UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS ◆

JUDUL: DEVELOPMENT OF ATTACHMENT FOR CUSTOMIZED STEERING RACK ON 1 SEATER DRAG BUGGY

SESI PENGAJIAN: 2008/2009

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DEVELOPMENT OF ATTACHMENT FOR CUSTOMIZED STEERING RACK ON ONE SEATER DRAG BUGGY

MUHAMMAD SHAHRIN BIN SUHAIMI

A report submitted in partial fulfillment of the requirements
for the award of the
Diploma of Mechanical Engineering

Faculty of Mechanical Engineering
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NOVEMBER 2008

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion this project is satisfactory in terms of scope and quality for the award of Diploma of Mechanical Engineering

Signature:
Name of Supervisor:
Position:
Date:

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I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ACKNOWLEDGEMENTS

I would like to acknowledge with appreciation the numerous and valuable comments, suggestions and constructive criticisms from a lot of people around me during the project period such as my parents, friend, all the instructors at FKM laboratory and to the very importance men behind this project, En. Mohd Fazli Bin Ismail as the Supervisor for this project and En. Mohd Farizul Shahidan Bin Rajuli as the Instructor for this project. Because of their suggestions, support and guidance this project had achieve the required objectives on time even though facing a lot of problem during this project period.

I'm very grateful to have a supportive team mate for this project that work for other major systems on the buggy. The experiences that I gain during this project period and also the knowledge that I got from the supervisor and instructor for this project are valuable and very important. Lastly to my beloved parents that always give moral support for me to stand and continue fighting for my future.

ABSTRACT

The title for this project is Development of Attachment for Customized Steering Rack on One Seater Drag Buggy. This project is under the UMP Mechanical Faculty. The main target for this project to the final year project student is to design, fabricate and analysis the customized mechanical part at the steering system of this buggy. This is to achieve the objective which is the steering system for the buggy is function without any problem. The steering system is very important to a vehicle to control and to navigate the vehicle movement direction. The system used mechanical principle to transfer the rotation from the steering wheel to the wheel through the steer rack that consist mechanical part such as pinion gear, bar gear and shaft. The analysis of the part is very important to gain the information on the maximum stress, minimum stress, load, FOS and the application of each material used to withstand the load. This buggy is design to roll at extreme terrain such as off-road and mud. The fabrication of the customized part and attachment of the part must be done properly to withstand the environment used of this vehicle. The other important aspect during fabrication and attachment process is the driver safety, this aspect is the priority during the development of the system.

ABSTRAK

Projek Tahun Akhir ini bertajuk Development of Attachment for Customized Steering Rack on One Seater Drag Buggy. Projek ini merupakan satu teras bagi pelajar tahun akhir bagi Fakulti Kejuruteraan Mekanikal UMP. Tujuan utama projek tahun akhir ini dijalankan adalah untuk melatih pelajar supaya berkeupayaan untuk mereka, mencipta dan menganalisis bahagian-bahagian yang direka supaya mencapai matlamat projek tahun akhir ini iaitu keupayaan megawal kenderaan ini tanpa masalah. Sistem kawalan kenderaan ini merupakan satu sistem yang penting dan utama dalam sesebuah kenderaan kerana ia akan menentukan arah pergerakan kenderaan dan mengawalnya. Sistem ini yang beroperasi secara mekanikal untuk memindahkan arah putaran pegemudi ke roda melalui rack kemudi yang mengandungi bahagian-bahagian mekanikal seperti gear pinion, gear bar dan juga shaft. Tujuan menganalisis bahagian-bahagian yang direka adalah penting kerana untuk memperoleh maklumat tambahan seperti maximun stress, minimun stress dan juga FOS untuk setiap bahagian yang terlibat dalam operasi pengemudian ini. Kenderaa buggy ini direka untuk pemanduan di luar jalan raya dan akan menerima tekanan yang tinggi di bahagian pengemudi. Setiap bahagian perlu mampu menampung tekanan akibat dari hentakan dan gegaran ketika memandu di kawasan tanah dan berlopak. Selain dari ketahanan, keselamatan pemandu juga penting dan keutamaan ketika proses reka cipta di jalankan.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

This project was purpose to make an off-road buggy for FELDA usage. It is design for off-road exploration through estate and can withstand extreme terrain. This buggy will be proposed for FELDA from UMP-MECHANICAL FACULTY after the fabrication, modification and basic analysis completed. This project was divided into three major parts for PTA students to handle under En. Mohd Fazli Bin Ismail (supervisor). Overall this project required the skills of designing, knowledge of the system and analysis of each component or part in the system.

1.2 Problem Statement

This Project will need modification and fabrication of extra part for the buggy's steering system. This is because on early development of this project the steering system had a rotation problem on the steer rack. The rotation motion of the rack is inverted with the front wheel steer direction. The main focus is to design and fabricate a gear box that will convert the rotation motion before it transfer to the steer rack. Others are to modified aftermarket steer system to perfectly fit when attaching the system with the buggy main chassis.

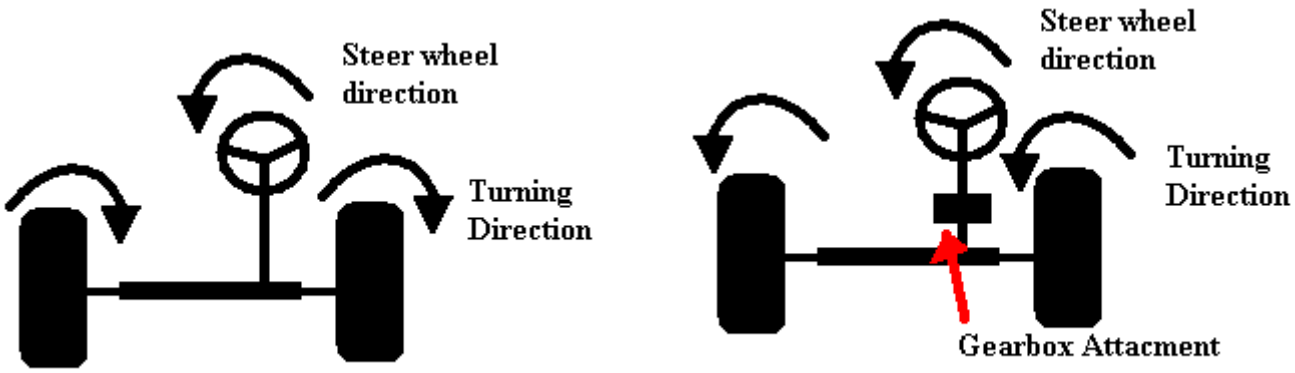


Figure 1.1

Problem statement and gearbox attachment to solve the problem

1.3 Project Objective

The objective of this project is to design, fabricate and modified the steering system on the buggy. By using the mechanical steer system, installation of additional custom part is required to convert the rotation of the steering wheel before it transfer to the steering rack.

- Modified – universal joint, alignment rod and steering rack.
- Fabricate – gear box.

1.4 Project Scope

Project Scope is the required step to gain knowledge and understanding on the main focus on the project.

The project scopes are:-

a) Investigation of the problem.

In this process, the main idea is to find the problems that occur on the steering system. Identifying latent or hidden problems on the buggy's steer system and then list down the possibility solution for solving the problem.

b) Set target specifications

Base on steering types and benchmarks (Benchmarking is information on competing products gathered to support the positioning). Develop metrics for each types of steering to help identify the specification of the system. Set ideal and acceptable values for each steer system.

c) Conceptualization.

Concentrate on designing the assembly line and create custom part for the steer system by making simple sketches known as thumbnail sketches of each concept. This is the brainstorming on the designing of costume made part that will fulfill the required specification needed for the part.

d) Further refinement and final concept selection.

Draw in 2D or 3D for part studies and for testing to the proposed product features and functionality (solid work).The Drawing will be analyze by using COSMOS Xpress to get the required information such as maximum stress, minimum stress and the factor of safety of each part.

e) Control drawing

In this stage, the main focus is to gain information on document functionally, features, size, surface finish and key dimension on each part. This information is helping in fabricate the final design models for the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Steer System

Steering system in automobiles are build from several component such as steering wheel, gears, linkages, and other components used to control the direction of a vehicle's motion. Because of friction between the front tires and the road, especially in parking, effort is required to turn the steering wheel. To lessen the effort required, the wheel is connected through a system of gears to components that position the front tires. The gears give the driver a mechanical advantage. Various types of gear assemblies, none with any decisive advantages over the others, are used, although some manufacturers prefer a rack-and-pinion system. In faster, heavier cars the amount of force required to turn the tires can be very great. Many of these cars use a power-steering system. The system contains a hydraulic booster, which operates when the engine is running and supplies most of the necessary force when the driver turns the wheel.

Figure 2.1 Mechanical Steer Systems

2.2 Type of Steer System Used In This Project

2.2.1 Rack-and-pinion Steering

Rack-and-pinion steering is quickly becoming the most common type of steering on cars, small trucks and SUVs. It is actually a pretty simple mechanism. A rack-and-pinion gear set is enclosed in a metal tube, with each end of the rack protruding from the tube. A rod, called a tie rod, connects to each end of the rack.

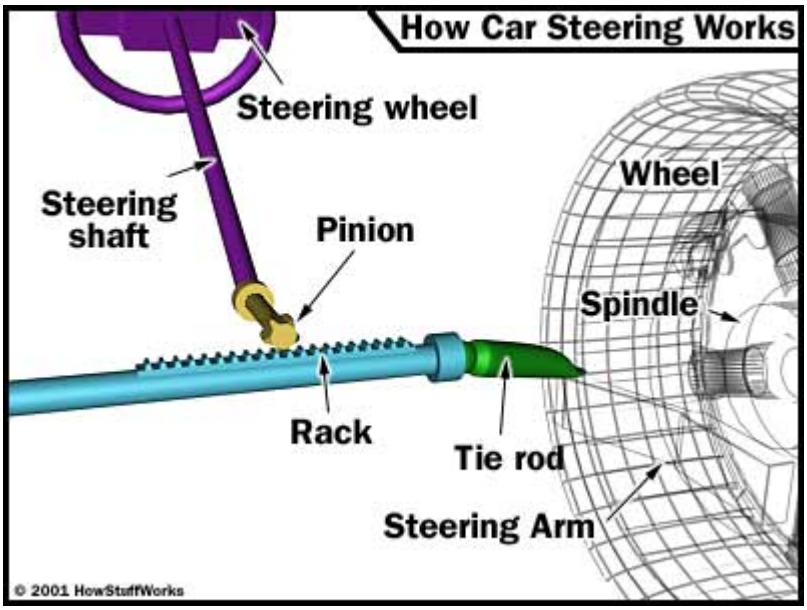


Figure 2.2 Mechanical Steer Rack inside View

The pinion gear is attached to the steering shaft. When you turn the steering wheel, the gear spins, moving the rack. The tie rod at each end of the rack connects to the steering arm on the spindle **(**see diagram above).

The rack-and-pinion gear set does two things:

- It converts the rotational motion of the steering wheel into the linear motion needed to turn the wheels.
- It provides a gear reduction, making it easier to turn the wheels.

2.2.2 Power Rack-and-pinion

When the rack-and-pinion is in a power-steering system, the rack has a slightly different design.

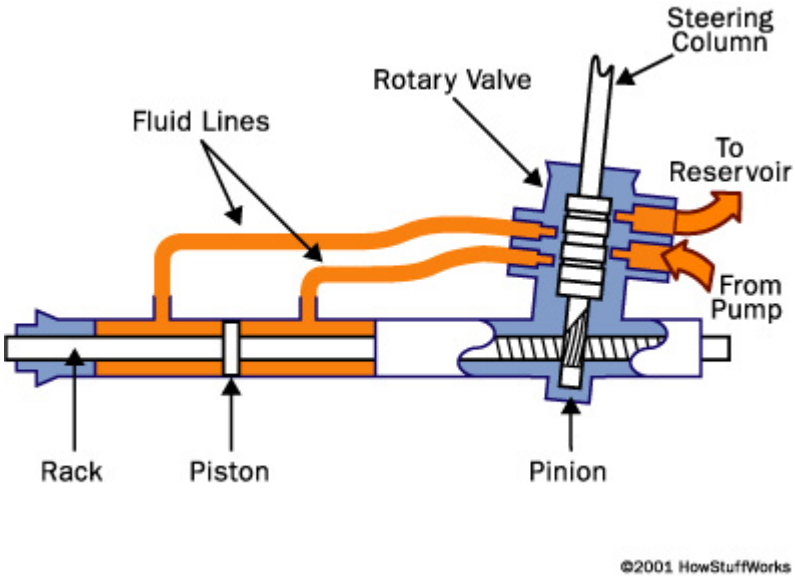


Figure 2.3 Power Steering System

Part of the rack contains a cylinder with a piston in the middle. The piston is connected to the rack. There are two fluid ports, one on either side of the piston. Supplying higher-pressure fluid to one side of the piston forces the piston to move, which in turn moves the rack, providing the power assist.

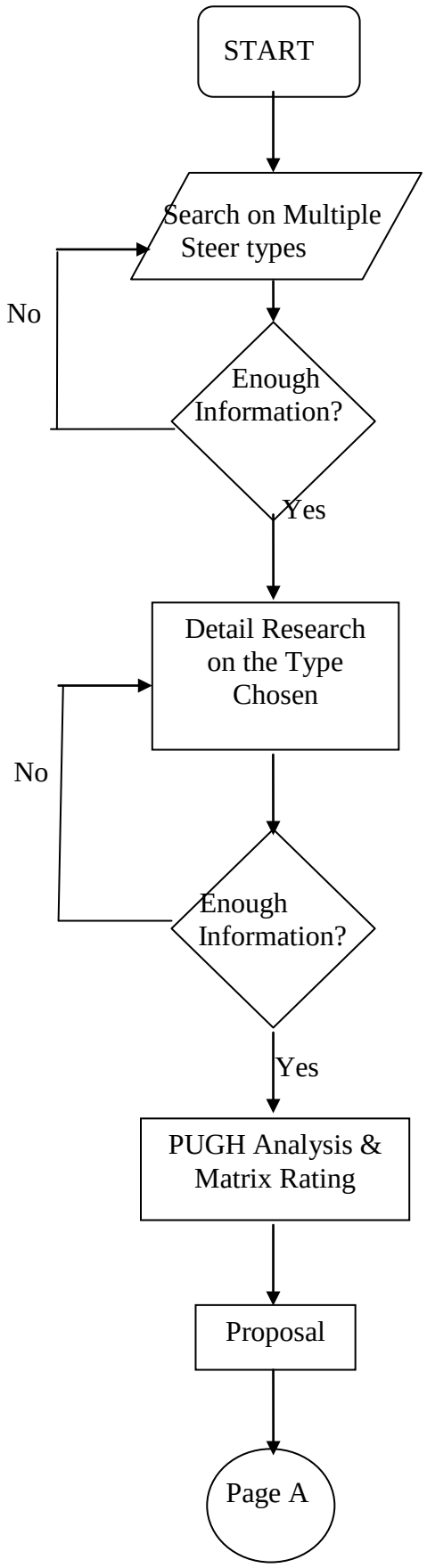
CHAPTER 3

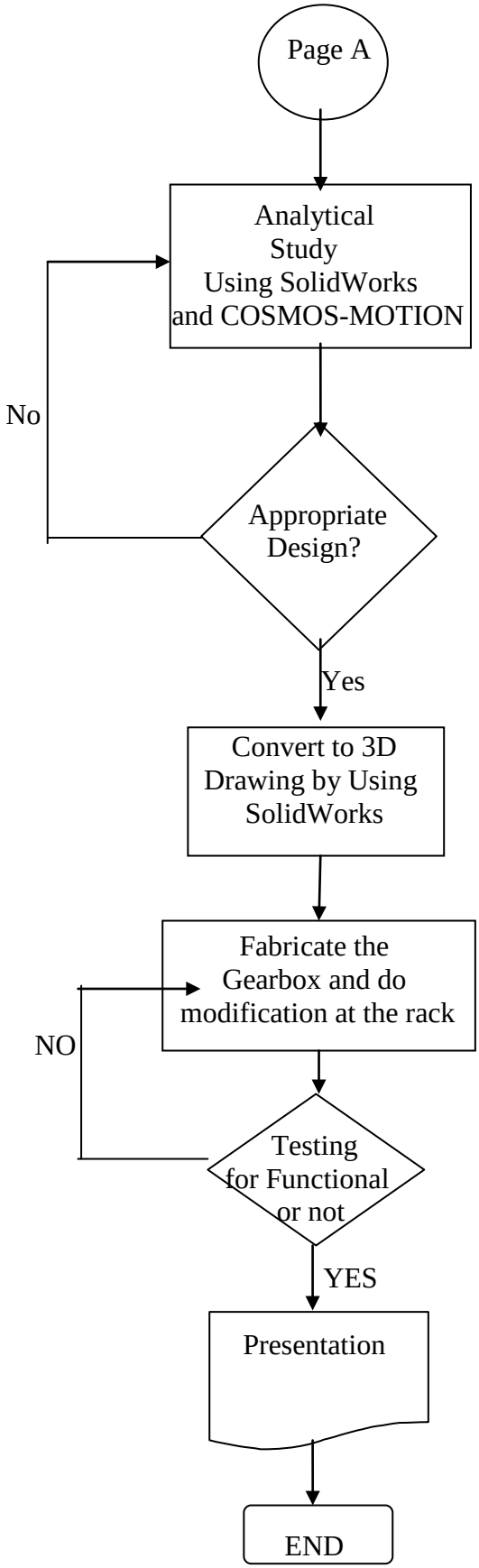
PROJECT METHODOLOGY

3.1 Project Flow

Methodology is the method that been used from early project develop until the end product release. It consist several stage of conducting this whole project. This flow will explain detail about each step of **Industrial Design Method** in developing new product that will achieve the required specification. To make sure this project complete on schedule, flow chart is important to assure all the planning running smoothly. The processes start with doing researches on the types of steer systems to gain more knowledge about the principle of the steer rack. The next step is doing metric and pugh analysis to select the best type of steering rack and propose to the supervisor before starting the next steps of the process. Brainstorming to get various concepts and do analysis of each concept to determine the best concept for the fabrication process. The concept will be converted to the 3D drawing for further studies on the dimension and the logical movement. The testing of the product will be done after the fabrications are finish. The last step is to compile all the information for presentation and report submission.

a) Flow Chart


START
Search on Multiple Steer types
No
Enough Information?
Yes
Detail Research on the Type Chosen
No
Enough Information?
Yes
PUGH Analysis & Matrix Rating
Proposal
Page A


Page A
Analytical Study Using SolidWorks and COSMOS-MOTION
No
Appropriate Design?
Yes
Convert to 3D Drawing by Using SolidWorks
Fabricate the Gearbox and do modification at the rack
NO
Testing for Functional or not
YES
Presentation
END

3.1.1 Problem and Part Studies

This is the first step of the flow. This is to identify the problems in the system and list down the causes of the problems. It also includes the studies of each part in the steering system to gain more knowledge and understanding on the principal of each component.

3.1.2 Designing Concept and Selection of Best Concept

This stage will need a lot of new concept develop in sketches to help in development of the best concept. This is because the concepts that have been develop from sketches are being compared in several aspects such as size, strength, material and ergonomic.

3.1.2.1 Concepts

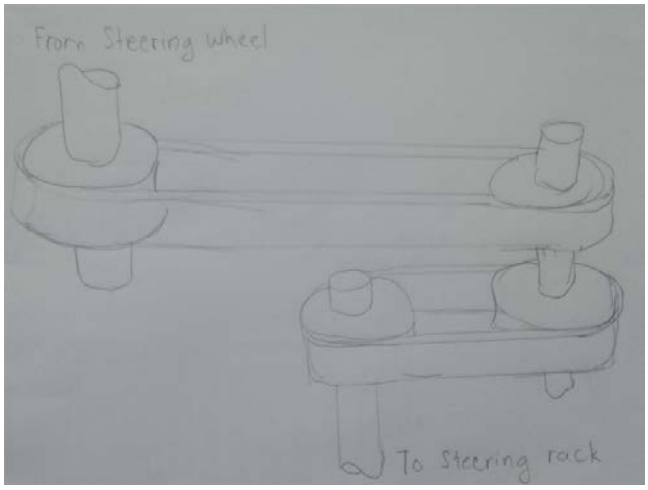


Figure 3.1:

CONCEPT 1 - Rotation transfer by belting concept

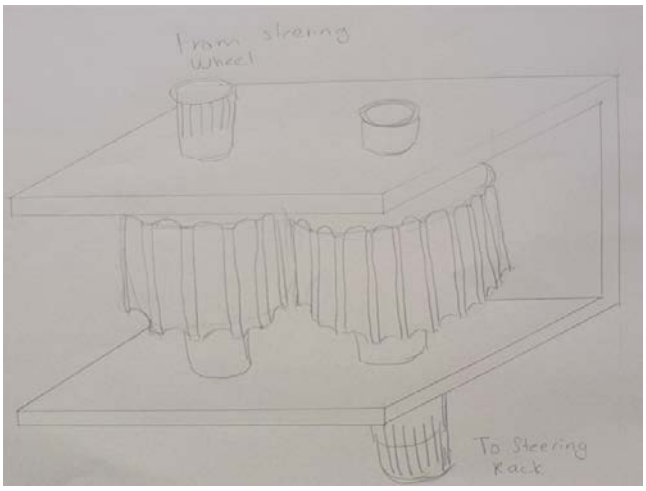


Figure 3.2:

CONCEPT 2 - Twin gear rotation concept

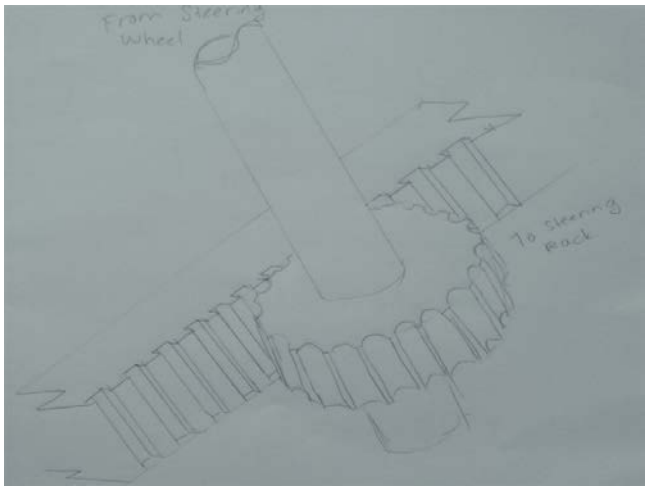


Figure 3.3:

CONCEPT 3 - Direct gear connection concept

3.1.2.2 Best Concept Selection

Basic Concept Analysis is done on each concept to compare the characteristic of each concept.

Table 3.1:- Concepts Comparison

Design	Advantages	Disadvantages
No.1	Low production cost. Easy installation and maintenance	No ergonomic value.
No.2	Small size High force	High production cost
No.3	Small size Low cost	Failed at high force

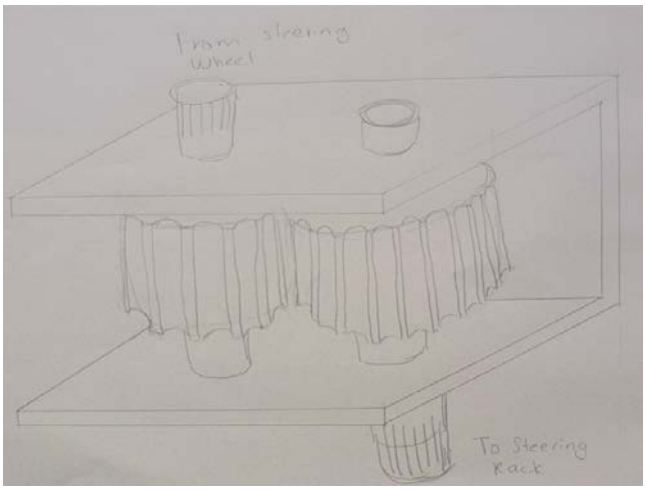


Figure 3.4

Best concept that fulfill the required specification.

Concept 2 is selected as the best concept because it fulfills the required specification such as:-

- Compact size
- Can work under heavy forces
- Material propose:-
    - Stainless Steel
    - Mild Steel

3.1.3 Detail Drawing and Analysis

In this stage the final concept is finalize using 3D CAD drawing and analyzes using COSMOS-MOTION software to determine the maximum point load at the component and the logical physical movement by doing the motion simulation. .

PART:- GEAR SHAFT

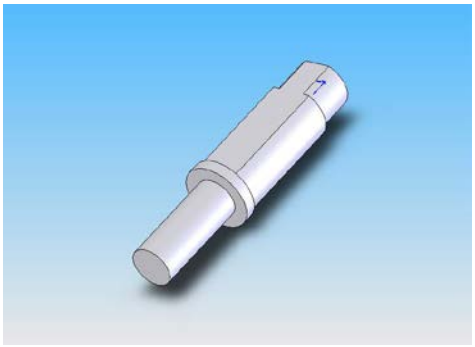


Figure 3.5 : Shaft

PART:- PINION GEAR

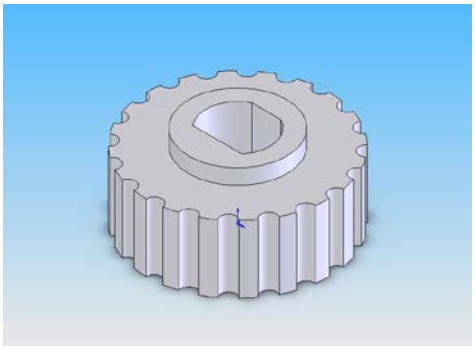


Figure 3.6 : Pinion Gear

PART:- GEARBOX CHASSIS

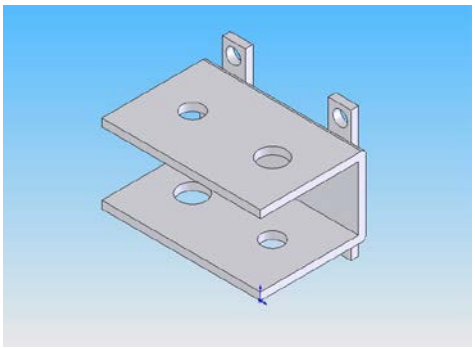


Figure 3.7 : Chassis

FINAL ASSEMBLE DRAWWING

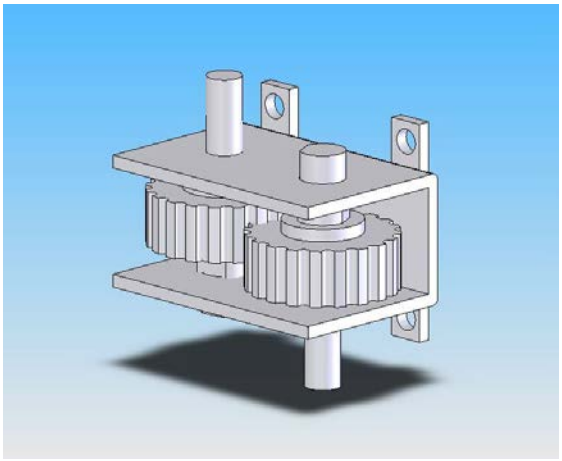


Figure 3.8 : Full Gearbox assembly

3.1.4 Selecting proper material for product

To select the materials that fulfill the specification of the product, the studies about the parameter of the material is required. The materials that are proposed are stainless steel and mild steel.

3.1.4.1 Material Applications

In this project development, two main material are been used for fabrication of the gearbox.

Stainless Steel Applications

- Resistance to corrosion and staining.
- Low maintenance
- Relative in expense

Mild Steel Application

- High strength
- Withstand high temperature

3.1.5 Fabrication and Modification

In this stage I have to start fabricate the prototype of the gearbox from the finalize concept using the selected materials. And also do the modification on the original system to fit well in the new buggy chassis.

The fabrication of the gearbox begins with machining process of the gear shaft. These processes were done on the conventional lathe machine and conventional milling machine. And next the chassis fabrications were done by using CNC milling and the conventional arc-welding to joint each section of the chassis.

The modification of the steer rack was about the size of the component that need to otter to fit precisely at the buggy's chassis. The tie rod and the Universal joint are cut and rejoin to get the precise size needed.

3.1.6 Parts Attachment

Final stage is to assemble all the part together to determine the final outcome of this project. The system must be tested for the safety of the driver. Several tests have been done and the result is in ok condition.

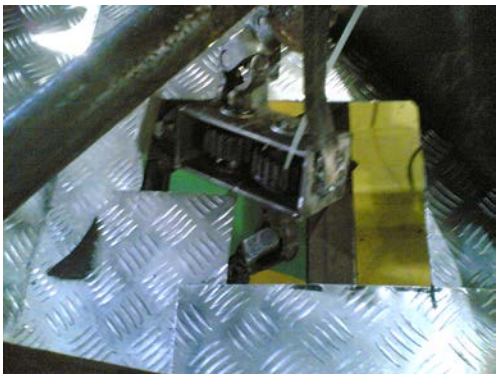


Figure 3.9:- Gearbox placement at the buggy

Figure 3.10

Modification of universal joint to fit with the limited space at the buggy's leg compartment

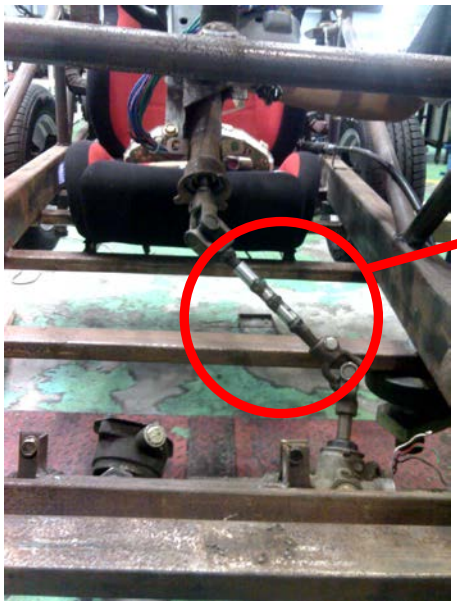


Figure 3.11:- Front view of the buggy's steer system before gearbox attachment made.

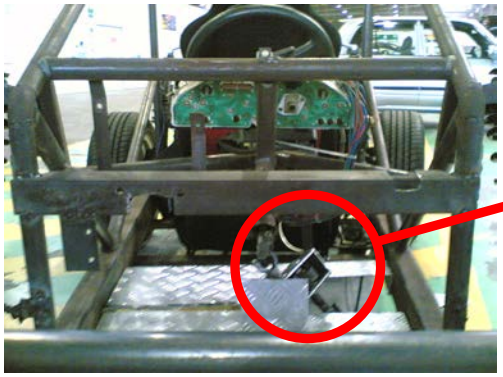
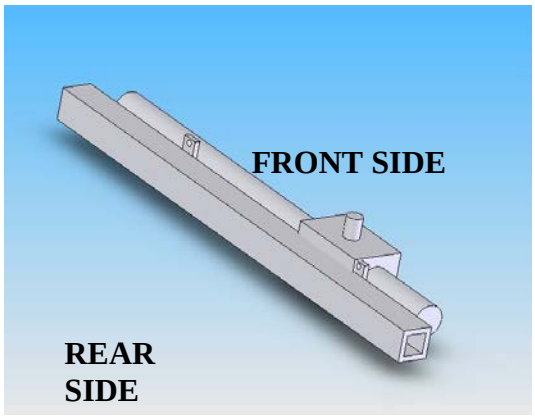


Figure 3.12:- Front view of the buggy's steer system before after attachment made.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Steering Rack Problem



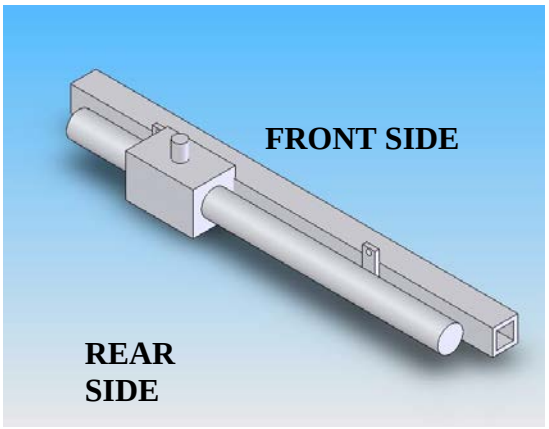


Figure 4.1 and Figure 4.2

Figure 4.1 show the Original steering rack at a standard car is located frontward of the car chassis. Figure 4.2 show the modification on the placement of steer rack, it is located at the back of the buggy chassis. The allocating of this steer rack is determined by the placement of the engine.

The placement of the steering rack at the buggy's chassis is determined by the placement of the engine. The steer system had major problem after the placement of the steer take place. This is because the rotation of the steering wheel is inverted with the front wheel. To solve this problem, a gearbox is needed to convert the rotation to its original rotation directions. A gearbox that used two pinion gears to transfer the rotation and convert the direction before it reaches the steer rack. This concept been choose because of high amounts of force it can handle during the rotation transfer.

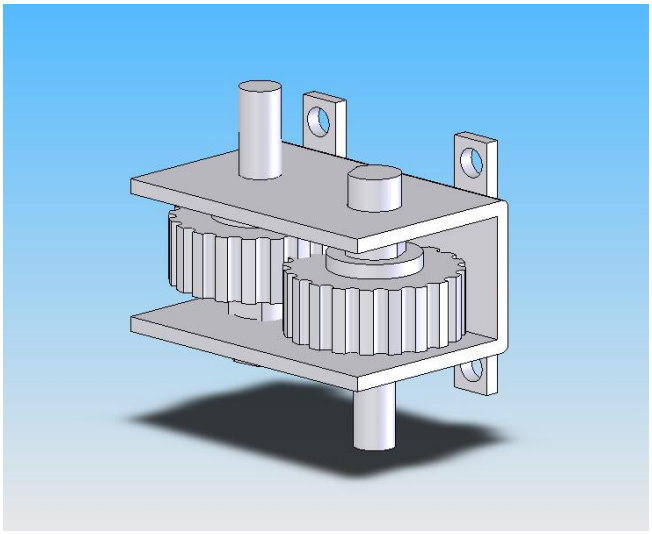


Figure 4.3

Pinion gearbox that operate to convert the steering wheel rotation.

4.2 Gearbox Analysis

The main purpose of gearbox fabrication at the buggy's steering system is to convert the direction of the steering wheel rotation before it reach the steering rack. This gearbox used two pinion gears with the same ratio of 20 teeth. The first gear is rotating the same way with the steering wheel while the other one will rotate counter direction from the first gear. The rotation rate of first gear will be equal with the second gear because the ratio is 1:1.

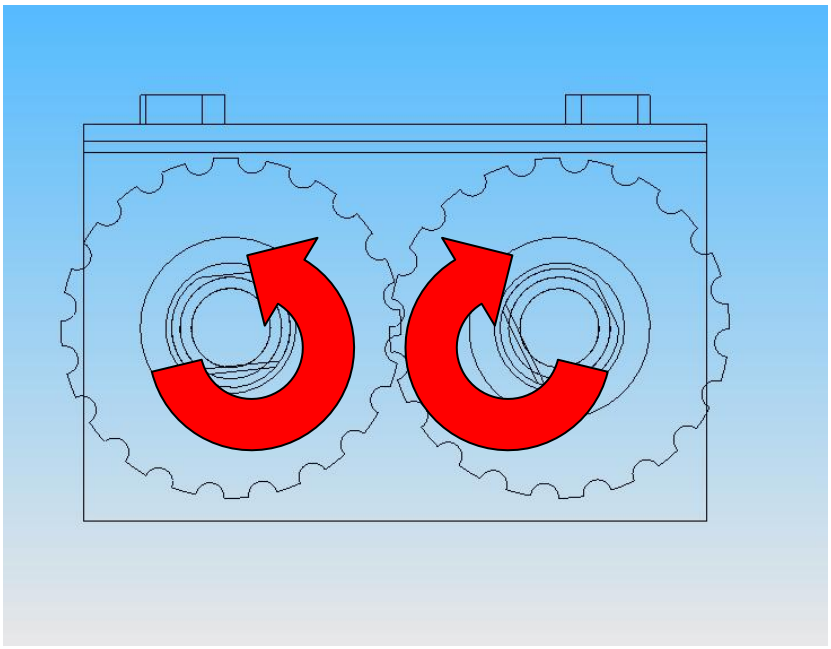


Figure 4.4
The direction of pinion gears movement when the converting process happens.

4.2.1 Fabrication Requirements

This gearbox must have several specific criteria such as high strength, anti-corrosion, and light weight to withstand the twisted force from the steering wheel. To achieve this specification needs the materials that been used to fabricate this gearbox must be selected through the specific material characteristic.

4.2.1.1 Material Selection

Materials that been used in these gearbox fabrications are:-

- Stainless Steel – anti-corrosion, this material is process to fabricate the pinion gear shaft.
- Mild Steel – high strength, this material is used to build the chassis of the gearbox.
- Mild Steel pinion Gear – this part is an after market product.

4.2.1.2 Concept Selection Method

The selections of gearbox concepts were done by getting the rating of each concept by comparing each specification and characteristic. This is done by using Metric and Pugh method to clarify each specification and characteristic at each concept.

4.2.1.3 Metric Analysis

Table 4.1:- Metric Rating For Each Concepts

NO	NEED	Concept 1	Concept 2	Concept 3
1	Material Characteristic	***	****	***
2	Size	*	*****	****
3	Maintenance	*	*****	**
4	Safety	**	*****	****

Rating Description:

***** Excellent

**** Best

*** Good

** Average

* Poor

4.2.1.4 Pugh Analysis

Table 4.2:- Pugh Rating For Each Concept

NO	NEED	Concept 1 (DATUM)	Concept 2	Concept 3
1	Material Characteristic	**0**	**+**	**+**
2	Size	**0**	**+**	**+**
3	Maintenance	**0**	**+**	**-**
4	Safety	**0**	**+**	**+**
	PLUSES	**0**	**4**	**3**
	SAME	**4**	**0**	**0**
	MINUSES	**0**	**0**	**1**
	NET	**0**	**4**	**2**
	RANK	**3**	**1**	**2**
	CONTINUE	**NO**	**YES**	**NO**

4.2.2 Gearbox Parts

The gearbox consist of two shafts made from stainless steel material and two pinion gears from after market made from mild steel. The chassis of the gearbox are made from mild steel plate with dimension of 140mm X 80mm X 8mm (two pieces) and 80mm X 90mm X 8mm (two pieces).

Figure 4.5

Components inside the gearbox are stainless steel shafts and mild steel pinion gears.

4.2.2.1 Parts Dimensions

a) Shaft

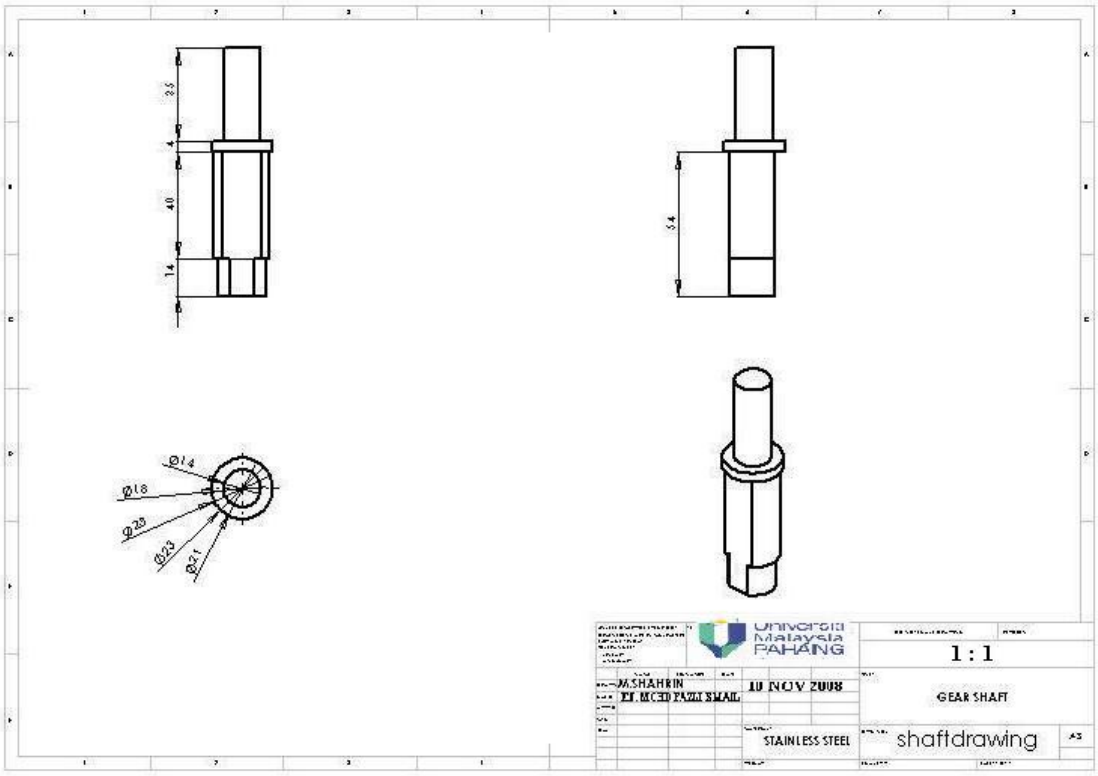


Figure 4.6 : Shaft dimensions (APPENDIX B)

b) Pinion Gear

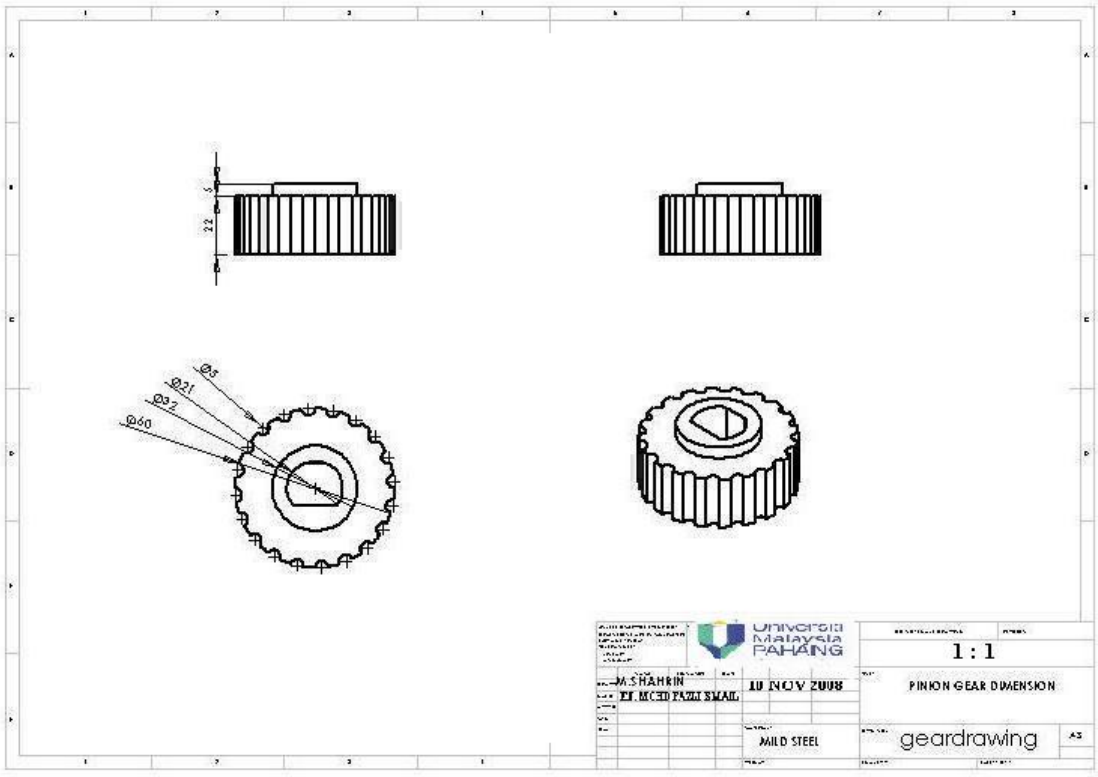


Figure 4.7 : Pinion gear dimensions (APPENDIX B)

c) Chassis

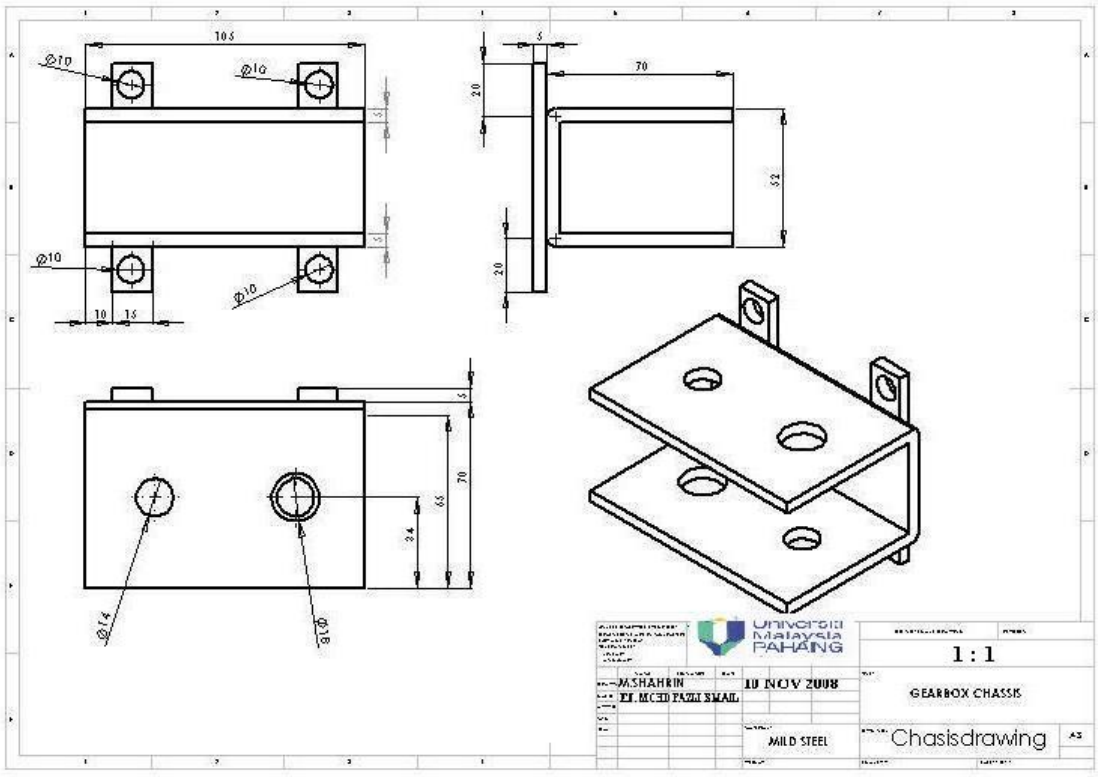


Figure 4.8 : Gearbox Chassis dimensions (APPENDIX B)

d) Full Assemble Dimensions

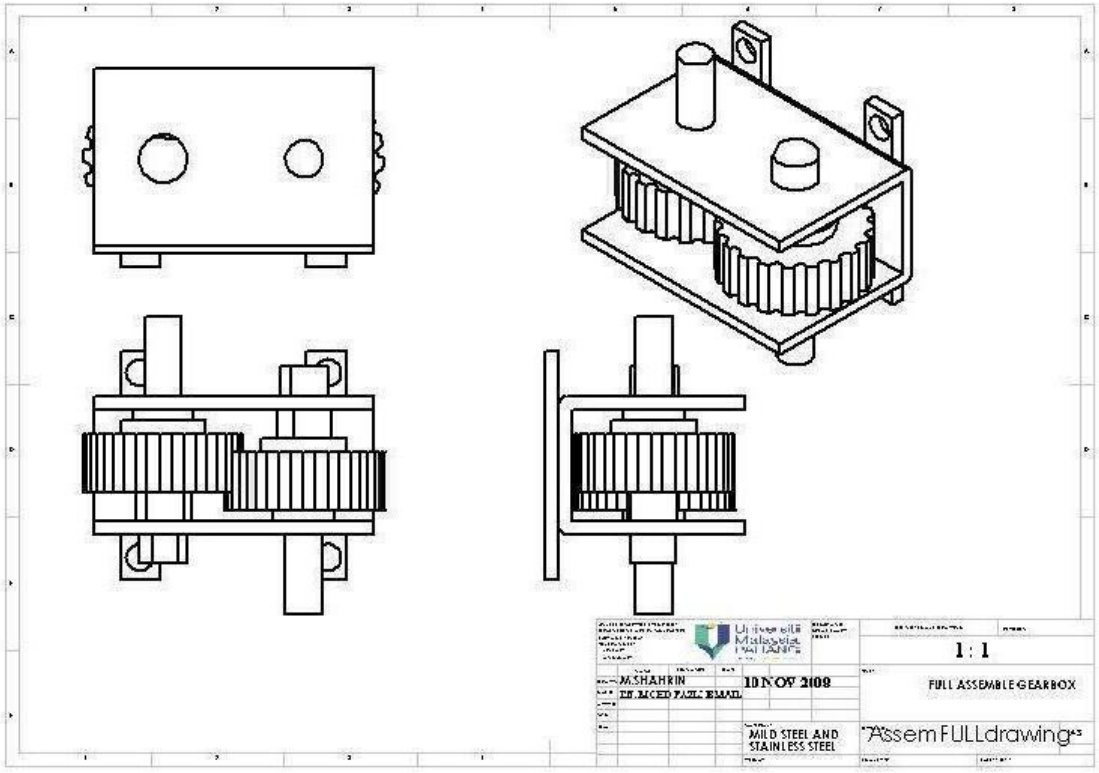


Figure 4.9 : Full Assemble dimensions (APPENDIX B)

4.3 COSMOS Xpress Analysis on gearbox parts

This analysis is to determine the maximum and minimum stress that can be applied to the gearbox by using the COSMOS Xpress software. This software will generate the output (max. and min. stress) based on the input (load that been applied to the surface). Each major part will be analyzed based on this method.

4.3.1 Gearbox Chassis Analysis

Type of Analysis: - Minimum and Maximum Stress point at gearbox chassis and FOS (Factor of Safety).

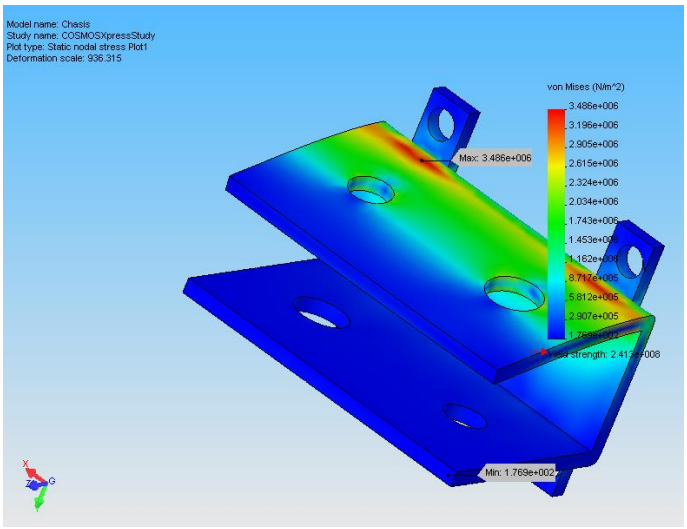


Figure 4.10

Maximum and minimum stress result on the gearbox chassis.

The result shows that this chassis can withstand the maximum stress of 3.846 MN/m² and the minimum stress of 176.9 N/m² after 50 N of load is applied on the surface. The material that is used is mild steel with the yield strength of 241.3 MN/m² before it reaches the maximum point of elastic region.

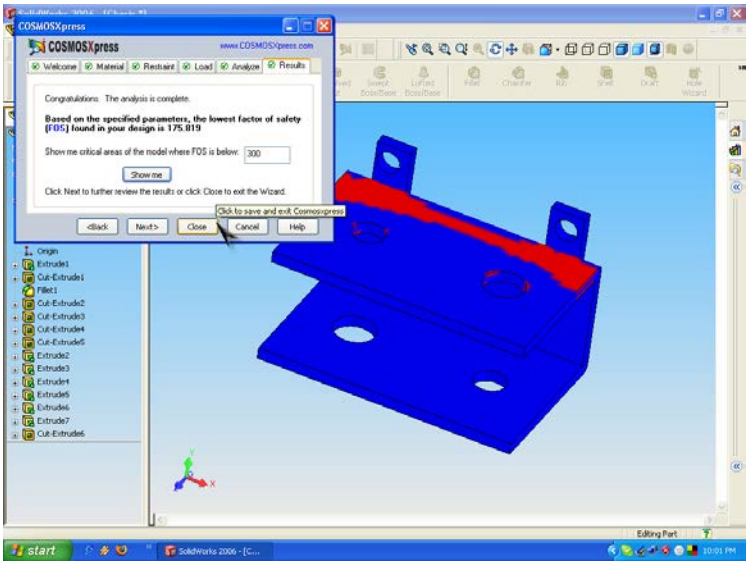


Figure 4.11

The Factor of Safety result at the chassis

Factor of safety is the amount of load which this chassis can withstand without need to reach the stress point of failure. The amounts of FOS that been generate is 175.819.

4.3.2 Gearbox Shaft Analysis

Type of Analysis: - Minimum and Maximum Stress point at gearbox chassis and FOS (Factor of Safety).

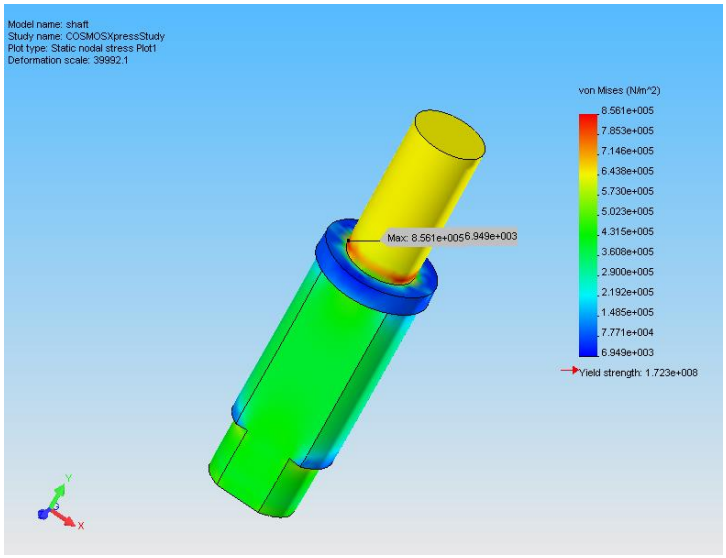


Figure 4.12

Maximum and minimum stress result on the gearbox shaft.

The result shows that this shaft can withstand the maximum stress of 856.1 KN/m² and the minimum stress of 6.949 KN/m² after 100 N of load is applied on the surface. The material that is used is stainless steel with the yield strength of 17.23 MN/m² before it reaches the maximum point of elastic region.

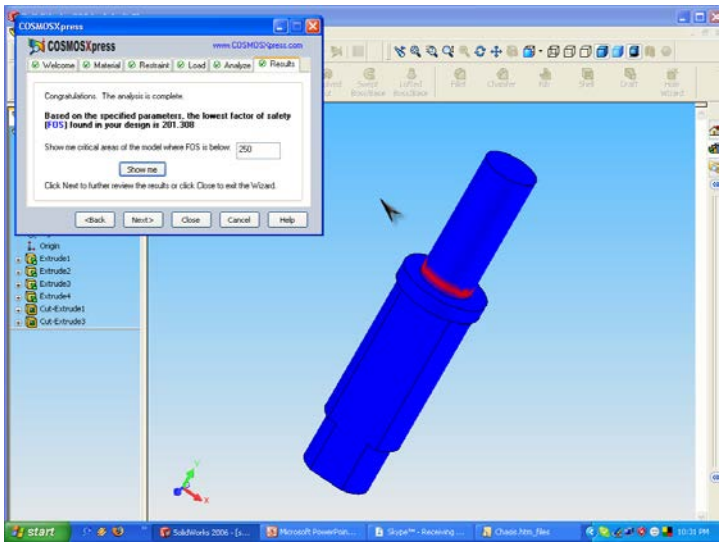


Figure 4.13

The Factor of Safety result at the shaft.

Factor of safety is the amount of load which this chassis can withstand without need to reach the stress point of failure. The amounts of FOS that been generate is 201.308

4.4 Steering Rack Modification

The original steering rack that been used is from Daihatsu Mira steer rack. Some modification has been done to this steering rack to fit properly at the buggy chassis. This modification is about set the best length of the tie rod so it can fit with the small size buggy's chassis.

Figure 4.14

Tie rod resizing by cut out some slot at the rod. This is to achieve the specific size that can fit with the chassis wide.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

At the end of this project, all the objective were achieved which is to design the attachment for customized steering rack for 1 seater drag buggy and to fabricate the mechanical part at the system to solve the steer problem at the buggy. The additional mechanical part that help to solve the problem is the gearbox and it function according to the plan. This project were accomplished on schedule even it facing a lot of problems during the fabrication stage.

Figure 5.1:-Drag Buggy

5.2 Problem Faced During the Project

A lot of minor and major problem had happen from the beginning until the end of the project. The first problem happens during the fabrication stage is to get the proper size of pinion gears at the market and the market price of other part are very expensive even it is from half cut dealer. For example the price of Daihatsu Mira steering rack is RM200. And the major problem during the project is the attachment of the gearbox at the buggy steering rack. The early plan attachment did not working which was U-joint at the gearbox can't rotate because the bend angle had reach more than 45 degrees. It is hard to get the correct angle because of the spacing at the buggy is limited and the safety factors have to be priority in this project.

5.3 Recommendation

This buggy project need a lot of improvements before the buggy can be propose to FELDA. The Steer system needs to be change from mechanical steer system to the power steering system to give an ease controlling to the driver. This is because this buggy will be use as an off-road vehicle that travels at estate. Since the project will be used in the heavily condition such as off road scene in plantation, the project should be provided with a roll cage at the driver compartment to protect the driver and also to give a rigid condition to the vehicle when accident happens. The safety of the driver is very important due to the extreme environment usage of the buggy.

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1. Thomas net.carsuspensionguide : http://www.carsuspensionguide.com/:-2004-2005

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APPENDIX A

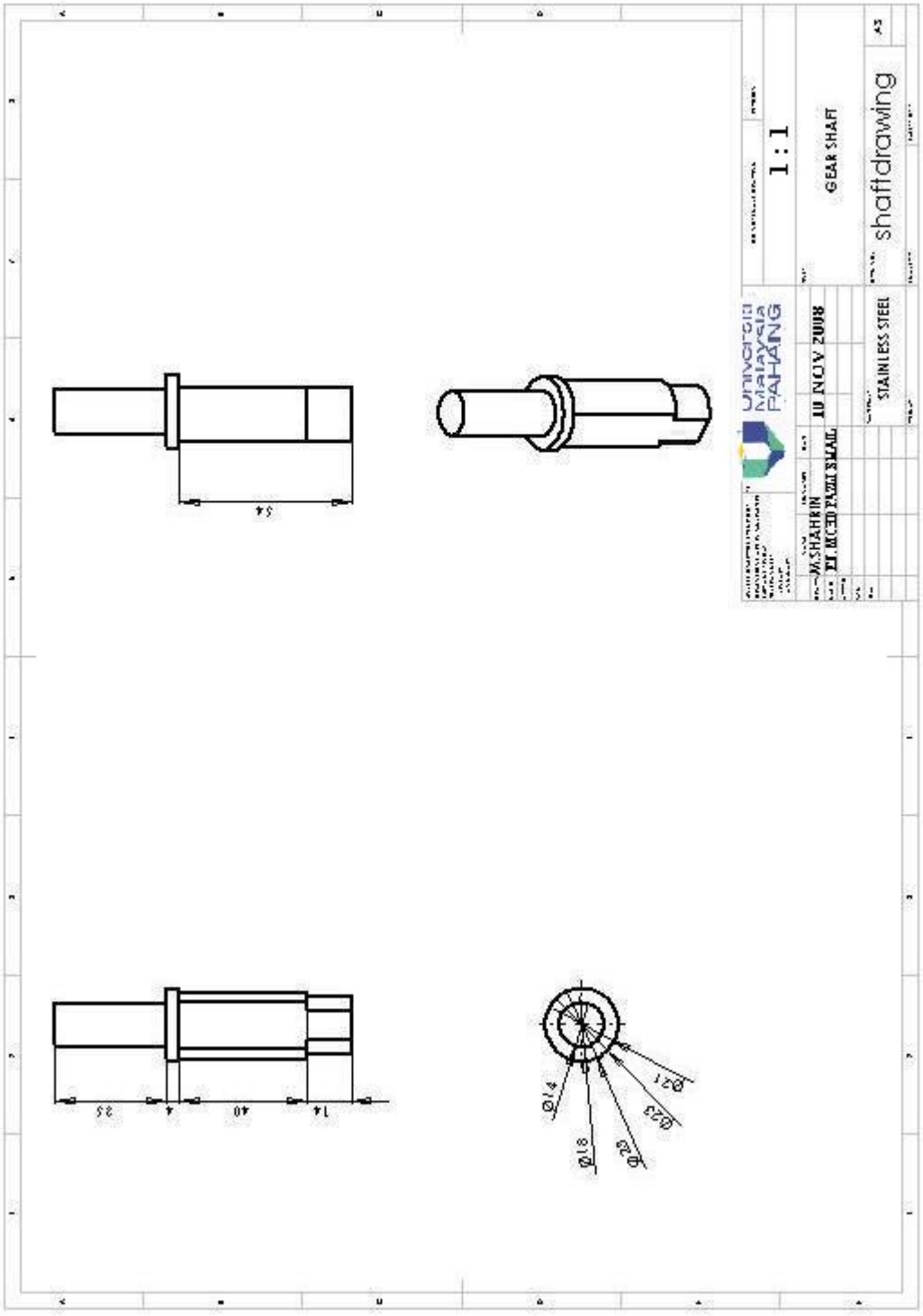
This chart is representing the schedule of entire process in this project.

WEEK / PROGRESS	1	2	3	4	5	6	7	8	9	10	11	12
PROJECT TITLE SELECTION												
BRIEF & IDENTIFIED PROJECT PROBLEM												
SOLVE PROBLEM & SKECTH DESIGNS												
ANALYSIS DESIGNS												
GEARBOX FABRICATION												
PROGRESS REPORT & PRESENTATION												
ASSEMBLE THE GEARBOX & OTHER PROJECT PART												
FINAL REPORT & PRESENTATION												

Process planning

Actual process

APPENDIX B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GEAR SHAFT
shaftdrawing
STAINLESS STEEL
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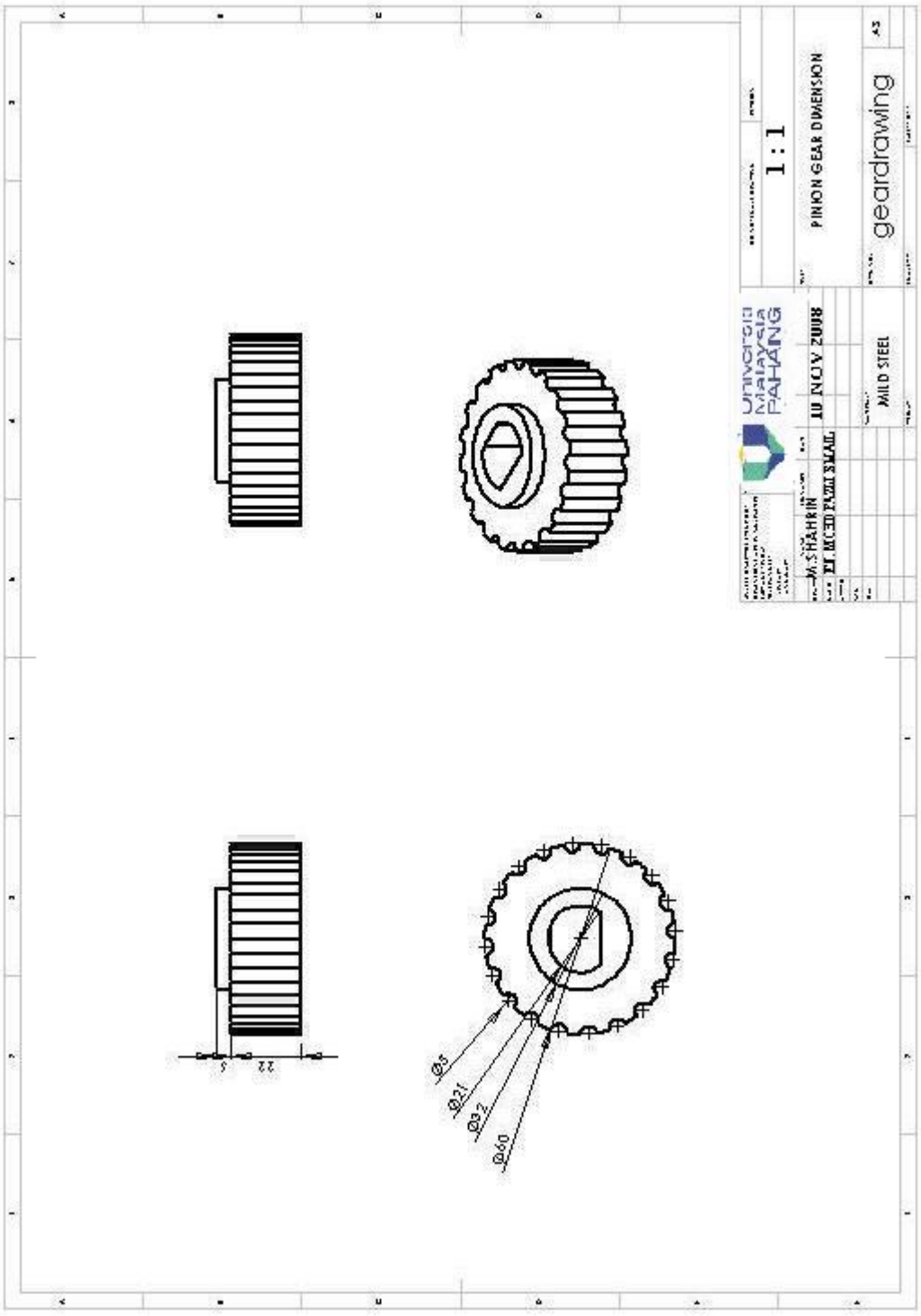
4
40
14
Ø14
Ø18
Ø23
Ø23
Ø21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geardrawing
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MILD STEEL
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M.SHAHRIN
Universiti Malaysia PAHANG
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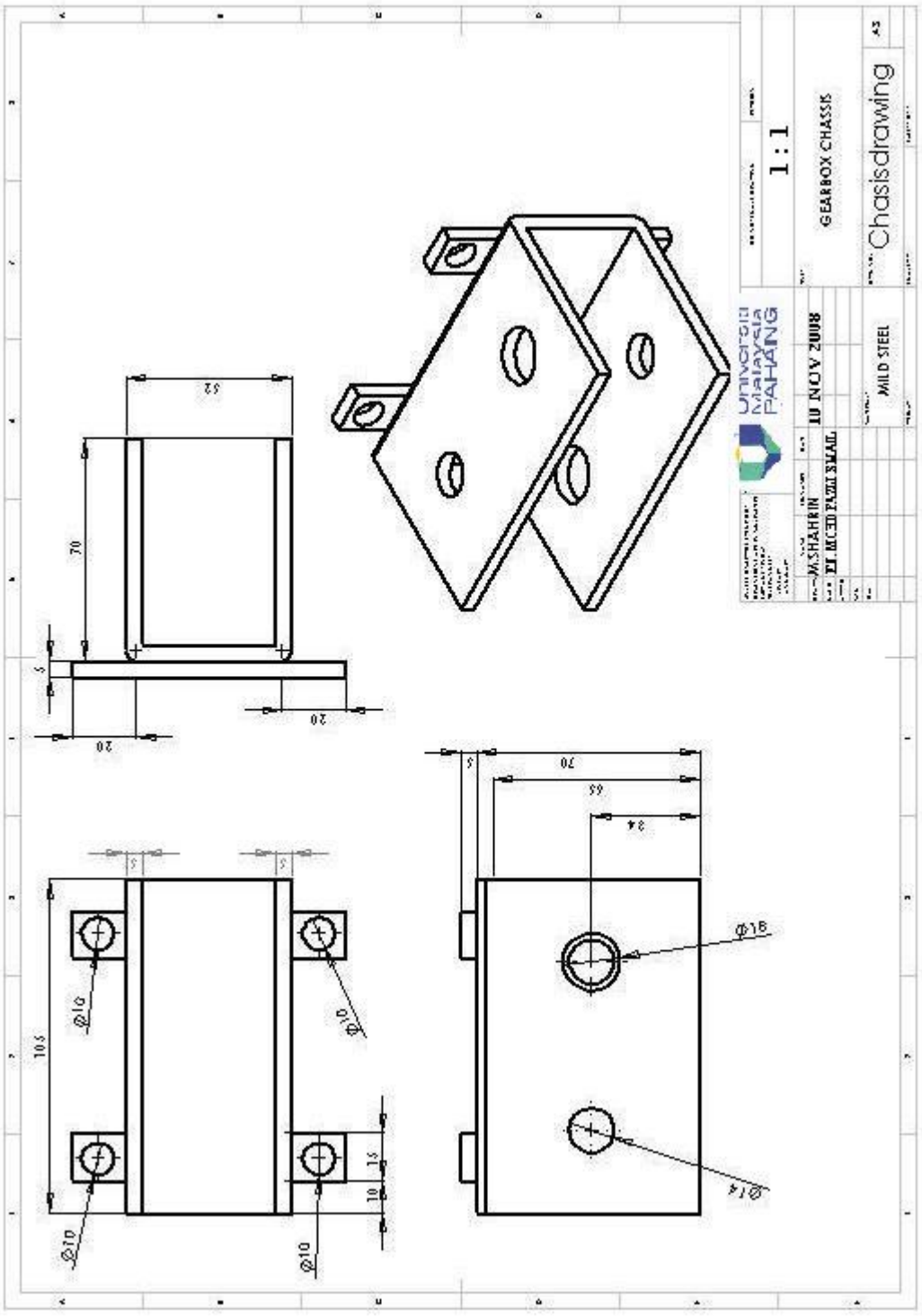
Ø37
Ø60
22
5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MILD STEEL
Chasisdrawing
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Universiti Malaysia PAHANG
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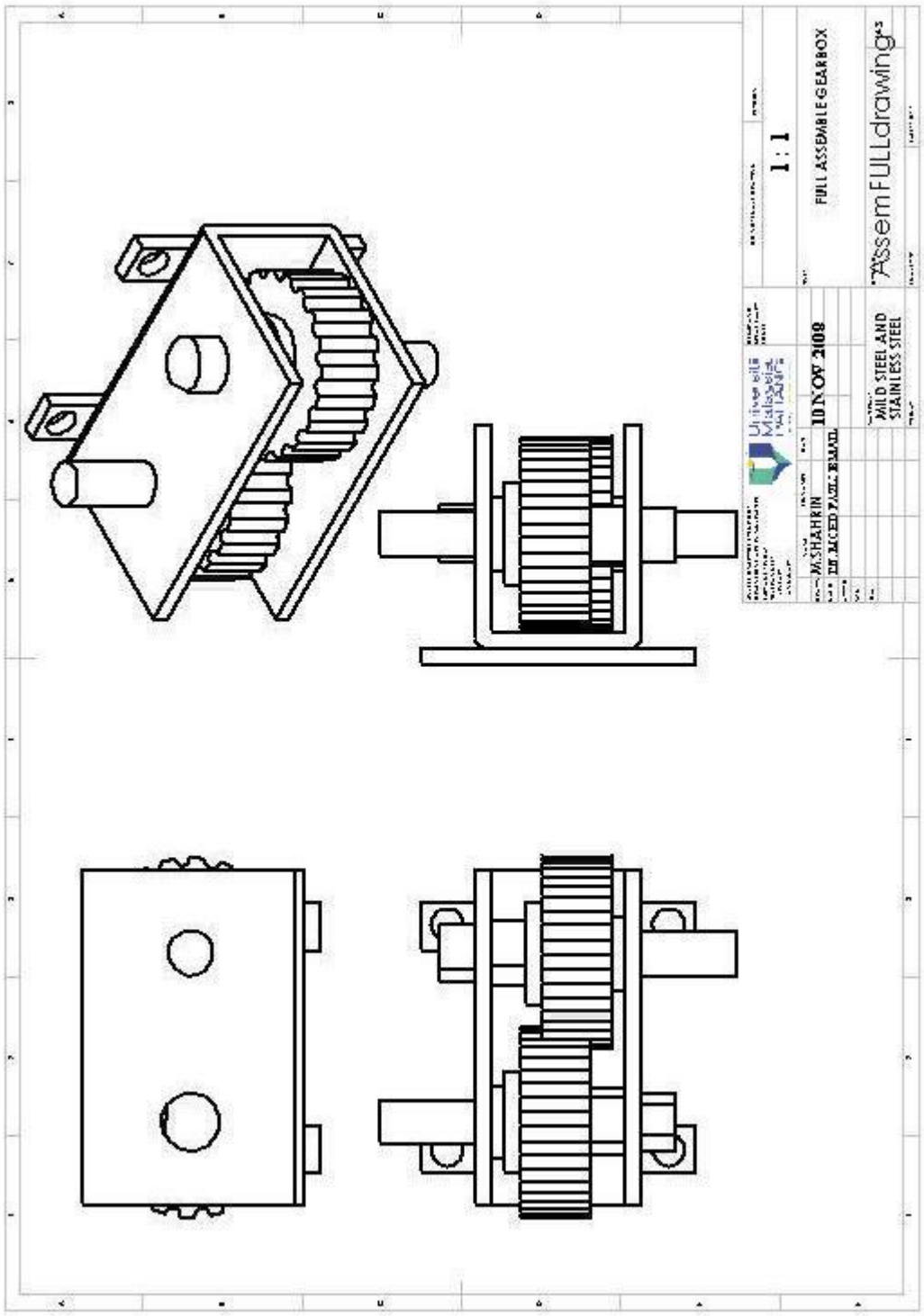
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FULL ASSEMBLE GEARBOX
M.SHAHRIN
ID NO: 2108
MILD STEEL AND
STAINLESS STEEL
AssemFULLdrawing