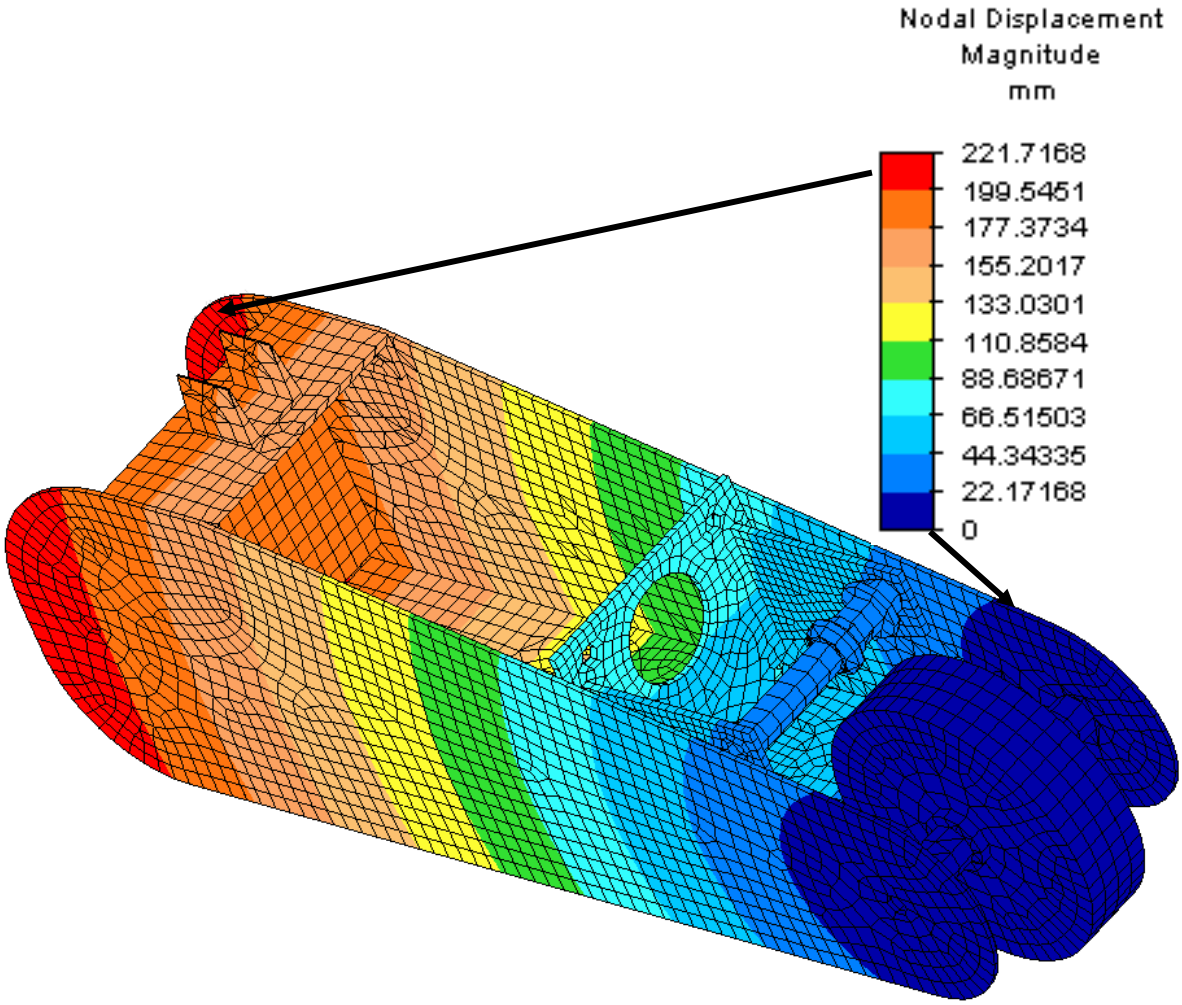


Figure 4.12: Deflection on rear arm structure

4.4 RESULT OF FABRICATION MODEL REFINEMENT

Refinement on model is done to make sure joining can be perfectly, good and safety product create. Some of refinement is done on this project such as discuss below. As a result, refinement is made to makes the model can run properly.

4.4.1 Attachment Support to Make Structure Strong

After fabricate the model it being refinement at certain part to make the structure more tough and strong enough to bring load. Supported will be put on the main body which is located between vertical bar and rear main frame. Figure 4.13 shows that supports being attach to hold rear frame and makes it strong to bring load.

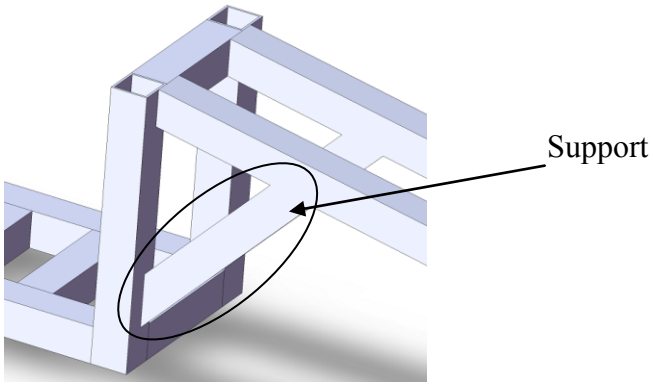


Figure 4.13: Support at main frame

For bottom arm structure, there is no frame structure. Aluminum was use as main structure and joined with other side by long steel plate at their bottom and small plate at the top. Suspension will attach on this small sheet metal to the main frame structure. This structure joined by rivet at certain part. After attach the support beam, structure was try to press at their edge. It is tougher and not shakes anymore.

4.4.2 Removes Sharp Edge

Aluminum sheet metal will attach on main frame by rivet. Sharp shape of aluminum edge will be trim to be smooth and not injury rider by pile. Another

component that trims is steel plate and front fork. The front fork makes round shape at their bottom.

Besides that, basement for hold DC motor also being trim. This is because the rear wheel too closed with that plate and hit the plate while it moving. By using hand grinder, it trims to be curve follow up rear wheel shape. After take out some part of basement, wheel can run properly and not stuck with it again.

4.4.3 Small Modification

At main cover, there is some modified done. A little bit part is pull out to able rear arm can place under main frame structure while in foldable condition. This is because rear arm bolt is outside of dimension that being determine before fabrication process. A little bit main cover pulls out to give compartment for these bolts enter while folding condition. Smoothly rear arm can put under main structure after this modification. The sharp edge then had been removes to avoid injury to rider.

4.4.4 Surface Finishing

Welding part which look poor and at contact surface between aluminum and main frame will be grinding fist until it look flat. This is to make sure closed joining between these two materials. Besides that, poor welded being grinding to make it looks smooth and clean. After this process, that part being spray with layers spray paint to avoid corrosion and keep long life of structure.

4.4.5 Major Modification

After first model crates, there is a problem occur on riding this scooter. It is really hard to control due to angle of front wheel. Major modification is makes on angle of front wheel handle. Due to hard control in the first running time, it was being development again. Whole part and scooter component was takes out during this modification. The front handle holder be cut again and trim back. Their base is design with new one such as Figure 4.14. After all design done, the part makes is

welded back using MIG welding. Then all components are assembles again. Figure 4.15 shows the model before and after modification process.

Figure 4.14: New shape design of handle base

Figure 4.15 (a): Before modification

Figure 4.15 (b) After modification

Figure 4.15: Model before and after modification process

4.5 RUNNING BEFORE MODIFICATION

Since the project done, some experimental done to test the model. The model being ride by Amran Kaharudin and Muhammad Jamil Zakaria with weight about 53Kg and 70Kg. Both of them from mechanical engineering student and they can ride the scooter. This running was done on 22 August 2008 at FKM lab and Kuantan Prade.

Although the model can moves, but it is hard to handle due to wheel angle fall sharply. The handle cannot rotate like bicycle handle. It is similarly to balance our body to turn the scooter and should use large radius to turn.

4.6 RUNNING AFTER MODIFICATION

After modification done, same person in test one was test the model again. Then followed by Mohd Safuan and laboratories assistant which is Mr. Mohd Fazli Ismail. Both of that is new tester but they can handle very well. Compare to Jamil and Amran which takes long time to control this model before modification. Since that all of them satisfied and ride very well this scooter.

Due to hot while welded, some of ball bearing was melt and this cause some loose on handle holder. This test was done on 14 November 2008 at FKM lab, FKM road environment and brick road at FKM entrance. The model was running for two hours.

4.7 PART OF MODEL PROBLEM

Other than that, gearing also always miss because it not use gear with real 90 degree. Using grass trimmer gear, its angle is around 120 degree. The teeth gears attach in small contact area each other when it positioned at 90 degree. Due to that, it always misses and noisy of this missing gear very can be heard loudly.

Bracket for gearing also needs to put another support. This is because it not so tight and fixed to hold gear maintain at their position.

4.8 CHARGING TIME

Based on type of battery using, charging time for fully full is in rage of eight hour. This battery also poor self discharge because it power will reduce while unused and must be charge back. Table 4.7 is summarizing of testing that was done on scooter model.

Table 4.7: Testing on scooter model

Testing	Result
Charging time	8 Hour
Running time	2 Hour

4.9 RIDING SCOOTER IN DIFFERENT ROAD SURFACE

Besides that, tested also had been done on several road surface. Firstly, it had been run on smooth concrete floor which is in Mechanical Engineering Laboratory. At this condition, scooter can move very well and fast. Figure 4.16 shows FKM lab floor.

Then it was tested at brick arrange road surface. This is at main entrance of FKM lab. During this surface, it is quite hard to handle due to small diameter wheel. Although it still can move, but vibration produce is too high.

Figure 4.16: Mechanical Engineering Laboratory floor

Lastly, the model test on bitumen road. It is front of FKM lab. Due to rough surface road, vibration produce still high and not so hard such as riding on brick arrangement. Figure 4.17 shows road surface tested.

Figure 4.17: Road surface in front of FKM area

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

From the literature review, there are lots of scooter types. To manufacturing the scooter is depend on what it being use and rider comfort and satisfaction. In this project, modeling by using software can give fast result of model to be created. It also can give accuracy of dimension near real one. By using the 3D software, it also can save time and reduce manufacturing cost.

Based on research and materials finding, selection of materials is considering by weight less, strong and low cost to buy. Mild steel hollow bar 1" x 1" is selected due to their light, cheap and strong by welded joining. Another material use is aluminum 2.5mm thickness as a main cover and rear arm structure. It takes from aluminum alloy 6000 series which is tough and light.

Part by part will be draw and when finish, all it be assemble to get real location component of model. Then, part of model will be analysis by ALGOR software. Modification on model will be doing to get strong structure and adding support at certain part.

From the technical drawings, real dimension and image will be easy to created and manufacture. Fabrication is based on this information. This is also easier way to communicate with manufacture of what needs to do and what materials and equipment needs. Some refinement on model at sharp edge, welded joining surplus

and modification to make sure all component exactly attach on model. The scooter is free test running first before running by person.

As a conclusion, there are two objectives to achieve in this project and both of that achieve. The fabrication model development of single seater electric scooter is done very well.

Another one is doing analysis on structure of model also done in time given. Result of this analysis shows that it can support load until 85kg. This scooter can properly moves after major modification on handle angle.

5.2 RECOMMENDATION

After finished this project, there are some modification should be done to make it looked more interested and maximize their capability before enter the market. This kind of scooter may be can be powered by small capacity engine to make it operate with high performance. But using engine, it will produce some noisy and gas exhaust emissions.

Other than that, if it still using DC electric power motor which supply energy from battery, may be alternator or dynamo can be attach on moving part to charge back battery. This will increase time using and reduce charging time.

This model actually is still heavy due to its component like two dry cells rechargeable batteries and DC electric motor. So, this cause becomes hard for women to carry or bring it into car boot. The recommendation is using light battery which can produce more power. Besides that, main structure also can be reducing the weight by using carbon fiber structure or alloy steel.

Moreover, shape of this wheel also not suitable for riding. It is actually use trolley wheel which is not rounded shape at their side. Tire slip may occur at high velocity cornering. Furthermore the tires are too small and not suitable for riding on bitumen road. By using larger wheel, brake can be attached on wheel of this scooter.

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